BIBLIOGRAPHY OF THE GEOLOGY OF INDONESIA AND SURROUNDING AREAS
NEW ENTRIES FOR EDITION 7.0
(= Supplement to Ed. 6.0 - 2016)
J.T. VAN GORSEL - July 2018
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NEW (AND NOT SO NEW) TITLES IN EDITION 7.0:

* This volume contains the new titles in Edition 7.0, that have been added to the Bibliography since the 6th Edition of October 2016. This includes both new papers published since mid-2016 as well as many older papers that were missed in earlier editions of this Bibliography.

* 3490 new titles, including:
  - 1560 papers on regional geology and on geology of areas in Indonesia and North Borneo
  - 1337 papers on geology of areas around Indonesia
  - 570 papers on paleontology and other special topics.

* >1375 new titles have links to open access online repositories.

* Also >3000 updates of references that were already in Edition 6.0.
I. REGIONAL GEOLOGY (303)

I.1. Indonesia Regional Geology (52)


(Three 'conventional' paradigms in areas of TGS IndoDeep project: (1) Sumatra Fore-arc totally unprospective, (2) not sufficient sediment thickness in Bone Bay to have generated hydrocarbons; (3) Cenderawasih Bay underlain by oceanic crust and unprospective (pretty pictures of seismic lines and seafloor bathymetry, but no explanations of new insights; JTvG))


(Review of limestone karst development in Indonesia (mainly in Tertiary limestones). Tropical karst areas generally controlled by heavy torrential tropical rains and characterized by predominantly positive landforms (conical and pinnacle karst hills), while depressions (sinkholes, etc.) more common expression of dissolution in areas of slow rains in temperate belt)


(Discussion of karst weathering in Gunung Saribu (W Sumatra; Permo-Carboniferous), Gunung Sewu (S Mountains) and other localities on Java and SW Sulawesi (Maros))

Bijlaard, P.P. (1935)- Beschouwingen over de knikzekerheid en de plastische vervormingen van de aardkorst in verband met de geologie van den Oost-Indischen archipel. De Ingenieur in Nederlandsch-Indie 1935, (I), 11, p. 135-156.

('Discussion of buckling potential and plastic deformation of the Earth's crust as related to the East Indies Archipelago'. On the physics of plastic deformation of Earth's crust in the Indonesian region. Expansion of Vening Meinesz' theory of crustal downbuckling)

Bijlaard, P.P. (1936)- Nadere toelichting van mijn theorie der plaatselijke plastische vervormingen op de tektoniek. De Ingenieur in Nederlandsch-Indie 1936, (I), 11, p. 160-170. (Second part of discussion between Van Bemmelen and Bijlaard on tectonic theory for Indonesian region)

Brunn, J.H. & P.B. Burollet (1979)- Island arcs and folded ranges. In: W.J.M. van der Linden (ed.) Fixism, mobilism or relativism: Van Bemmelen's search for harmony, Geologie en Mijnbouw 58, 2, p. 117-126. (online at: https://drive.google.com/file/d/0B7j8bPm9Cse0RGQxdG1sTNnIaM/view)

(Includes chapter on Seram arc and Banda Sea. With Hamilton (1979) one of first to suggest Banda sea formed by longitudinal extension)


(see also online at: http://geoseismic-seasia.blogspot.com/p/home.html)
(24 chapters of Indonesian basins with short basin characterization and typical seismic lines)

(online at: http://www.iagi.or.id/fosi/berita-sedimentologi-no-40.html)
(Examples of P3GL seismic lines over several East Indonesia basins around Waigeo, Misool, Seram, Aru, etc.)

(New zircon ages of igneous rocks in E Indonesia. Biotite-cordierite dacites (ambonites) from Ambon Pliocene (3-4 Ma), with inherited material from ~150-450 Ma. Banggai-Sula granites mainly Triassic age (226-244 Ma), with inherited zircons of ~1000, ~1400-1500, 1800 and 2200 Ma. Birds Head granites similar Triassic ages (~235-248 Ma; roots of Triassic volcanic arc system). Baca diorite ~330 Ma. On Seram Triassic siliciclastic Kanikeh Fm sst same zircon age spectra as metasediments of Tanusa and Tehoru complexes. Sirga Fm quartz elastics in New Guinea Lst several units of different ages, derived from local uplifts in Eocene-Oligocene)

(Order of structure belts/rocks around Banda Sea is not a logical one in terms of plate tectonics. Outer Banda Arc not accretionary complex but compressed northern rim of Australian continental margin)

(online at: https://www.ncgeo.nl/downloads/08DeVos.pdf)
(Calculations on gravity measurements by Vening Meinesz suggest irregularities in vertical gravity deflections and shape of geoid in E Indonesia. No discussion of geologic implications)

(online at: www.gsm.org.my/products/702001-101723-PDF.pdf)
(Productive Tertiary basins in SE Asia similar geodynamic developments, with 5 facies associations: (1) lacustrine (early synrift of Sundaland; mainly oil) (2) paralic (late synrift); (3) open marine shelf (post-rift, E Indonesia and Philippines) (4) deeper marine (post-rift; mainly gas) and (5) pre-Tertiary (E Indonesia and Thailand, mainly terrestrial). Around Borneo thick late post rift passive margin delta sequences with oil- and gas-prone coaly source rock; transported terrigenous organic material common in related deep marine environments and contributes to marine source facies. In SE Asia terrestrial and lacustrine source rocks rel. difficult to locate, variable in quality and often distributed in thin beds)

(online at: https://ia601700.us.archive.org/35/items/jstor-1797916/1797916.pdf)
(Early depiction of major structural elements elements of Indonesian archipelago: two continental blocks ('Great Asiatic Bank' in W and 'Great Australian Bank' in SE, surrounded by mountain and volcanic ranges)

(Brief review of issues in SE Asia tectonic models. Three important periods in regional development: ~45 Ma, 25 Ma and 5 Ma, when plate boundaries and motions changed, probably due to major collision events. Little indication that India was driving force of tectonics in SE Asia. Principal 'myths': myth of India indentor, myth of Australian micro-continent collision events and myth of convergence in New Guinea. No figures)


Linthout, K., H. Helmers & J. Sopaheluolawan (1999)- Dual subduction and a Neogene microplate between Australia and the Banda Sea. In: H. Darman & F.H. Sidi (eds.) Tectonics and sedimentation of Indonesia, FOSI-IAGI-ITB Regional Seminar to commemorate 50th anniversary of Van Bemmelen’s Geology of Indonesia, Bandung 1999, p. 92. (Abstract only) (New tectonic model requires separate Timor microplate in Neogene, now part of Banda collision zone. Paleomagnetic data suggests Timor island contains allochthonous terranes that were separated from N Australian margin by >2500km in E Cretaceous; Late Neogene Banda Arc not related to subduction of 2500km of oceanic crust between Cretaceous- Pliocene; upside-down metamorphism of Late Miocene age in soles of ultramafites requires obduction of hot lithosphere, etc. No figures)


Morley, R.J. & H.P. Morley (2018)- Montane pollen indicates character of Mid Cenozoic uplands across Sunda Shelf. In: PESGB SEAPEX Asia Pacific E&P Conference, London, 4p (Extended Abstract) (Montane pollen common element of palynomorph assemblages across Sundaland region and provides insight into paleoaltitudes and paleoclimates from Paleocene- Pliocene. In Late Eocene-Oligocene, Natuna Arch, Con Son Swell and Ammanite Ranges likely of sufficient altitude to support temperate broadleaf and cool temperate
conifer forests at summits, with altitudes of 2500m or more. Late Miocene-Pliocene uplifts in Borneo, (Kinabalu, Meratus) and Sumatra Barisan Range. Volcanoes of Java formed in Pleistocene)


Setiawan, N.I., Y. Osanai & M.I. Khalif (2016)- U-Pb detrital zircon geochronology of metamorphic rocks from South Kalimantan, South Sulawesi, and Central Java, Indonesia: related metamorphism and tectonic implications in Central Indonesia region. Proc. GEOSEA XIV and 45th Ann. Conv. Indon. Assoc. Geologists (IAGI) (GIC 2016), Bandung, p. 289-292. (High P metamorphics from Meratus in SE Kalimantan, Bantimala in S Sulawesi and Luk Ulo in C Java generally tied to NW-directed Cretaceous subduction. Zircons show no metamorphic rims and therefore viewed as detrital grains and provenance ages of metamorphic rock protoliths. Youngest detrital zircon ages in Bantimala- Meratus ~199-194 Ma, in Luk Ulo ~100 Ma. Ages from Bantimala glaucophane-quartz schist ~430-199 Ma (Silurian- E Jurassic), Baru garnet schist ~1930, 1730, 1600-1400 Ma, 1050 Ma (Proterozoic), and 550-280 Ma (Cambrian-Permian); Meratus epidote-barroisite schist 232 ± 39 Ma (Late Triassic; range 296-194 Ma); Luk Ulo gneiss mainly 127-100 Ma (E Cretaceous; also older)
Situmorang, B. (1977)- The western Indonesia fault pattern: tectonic significance with relation to wrench tectonics. Lemigas Scientific Contr. 1, 2, p. 5-18

(Four compression phases in W Indonesia since pre M Mesozoic: (1) N80°- 260E pre- M Mesozoic equatorial compression; (2) N158- 338E M Mesozoic meridional compression; (3) N2- 182E late Cretaceous- E Tertiary meridional compression, and (4) N174- 35E Plio-Pleistocene compression. Bantam trend three fault systems of different ages: M-Mesozoic left lateral strike-slip faults in C and S Sumatra, late Cretaceous- E Tertiary right lateral strike-slip faults in Sunda Strait and on Java, and Plio-Pleistocene left lateral strike-slip faults in Sumatra. M-Mesozoic and late Cretaceous- E Tertiary compression responsible for creation of basic basin configuration in C and S Sumatra, W Java and W Java Sea areas. En echelon folds forming hydrocarbon bearing anticlines in Sumatra and Java related to Plio-Pleistocene compression)


(Summary of lecture on tectonics of Indonesian region, incorporating zoogeographic data)


(Soesilo et al. 2015: Includes new U-Pb dating of zircons in high-metamorphic rocks of Meratus (136.8 ± 3.6 and Luk Ulo (125-101 Ma))


('The Malay Archipelago and Alps'. Comparison of Indonesian region tectonics and Alps)


(GPS measurements from 1993-2014 across Indonesia region provide 2-3mm-level precision of surface velocity estimates. GPS velocities used here to construct a crustal strain rate map. Highest strain rates along Sumatran fault, Sumatra-Java trench, North Molucca Sea and Sera- northern West Papua areas)


(online at: http://digitalcommons.lsu.edu/cgi/viewcontent.cgi?article=7792&context=gradschool_disstheses)


(Effective Elastic Thickness map at incipient continental collision (Pliocene-Recent) along N Australian continental lithosphere along Banda orogen suggests more rigid N Australian lithosphere indenting between 125-127°E longitude. Sharp decrease in EET from 230-180 km on continental shelf (from Roti to W of Aru Island) down to ~40 km on continental slope and beneath Banda orogen favoring inelastic failure at start of continental subduction)


(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1986/5083...)
(Sundaland Holocene sealevel rise 2cm/year after last deglaciation, reaching 4m above present 6000 yrs ago. Vertical uplifts of coral reef terraces and abrasion surfaces in region up to ~1300m. 500 Quaternary volcanic centers identified, 130 active. Etc.)

Van Bemmelen, R.W. (1933)- Moderne richtingen in de geotektoniek (in verband met de geotektonische positie van den Nederlandsch-Indischen archipel. De Mineringenieur 14, 12, p. 205-212. ('Modern theories in geotectonics (in relation to the geotectonic position of the Netherlands Indies archipelago'. Discussion of tectonic theories. At that time in the Indonesian region were several supporters of the Wegener/Holmes-inspired 'mobilist' school (Vening Meinesz, Escher, Umbgrove, Smit Sibinga), while Van Bemmelen with his undation theory is firmly in 'fixist' camp)

Van Bemmelen, R.W. (1936)- Kritische beschouwingen naar aanleiding van Bijlaard's theorie over plastische deformaties van de aardkorst. De Ingenieur in Nederlandsch-Indie 1936, (I), 7, p. 87-93. ('Critical discussion of Bijlaard's theory on plastic deformations of the Earth's crust')

Van Bemmelen, R.W. (1936)- Geologische contra mechanische analyse der geotektoniek (Geologische bezwaren tegen Bijlaard's theorie der lokal, plastische deformaties van de aardkorst). De Ingenieur in Nederlandsch-Indie 1936, (I), 11, p. 150-160. ('Geological versus mechanical analysis of geotectonics (Geological objections against Bijlaard's theory of local plastic deformations of the Earth's crust'). Second part of discussion between Van Bemmelen and Bijlaard on tectonic theory for Indonesian region)

Van Bemmelen, R.W. (1954)- The geophysical contrast between orogenic and stable areas. Geologie en Mijnbouw 16, 8, p. 326-334. (online at: https://drive.google.com/file/d/0B7j8bPm9Cse0Q==A4cUJzVmlrNGM/view) (Extended commentary of Collette (1954) thesis 'On the gravity field of the Sunda region'. Includes chapter on interpretation of gravity field of West Indonesia. Positive anomaly with steep gradients over Wijnkoopsbaai (Ciletuh Bay) on Profile VI probably results from ophiolitic high-density rocks near surface. Belt of negative anomalies over Kendeng zone of NE Java result of either bending down of crust and filling with low-density sediments or small asthenolithic blisters at base of sialic crust. Etc. With Collette reply)


Study of 27 fault systems in Eastern Indonesia. Most fault systems highly segmented, many linked by narrow (<3 km) stepovers to form quasi-continuous segments capable of M> 7.5 earthquakes. Sinistral shear across soft-linked Yapen and Tarera-Aiduna faults and continuation into transpressive Seram fold thrust belt perhaps most active belt of deformation. Palu-Koro Fault of Sulawesi long, straight and capable of super shear ruptures, considered to be greatest seismic risk in region.

I.2. SE Asia Regional Geology, Tectonics, Palaeobiogeography (79)

(Comparison of Paleogene larger foraminifera from E part of NeoTethys in Kohat Basin of Pakistan compared with W, C Neo-Tethys to establish Paleogene migration pathways in Neo-Tethys. LBF species mostly confined to blocks derived from Gondwana (Iran, Iraq, Pakistan, India, Indonesia) and Laurasia (Italy, France, Spain), with only few on margin of Gondwanan continents (Oman). Includes brief review of Indonesian LBF)

(online at: https://academic.oup.com/botlinnean/article/174/3/326/2416344)
(Angiosperms (flowering seed plants) originated abruptly in E Cretaceous (Hauterivian), followed by rapid diversification in Hauterivian-Aptian. Islands in SE Asia region today probably played major role in angiosperm diversification in Late Jurassic- E Cretaceous (but no discussion of support from actual fossil botanical records of SE Asia; HvG)


(online at: https://rk.msu.ac.th/wp-content/uploads/2017/09/Clive-Burrett4-compressed.pdf)
(Review of Cambrian-Permian predominantly shelfal marine silicilastics and carbonates of Sibumasu Terrane in NW Malaysia (Langkawi), S Thailand (Satun), Shan States of Myanmar and Baoshan Block of W Yunnan. Continuous platform sequences in W Sibumasu and deep-water shales and cherts in E Sibumasu, without significant unconformities. Silurian-Devonian faunas mainly peri-Gondwana distributions. Sibumasu part of Australia until E Permian breakup (oriented with Baoshan near Himalayan margin; Sumatra closer to West Papua). Late Triassic (late Norian?) collision with Indochina/Sukhothai Arc terrane)

(online at: https://manuscript.elsevier.com/S0012821X15007906/pdf/S0012821X15007906.pdf)
(Petrographic and detrital zircon analyses of U Triassic sandstones from N margin of India (Tethyan Himalaya Sequence, S Tibet) dominated by Indian-affinity Precambrian detrital zircons, but nearby areas with populations of Permian- E Jurassic (291-184 Ma) zircons for which there is no known Indian source, so probably derived from continental crustal fragments that were adjacent to NW margin of Australia. May be part of Late Triassic submarine fan along N Australian shelf, together with age-equivalent beds in W Sulawesi, Timor and W Papua with similar zircon age populations. U Triassic Mailonggang Fm from S margin of Eurasia (S Lhasa terrane) dominated by Permian zircons from proximal Lhasa terrane sources; differs from Tethyan Himalaya beds, suggesting separation from Greater India by Neo-Tethys Ocean)


Chatterjee, S., C.R. Scotese & S. Bajpai (2017)-The restless Indian plate and its epic voyage from Gondwana to Asia: its tectonic, paleoclimate, and paleobiogeographic evolution. Geol. Soc. America, Spec. Paper 529, p. 1-147. (Review of tectonic evolution of India plate since breakup of Gondwana in Late Jurassic, partial isolation in E Cretaceous, collision with Kohistan-Ladakh arc at ~80 Ma (= continuation of Woyla Arc of W Sumatra?), Cretaceous- Paleogene boundary Shiva impact and Deccan volcanism. In Late Cretaceous (~67 Ma), Indian plate motion acceleration between two transform faults that facilitated N-ward movement, etc.)


Duan, L., Q.R. Meng, G.L. Wu & S.X. Ma (2012)- Detrital zircon evidence for the linkage of the South China block with Gondwanaland in early Paleozoic time. Geol. Magazine 149, 6, p. 1124-1131. (Detrital zircons from Lower Devonian sections in S China block dominant Grenvillian and Pan-African populations, similar to E Paleozoic from Gondwana, Tethyan Himalaya and WAustralia. Hf isotopes indicate contributions of juvenile crust at 1.6 Ga and 2.5 Ga. S China block was integral part of E Gondwana in E Paleozoic, not continental block in Paleo-Pacific or fragment of Laurentia)
Fan, W., Y. Wang, Y. Zhang, Y. Zhang, F. Jourdan, J. Zi & H. Liu (2015)- Paleotethyan subduction process revealed from Triassic blueschists in the Lancang tectonic belt of Southwest China. Tectonophysics 662, p. 95-108. (Subduction of Paleotethys Ocean and subsequent continental collision recorded in blueschists in Lancang SE Paleotethyan belt in SW China. Suvi blueschists zircon U-Pb age of 260 ± 4 Ma and glaucophane formed during prograde metamorphism with 40Ar/39Ar plateau age of 242 ± 5 Ma (M Trias). Protolith formed at 260 Ma and originated from basaltic seamount. Basaltic rocks subducted down to 30-35 km under Lincang arc to form epidote blueschists at ~242 Ma. Blueschists subsequently transported to shallower crustal levels in response to continuous underthrust of subducted slab and continent–continent collision in M-L Triassic)

Fang, Wu (1989)- Paleozoic paleomagnetism of the South China block and the Shan Thai block: The composite nature of Southeast Asia. Ph.D. Thesis, University of Michigan, p. 1-165. (Paleomag of Paleozoic samples from E Yunnan (S China Block) and W Yunnan (N end of Shan-Tai Block). Contrasting paleolatitudes for Devonian samples: equatorial position for E Yunnan, of ~40° for W Yunnan, which probably was part of Gondwana supercontinent)


Fyhn, M.B.W., P.F. Green, S.C. Bergman, J. Van Itterbeeck, T.V. Tri, P.T. Dien, I. Abatzis, T.B. Thomsen, S. Chea, S.A.S. Pedersen et al. (2016)- Cenozoic deformation and exhumation of the Kampot Fold Belt and implications for south Indochina tectonics. J. Geophysical Research, Solid Earth, 121, 7, p. 5278-5307. (Latest Mesozoic-earliest Cenozoic deformation of Sundaland core between SE Asian fusion and Cenozoic era of rifting and basin formation. In S Cambodia and Vietnam major latest Cretaceous- Paleocene thrusting and uplift of Kampot Fold Belt and surrounding regions, with up to ~11 km exhumation. Latest Cretaceous-Paleocene orogenesis affected much of greater Indochina, probably due to plate collision along E Sundaland or combination of collisions along E and W Sundaland. AFTA and ZFTA data document protracted cooling of Cretaceous granites and locally elevated thermal gradients 10's of My afterr emplacement. Thermal gradient stabilized by E Miocene time, and Miocene cooling probably reflects renewed denudation pulse)


Hall, R. & H. Breitfeld (2017)- Nature and demise of the Proto-South China Sea. Bull. Geol. Soc. Malaysia 63 (Geol. Soc. Malaysia 50th Anniversary Issue 1), p. 61-76. (online at: www.gsm.org.my/products/702001-101708-PDF.pdf) (Proto-South China Sea should be used only for oceanic slab subducted beneath Sabah and Cagayan between Eocene- E Miocene; Paleo-Pacific Ocean used here for lithosphere subducted under Borneo in Cretaceous. Good evidence for subduction between Eocene- E Miocene below Sabah, and W limit of Proto-S China Sea subduction was W Baram Line; subducted slab imaged in lower mantle by P-wave tomography. Present-day NW Borneo Trough and Palawan Trough not subduction trenches: NW Borneo Trough flexural response to gravity-driven deformation of Neogene sediment wedge NW of Sabah. Palawan Trough is continent-ocean transition at SE edge of modern S China Sea)


(S China block composed of sub-blocks Yangtze in NW and Cathaysia in SE), which collided and amalgamated in Neoproterozoic along Jiangnan Orogen. Felsic lower crust of Cathaysia Block and Jiangnan orogenic belt may represent fragments derived from Gondwana supercontinent)


(Tomographic images of mantle under SE Asia show high-velocity zones high-V zones around SE Asia which generally represent subducting slabs. Slabs generally extend down to the Mantle Transition Zone. Low-velocity zones with trench-normal anisotropy in uppermost mantle, indicating back-arc spreading or secondary mantle-wedge flow induced by slab subduction. Trench-parallel anisotropy in deep upper mantle reflects structures in subducting slab or in upper mantle surrounding slab. Gap in slab under area between Sumatra and Java)


(Examples of use of natural stone in construction of temples, monuments, castles, forts, etc., in 9 SE Asian countries. Incl. chapter on Indonesia by S. Baskoro (not much detail on rock types and nothing on West Papua)


Kobayashi, T. (1944)- Reciprocal development of radiolarian rocks as between Asiatic and Australian sides. Proc. Imperial Academy (Tokyo) 20, 4, p. 234-238. (online at: https://www.jstage.jst.go.jp/article/pjab1912/20/4/20_4_234/_pdf)

(Brief review of radiolarian bearing formations in Japan, SE Asia, Australia. Sambosan and Higashigawa suites of Japan mainly Permo-Triassic age. Also in chert series in Malay Peninsula, Tuhur Fm of Sumatra and Danau Fm in Borneo. Danau Fm suggested by Hinde to be Jurassic age, but here thought to be mostly Permo-Triassic (based on Krekeler observations). Danau facies appears continues into Philippines via Palawan and Jolo or Sulu arcs, where radiolarian cherts are called Babuyan Fm)

Li, C.F. & J. Wang (2016)- Variations in Moho and Curie depths and heat flow in Eastern and Southeastern Asia. Marine Geophysical Research 37, 1, p. 1-20. (Oldest continental and oceanic domains (N China craton, Pacific and Indian Ocean) thermally perturbed by events probably linked to small-scale convection or serpentinitization in mantle and volcanic seamounts and ridges. W Philippine Sea Basin anomalously small Curie depths. W Pacific marginal seas have lowest Moho

(E Devonian plants from Posongchong Fm of SE Yunnan, suggest E Devonian NE Gondwana phytogeographic unit in Equatorial position, comprising Australia, S China Block and perhaps Shan-Thai Block)
temperature; contrary in most parts of easternmost Eurasian continent. Magmatic processes feeding Permian Emeishan large igneous province along plate boundary may be caused by tectonic processes along plate margins, rather than by deep mantle plume

Li, S., E. Advokaat, D.J.J. van Hinsbergen, M. Koymans, C. Deng & R. Zhu (2017)- Paleomagnetic constraints on the Mesozoic–Cenozoic paleolatitudinal and rotational history of Indochina and South China: review and updated kinematic reconstruction. Earth-Science Reviews 171, p. 58-77. (Review of paleomagnetic data suggests (1) no significant rotations of S China Block relative to Eurasia since latest Jurassic; (2) No paleomagnetically resolvable S-ward motion of Indochina Block (inclinations lower than expected, probably due to inclination shallowing in sediments; (3) large rotating blocks in N Indochina and SE Tibetan margin (up to 70° CW), more than ~10-15° rotation of stable SE Indochina Block. Blocks bounded by fold-thrust belts and strike-slip faults, accommodating Cenozoic block rotations. NW part of Indochina extruded 350 km more along Ailao Shan-Red River fault than SE part, accommodated by internal NW Indochina rotation and deformation. 250 km of extrusion of SE part of Indochina)

Li, S., B.M. Jahn, S. Zhao, L. Dai, X. Li, Y. Suo, L. Guo, Y.M. Wang et al. (2017)- Triassic southeastward subduction of North China Block to South China Block: insights from new geological, geophysical and geochemical data. Earth-Science Reviews 166, p. 270-285. (Subduction prior to assembly of S China and N China blocks traditionally considered directed N-ward, but new tectonic model suggests S-ward subduction of N China under S China. S margin of N China Block passive margin in Triassic, without arc magmatism, etc. Suture lateral subduction zone rather than collision zone)


Liao, S.Y., F.G. Yin, Z.M. Sun, D.B. Wang, Y. Tang & J. Sun (2013)- Early Middle Triassic mafic dikes from the Baoshan subterrane, western Yunnan: implications for the tectonic evolution of the Palaeo-Tethys in Southeast Asia. Int. Geology Review 55, 8, p. 976-993. (Zircon U-Pb data indicate tholeiitic dikes similar to enriched mid-ocean ridge basalts emplaced at N part of Sibumasu terrane at 240± 3 Ma. Mafic dikes interpreted to be generated during suturing of Baoshan (Sibumasu) and Simao (Indochina) subterrane)


(NE branch of Paleo-Tethys Ocean that separated N China and South China plates closed by oblique collision along two N-dipping suture zones in C China. Shangdan suture developed in Late Paleozoic; Mianhuo suture to S in M-L Triassic (collisional sutures obscured by thrust faults in S Qinling-Dabieshan orogen))


(Main Paleotethys Ocean basin, which separates Late Paleozoic Gondwanaland terranes from Late Palaeozoic Cathaysian terrane, represented by Triassic suture zones Lancangjian and Changning-Menglian (SW China), Nan-Uttaradit and Sra Kaeo (Thailand) and Bentong-Raub (Peninsular Malaysia). Subsidiary branches of Paleotethys represented by Ailaoshan suture in Yunnan, Song Ma suture in Vietnam (E Carboniferous) and other possible suture segments in N Thailand and S China. Radiolarian assemblages from deep marine cherts show Paleotethys opened in M-L Devonian and closed in Late Triassic)


(Latest in series of Metcalfe review papers on SE Asian plate tectonics. By Late Triassic principal continental core blocks of Sundaland (Sibumasu, Sukhothai Arc, Simao, Indochina) had amalgamated and collided with S and N China to form proto-E and SE Asia. Paleo-Tethys represented by Changning-Menglian, Chiang Mai-Chiang Rai, Chanthaburi and Bentong-Raub Suture Zones that form boundary between Sibumasu and Sukhothai Arc. Sukhothai Arc formed on margin of Indochina in Carboniferous, then separated by back-arc spreading in Permian. Jinghong, Nan-Uttaradit and Sra Kaeo Sutures represent this closed back-arc basin. Cathaysian W Sumatra Block with its continental margin arc may well be displaced segment of Sukhothai Arc system, translated outboard of Sibumasu by strike-slip tectonics in Triassic. W Burma Block was already attached to Sundaland before Late Triassic and is likely disrupted part of Sibumasu. Nature of any hidden continental core of SW Borneo remains enigmatic. Etc.)


(Basement of continental shelf beneath E and S China Seas may be of exotic origin, geologically unrelated to continental lithosphere of E China. Jurassic-Cretaceous granitoids in region associated with W Pacific oceanic subduction. 'Sudden' termination of granitoid magmatism at ~88 ± 2 Ma suggests trench jam at ~100 Ma, pointing to collision of buoyant oceanic plateau or microcontinent. Jammed trench (suture) located near coastline of SE continental China. Trench jam at ~100 Ma led to re-orientation of Pacific plate motion, making boundary between Pacific plate and newly accreted plate of E Asia transform fault E of exotic-origin continental shelf. This explains apparent ~40 Myr magmatic gap from ~88 to ~50 Ma)


(Silurian shallow marine brachiopod Retziella Fauna known from SW Tienshan, China, N Vietnam and E Australia. Possibly also in N Korea, C Pamirs, Afghanistan and New Zealand (Sino-Australian Province). Coeval Tuvaella Fauna occurs only in S marginal belt of Siberian Plate (Mongolo-Okhotsk Province))

(Recent petroleum exploration contributed to solving debates on tectonics of Indonesia: (1) N Makassar Straits opening mechanism and nature of basement (extended continental crust from interpretation of volcanic geochemistry in well), (2) origin of Sumba micro-continent (rifled block from Sulawesi), (3) basement of Cendrawasih Bay (Pacific Plate oceanic/ arc volcanic crust). Some issues now better defined: (4) forearc areas of Sumatra- W Java (with Paleogene rift structures), and (5) foredeep areas of Seram-Tanimbar-Timor troughs (foredeeps, not subduction troughs). New knowledge of tectonics: (6) presence of Late Paleozoic-Mesozoic sections of Gondwana micro-continents in East Java and S Makassar Straits (from interpretation of seismic and geochemical data), and (7) multiple rifts/terranes of Gorontalo Basin (from seismic interpretation))


(Genesis of mineral deposits in Tethyan collision zones of Asia, in: (1) oceanic crust (hydrothermal Cu-Au; Fe, Mn nodules) and mantle (Cr, Ni, Pt), in ophiolite complexes around Arabia/India- Asia collision (Oman, to Myanmar, Andaman Islands); (2) island arcs and ancient subduction complexes (VMS Cu-Zn-Pb), in Dras-Kohistan arc (Pakistan) and arc complexes along Myanmar-Andaman segment; (3) Andean-type margins (Cu-Au-Mo porphyry; epithermal Au-Ag) in Jurassic-Eocene Transhimalayan ranges and Myanmar; (4) continent-continent collision zones prominent along Myanmar-Thailand-Malaysia Sn-W granite belts, less common along Himalaya. Mogok metamorphic belt of Myanmar known for gemstones associated with regional high T metamorphism (ruby, spinel, sapphire, etc))


(Five maps of magmatism along the Tethysides for: Late Carboniferous and Permian (320-248 Ma), Triassic and E Jurassic (247-188 Ma), M Jurassic-Early Late Cretaceous (187-98 Ma), early Late Cretaceous-early Cenozoic (97-25 Ma), and late Cenozoic (24-0 Ma))


(Late Triassic- E Jurassic fluvial sandstones from S China Craton basins with four similar detrital zircon age populations: 2.6-2.4 Ga, 2.0-1.7 Ga (with remarkable age peaks at ~1.85 Ga), 850-700 Ma and 480-210 Ma. Hf values between -22.5 and +3.6, suggest derivation from reworked Archaean crust and minor late Paleoproterozoic juvenile crustal additions. Correlate well with E Cathaysia Block (not Yangtze). Similarities in provenance of Triassic-Jurassic around S China Craton delineate E-W sediment belt from Korea to W China and ~2000km long W-draining transcontinental paleo-river feeding basins in Korea, S and W China)


(38 brachiopod species from Yudong Fm in W Yunnan. Associated coral and conodont faunas suggest late Tournaisian (E Carboniferous) age, possibility extending into earlyVisean)


(Maps of spatial variations of Effective elastic thickness for SE Asia from coherence of topography and Bouguer gravity anomaly data. Results suggest E Borneo may share similar crustal basement, and represent broad tectonic zone of destroyed Mesotethys Ocean extending from W-C Java, through E Borneo to N Borneo. Indosinian suture between Indochina and Sibumasu may extend further SE across Billiton to offshore SE Borneo, and Singapore platform and SW Borneo may belong to same block)
(New global tomographic image shows slab-like structure under S Indian Ocean, interpreted as ancient tectonic plate that sank into mantle along extensive intra-oceanic subduction zone that retreated SW across Tethys Ocean in Mesozoic. Jurassic-E Cretaceous oceanic volcanic arc system of Wayla terranes of W Sumatra may represent exposed remnant of this intra-oceanic system)

(U Triassic Jiapila Fm lavas on N edge of Qiangtang block of C Tibet (34.1°N) dated to 204-213 Ma. Paleomagnetic data suggest Late Triassic latitude for block at 31.7 ± 3.0°N. Closure of Paleo-Tethys Ocean at longitude of Qiangtang block most likely in Late Triassic)

Song, P., L. Ding, Z. Li, P.C. Lippert & Y. Yue (2017)- An early bird from Gondwana: paleomagnetism of Lower Permian lavas from northern Qiangtang (Tibet) and the geography of the Paleo-Tethys. Earth Planetary Sci. Letters 475, p. 119-133.
(online at: https://www.sciencedirect.com/science/article/pii/S0012821X17304016)
(Paleomagnetic data from Lower Permian Kaixinling Gp lavas on N Qiangtang block suggest paleolatitude of 21.9 ±4.7 °S at ~297 Ma. Corroborates earlier hypothesis that N Qiangtang block rifted away from Gondwana before Permian, and accreted to Tarim- N China continent by Norian time. Total N-ward drift ~7000km over ~100 My (~7 cm/yr). N Qiangtang no Laurasian affinity. C Qiangtang metamorphic belt possible intra-Qiangtang suture that developed at N latitudes outboard of Gondwanan margin)

(First find of peltasperms in Permian of Gondwana, in Lower Permian Barakar Fm of Satpura Basin, C India, where they co-occur with diverse glossopterids. These are dominant group of N American- European arboreal vegetation and suggest floristic exchanges between Laurasia and Gondwana. Satpura occurrence assigns Indian subcontinent to low-latitude zone of mixed Laurasian/Gondwanan floristic assemblages)

(Eight SE Asia plate reconstruction models from 55- 0 Ma. SW Borneo and Peninsular Malaysia part of same rigid Sundaland basement terrane. 'Rotational extrusion' of Sundaland caused clockwise rotation of Sundaland + Borneo in two phases in Late Eocene and Oligocene. Counter-clockwise rotation of Bird’s Head. E Indonesian 'salami-slicer' extends NW to Borneo, where it accounts for M Miocene Sabah Orogeny. Etc.)

Tong-Dzuy, T., P. Janvier & P. Ta Hoa (1996)- Fish suggest continental connections between South China and Indochina blocks in Middle Devonian times. Geology 24, 6, p. 571-574.
(Yunnanolepisiform antiarch (placoderm fish) from Givetian Dong Tho Fm, C Vietnam, on Indochina Block, well S of Song Ma suture. Previously known only from Lower Devonian of South China block. Massive sandstones of Dong Tho Fm may be southern extension of Do Son Sst of Hai Phong area, S China)

(Basic review of granitic rocks, weathering and distribution in Southeast Asia)

(Detrital zircons from river sediment in Truong Son Belt of Indochina block in N-C Vietnam with mainly Neoarchean (~2.5 Ga), Mesoproterozoic (1.7-1.4 Ga), Grenvillian (~0.95 Ga) and Pan-African (0.65–0.5 Ga)

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Bibliography of Indonesia Geology, New for Ed. 7. www.vangorselslist.com 8/6/18
ages. Similarity of age distribution and Hf isotope compositions of Indochina and those of Tethyan Himalaya, W Cathaysia, and Qiangtang suggests Indochina was outboard of Qiangtang and S of S China in Indian margin of Gondwana in E Paleozoic. Results consistent with paleontological correlations of E Gondwana margin)

Van der Meer, D.G., D.J.J. van Hinsbergen & W. Spakman (2018)- Atlas of the underworld: slab remnants in the mantle, their sinking history, and a new outlook on lower mantle viscosity. Tectonophysics 723, p. 309-448. (online at: www.sciencedirect.com/science/article/pii/S0040195117304055) (Global inventory of 94 subducted slabs in mantle, as identified from tomography. Including slabs from SE Asia: Arafura, Banda, Burma (formerly part of Sunda slab), Halmahera (15-0 Ma), Kalimantan (active from ~70-20 Ma: interpreted by some as deeper part of Sunda slab)), Papua (base age 90-45 Ma, top age 26-20 Ma), Sangihe (base age 30-25 Ma; at shallow upper mantle levels separated into several slabs: Philippine Trench slab, Molucca Sea West slab, Sulu and Celebes Sea South slab) and Sunda slab (active since 50-45 Ma). (see also associated website: www.atlas-of-the-underworld.org/)

Von Hagke, C., M. Philippon, J.P. Avouac & M. Gurnis (2016)- Origin and time evolution of subduction polarity reversal from plate kinematics of Southeast Asia. Geology 44, 8, p. 659-662. (online at: http://web.gps.caltech.edu/~avouac/publications/vonHagke-Geology-2016.pdf) (Regional model of plate geometry and kinematics of SE Asia since Late Cretaceous and origin of subduction polarity reversal currently observed in Taiwan)

Wang, Q., J. Deng, C. Li, G. Li, L. Yu & L. Qiao (2016)- The boundary between the Simao and Yangtze blocks and their locations in Gondwana and Rodinia: Constraints from detrital and inherited zircons. Gondwana Research 26, p. 438-448. (Simao (N Indochina) and Yangtze (S China) continental blocks amalgamated in Late Paleozoic - Triassic by closure of Paleotethys branch (Ailaoshan ocean). Detrital and inherited zircons suggest Laowangzhai-Mojiang suspect terrane belongs to Simao-Indochina block, so Paleotethys suture along Ailaoshan late-Devonian- E Carboniferous ophiolite belt. Precambrian detrital zircon ages suggest Yangtze block not part of Australia or India in Rodinia, while Simao-Indochina block derived from Indian Gondwana)


Wang, X.D., T. Sugiyama, K. Ueno, Y. Mizuno, Y. Li, W. Wang et al. (2000)- Carboniferous and Permian zoogeographical change of the Baoshan Block, SW China. Acta Palaeontologica Sinica 39, 4, p. 493-506. (Carboniferous- Permian of Baoshan block three main sequences: (1) Lower Carboniferous carbonates (warm, diverse, and abundant 'Eurasian' faunas), (2) Lower Permian siliciclastics (cold, low diverse faunas; conodont Sweetognathus fauna at top; glacio-marine diamictites, Sakmarian- E Artinskian ;peri-Gondwanan') (3)M Permian carbonates (warm water but low diverse fauna; 'marginal Cathaysian/Cimmerian'). Cimmerian blocks comparable in Carboniferous- E Permian. In M Permian E Cimmerian blocks (Sibumasu s.s, Baoshan, Tengchong) not far from paleoequator, but further than W Cimmerian blocks (lack of Eopolydiesodina and Neoschwagerina fusulinids, corals Thomasiphymyllum, Wentzellophylum)

Wang, Y., X. Qian, P.A. Cawood, H. Liu, Q. Feng, G. Zhao, Y. Zhang, H. He & P. Zhang (2018)- Closure of the East Paleotethyan Ocean and amalgamation of the Eastern Cimmerian and Southeast Asia continental fragments. Earth-Science Reviews, 36p. (in press) (Review of geological features of Paleotethys suture zones, bounding continental fragments and magmatic, metamorphic and sedimentary records. Data from Changning-Menglian, Inthanon and Bentong-Raub suture zones argue for linkage with Longmu Co-Shuanghu suture zone in C Tibet and together constitute main E Paleotethys Ocean relict. E-ward subduction of ocean resulted in series of magmatic arc/ backarc basin/ continental fragments in SE Asia (from W to E: Lincang-Sukhothai-E Malaya arc, Jinghong-Nan-Sa Kaeo back-arc basin, Simao/ W Indochina fragment, Luang Prabang-Loei back-arc basin, S Indochina fragment, Wusu and Truong Son back-arc basins, N Indochina fragment, Jinshajiang-Ailaoshan-Song Ma branch/back-arc basin and
S China Block. Assembly of these fragments resulted in Triassic (Indosinian) metamorphism and related tectono thermal event. Switch from subduction of main E Paleotethyan Ocean to collision of Sibumasu with Simao/Indochina at ∼ 237 Ma. Timing of collision events along Jinhaijiang-Ailaoshan-Song Ma suture generally ∼ 10 Ma older than along Changning-Menglian, Inthanan and Bentong-Raub suture zones.

(online at: https://link.springer.com/article/10.1007/s12583-017-0813-x)
(Reconstruction of vanished Proto-South China Sea ocean from tomography imaging of subducted slab. Two slabs identified, now at depths of 750-900 km. Proto-South China Sea consumed by double-sided subduction: (1) ‘N Proto-South China Sea’ (now under N S China Sea- Philippines) subducted in Oligo-Miocene under Dangerous Grounds southward, expanding S China Sea by in-place ‘self subduction’ similar to W Mediterranean basins; (2) limited S-ward subduction of proto-S China Sea under Borneo before Oligocene (35 Ma), represented by 800-900 km deep ‘S Proto-South China Sea’ slab (now under S S China Sea- N Borneo))

(Reconstructed Philippine Sea and E Asian plate tectonics since E Eocene from 28 slabs mapped from global tomography, with subducted area of ∼25% of present-day global oceanic lithosphere. Slab constraints include subducted parts of existing Pacific, and Philippine Sea oceans, plus subducted proto-S China Sea and newly discovered 8000 × 2500 km ‘East Asian Sea’ between Pacific and Indian Oceans at 52 Ma based on lower mantle flat slabs. Philippine Sea formed above Manus plume near Pacific- E Asian Sea plate boundary. Philippine Sea W-ward motion and post-40 Ma max. 80° CW rotation accompanied late Eocene-Oligocene collision with Caroline/Pacific plate. Philippine Sea moved N post-25 Ma over northern East Asian Sea, forming N Philippine Sea arc that collided with SW Japan-Ryukyu margin in Miocene (∼20–14 Ma))

 manuscipt online at: http://dro.dur.ac.uk/21242/1/21242.pdf
(Reoprted Neoproterozoic amalgamation history of Yangtze and Cathaysia blocks, forming S China Block: (1) ∼1000-860 Ma NW-ward intra-oceanic subduction and SE-ward ocean-continent subduction (with continental margin magmatism in Cathaysia Block); (2) ∼860-825 Ma steepening subduction caused development of back-arc basin in intra-oceanic arc zone and slab rollback induced arc and back-arc magmatism in Cathaysia Block. NW-ward ocean-continent subduction formed continental margin magmatism in Yangtze Block; (3)∼825-805 Ma continent-arc-continent collision and final amalgamation between Yangtze and Cathaysia blocks (Jiangnan Orogen); (4) ∼805-750 Ma collapse of Jiangnan Orogen and Nanhua rift basin formed)

Xu, C., H. Shi, C.G. Barnes & Z. Zhou (2016)- Tracing a late Mesozoic magmatic arc along the Southeast Asian margin from the granitoids drilled from the northern South China Sea. Int. Geology Review 58, p. 71-94.
(Granitoids drilled in N S China Sea two magmatic episodes: Late Jurassic (162-148 Ma) and E Cretaceous (137-102 Ma). Jurassic magmatism probably began in late M Jurassic, documented by inherited zircons. I-type granites, generated in continental arc environment. Arc granites of SCS, with accretionary wedge of Palawan terrane to SE and zone of lithospheric extension to N throughout SE China, define late Mesozoic SW-NE trench-arc-backarc setting for SE Asian continental margin , related to subduction of Paleo-Pacific slab beneath Asia)

(E Jurassic granite and diorite in wells in NE S China Sea and SW East China Sea (198-187 Ma), probably part of arc-related granitoids,that, along with those from SE Taiwan, could define E Jurassic NE-SW trending Dongsha-Talun-Yandang magmatic arc zone along East Asian continental margin paired with Jurassic
accretionary complexes from SW Japan, E Taiwan to W Philippines. Arc-subduction complex associated with oblique subduction of Paleo-Pacific slab beneath Eurasia)

(online at: http://onlinelibrary.wiley.com/doi/10.1002/tect.20099/epdf)
(Cambrian sedimentary rocks in S part of S China Craton derived from source to S or SE, beyond current limits of craton. U-Pb ages and Hf isotope data on detrital zircons from Cambrian two age peaks at 1120 Ma and 960 Ma, with εHf(t) values similar to coeval detrital zircons from W Australia and Tethyan Himalaya zone, respectively. ~1120 Ma detrital zircons likely derived from Wilkes-Albany-Fraser belt (between SW Australia-Antarctica); ~960 Ma zircons possibly sourced from Rayner-Eastern Ghats belt (between India-Antarctica). Suggesting S China was at nexus between India, Antarctica, and Australia along N margin of E Gondwana)

(Seismic tomographic images suggest possible mantle plume beneath and around Hainan island (sub-vertical low-velocity column, extending from shallow depths to 660-km seismic discontinuity and continuously to depth of 1900 km. Large quantity of Cenozoic alkali basalts distributed in S China Sea and adjacent areas)

(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5805767/pdf/41598_2018_Article_20712.pdf)
(Intraplate volcanism started after 16 Ma, shortly after cessation of seafoor spreading in S China Sea, affecting large areas. Geochemistry of Late Miocene- Pleistocene basalts from Khorat Plateau and Sukhothai arc terrane in Thailand show Oceanic Island Basalt -like characteristics. Post-spreading intra-plate volcanism around S China Sea region probably induced by Hainan mantle plume)

(Case study for ~260 Ma Emeishan Large Igneous Province in S China, where silicic volcanic rocks are minor component of preserved rock due to extensive Late Permian erosion. Silicic volcanic rocks ~30% of volume of eroded Emeishan volcanics. Basalt-derived silicic eruptions released sulfur gases into higher atmosphere, contributing to climate cooling at Capitanian-Wuchiapingian transition at ~260 Ma)

(U Permian- M Triassic sediments in Youjiang Basin, S China, record change from Late Permian within-plate mafic-dominated source to NW (zircons ages ~260 Ma; mainly from Emeishan Large Igneous Province), to E-M Triassic mixed magmatic arc-reycled orogenic source to W (subduction-collision rocks of Indosinian Orogeny) and E (recycled Precambrian- E Paleozoic rocks in S China hinterland))

(Deep thermal structure of SE Asia, derived from empirical relation between S-velocity and T. Temperature at depth of 80 km in rifted and oceanic basins (Thailand Rift Basin, Gulf of Thailand, Andaman Sea and S China Sea) is ~200 °C higher than in plateaus (Khorat Plateau, Sumatra Island) and subduction zones (Philippine Trench). Surface heat flow in S China Sea mainly dominated by deep thermal state. Temperatures at 100-120 km depths more uniform. Estimated base of lithosphere corresponds to ~1400 °C isotherm; good correlation with tectonic setting.


(Detrital zircons from Ordovician? Lancang Gp (separate Lancang Block?) and Mengtong and Mengdingjie Gps (Baoshan Block) with three age peaks: older Grenvillian (1200-1060 Ma), younger Grenvillian (~960 Ma) and Pan-African (650-500 Ma), with εHf(t) values similar to W Australia and N India. E Paleozoic Proto-Tethys represents narrow ocean basin separating 'Asian Hun superterrane' (N China, S China, Tarim, Indochina, N Qiangtang blocks) from N margin of Gondwana in Late Neoproterozoic- E Paleozoic. Proto-Tethys closed in Silurian at ~440–420 Ma when 'Asian Hun superterrane' collided with N Gondwana margin. Lancang Block separated from Baoshan Block in E Devonian when Paleo-Tethys opened as back-arc basin)

(E Norian (225.1±1.2 Ma) ages of post-collisional rhyolites in Lampang area minimum age of final closure of E Paleo-Tethys between Sibumasu and Indochina blocks. Older age from inherited zircons (242±1.9 Ma) resembles arc volcanic rocks from Doi Luang belt in same area. High-K calc-alkaline Lampang rhyolites formed in post-collisional extensional environment, controlled mainly by lithospheric delamination or slab breakoff. Youngest pelagic sediments in Changning-Menglian and Inthanon Suture Zones M Triassic (Triassicampe deweveri radiolarian assemblage), suggesting Paleo-Tethys ocean not yet closed in M Triassic)
I.3. Volcanism, Volcanic rocks geochemistry (52)

(S-wave tomographic image under Krakatoa shows subducted slab has been intruded by hot mantle material, suggesting possible tearing of subducting plate)

(online at: www.mdpi.com/2076-3263/8/4/111)
(Tomographic image and geochemical data of Krakatoa area lavas suggests subducted slab intruded by hot material of mantle upwelling. Partial melting of mantle wedge and mantle upwelling in upper mantle may be caused by thinning of subducted slab under Krakatoa Volcano)


('Structural control on Indonesian volcanism (Sumatra, Java-Bali); application and critique of the Nakamura method')

(Little known Dukono volcano on N Halmahera island regularly erupting since 1933. Gas emissions show huge magmatic volatile contribution into atmosphere, with annual output of ~290 kt SO2, 5000 kt H2O, 88 kt CO2, 5 kt H2S and 7 kt H2 (in top 10 volcanic SO2 sources on Earth). Degassing sustained by depleted Indian-MORB mantle source, currently undergoing lateral pressure from steepening of subducted slab, downward force from Philippine Sea plate and W-ward motion of continental fragment along Sorong fault)


(Reprint collection of 39 papers, originally published between 1987-2011)

('The volcanic island Ruang (Sangi Islands) after the eruption of 1914')

('The volcano island Ruang'. Active volcano in Sangi islands group)

(online at: https://www.nature.com/articles/srep40624.pdf)
(Quartz crystals from 75ka Toba tuffs rel. high δ18O values (up to 10.2‰), due to magma residence within and assimilation of local granite basement. Decrease in δ18O values in outer growth zones suggests assimilation of altered roof material and may represent eruption trigger in large Toba-style magmatic systems)


De Silva, S.L., A.E. Mucek, P.M. Gregg & I. Pratomo (2015)- Resurgent Toba- field, chronologic, and model constraints on time scales and mechanisms of resurgence at large calderas. Frontiers Earth Sci. 3, 25, p. 1-17. (online at: http://journal.frontiersin.org/article/10.3389/feart.2015.00025/full) (Samosir Island in Lake Toba caldera was submerged below lake level (~900m above s.l.) at 33 ka. Since then uplifted 700m as tilted block dipping to W. 14C ages and elevations of sediment reveal minimum uplift rates of ~4.9 cm/yr from ~33.7-22.5 ka, but diminished to ~0.7 cm/yr after 22.5 ka)

Fabir, F.J. (1964)- Modderkogels, mergelconcretes of askogels van Krakatau. Geologie en Mijnbouw 43, 11, p. 467-475. ('Mudballs, marl concretes or ash bullets from Krakatoa'. Example of spherical mud balls or 'ash-balls' up to 7 cm in diameter. Origin somewhat unclear)


(Rajabasa dormant Quaternary volcano at S tip of Sumatra. Volcanics mainly basaltic andesite, with K-Ar ages of volcanics 0.31-0.12 Ma (Pliocene). Older volcanics SE of Rajabasa at nearby Tangkil (4.33 Ma; Pliocene). Two distinct type of magmas in Tangkil, calc-alkaline dacite and tholeiitic basalt)

(Critique of Mark et al 2013 paper)

('Determination of source of eruption of Tertiary volcanic rocks and their implications for minerals')

Kuenen, P.H. (1945)- Volcanic fissures, with examples from the East Indies. Geologie en Mijnbouw, N.S., 7, 3-4, p. 17-23.
(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0S3ZmOTNXYmR6Qk0/view)
(Review of volcanic fissures and volcanic lines, with examples of Halmahera, E Java, etc.)

(Weh Island with Sabang City at NW tip of Sumatra with volcanic cone morphology and with fumaroles, on surrounding seafloor and coastal area vents. Fumarole vents associated with common rare earth elements (REE). Co-existence between active Sumatra fault of current volcanism produce hydrothermal mineralization)

(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/247/224)
(Rare earth elements at fumaroles surrounding submarine craters off Sabang island)

(online at: http://ejournal.mgi.esdm.go.id/index.php/bomg/article/view/317/278)
(Fumaroles and solfatara are REE vapor transport agents in Weh Island submarine volcano, Aceh. Central part of Weh submarine volcano most active REE deposition, where normal faults and N-S grabens acted as channel for hydrothermal fluids reaching seafloor surface)

(4cm thick ash layer in Core MD01-2393 from SW S China Sea at Marine Isotope Stage 4-5 transition at ~74 ka. Morphology and geochemistry of glass shards confirm origin from Youngest Toba eruption, N Sumatra)

(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0QTJrWms0Rmd6cFk/view)
(Activity and changes in shape of Mt Ruang in S part of Sangihe Archipelago since 1808)

Pearce, N.J.G., J.A. Westgate, E. Gatti, J.N. Pattan, G. Parthiban & H. Achyuthan (2014)- Individual glass shard trace element analyses conﬁrm that all known Toba tephra reported from India is from the c. 75-ka Youngest Toba eruption. J. Quaternary Sci. 29, 8, p. 729-734.
(Glass shards from all Toba tephra samples from India thus far analysed, same multi-population composition as Young Toba Tuff and are products of ~75-ka Youngest Toba eruption. Composition different from Oldest Toba Tuff (OTT) in Layer D from ODP site 758 (~800 ka))
Bibliography of Indonesia Geology, New for Ed. 7.

('Volcanoes of West Nusa Tenggara')


(online at: digitool.library.mcgill.ca/dtl_publish/7/110439.html)

(Kawah Ijen crater in E Java ~1 km in diameter, and hosts one of world’s largest hyperacidic lakes. With small actively degassing solfatara field, surrounded by much larger area of acid-sulfate alteration. Area exposed after phreatomagmatic eruption in 1817, which excavated crater to depth of 250m. Magmatic vapors caused (uneconomic) high sulfidation epithermal Cu-Au-Ag ore deposits at very shallow depth)

(Toba volcanic event documented in marine sediment cores from NE Arabian Sea. Distinct concentration spikes and ash layers of rhyolitic volcanic shards near marine isotope stage 5-4 boundary with chemical composition of 'Youngest Toba Tuff'. Toba event between two warm periods lasting a few millennia. Toba had only minor impact on evolution of low-latitude monsoonal climate on centennial to millennial time scales)

(New estimates for mass of magma and aerosol generated by Tambora in 1815: 30 -33 km3 magma, 53-58 Tg SO2, and 93-118 Tg sulfate aerosols. Aerosol cloud distributed globally, but more in S than in N Hemisphere)

('Evolution of the Batur caldera, Bali')

(Review of active volcanism (177 volcanoes), products volcanic eruptions, composition of volcanic products and distribution and composition of associated igneous rocks)

(With two Atlas volumes. Text volume online at: https://archive.org/details/krakatau00verbgoog)
(Classic account of the 1883 cataclysmic eruption and its effects (incl. human casualties, tuff and tsunami deposits, etc))

(online at: https://www.nature.com/articles/srep34868.pdf)
(Great 1257 eruption of Samalas (Lombok) released enough sulfur and halogen gases into stratosphere to produce reported global cooling during second half of 13th century)

(Toba Ash layer in NE Arabian Sea SW of Pakistan near base of 20.2m piston core. Also two younger ash layers, presumably from Indonesian volcanoes. Toba event (70 ±4 ka BP) well documented in Arabian Sea and Bay of Bengal records at end of Oxygen Isotope Stage 20. With map of known Toba ash distribution)

('Vulkano-telmatic melanien tuff at the Danau Batur caldera lake on Bali (Indonesia'). Recent tuffs of Batur)


(After 1991 eruption of Mount Pinatubo, Philippines, volcanic ash transported W to S China Sea in atmospheric plume, formed up to 10cm thick graded layer over ~400,000 km2. Immediately after deposition surviving deep-burrowing animals re-opened connection to sea floor. Later, small meiofauna and macrofauna recolonized sea floor, mixing newly deposited organic material with underlying ash. Ash deposits <1mm thick not often observed as continuous layer when cored 6 years after eruption; ash ~2mm thick now patchily bioturbated. Areas affected by deposition of turbidites ash layer often preserved due to rapid burial)

(online at: http://link.springer.com/article/10.1007/s00445-014-0893-8?view=classic)
(~733 active and potentially active volcanoes in SE Asia region, of which 70 have erupted in last 100 years)

('On the Soputan volcano in the Minahasa', NE Sulawesi. Critique of Ahlburg (1910) description of Soputan eruption history on date of last major eruption (1828 or 1838), etc.)

(online at: https://www.biodiversitylibrary.org/item/182872#page/926/mode/1up)
('On the eruptions of the Soputan in the Minahasa', NE Sulawesi'. Continuation of unusually harsh critique of Ahlburg 1910 papers. Nothing new here)

(Large Mo isotope variability in Banda Arc convergent margin lavas)

(Popular, but thorough account of the 1883 eruption of Krakatoa volcano in Sunda Strait that killed nearly 40,000 people)
Wirakusumah, A.D. & H. Rachmat (2017)- Impact of the 1815 Tambora eruption to global climate change. In: 2nd Int. Conf. Transdisciplinary research on environmental problems in Southeast Asia (TREPSEA), Bandung 2016, IOP Conf. Series, Earth Environm. Science, 71, 012007, p. 1-9. (online at: http://iopscience.iop.org/article/10.1088/1755-1315/71/1/012007/pdf) (April 1815 paroxysmal destructive eruption of Tambora formed caldera and emitted 60 to 80 megatons of SO2 to stratosphere. SO2 circled the world and oxidized to form H2SO4, an aerosol limiting sunlight to reach earth surface. 1816 was year without summer in Europe, epidemic diseases in Benggal, etc.)


Zielinski, G.A., P.A. Mayewski, L.D. Meeker, S. Whitlow, M. Twickler & K. Taylor (1996)- Potential atmospheric impact of the Toba mega-eruption. Geophysical Research Letters 23, 8, p. 837-840. (~6-year long period of volcanic sulfate recorded in Greenland GISP2 ice core at ~71.1 ± 5 ka may reflect Toba mega-eruption. Deposition of these aerosols at beginning of ~1000-year long stadial event, but not immediately before longer glacial period beginning ~67.5 ka. Toba aerosols may be responsible for enhanced cooling during initial 200 yrs of ~1000-year cooling event ('volcanic winter'))
I.4. Modern depositional environments, Oceanography, Indonesian Throughflow (96)

(online at: http://onlinelibrary.wiley.com/doi/10.1002/joc.950/epdf)  
(Three rainfall regions in Indonesia, related to island topography and sea-surface Temperature variability: (A) S Indonesia (S Sumatera to Timor, S Kalimantan, Sulawesi and part of Irian Jaya); (B) NW Indonesia (N Sumatra to NW Kalimantan); (C) Maluku and N Sulawesi. All with strong annual and (except A) semi-annual variability. Region C strongest El Nino- Southern oscillation influence)

(Recent tsunamiites of Java S coast have erosional base, homogeneous m-f sand grain size and no fining-upward trend. Sedimentary structures parallel lamination in lower part and ripples in upper part)


(online at: https://www.tandfonline.com/doi/abs/10.1080/17550874.2018.142902)  
(Review of modern forests zonation in tropical Asia: lowland forests, lower montane forests, upper montane forests, subalpine thickets/ shrublands)

(online at: http://journal.ipb.ac.id/index.php/jurnalikt/article/view/13221/10223)  
('Spatial and temporal variation of Indonesian Throughflow in the Makassar Strait'. On the main axis of southward jet of Indonesian Throughflow in Makassar Straits, mainly following western shelf slope)

(Revised structure and variability of Indonesian Throughflow Water in major outflow straits (Lombok, Ombai, Timor))

(online at: http://journal.ipb.ac.id/index.php/jurnalikt/article/view/9012/7080)  
(On upwelling events in S Makassar Strait during SE Monsoon period, associated with low sea surface temperature and high chlorophyll-a concentrations in seawater. Upwelling controlled by SE monsoon winds and enhanced by Indonesian Throughflow TF Makassar jet that creates large circular eddies flow due to complex topography in triangle area of S Makassar- E Java Sea- W Flores Sea)

(online at: https://www.nat-hazards-earth-syst-sci.net/10/589/2010/nhess-10-589-2010.pdf)  
(Review of tsunamigenic events triggered by submarine landslides. Largest documented recent slides (SE of Sumba, etc.) have volume of 15-20 km3. Many large recent tsunamigenic landslides have been ultimately triggered by earthquakes)

(Data from core from 485m depth at S edge of Timor Trough suggest lower thermocline warming during globally cold periods (MIS 4-MIS 2), related to weaker and contracted thermocline ITF and advection of warm-salty Indian Ocean waters)


(Late Miocene- M Pleistocene sedimentary proxy records (incl. IODP Site U1463) show NW Australia underwent abrupt transition from arid to humid climate conditions at 5.5 Ma, likely receiving year-round rainfall. After ~3.3 Ma climate shift to increasingly seasonal precipitation, back to arid interval after 2.4 Ma. Linked to progressive restriction of flow of warm surface currents from Pacific (Indonesian Throughflow))

(Asian monsoon large-scale seasonal reversal of normal atmospheric circulation pattern. Low-pressure systems develop in tropics due to rising hot air that cools and descends in subtropics (arid regions). In contrast, summer heating of Asian continent (mainly Tibetan Plateau) generates low-pressure cells and summer rains in S and E Asia. In winter reversed high-P system established, with dry, cold winds blowing out of Asia. Monsoon intensity varies in 21, 40 and 100 thousand year timescale, with periods of glacial advance and retreat: summer monsoons strong and winter monsoons weaker during warm, interglacial periods (reverse during glacial times)

(Study of sedimentation in Klang and Langat Rivers delta in Malacca Strait)

('The coasts of SE Asia'. Geographic description of coastlines and processes in SE Asia)

(Current measurements in Timor Strait suggest transport of about 7 Sv toward Indian Ocean, with about half of this in upper 350m)

(NE Java tsunami deposits)

(online at: https://geoscienceletters.springeropen.com/articles/10.1186/s40562-016-0054-3)
(Review of climatic significance of Indo-Pacific Warm Pool, a large area with permanent surface T >28 °C in SW Pacific/ Indonesian region ('heat and steam engine’ of globe))
(online at: http://www.whoi.edu/fileserver.do?id=186164&pt=2&p=17766)
(Climat proxy data 30 surface marine sediment samples from throughout Indo-Pacific warm pool. Sediment core from offshore NE Borneo show broadly similar vegetation during Last Glacial Maximum and Holocene, suggesting that, despite generally drier glacial conditions, no pronounced dry season. Core off Sumba indicates enhanced dry season aridity and water stress during most recent glaciation)

(online at: https://www.nature.com/articles/s41598-018-24055-1.pdf)
(Thermocline T and salinity gradient across Makassar Strait increased during the last glacial period relative to Holocene and was significantly larger during 13.4~19 ka BP and 24.2~27 ka BP)

(online at: https://link.springer.com/content/pdf/10.1186%2Fs40562-018-0102-2.pdf)

(online at: https://link.springer.com/content/pdf/10.1186%2Fs40529-018-0167-9.pdf)
(Global, ultramafic outcrops known for floras with high levels of endemism, including plants adapted to nickel or manganese hyperaccumulation. Soils derived from ultramafic regoliths generally nutrient-deficient, with major cation imbalances and high concentrations of potentially toxic trace elements, especially nickel. SE Asian region large surface occurrences of ultramafic regoliths, but geoecology still poorly studied)

(online at: https://academic.oup.com/biolinnean/article/75/4/453/2639628)
(In SE Asia, during Quaternary glaciations increased seasonality and sea level drops of ~120m caused fragmentation of rainforest. During Last Glacial Maximum, most of Thailand, Peninsula Malaysia, W and S Borneo, E and S Sumatra, and Java probably covered by savannah. Rainforest refugia probably present in N and E Borneo, N and W Sumatra and Mentawai islands.)

(Warm, low salinity Pacific water flows through Indonesian Seas into E Indian Ocean, spreading within S Equatorial Current. Low salinity throughflow trace, centered along 12°S, stretches across Indian Ocean, separating monsoon-dominated regime of N Indian Ocean from subtropical stratification to S)

(online at: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2008GL036372)

(Mekong Delta early delta growth during transgression-related inundation between 8 ka BP (maximum flooding) and 5.7 ka BP (sea-level highstand), characterized by tide-and marine-influenced nearshore conditions with extensive mangrove and tidal-flat deposits aggrading on wide abrasion platform. Onset of regression/progradation at ~4.8 ka)

Hendrizan, M., W. Kuhnt & A. Holbourn (2017)- Variability of Indonesian Throughflow and Borneo Runoff During the Last 14 kyr. Paleoceanography 32, 10, p. 1054-1069. (Reconstruction of hydrological changes in Makassar Strait over last 14 kyr from Core SO217-18S17 off Mahakam Delta (698 m water depth). Sea surface T based on Mg/Ca of Globigerinoides ruber, etc. provide evidence for increased precipitation during Bolling-Allerød (BA) and E Holocene, and for warmer/ more saline surface waters and decrease in Indonesian Throughflow during Younger Dryas (YD). Changes in Makassar Strait surface hydrology reflect S-ward displacement of Intertropical Convergence Zone)


Hope, G.S. (2015)- Peat in the mountains of New Guinea. Mires and Peat 15, 13, p. 1-21. (online at: http://mires-and-peat.net/media/map15/map_15_13.pdf) (Peatlands common in montane areas above 1000m in New Guinea and extensive above 3000m. Montane mires up to 4-8m deep and up to 30,000 years in age. Above 3000m peat soils form under blanket bog on slopes as well as on valley floors. Typical peat depths 0.5-1 m on slopes, but valley floors up to 10m of peat. Peats record vegetation shifts at 28, 17-14 and 9 ka and variable history of human disturbance from 14 ka)

Iwatani, H., M. Yasuhara, Y. Rosenthal & B.K. Linsley (2018)- Intermediate-water dynamics and ocean ventilation effects on the Indonesian Throughflow during the past 15,000 years: ostracod evidence. Geology 46, 6, p. 567-570. (Ostracods in core from central part of Makassar Strait suggest warm water/ low oxygen water fauna and species diversity rapidly increased at ~12 ka, reaching maxima during Younger Dryas. Interpreted as response to stagnation of intermediate water due to decline in Indonesian Throughflow intensity. After ~7 ka, ostracod faunal composition changed to deeper, colder and high oxygen fauna, responding to deglacial E Holocene sea-level rise. Etc.)

James, N.P., L.B. Collins, Y. Bone & P. Hallock (1999)- Rottnest shelf to Ningaloo reef: coolwater to warmwater carbonate transition on the continental shelf of Western Australia. J. Sedimentary Res. 69, p. 1297-1321. (W continental margin from Cape Naturaliste to NE Cape 1200km long and with carbonate deposition throughout. Temperate (cool) water in S to tropical in N, influenced by Leeuwin current)

Kamaludin B. & B.Y. Azmi (1997)- Interstadial records of the last glacial period at Pantai Remis, Malaysia. J. Quaternary Science 12, 5, p. 419-434. (Two eustatic high sea stands during last glacial period recognised at Pantai Remis, both lower than present-day sea-level: (1) -14.6m , synchronous with Oxygen Isotope Stage 5a ; (2) -4.3 m , dated as ~54ka. Palynology data show interstadial coastal Pandanus and mangrove swamps, succeeded by mixed freshwater swamp forests of Campnosperma- Calophyllum assemblage, followed by drier mixed swamp forest)


(Pollen records from SE Asia suggest that during 1st Glacial Maximum (~18 ka) precipitation was probably lower by ~30-50% than today, and temperature was reduced by as much as 6-7°. Rainforest was replaced by grassland in some areas. Montane forest elements descended to low altitudes. Exposed continental shelves covered largely by rainforest in wetter areas, by grassland and open woodlands in drier areas)


(Last Glacial Maximum was cool and dry over Indo-Pacific Warm Pool region. Pervasive aridity and reduced rainfall coincided with apparent increase in circulation intensity in IPWP)


(Review of sediment distribution patterns in 27 deltas worldwide, incl. Mahakam)


(online at: https://phyoce.es.ntnu.edu.tw/pdf/ JAES_Circulation%20and%20oxygenation%20of%20the%20glacial%20South%20China%20Sea.pdf)


(Paleoclimate reconstructions from core SO184-10043, offshore S Sumatra, in 2171m water depth)


(online at: https://marine.rutgers.edu/pubs/private/Holocene%20WPWP-ITF_N_Geo2010_w_SOM.pdf)

(Sediment cores from across the Indonesian Throughflow area suggest that from ~10,000 to 7000 years ago, (Holocene Climate Optimum) sea surface T in western W Pacific warm pool ~0.5 °C higher than during pre-industrial times. About 9500 years ago, when South China and Indonesian seas were connected by rising sea level, surface waters in Makassar Strait became relatively fresher)


(online at: https://tos.org/oceanography/assets/docs/30-3_liu.pdf)

(Mekong River discharges into S China Sea and formed third largest delta plain in world (~50,000 km2; after Amazon and Ganges-Brahmaputra). Subaerial delta prograded ~220 km SE-ward in last 7500 years, showing 15m thick sigmoidal clinoforms immediately off distributaries. Mekong-derived sediment extends ~300 km along shelf to SW. From 1973- 2005 seaward shoreline growth decreased gradually, due to construction of dams, sand mining, delta subsidence, increasing storms and sea level rise)

(Pollen-spores from 62 seafloor sediments of southern Sh China Sea dominated by trilete spores (from ferns). Most pollen and spores on Kalimantan Island coast from herbaceous plants and trees, with few trilete spores)


(Simulated total Indonesian Throughflow (~13.4 Sv) is similar to observational estimate (~15.0 Sv) and distributed among three outflow passages (Lombok Strait, Ombai Strait and Timor Passage). Makassar Strait carries ~75% of observed total ITF inflow. Wide and shallow Java and Arafura Seas carry ~0.8 Sv of inflow)


(Shell chemistry of planktic foraminifera in 69 seafloor samples in E Indian Ocean off W and S Indonesia)


(online at: http://www.stuut.tv/Mohtadi_et_al_2011.pdf)

(Planktonic foraminiferal oxygen isotopes and faunal composition in a sediments offshore S Java show glacial-interglacial variations in Australian-Indonesian winter monsoon in phase with Indian summer monsoon system. Australian-Indonesian summer and winter monsoon variability closely linked to summer insolation and abrupt climate changes in N hemisphere)


(online at: https://www.nature.com/articles/s41467-017-00855-3.pdf)

(Climate proxies in E Indian Ocean sediment cores off W and S Sumatra and S Java. During Last Glacial Maximum increased thermocline depth and rainfall, indicating stronger-than-today Walker circulation)


(Planktonic foraminifera primary production rates in Indian Ocean off S Java highest during SE monsoon-induced coastal upwelling period in July-October, with Globigerina bulloides, Neogloboquadrina pachyderma (d) and Globigerinoides glutinata 40% of total fauna. Habitats of 0-30m for G. ruber (mixed layer depth); 60-80m for P. obliquiloculata and 60–90m for N. dutertrei (upper thermocline depth); and 90-150 m for G. menardii (lower thermocline depth))


(Record of sea surface salinity in S Makassar Strait from 1927 to 2011, based on Porites coral δ18O from Doangdoangan Besar island. East Asian Winter Monsoon drives less saline surface waters from S China Sea into the Makassar Strait, obstructions surface Indonesian Throughflow, and strongly influences interannual sea surface salinity variability during boreal winter over 20th century)

(Morphology of deltas largely determined by balance between river inputs and ability of waves to spread sediments along coast. 'Fluvial dominance ratio' tested on 25 deltas on N shore of Java)

(Seismic profiles in E Banda Sea area show evidence of several slumping- sliding events. High potential for slope failures in Banda Sea area due to high seismicity, steep submarine slopes and soft sediment deposits, especially below 1000m water depth)

(online at: http://rstb.royalsocietypublishing.org/content/royptb/371/1696/20150176.full.pdf)

(Case study for interpretation of coastal sedimentation associated with large tsunamis)

(Discussion of storm- and tsunami-related transport, with examples from Thailand, Malaysia, etc. Paleotsunami deposits commonly recognized as anomalous sand sheets that were washed into marsh or lake sediments. Marine microfossils often dominate tsunami overwash deposits because of landward transport and deposition of scoured marine sediment. Nearshore benthic foraminifera (Ammobaculites spp., Ammonia, etc.) may also be entrained by tsunami run-up and subsequently transported seaward by backwash, where they end up as allochthonous assemblages in low-energy submarine sediments)

(December 26, 2004 tsunami deposits generally characterized as relatively thin sheets (<80cm), mostly of sand)

(Includes discussion of shallow southern Sunda Shelf/ Java Sea environments. Remnants of Pleistocene drainage channels still detectable on present sea floor. Java Sea modern carbonate buildups strong E-W orientation, response to dominant current directions triggered by monsoonal wind directions. Westerly monsoon brings large quantities of suspended terrigenous sediment to Sunda Shelf; easterly monsoon drives higher salinity water (33-35 ppt) into region from Banda Sea. Java Sea sediments mainly terrigenous muds derived from weathered volcanics (Sumatra and Java) and other crystalline rocks from Kalimantan, but with significant areas of carbonate sedimentation and reef development (Pulau Seribu, East Sunda Shelf margin))

(Received data δ13C from 6.8m core in Lake Logung, E Java indicate E Java became wetter over last millennium until ~1800 Common Era, consistent with evidence for S-ward migration of Intertropical Convergence Zone at this time. Century-scale hydrologic variability relates to changes in Walker Circulation)


(online at: http://www.pnas.org/content/111/14/5100.full.pdf)

(Terrestrial sedimentary record of surface hydrology and vegetation in Indonesia in the last 60,000 yr, based upon geochemical data from Lake Towuti, Sulawesi. Wet conditions and rainforest ecosystems present during Holocene and during Marine Isotope Stage 3, alternating with severe drying between ~33,000 and 16,000 yr B.P., when high-latitude ice sheets expanded and global temperatures cooled)


(Analysis of recent changes of five major mangrove deltaic systems in Asia-Pacific region: Fly and Kikori-Purari, Ganges-Brahmaputra, Irrawaddy-Mekong. Overall net contraction in mangrove areas)


(online at: www.iagi.or.id/fost/berita-sedimentologi-no-36.html)

(Modern sediments of Sumpur axial-fluvial delta and Malalo alluvial fan delta in N part of Lake Singkarak, and comparison to Paleogene rift-fill of C Sumatra Basin)


(S Java Current poorly understood boundary current, reversing to SE-ward flow semi-annually around May and November. June-October SE monsoon winds lead to upwelling of cold, salty water)


(online at: http://aoe.scitec.kobe-u.ac.jp/~mdy/library/papers/Sprintalletal2014NG.pdf)

(Indonesian Throughflow from Pacific to Indian Ocean through series of narrow straits. Strong velocities at depths of ~100 m. Intense vertical mixing within Indonesian seas, resulting in net upwelling of thermocline water, lowering sea temperatures by ~0.5 °C. Throughflow slows and shoals during El Nino events)


(Along S coasts of Java, S Sumatra and Lesser Sunda Islands, SE winds from Australia generate intensive coastal upwelling in austral winter (June-September), bringing cooler nutrient-rich waters to surface resulting in enhanced biological productivity. Proxies for upwelling for last 2000 years in deep sea cores show strong upwelling during Little Ice Age and weak during Medieval Warm Period and Roman Warm Period)


(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/106/96)
(Indication of fluctuations in Indonesian Throughflow in the Makassar Strait)

(Tsunami deposits from Aceh earthquake of 26 December 2004 and Nias earthquake on March 2005. In 2004 tsunami sediments basal rip-up clasts and 6 (9?) fining-upward patterns and 6 coarsening upward patterns; in 2005 tsunami sediment only 1 fining upward pattern. With foraminifera assemblages from inner shelf (2004 and 2005) and middle shelf (2004 only))

(Planktonic foraminifera O-isotope and Florisphaera profunda abundance data from Core MD06-3050 in W Philippine Sea on margin of W Pacific Warm Pool)

(In Mahakam Delta upper delta plain (10-30 km from head-pass) only fresh water. Only last 10km of lower delta palain has brackish water with salinities from 0-10 kppm. Brackish water in tidal channels with salinity 0-25 kppm. In active distributaries fresh water floats above saline water for 4-6 km)

(online at: https://tos.org/oceanography/assets/docs/29-2_susanto.pdf)
(Sunda Strait current velocity strongly affected by seasonal monsoon winds. During boreal winter monsoon NW winds draw waters from Indian Ocean into Java Sea. During the summer monsoon higher T, lower-salinity, and lower-density waters from Java Sea exported to Indian Ocean through Sunda Strait)

(Coral reef at NE front of Mahakam Delta with 30 genera of hard coral and 11 genera of soft coral)

(online at: https://link.springer.com/article/10.1007/s11069-011-9956-8)
(2004 Indian Ocean tsunami flooded Andaman Sea coastal zone, leaving few mm to 10's of cm thick deposits over ~1 km-wide inundation zone. After 4 years tsunami deposits preserved at only half of studied sites)

(71m long core in incised valley fill shows post-glacial transgressive -regressive fill cycle. Maximum Holocene marine influence at ~5300 yr BP, with bay/estuary muds with common planktonic diatoms (Coscinodiscus, Thalassionema, etc.) and open marine foraminifera (Bolivina, Bulimina, Quinqueloculina, Pararotalia). Regressive succession of prodelta- delta front (4000-5000 yr BP)- delta plain.)


Tamura, T., Y. Saito, S. Sieng, B. Ben, M. Kong, I. Sim, S. Choup & F. Akiba (2009)- Initiation of the Mekong River delta at 8 ka: evidence from the sedimentary succession in the Cambodian lowland. Quaternary Science Reviews 28, 3-4, p. 327-344. (Most modern deltas initiated around 7.5-9 ka, in response to deceleration of Holocene sea-level rise. Initial stage of Mekong River delta recorded in Cambodian lowland sediment cores: (1) aggrading flood plain and tidal-fluvial channels during postglacial sea-level rise (10- 8.4 ka); (2) aggrading to prograding tidal flats and mangrove forests around maximum flooding of sea (~8.0 ka,); (3) prograding fluvial system on delta plain (6.3 ka- Present). Delta progradation initiated as result of sea-level stillstand at around 8-7.5 ka. Thick mangrove peat accumulation from ~7.5- 6.3 ka. Since 6.3 ka fluvial system and delta progradation)


Unverricht, D., W. Szczucinski, K. Stattegger, R. Jagodzinski, X.T. Le & L.L.W. Kwong (2013)- Modern sedimentation and morphology of the subaqueous Mekong Delta, southern Vietnam. Global and Planetary Change 110, B, p. 223-235. (Mekong River Delta influenced by tides (meso-tidal system), waves, coastal currents, monsoon-driven river discharge and human impact. Subaqueous part large lateral variability, with two delta fronts, 200 km apart, one at mouth of Bassac distributary, one around Cape Ca Mau in SW. Two different sediment types in delta)

Valsala, V. & S. Maksyutov (2010)- A short surface pathway of the subsurface Indonesian Throughflow water from the Java Coast associated with upwelling, Ekman transport, and subduction. Int. J. Oceanography 2010, 540783, 15p. (online at: https://www.hindawi.com/journals/ijocean/2010/540783/) (Circulation modeling suggests Pacific-origin Indonesian Throughflow water can upwell from position below 100m to surface along S Java coast during upwelling season)

Van Andel, T.H., G.R. Heath, T.C. Moore & D.F.R. McGeary (1967)- Late Quaternary history, climate, and oceanography of the Timor Sea northwestern Australia. American J. Science 265, p. 737-758. (In late Quaternary climate in Timor Sea region more arid than adjacent land is today. Area mainly above sea level during last glaciation and covered by savanna vegetation. Subsequent transgression rapid. Supports Fairbridge contention that during glacial periods W-wind belts with associated rainfall displaced 5-10° N - ward and equatorial pluvial zone was compressed)

Van der Kaars, S. & G.D. van den Bergh (2004)- Anthropogenic changes in the landscape of west Java (Indonesia) during historic times, inferred from a sediment and pollen record from Teluk Banten. J. Quaternary Science 19, 3, p. 229-239. (Palynological and charcoal analyses of core from coastal area of NW Java provide vegetation history for last few centuries. Effect of Krakatau eruption insignificant compared to human impact on vegetation in Banten)

(High resolution seismic and acoustic profiles from Snellius-II Expedition in Savu Basin show widespread recent acoustic voids (transparent 'bright spots') that probably formed from local expulsion of pore-waters, caused by sediment mass movements down uplifted ridge between Sumba and Savu/Roti)

Webster, P.J & N.A. Streten (1978)- Late Quaternary ice age climates of tropical Australasia: interpretations and reconstructions. Quaternary Research 10, 3, p. 279-309.

(online at: https://journals.ametsoc.org/doi/pdf/10.1175/JPO-D-16-0132.1)

(Nereites trace fossil ichnofabrics in box cores from >4000m water depths in central S China Sea. Appear to be restricted to oxygenated sediments above redox boundary)

(online at: https://journals.ametsoc.org/doi/pdf/10.1175/2008JPO3987.1)


(Temperature record in two cores from Holocene incised valley fills on Sunda Shelf off Sarawak)

(With E Holocene sea level rise warm and low-salinity sea water from Java Sea was transported into E Indian Ocean after opening of Sunda Strait. Core CJ01-185 (1538m water depth) in E Indian Ocean off Sunda Strait sediments derived mainly from Java Island. Sedimentation rate increased from last glacial period to Holocene. Additional terrigenous nutrients from Java Sea induced paleoproductivity with higher TOC and TN concentrations after opening of Sunda Strait)

(online at: http://ejournal.mgi.esdm.go.id/index.php/bomg/article/view/45/46)  
(Thickness of 2010 Mentawai tsunami deposits on Sipora and Pagai islands off W Sumatra 1.5-22 cm. Generally composed of fine-coarse sand, in irregular contact with underlying soil. Commonly multiple layers: run up at bottom and back wash at top. Fining upward, parallel lamination and soil clasts observed. Fossils generally rare, but include shallow marine foraminifera and abundant sponge spicules)

(online at: http://oaji.net/articles/2014/1150-1408504454.pdf)
(In Pangandaran, S Java, two possible tsunami deposits on top of soil horizons: 5-6 cm layer of coarse sand at top as 2006 tsunami deposit and 5-10 cm sand layer at bottom as paleotsunami. Sands contain (Miocene?) planktonic and shallow marine foraminifera)


(Horizontal and vertical distributions of δ18O and δ13C investigated in Globigerinoides ruber, Gs sacculifer, Pulleniatina obliquiloculata and Neogloboquadrina dutertrei, from 62 core-top samples from Indonesian Throughflow region. In Makassar Strait depleted δ18O and δ13C linked to freshwater input. In Bali Sea depleted δ18O result of freshwater input, while depleted δ13C more likely due to Java-Sumatra upwelling. G. ruber and G. sacculifer calcify within mixed-layer, respectively at 0-50 m and 20-75 m water depth, and P. obliquiloculata and N. dutertrei within upper thermocline at 75-125 m water depth)

1.5. SE Asia Carbonates, Coral Reefs (24)


(Development of New Caledonia barrier reef result of interplay between margin subsidence and sea-level changes. Major W shelf-margin building appears to have started during MIS 11 (400 ka) from shallow-water carbonate platform deposits older than 780 ka. Climatic conditions likely not optimal before late Quaternary, resulting in luxuriant reef expansion only in last 400,000 yrs)


(NW Shelf is modern tropical ramp, underlain by Cretaceous-Tertiary carbonates. Late Tertiary-Quaternary, fringing to isolated coral reefs rise from deep-ramp settings. Scott Reef is isolated reef formed mainly during Last Interglacial (~125 ka). Other reefs that apparently grew to sea level are now 30m below present sea level, indicating significant subsidence in Late Quaternary. Contemporary reefs grew during Holocene in accommodation space provided by subsidence and are up to 35m thick. Rowley Shoals emergent annular reefs rise from depths of 200-400 m. Possible spatial association between reef systems and hydrocarbon seeps)


(Scott Reef is small carbonate platform located in distal ramp setting on Australia NW Shelf. Rising from depths of 400-700 m. Composed of two large isolated coral reefs. Present-day reef morphology developed mainly in Holocene. Developed over Late Triassic anticline; area probably above sea level from Permian- Late Jurassic)


(Grande Terre island of New Caledonia enclosed by one of longest barrier reefs in world. Forereef slopes from 40- 320m depth with 7 sedimentary facies. From upper reef slopes to ~90m thick coralline algal crusts dominant. Three groups: (C), shallowest, mainly mastophorids (Hydrolithon, Lithoporella, Neogoniolithon) and Lithophyllum; (B) Lithophyllum spp, Mesophyllum and Peyssonnelia from 15-40m; (A) rich in Mesophyllum, Peyssonnelia, Sporolithon on deep reef slopes up to 90m. Below ~90m encrusting foraminifera acervulinids progressively replace coralline algal crusts)

(Previously unknown series of drowned fossil reefs in NW Australia shelf described. Reefs formed around 0.5 Ma with oldest ooids in Indian Ocean. Reef expansion partly due to increased Leeuwin Current intensity. Tropical facies expanded with onset of aridification of Australia after 0.6 Ma)


(Reefs across S China Sea with 571 known species of reef corals)


(Well-rounded rhodoliths 1-8 cm consist of multiple species of nongeliculatecoralline algae and encrusting foraminifer Acervulina inhaerens, together forming concentric internal structure. Thought to have formed in deep fore reef to shelf, at 50-150m depth. Often associated with Cyclocytopus- Operculina foram assemblage)


(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3774232/pdf/rsph20130818.pdf)

(On concordance between geological features and coral biogeographical structure)


(online at: https://www.frontiersin.org/articles/10.3389/fmars.2017.00145/full)


(Rhodoliths common in deep fore-reef to shelf areas at 50-135m water depths around Okinawa-jima)


(Halimeda bioherm formation and distribution controlled by interaction of outer-shelf geometry, regional and local currents, coupled with morphology and depth of continental slope submarine canyons determining delivery of cool, nutrient-rich water upwelling through inter-reef passages)


(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5309900/pdf/ncomms14387.pdf)

(Slabs of colonial coral from microatolls of Belitung Island on Sunda Shelf suggest sea level history between 6850-6500 yrs BP with two 0.6m fluctuations. Similar observations along S coast of China. Observed sea level fluctuations may reflect changes in dynamic sea surface height, local steric effects or eustatic changes)


(Evidence for several episodes of coral mass mortality in uplifted E-M-Holocene reef terraces and reefs along Huon Peninsula. Most striking mortality event at 9100-9400 yr B.P., associated with volcanic ash horizon)


(Halimeda banks of Great Barrier reef consist of ridges up to 15m high. Two species of Halimeda. Reefs grown only in last 8000 yrs. Positions suggest association with ingestions of nutrient-rich water into lagoonal area)


(Limestone at Ujung Genteng, SW Java, with three Acropora coral associations, tied to 0-13m paleobathymetry. (Age?))

(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/386/247)

(online at: www.repository.naturalis.nl/document/149596)

(online at: http://iopscience.iop.org/article/10.1088/1755-1315/118/1/012013/pdf)

(online at: http://journal.frontiersin.org/article/10.3389/fmars.2014.00081/full)

(Global study of present-day geographic distributions of corals. Birds Head- Sulu Sea region is global center of peak coral diversity)

(Distribution patterns of 89 species of Acropora staghorn coral, which has highest diversity in Wallacea region (but is not center of origin). In Indonesian Archipelago overlap of Indian Ocean species (diminishing E-ward) and Pacific Ocean species (diminishing W-wards), with stronger Pacific influence)

(Mainly review of Tertiary carbonates of Kutai Basin of E Kalimantan)


(Encrusted grains facies (rhodoliths, macroids) generally distributed at depths of 75-200m and associated with Cycloclypeus carpenteri. Ahermatypic coral facies on cone-like mounds at depths of 240-520m)
II. SUMATRA- SUNDA SHELF (283)

II.1. Sumatra - General, onshore geology, volcanism, minerals (90)


Abidin, H.Z. & H. Utoyo (2014)- Mineralization of the selected base metal deposits in the Barisan Range, Sumatera, Indonesia (case study at Lokop, Dairi, Latong, Tanjung Balit and Tuboh). Indonesian Mining J. 17, 3, p. 122-133. (online at: http://jurnal.tekmira.esdm.go.id/index.php/imj/article/view/316/199) (Three types of base metal occurrences along Barisan Range: (1) skarn (e.g. Lokop, Latong, Tuboh) (2) sedimentary exhalative (sedex) (Dairi; in Kluet Fm) and (3) hydrothermal (Tanjung Balit; in Silungkang Fm)

Acocella, V., O. Bellier, L. Sandri, M. Sebrier & S. Pramunijoyo (2018)- Weak tectono-magmatic relationships along an obliquely convergent plate boundary, Sumatra, Indonesia. Frontiers Earth Sci. 6, 3, p. 1-20. (online at: https://www.frontiersin.org/articles/10.3389/feart.2018.00003/full) (Sumatra volcanic arc 48 active volcanoes; 46% within 10 km from dextral Great Sumatra Fault, which carries most horizontal displacement on overriding plate. Half of these show possible structural relation to GSF. Data suggest limited tectonic control of GSF on arc volcanism)


(online at: http://iopscience.iop.org/article/10.1088/1755-1315/118/1/012002/pdf)
(On two lake-forming pull-apart basins between overstepping segments of Great Sumatra Fault zone in S Sumatra; Ranau and Suoh)

(online at: http://pustaka.geotek.lipi.go.id/index.php/2017/10/05/prosiding-2016/)
('Structural geology of ancient subduction zone in the Gunungkasih Complex, Lampung Province')

(New mineral uytenbogaardtite (Ag3AuS2) from hydrothermally-altered Tertiary andesitic rocks of Tambang Sawah, Bengkulu District, W Sumatra)

(parts online at: https://openaccess.leidenuniv.nl/handle/1887/57351)
(E Permian (296 Ma) 'Cathaysian' Jambi Flora from outcrops near Bangko in Sumatra characterized by plant groups known from classic coal swamp floras, as well as newly emerging groups that would play important role in vegetations of Permian era. Latter group with ecology generally drier than swamp flora species. Quantitative morphologic analysis of early gymnosperm woods suggests no individual species can be discerned)

(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/102/94)
('Paleovolcanoes in the Bakauheni area- Sangiang Island, Sunda Strait, South Lampung Regency'. Three paleovolcanoes in N Sunda Straits, along planned Sunda Strait bridge route between Merak- Bakauheni)

(online at: https://www.digizeitschriften.de/dms/img/?PID=GDZPPN000452483)
('About a granite contact zone in Central Sumatra'. Hornfels contactmetamorphism rich in biotite at contact between granite and adjacent shales, between Rakan and Lubuk Bandhara)

(online at: www.dwc.knaw.nl/DL/publications/PU00012536.pdf)
(Contact-metamorphic hornfelses near contact with tourmaline-bearing granites (without biotite?) in hill countries of Siak with common tourmaline. Also alluvial tin ores in area)

(online at: http://journal.frontiersin.org/article/10.3389/feart.2014.00016/full)
(Model of ash distribution and volume of Youngest Toba Tuff, erupted 75,000 years ago. Eruption dispersed ~8600 km3 of ash (= ~3800 km3 dense rock equivalent/ DRE), covering ~40 million km2 with >5 mm of ash. Total volume (incl. 1500 km3 DRE pyroclastic density current deposits on Sumatra) was ~5300 km3 DRE)

(Brief review of W Sumatra Padang map sheet geology and metallic mineral occurrences (Au-Ag, Cu, Pb-Zn). With old gold-silver mines Mangani, Balimbing, Pamicikan, Pagadis, etc., in epithermal quartz veins, associated with Plio-Pleistocene andesitic volcanics and young extensional faults. Also Pb-Zn anomalies at Salodako NNE of Padang near skarn associated with Tertiary granite)

(Summary of SW Sumatra Solok quad geology and metallic mineral occurrences (Cu, Au, Ag, Fe). Gold-silver in quartz veins hosted in Oligo-Miocene volcanics, copper mineralization in hydrothermal veins (Timbulan) and limestone skarns and alluvial gold deposits in Bengkalis area)

(Painan Sheet of W Sumatra with basement of Carboniferous? and Permo-Triassic metasediments (with Permian arc volcanism, deep marine Triassic), Late Triassic-Jurassic granitoids, late Jurassic- Cretaceous metalimestones and clastics (Woyla Gp), also serpentinite bodies. Unconformably overlain by Oligocene and younger sediments and volcanics. With listing of metallic mineral occurrences)

(SW Sumatra map sheets, with active Lebong Tandai gold-silver mine in mineralized breccia in Ketaun Quad. Oldest rock is extreme NE corner: M Permian volcanics of Palepat Fm, intruded by laterst Triassic-Jurassic Tantan Granite. M-L Jurassic flysch-type Asai Fm and shallow marine Late Jurassic- Cretaceous Peneta Fm (part of Woyla Gp foreland to island arc). With listing of metallic mineral occurrences (Cu, Pb, Zn, Au, Ag))

(Map sheet dominated by Tertiary-Recent volcanic products of Barisan Range. In SE corner Gumai Mts with remnants of Late Mesozoic subduction Complex, similar to Woyla Gp in N Sumatra. With many former mines of Lebong Mining District, active between ~1906-1941. Etc. With listing of metallic mineral occurrences (Au, Ag, Pb, Zn, Cu))

(SW Sumatra map sheet dominated by Tertiary-Recent volcanic products of Barisan Arc and flanking Bengkulu forearc basin. With listing of metallic mineral occurrences (Au, Pb- Zn, Ag, Cu), mainly around Tanjungsakti of Sumatra Fault Zone)

(SE Sumatra map sheet with oldest exposed rocks metasediments and NW-SE striking low metamorphic Permo-Carboniferous Tigapuluh Gp meta-clastics and limestones (probaby correlative to glacial or debris flow Bohorok Fm of N Sumatra). Intruded by porphyritic granitoids with K-Ar ages from ~198-128 Ma (most whole rock radiometric ages too young; granites may be slightly younger (earliest Jurassic) continuation of Late Triassic (~220 Ma) Main Range-equivalent S-type granites of Malay Peninsula). Three deformation phases. Many small alluvial Sn, W(cassiterite) occurrences near granites of Tigapuluh Mts in S, Au occurrences in W. Also primary cassiterite veins in greisen at Sungei Isahan granite))

(Oldest rocks exposed in Tigapuluh Mts: NW-SE striking low metamorphic Permo-Carboniferous Tigapuluh Gp meta-clastics and limestones, intruded by Late Triassic- E-M Jurassic granitoids (K-Ar mineral ages ~198, 180 Ma). With Permian pebbly mudstones, probably correlative to glacial Bohorok Fin of N Sumatra. Etc. With listing of metallic mineral (Sn, Au) deposits (rel. common alluvial cassiterite, but non-economic))


(Oldest rocks exposed in Baturaja Sheet in Garba Mts and are ?Carboniferous- Mesozoic metasediments. Mesozoic of Garba Mts includes highly tectonized late Jurassic- E Cretaceous radiolarian cherts, associated with metavolcanics, melange and ultrabasic rocks; can be correlated with Lingsing series of Gumai Mts and oceanic sequences of Woyla Gp. Granitoids along E side of Barisan Range of M-L Cretaceous age (115-80 Ma), postdating accretion of Woyla Gp. With listing of metallic (Au, Ag, Sn) mineral deposits)


(‘The soil of Deli. II. Mineralogical investigations of the soil of Deli’. Part 2 of 3-volume series)


(‘The soil of Deli (Final). The soils of Deli and their characteristics’. Part 3 of 3-volume series)


(‘Analysis of the relations between the Great Sumatra Great Fault and the compressional structures of the back arc’. Total young shortening in C Sumatra basin ~14 km since M Miocene, representing 4% of initial width of basin. Compressional movements in back-arc accommodate only small portion of oblique convergence in Sumatra)


(online at: http://runeberg.org/tektd/1933b/0003.html)

(In Swedish: ‘Gold-silver mines in West Sumatra’. Brief review of geology and mineralization at W Sumatra gold mines Mangani, Simau, etc. With follow-up on mining practices and reserves in 1933-2 issue, p. 12-16)


(Study of northern sector of Sumatran Fault System at northernmost tip of Sumatra and islands to NW. Fault bifurcates into two fault strands and two independent kinematic regimes evolve: E branch is classic Riedel system, W branch features fold-thrust belt, accommodating ~20% of shortening of system in study area)


(Pinang-Pinang gold-copper-molybdenum project ~20km SE of Tapaktuan on SW coast of Aceh consists of two skarn deposits, ~3km apart. Granitoids and limestones present but no ages discussed)
(Zn-Pb sedimentary-exhalative deposits in the Pagar Gunung area, Kotanopan and Madina regencies, North Sumatra)

(Fe-Cu skarn deposit at contact of Miocene? Geunette granodiorite and E Cretaceous Raba and Lambo Limestones associated with Bentaro Volcanics in Barisan Mts of N Sumatra (= probably part of Woyla arc terranes; see also Susanto and Suparka 2012)

(Upper Tengkereng Au-Cu-(Mo) porphyry deposit in Gayo Luks regency, C Aceh. One of six porphries in Tengkereng - Ise Ise mineralization belt, associated with Late Pliocene (~2.0 Ma) age intrusive complexes in M Jurassic? volcanics and limestones of the Woyla Gp)

(Petrology of basement rocks (Basement) Pre-Tertiary in Garba Mountains, South Sumatra’. Brief report on basement rocks in Garba Mts: (1) metamorphics dominated by phyllites (Carboniferous - E Permian Tarap Fm?);(2) andesites- gabbro (E Cretaceous); (3) polymict breccia of clay matrix with chert, marble blocks; (4) youngest unit Garba granite, with new K-Ar date of 91.3 ± 1.9 Ma. Garba Mts part of Jurassic- Cretaceous Salting volcanic arc, in E Cretaceous collision zone between Woyla and W Sumatra terranes?)

(‘Characteristics of fluid inclusions in gold mineralization in the Lumban Julu area, Tobasa, North Sumatra’. Quartz veins in Lumban Julu area with Ag-Au-Cu-Pb-Zn mineralization. Fluid inclusions in quartz consist of liquid and vapor. Two systems of mineral deposition in area: (1) associated with high-T with mesothermal system at ~1600m depth and (2) associated with ephithermal system at ~550m depth)

(Cassiterite- arsenopyrite mineralization in 70-100cm quartz veins in marginal greisen zone of Sungai Isahan granite, Tigapuluh Mts, E C Sumatra. Up to 7.5 kg/m3 cassiterite in stream sediment (see also Schwartz 1987))


(online at: http://iopscience.iop.org/article/10.1088/1755-1315/71/1/012034/pdf)  
(Pleistocene- Holocene pyroclastic deposits in Maninjau area in Barisan Mts range in composition from high-K rhyolite to calc-alkaline andesite)

('Mining investigation of the copper ores in the Padang Highlands'. Old report on survey of relatively widespread copper mineralization in Batipo- Kotta's area of Barisan Range (Timboelon, etc.). No maps)


(Sedimentary exhalative style mineralisation in Permo-Carboniferous Tapanuli Gp of Sopokomil dome of Dairi Regency)


(M Eocene- Oligocene palynology of Pematang Gp of C Sumatra. Pematang Gp not older than Proxapertites operculatus zone to not younger than Meyeripollis naharkotensis subzone)


(Size and level of maturity of large volcanic reservoir estimated from radial seismic anisotropy (ambient-noise tomography) below Toba caldera, N Sumatra. Many partially molten sills present in the crust below 7 km)


(No known metalliferous occurrences in Palembang Quadrangle, S Sumatra)


(online at: www.nature.com/ncomms/2016/160719/ncomms12228/pdf/ncomms12228.pdf)

(Toba Caldera site of several recent, large explosive eruptions, including world’s largest Pleistocene eruption 74,000 years ago. Major cause may be subduction of fluid-rich Investigator Fracture Zone under continental crust of Sumatra and possible tear of slab. Seismic tomography model shows multi-level plumbing system. Large amounts of volatiles originate in subducting slab at of ~150 km depth, migrate up and cause melting in mantle wedge. Volatile-rich basic magmas accumulate at base of crust in a ~50,000 km3 reservoir. Overheated volatiles continue ascending through crust, cause melting of upper crust rocks, leading to shallow crustal reservoir responsible for supereruptions)


(Beutong porphyry copper deposit ~60 km NE of Meulaboh, Aceh. Two mineralized Cu-Mo-Au porphyry centers in E Pliocene (~4.2 – 4.6 Ma) Beutong Intrusive Complex, into Jurassic-Cretaceous Woyla Gp, which includes NW-SE-trending dismembered ophiolite slivers. Overprinted by high sulphidation epithermal event)


(Review of sedimentary-exhalative lead-zinc deposits. With example from Sopokomil in Permo-Carboniferous Tapanuli Gp in N Sumatra, with up to 8m thick massive sulphides over ~3km)

DPore from O (tentatively correlated to 'Old Toba Tuff'). Ages and group in the Beutong and Darul Makmue area of Sumatra.

785.6 ± 0.7 ka

Mulyaningsih, S. (2014) tsunami of AD 780 from coastal marshes of the Woyla Group of W Jambi Province preserves abundant evidence of E Permian forest, where pyroclastic flows often made way and destroyed vegetation and where epiclastic reworked pyroclastics rapidly entombed vegetation. In situ Agathoxylon close enough to which grew at foot of active volcano, where pyroclastic flows often made way and destroyed vegetation and where epiclastic reworked pyroclastics rapidly entombed vegetation. In situ Agathoxylon close enough to volcanic slope to be buried rapidly, but shallow enough to avoid recrystallization


Pre-Tertiary volcanism of the volcanic rocks of the Woyla Group in the Beutong and Darul Makmue sub-regency, Nagan Raya Regency, Nanggroe Aceh Darussalam'. Woyla Gp with intermediate volcanic rocks, metamorphic rocks and granodiorite intrusions. Metamorphic rocks thought to be alterations of volcanism)

(‘Traces of Mesozoic subduction in the Garba Complex, S Sumatra, from radiolarian fossils and geochemical analysis’. In S Sumatra trace of Mesozoic subduction complex(es) exposed in Gunam, Garba and Gunung Kasih (Lampung). In SE Garba Mts subduction complex rocks from continental margin and from oceanic plates. Presence of island arc basalts and radiolaria of possible Triassic age)


(Latest geological and GPS studies suggest slip rates along Sumatran Fault Zone ~15 mm/yr. Total amount of extension in the Sunda-strait marine grabens ~18.7 km, almost identical with largest geomorphic offset along SFZ. Sumatran fore-arc moving N along SFZ like rigid block instead of being stretched)


(Paleosols buried under Ranau Tuff constrain large caldera-forming eruption to ~33,830–33,450 yrs BP. In N Sumatra lateral displacement of river channels incised into Ranau Tuff show right-lateral channel offsets of ~350 ± 50m (minimum slip rate 10.4 ± 1.5 mm/yr). S of Suoh pull-apart depression. In SW Sumatra West Semangko segment offsets Semangko River by 230 ± 60m, (slip rate of 6.8 ± 1.8 mm/yr))


(‘Petrology of basement rocks of the Gunungkasih Complex, Tanjungkarang, South Lampung’. Pretertiary Gunungkasih complex rocks in Lampung greenschist-facies metamorphics (derived from volcanic arc or oceanic crust rocks; Sikuleh-Sekampung arc?). Basement rocks of Ratai Bay mica schist, chloride schist and quartzite (meta-sediments; part of Woyla Accretionary Complex))


(‘Morphotectonics and Sumatran fault reactivation in Padangpanjang, West Sumatra’. Remote sensing study)

('Morphostratigraphy of the Maninjau ignimbrite tuff in Sianok Gorge, Belakang Balok village, Bukittinggi, West Sumatera'. Ignimbrite plateau of Sianok Valley produced by two periods of Maninjau volcanic eruptions, separated by fluvio-volcanic sands and conglomerates. Pyroclastic deposits faulted, forming terrace morphology. Sianok formed by reactivation of basement faults)


(Tembang low-sulphidation epithermal Au-Ag vein system in Barisan Mts, 130km NNE of Bengkulu, S Sumatra. Hosted in volcanics of E Miocene Hulusimpang Fm ('Old andesites') and M Miocene andesitic intrusions. Age of mineralization assumed to be similar to known epithermal Au-Ag deposits in S Sumatra and W Java. Near Rawas open pit mine, operational from 1997-2000)


(Sumatran Fault zone 1900 km long NW-SE trending transcurrent fault. 19 segments from Aceh to Sunda Strait with stepovess with pull-apart basin. CCW rotation of Sundaland in M Miocene triggered activation of fault in right-handed kinematics, facilitated by pre-existing basement grain (obduction of Woyla nappe))


(Massive chert of Situalanglang Mb of Garba Fm in Garba Mts with poor-moderate preserved radiolaria, low diversity and abundance. Presence of Triassocampe suggests Triassic age (older than supposed Jurassic-Cretaceous age of Woyla Group))


('Characteristics of the 1883 Krakatau tsunami deposits in the Tarahan area, Lampung'. Tsunami deposit of 1883 Krakatau volcano eruption off Lampung Bay is f-c sand layer (10-30cm thick?) with pumice and volcanic ash. Shallow marine benthic foraminifera and molluscs show tsunami waves erode sea floor sediments down to 30-40m depth. Four fining upward patterns indicate at least four tsunami waves inundated study area.)


(Toba eruption (~74,000 yrs ago) during δ18O Stage 5a-4 transition period of rapid ice growth and falling global sea level, which may have been a factor in creating stresses that triggered volcanic event. Stratospheric dust and sulfuric acid aerosol clouds may have created brief cooling (volcanic winter), with N Hemisphere surface T decreases of ~3°-5°C. Summer T decreases of ~10°C at high N latitudes adjacent to regions already covered by snow may have increased snow/sea-ice extent, accelerating cooling already in progress)


(Eruption of 74 ka Youngest Toba Tuff of N Sumatra produced 2800 km3 of ignimbrite and coignimbrite ashfall. Relatively many zircons nucleated before earlier eruption at 501 ka, but most zircons yielded interior dates 100-300 ka thereafter. Zircon growth likely episodic over protracted time intervals of >100- >500 ka. Repeated
magma recharge may have contributed to development of compositional zoning in YTT, but perturbations to magma reservoir over >400 ka did not lead to eruption until 74 ka)


Robock, A., C.M. Ammann, L. Oman, D. Shindell, S. Levis & G. Stenchikov (2009)- Did the Toba volcanic eruption of ~74k BP produce widespread glaciation? J. Geophysical Research 114, D10107, p. 1-9. (online at: https://pubs.giss.nasa.gov/docs/2009/2009_Robock_ro09900j.pdf) (Climate simulation model of 'volcanic winter' following supervolcano eruption of size of Toba suggests devastating consequences for humanity and global ecosystems)

Rolker, C.M. (1891)- The alluvial tin deposits of Siak, Sumatra. Trans. American Inst. Mining Engineers 20, New York, p. 50-84. (Old review of alluvial tin mining operations in headwaters of Siak (and Rokan and Kampar) rivers near Pakanbaru, in east part of C Sumatra. Worked mainly by Chinese contract miners (tin deposits known to VOC agents since 1670's; Barnard 2013))


(online at: www.pnas.org/content/109/46/18684.full.pdf)
(Toba supereruption in N Sumatra largest Quaternary terrestrial volcanic event, with ash and sulfate aerosol deposits in both hemispheres. Astronomically calibrated 40Ar/39Ar age of 73.88 ± 0.32 ka for sanidine crystals from up to 5m thick Toba ash deposits in Lenggong Valley, Malaysia, 6 km from archeological site with stone artifacts buried by ash. If made by Homo sapiens, age indicates modern humans reached SE Asia by ∼74 ka. Timing of eruption tied to peak in sulfate concentration in Greenland ice cores in middle of cold interval between Dansgaard-Oeschger events 20 and 19. Peak is followed by ∼10 °C drop in Greenland surface temperature over ∼150 yr, revealing possible climatic impact of eruption)

(Magmatic evolution and metallogenesis of molybdenum and uranium ore in the Sibolga Type A granitoid complex, North Sumatra'. Late Paleozoic- E Mesozoic granites in SE Asia, incl. Bangka and Belitung islands marked generally by S-type granitoid emplacement with regional tin mineralization. Sibolga Granitoid Complex of N Sumatra shows different, A-type granitoid. Biotite granites most common. Sibolga granitoid intruded into Klue Fm. K/Ar ages of ~219 Ma and 211 Ma by Rb/Sr on biotite (Late Triassic). A-type granitoid of Sibolga probably associated with anorogenic or rift related environment. Molybdenum anomalies imply magmas derived by partial melting of Late-Paleozoic lower-crustal rocks)

(Thick (>2000m?), deformed Jurassic Cretaceous sediments at E flank of Barisan Range, at S Sumatra (Jambi) Basin margin, intruded by Cretaceous Arai- Angai granite. M-L Jurassic Asai Fm marine 'flysch-type' meta-
sandstones and phyllite with minor limestone, rel. quartz rich, of continental provenance. Overlying Late Jurassic- E Cretaceous more variable, of recycled orogen and arc provenance. Paleomagnetic study suggests paleolatitude of 32°S. To N in tectonic? contact with Permian Mengkareng Gp)

Syafrie, I., E.T. Yuningsih & H. Matsueda (2015)- Geochemistry study of granitoid basement rock in Jambi Sub basin, South Sumatera, Indonesia, based on JSB-3, JSB-4 and JSB-6 wells data. In: ICG 2015, 2nd Int. Conf. and 1st Joint Conf. Faculty of Geology Universitas Padjaran and University of Malaysia Sabah, p. 305-311.
(Mesozoic? granitoid basement in Jambi sub basin is intermediate-acid, calc-alkaline, medium- high K, metalluminous (subduction at active continental margin). Granitoid basement rock of JSB-4 and JSB-6 shows magnetite series and I type (late orogenic). Mesozoic granitoid probably extension of Thailand and Burma granite province (see also Yuningsih 2006))

(Merangin River section in W Sumatra exposes Lower Permian (late Asselian) Mengkarang Fm. Section ~400m thick, composed of 8 fining-upward of volcanic tuffs and volcaniclastic sedimentary rocks, incl. pyroclastic flows, overlain by their reworked alluvial products. Base of section marine, with common brachiopods. Zircon dating indicates duration of ~630,000 years (296.77 ± 0.04 near base to 296.14 ± 0.09 Ma near top). Change in paleobotanical composition from dominated by Cordaites, ferns or club mosses, to seed fern-dominant. Similar paleofloral trends observed in other areas of Paleotethys.)

(Lower Cretaceous(?)) granitoid in Garba Mts near Mehanggin, Muaradua area, S Sumatra, classified as S-type, high-K, calc-alkaline (island arc or active continental margin)


(WayLinggo low sulphidation epithermal deposit of S Sumatra series of zeolite-bearing quartz veins emplaced along NW-NNW trending subsidiarystructures of Sumatra Fault Zone, in Miocene andesitic- dacitic pyroclastic rocks, intruded by porphyritic dacitic stock and minor andesite dykes. Prehnites formed below 220°C)


('Skarn-type iron mineralization in Bukit Gadang Lange, Tarung Tarung Village, Rao Sub-district, Pasaman District, West Sumatra'. Magnetite-hematite associated with garnet in contact zone between Tertiary granodiorite intrusion and Permian Silungkang Fm marble/limestone at Bukit Gadang Lange, Barisan Mts.)


('Miwah high sulphidation epithermal gold system in Aceh')


('Mineralogy of the Bukit Pagias granitoid, Ombilin Basin, West Sumatra'. Petrography of (Jurassic?) granite)


('Chemical analysis of granitoid basement rock of the Jambi sub basin, South Sumatra, based on data from wells JSB-3, JSB-4 and JSB-6'. Pre-Tertiary granitoid basement rocks in wells JSB-3 (~1990m) intermediate-acid magma, calc-alkaline, medium-high K, metalluminous (subduction at active continental margin). Granitoids at JSB-4 (2654m) and JSB-6 (2342m) magnetite series and I type, probably extension of Thailand-Burma granite province)

Zwierzyci, J. (1920)- Zijn de Indische petroleumterreinen, in het bijzonder die op Sumatra, peneplains of abrasievlakken? De Mijningenieur 1, 2, p. 3-5.

('Are the Indies petroleum-bearing areas, in particular those on Sumatra, peneplains or abrasion plains?’ Landscape of petroleum terrains in N and S Sumatra and Java routinely viewed as peneplains on gently folded Tertiary sediments. Age of folding probably Pleistocene, not leaving much time for peneplanation by complete fluviial erosion cycle; wave abrasion on coastal plains probably faster, and more likely mechanism)
II.2. Sumatra - Cenozoic Basins, Stratigraphy, Hydrocarbons, Coal (109)

(online at: http://jurnal.unpad.ac.id/bsc/article/view/8252/3800)

(Discussion of shifting of Baturaja limestone buildup development towards SE margin of Muara Enim Deep/ Kuang High during Early Miocene (not Upper Miocene suggested in title; see also Pannetier 1994; JTvG)

(online at: https://repository.ugm.ac.id/274230/1/PSP-12.pdf)
('Sequence stratigraphy of the South Palembang sub-basin stratigraphy based on drilling data of well 'SSB', Musi Waras District, South Sumatra Province'. Four sequences identified in Talang Akar- Air Benakat Fms interval (Early Miocene) in unspecified well 'SSB' in Pertamina block, S Sumatra)

(Suban gas field in Corridor Block, S Sumatra, world-class fractured reservoir with commingled production from fractured Tertiary (carbonate and sandstone) and Carboniferous- Cretaceous igneous and meta-sedimentary basement rocks. Fractures flow hydrocarbon down to 250-450m TVD below top basement. New wells to be placed: (a) high on fractured structure; (b) close to faults; (c) where brittle reservoir facies exist

('Distribution and process of CO2 formation and its relation with the economic value of prospects in the North Sumatera Basin'. Gases in wells from the N Sumatra basin locally high in CO2 (1-80%). CO2 probably originated from thermal breakdown of carbonate rocks, both in Pretertiary basement and Eocene (?) Tampur Fm dolomites). With map of CO2% distribution)

('Determination of the petroleum system in S and N Palembang subbasins, South Sumatra Basin, based on geochemistry analysis and basin modeling')

(Southern N Sumatra basin in E-M Miocene not just post-rift subsidence, but flexural basin (foredeep) in front of Barisan Mts thrust front after ~16-14 Ma)

(online at: www.geomatejournal.com/sites/default/files/articles/45-52-2519-Edy-May%202017-33-g1.pdf)
Gas content of Late Miocene low-rank coal seams in S Palembang basin from well log and core analysis varies from 4.1-5.3 m³/t, increasing with deeper burial. Total estimated gas-in-place ~3,019 MMm³. Onset of biogenic gas generation may be before Plio-Pleistocene inversion.


Aswan, S. Graha, D. Suryadi, T. Wiguna & S.I. Qivayanti (2016)- Oligocene cyclic sedimentation deduced from taphonomic analysis of molluscs in lacustrine deposits of the Pematang Group, Pesada Well, Central Sumatra Basin. J. Mathematical and Fundamental Sciences (ITB) 48, 1, p. 66-81. (online at: http://journals.itb.ac.id/index.php/jmfs/article/view/471/1155) (Taphonomic analysis of gastropods used to interpret cyclicity in lacustrine Brown Shale. Four types of shell concentrations: (1) early transgressive deposits erosion surface at base, with abraded and broken shells; (2,3) late and maximum transgressive deposits with rel. common complete shells in life position; (3) early regressive deposits alternating shell-rich and shell-poor layers. Seven sedimentary cycles in Pesada well)


(Kenali Asam field in Jambi sub-basin, S Sumatra, 1929 NIAM discovery on NNW-SSE anticline, 282 wells)

(Eocene to Miocene strata in J Block of S Sumatra Basin divided into six sequences. Intra-Gumai Fm deltaic sands in highstand systems tract of SQ4. In the highstand system tract of SQ4. Etc.)

(On Irin cluster of small E Miocene Baturaja Lst buildup prospects on Musi Platform, S Sumatra basin. Irin 1 (2013) gas-bearing with 400' of limestone reservoir with up to 28% porosity. Baturaja carbonates six stages of development: oldest in SM-1 well in W part, youngest stage in SE part of Musi platform)

(S Sumatra mature basin, with only very small prospects remaining. In Musi Platform area clusters of small E Miocene Baturaja carbonate prospects still offer potential)

(Two specimens of silicified wood from Quaternary of S Sumatra identified as being similar to modern plants Shorea negrosensis (Dipterocarpaceae) and Lagerstroemia colletti (Lythraceae) and named as new species Shoreoxylon sumatraense and Lagerstroemioxylon benkoelense)

(Updated E Miocene (17.5-22 Ma) depositional models of Bekasap and Bangko, Durt, Lower Telisa Fms in C Sumatra Basin. U Sihapas Gp deposited during marine transgression. Sediment source mainly Malayan Shield to NE, resulting in NE to SW depositional trend. Two major feeder systems controlled sedimentation in C Sumatra Basin, resulting in two major deltas in m-u Early Miocene (best reservoir quality))

(Facies study of Miocene- Pliocene elastic deposits in N Bengkulu Basin)

(online at: http://buletinsdg.geologi.esdm.go.id/index.php/bsdg/issue/archive)
('Preliminary study of Muaraenim coal liquefaction potential based on coal characteristics'. Muara Enim coal of S Sumatra good potential to be converted into liquid fuel)

Bibliography of Indonesia Geology, New for Ed. 7.


- (Bandar Agung (BDA)-1 exploration well drilled in 2014 in W of Ogan Komering block, S Palembang sub-basin, S Sumatra Basin, tested thermogenic gas (3.4 MMSCFD) and condensate (73.3 BCPD of 54.7°API) from fractured basement. Well penetrated >100m of fractured basalt with minor granodiorite and marble, underlain by ~25m of non-fractured phyllite. Basement part of Mutus Assemblage)

('Paleoenvironment and evaluation of lateral distribution of stratigraphic traps of Baoung and Belumai sandstone reservoirs by fossil correlation integrated with regional 2D seismic, North Sumatra Basin: Bio-sequence stratigraphic correlation study of M Miocene sandstones in N Sumatra basin)


('Geochemistry of limestones from the Gumai and Baturaja Formations in the Muaradua area, south Ogan Komering Ulu, South Sumatra')


(On unconventional oil and gas potential of Late Eocene- E Miocene shales of Jambi Basin, S Sumatra)


(online at: www.lemigas.esdm.go.id/publikasi/read/scientific/1/)

(S Sumatra basin with potential of shale hydrocarbons in Talang Akar and Lemat/Lahat Fms. Generally early maturity of oil (Ro = 0.6%) at ~2000m depth, oil formation (Ro 0.7-0.9%) between 2200 -3100m and formation of gas (Ro values 0.9-1.2%) at 3100-3500m. P50 assessment of non-conventional oil-gas resources up to 4200 MMBOE)


(online at: www.academicjournals.org/journal/JPGE/article-full-text-pdf/E2428FD531922)

(4 groups of oil in S Sumatra Basin: (1) marine/lacustrine (low pristane/phytane), (2) terrestrially derived (high pristane/phytane ratio), (3) lacustrine oils with bimodal distribution of n-alkanes and (4) biodegraded oils. Oils distributed randomly and sourced from terrestrial TalangAkar and lacustrine Lemat/Lahat formations)


('The influence of the formation mechanism of a Tertiary Basin and temperature history and the formation of hydrocarbons in the South Sumatra Basin'. S Sumatra basin categorized as hot basin, with average of heat flow value of 108 mWm-2. Start of rifting phase in Late Oligocene (30-25 Ma) re-activating three patterns of old basement faults. Thermal modeling along 3 sections. Thermal model and gravity models indicate Moho depth at 15.6 - 19.5 km (thin crust). Heat flow increased at 15-5 Ma, with average of 117 mW/m2, corresponding with onset of Bukit Barisan volcanic activity. Early mature oil generation reached at 25.2 Ma, end of gas generation at 16 Ma. Top Oil window at 1433m depth)


('Characteristics and depositional environment of Muaraenim Formation coal based on organic petrology at Darmo area, Lawang Kidul, South Sumatra'. Petrography of Late Miocene Muara Enim Fm coal in Banko Tenga coalfield, S Sumatra basin. Mainly vitrinite, followed by inertinite and exinite. Vitrinite reflectance ~0.40-0.45% (sub-bituminous B-C rank). Depositional environment lower delta plain)

(Petroleum system modeling suggests expulsion in Benakat subbasin started at 13 Ma while in Pigi subbasin it started from 9.5 Ma. Four migration patterns in Musi High, three charged from Benakat and one charged from Pigi subbasin. Saung Naga subbasin on Musi Platform still immature until present day)


(‘Early-Middle Miocene boundary (= boundaries of foram zones N8/ N9 and calcareous nannoplankton zones NN4/ NN5) in S Sumatra characterized by lowering of sea level (decrease in foraminiferal and calcareous nannoplankton assemblages) and climate change from wet during zone N8 to seasonal/dry climate around N8/ N9 boundary. Gradual changes to wetter climate through zone N9)

(online at: www.lemigas.esdm.go.id/publikasi/read/scientific/1)
(Pollen assemblage of Paleogene sediments in C Sumatra Basin less rich than in C Java, SE Kalimantan, S Sulawesi. Occurrences of spore Cicatricoisporites dorogensis and pollen Palmaepollenites kutchensis and Meyeripollis naharkotensis suggest most likely Oligocene age for Brown Shale and Upper Red Beds. Surprising absence of lacustrine fresh water algae Pediastrum and Bosedenia))


(Horizontal wells drilled by Chevron in C Sumatra Basin, mainly in Bekasap and Menggala sandstone reservoirs of 1960's Petani and Bekasap oil fields)

(online at: http://jurnal.unpad.ac.id/bsc/article/view/7455/3416) (without figures)
('Tectonostratigraphy of the Ombilin basin, West Sumatra': Ombilin Basin intramontane basin in Barisan Mts. Basement two parts: Mergui terrane (with Permian Silungkang Fm limestone) and Woyla terrane. Early Paleogene Ombilin Basin rifting in transtensional setting along Sitangkai and Silungkang faults)
(onlne at: www.lemigas.esdm.go.id/publikasi/read/scientific/1)
(In N Sumatra basin potential for shale play with gas sweet spots in Bampo, Belumai and Baong Fms. Total shale gas resource estimated at 48.4 TCF gas)

(Discussion of M-L Miocene coals of M2 horizon (Petai, Suban and Mangus coals) in Muara Enim Fm of Bukit Kendi coalfield, S Sumatra. Average ash content of Seam C is 6%, Seam B is 5%, and Seam A2 is 3.8%)

(onlne at: http://journal.uir.ac.id/index.php/JGEET/article/view/7/299)
(Three sequences in M Miocene Baong deep marine sands in N Sumatra basin. Clastic deposits interpreted to come from S-SW, from Barisan Mts that started uplift at this time)

(onlne at: http://journal.unpad.ac.id/bsc/article/view/13387/pdf)
(‘Facies analysis of the Menggala Formation A reservoir in the Central Barumun field, Central Sumatra Basin’. Tidal flat and lagoonal facies in E Miocene sandstones in BT-1 and BT-3 wells in NW-most part of Central Sumatra basin (TongaPSC?)

(Coals of fluvio-deltaic Late Oligocene Talangakar Fm in Jambi Subbasin both rich in vitrinite (56-77%) and inertinite (17-36%). Vitrinite content associated with bright lithotype deposited in wet-swampy area; inertinite associated with dull lithotype from dry-swampy area. Vitrinite reflectance 0.45-0.47% (subbituminous). Low-medium sulphur (most Sumatra coals <5% inertinite and >80% vitrinite)

(Sumpal Field is large gas field in Corridor block, currently producing from fractured pre-Tertiary crystalline basement rocks. E Miocene silty sandstone (Baturaja Fm/ Lower Telisa equivalent) present in many wells and contains light oil. Thickness 7-18m, but low permeability and requires fracking)

(Oil discovered in Suban 3 and Suban Baru wells in sandstones in marine upper Telisa Fm (late E Miocene) in Suban Baru Field, Corridor Block of C Palembang sub-basin of S Sumatra. Variable reservoir quality. Oils sourced from mixed terrestrial-marine facies, probably from source rock below Telisa Fm, although Telisa Fm may be mature in deeper parts of S Sumatra Basin)

(onlne at: http://cardinalscholar.bsu.edu/handle/123456789/197811)
(Test of 'W. Ade Rule', stating that “95% of all commercial oil fields in the Sumatra region occur within 17 km of seismically mappable structural grabens in the producing basin”. Graben mapping suggests in S Sumatra Basin 78% of oil fields located within 17 km margin from grabens. For Sunda/Asri basin number is 100%, for Ardjuna basin 92%)

(Miocene Baturaja Fm carbonate reservoir in Sungai Kenawang and Pulau Gading fields of Jambi Basin (buildups on NE-SW trending Merang and Ketaling Highs))

(On study of E Miocene Bekasap and Menggala Fms sandstones in mature Bekasap field (1955; 107 producing wells). Model delineates trends of estuarine, sand ridge and margin facies that reflect paleogeography. Thirty one horizontal wells drilled in field, predicted to improve ultimate recovery from 14% to 28%)


(Interpretation of depositional environment of coal seam D, Muara Enim Formation, Suban Burung Block, South Sumatera Basin’. M-L Miocene coal seam D of Muara Enim Fm dominated by vitrinite (~71%), inertinite (17.6%), liptinite (5.9%) and 6.4% mineral matter. Vitrinite reflectance Rvmax 0.25-0.38%, corresponding to lignite-subbituminous rank. Deposited in a limnic depositional environment)

(On potential for stratigraphic traps in Paleogene rift section of Puspa area in NE part of NE-SW trending Tempino-Kenali Asam Deep/ rift, NE part of Jambi Basin. Six sequences in M Eocene - Late Oligocene rift fill: early synrift (P10-P17; fluvi- lacustrine) and late synrift (P17-N4; fluvio-deltaic). Sediment source from NE)

(Air Benakat Fm at Tempino Field, Jambi Basin, ~500m thick. Age from late E- M Miocene (NN4-NN6 or N7-N11?; ~18-12 Ma?). Four sequences)

(Jambi subbasin nine sequences from E Eocene- M Miocene. Paleogeography maps for sequences 1-4 (Lemat-Gumai Fms. Based on richness, maturation, facies and amount of shale highest shale hydrocarbon potential in Sequence 3 (U Talang Akar- lower Baturaja Fm (also as p. 706-726 in same volume))

('Calcereous nanofossil biostratigraphy of well 'SSB', South Palembang sub-basin, S Sumatra'. Nanofossils study of (unspecified) well, from Lahat to Air Benakat Formations. Five zones, from Sphenolithus cipoensis

(Singa 1 (1997) well tested Batu Raja reefal limestone buildup, deep in Lematang Trough (~12,000'), ~3000' deeper than any wells previously drilled in area. Tested gas at 30.7 MMSCFD from 258' gross interval)


(Puja-I gas-condensate well drilled by Pertamina in 2009 on local high in Tempino-Kenali Asam Deep, Jambi subbasin, S Sumatra Basin, Indonesia. Structure controlled by SE and NW dipping normal faults, developed in transtensional rift setting and affecting synrift clastic sedimentation)


(online at: http://jurnal.tekmira.esdm.go.id/index.php/imj/article/view/608/470)

(Comparison of Eocene coals of Ombilin (W Sumatra) and Bayah (SW Java). Bayah with higher mineral matter; Ombilin higher vitrinite and liptinite contents, higher vitrinite reflectance and rank (sub-bituminous to anthracite). Thermally unaffected coals from both coalfields <90 % vitrinite. Variable vitrinite reflectances, due to igneous intrusions)


(Review of 3D fracture modeling in Pretertiary basement rocks of Sumatra, incl. outcrop fracture study in Ombilin Basin)


(online at: https://pubs.usgs.gov/fs/2016/3089/fs20163089.pdf)

(Undiscovered total coalbed gas resource of C and S Sumatra basins is most likely 20 TCF of gas (8 in C, 12 in S Sumatra; F95-F5 range 4.8- 42 TCF). Measurements indicated coals undersaturated with gas. Presence of liptinite led to hydrogen indices as high as 300 mg/g, suggesting coals may be able to produce liquids)


(Late Eocene?- E Oligocene lacustrine Brown Shale Fm of Pematang Group samped in Karbindo coal mine in Kiliran graben on W side of C Sumatra basin. Organic matter primarily from lacustrine organisms with minor terrestrial plant input. 4-Methylsterane concentrations and n-alkane distributions indicate non-marine dinoflagellates and Botryococcus braunii likely significant parts of local biosphere)


(online at: http://jurnal.unpad.ac.id/gsag/article/view/15615/7344)

(General discussion of standard planktonic foramin zonation (nothing on how applied to S Sumatra; HvG))

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(online at: www.lemigas.esdm.go.id/publikasi/read/scientific/1)

(Outcrop samples from Talang Akar and younger formations at Merangin River, Muara Jernih and Mengupeh areas show E-M Miocene ages. Top M Miocene age identified by pollen Florschuetzia levipoli and F. meridionalis, whilst base of E Miocene marked by appearance of nanoplankton Sphenolithus compactus)


(Geochemistry of five outcrop samples of shale near Kutacane, along Alas River, Aceh. With Jurassic-Cretaceous nanoplankton, but mapped as Paleozoic on Medan geologic map). TOC 0.29-0.57%, vitrinite reflectance 2.1-2.4% (overmature), gas prone source)


(Muaraenim coalbeds in Rambutan Field, S Sumatra, high vitrinitic coal (up to 83% huminite), making it target for CBM development. High sub-bituminous rank (Ro<0.5%), high moisture content (up to 21%). Minerals <5%, mostly iron sulfide. Cleat fillings dominated by kaolinite. Rambutan wells 3 main coal seams with thickness ~9-14m, between depths ~480-950m, Ro 0.3-<0.5%. Apparent high degree of undersaturation)


("Pattern of coal quality distribution and exploration drilling plan in the Bukit Kendi area, Tanjung Enim, South Sumatra‘. Muara Enim Fm Late Miocene- Pliocene coal in Bukit Kendi area, 12 km S of Bukit Asam coal mines. Folded in NW-SE anticlines. Coal rank increased by basaltic andesite intrusions)


(Sequence stratigraphic interpretations and correlatios in reservoir interval of Minas Field, C Sumatra)


(Sand-rich outcrops of Miocene age outcrop in NW corner of C Sumatra basin. Few 100m thick, correlated to Sihapas Group. No figures? and no supporting biostrat control?)


(Exploration history of Jabung Block in Jambi subbasin of S Sumatra basin. CO2 content of gas major challenge)


(online at: http://geomatejournal.com/sites/default/files/articles/2208-2215-1141-Sutriyono-July-2016.pdf)

(Geochemistry of outcropping shales in U Oligocene Talang Akar Fm at Lengkayap and Napalan rivers, Garba Mts, S Sumatra basin.Low-moderate TOC's. Vitrinite reflectance indicates immature- early mature for oil)
Suwarna, N., M. Iqbal, H. Hermiyanto & R. Koswara (2015)- Organic petrographic and geochemical characteristics of Eo- Oligocene Kasiro shales, Southern Sumatra, Indonesia. In: Hydrocarbons in the tropics, Abstracts 32nd Ann. Mtg. Soc. Organic Petrology, Yogyakarta 2015, p. 132-133. (*Extended Abstract*). (Late Eocene- E Oligocene lacustrine oil shales of Kasiro Fm from Sekeladi Village, Jambi, with high TOC (0.72- 16.1%) and kerogen mainly Type II. Good-excellent oil potential. Thermal maturity late immature- early mature; some samples mature- post mature (Rv 0.22- 0.63%, mainly 0.41%))


('Thermal maturity and estimation of shale oil content of the Sinamar Fm in the Dusun Panjang area, Jambi Province'. Oligocene Sinamar Fm shales ~10-25m thick in outcrop in W part of Jambi basin. Organic content up to 17%, dominated by Types I and II kerogen. Lipptinite and vitrinite up to 10%, inertinite up to 0.49%. Immature to overmature. May produce 5-90 liter oil/ton shale, giving oil resource of ~69,535,298 barrels)

('Intrusive rocks in the Bukit Kendi area, South Sumatra, related to maturation and improved quality of coal'. Intrusives of Bukit Kendi and Bukit Cepadang and associated sills in Tanjung Enim area generated hydrothermal temperatures of ~230°C, causong a local improved thermal maturation of Late Miocene-Pliocene Muara Enim Fm coals)

('Copper veins in the Padang Highlands'. Investigations in the canyon of Paningahang (low-Cu in veins in chlorite shale) and in the ore district of the Sibumbun-Djanten (multiple veins with malachite, etc.)

('Studies on the soil of Sumatra's East coast, its appearance and origin'. With discussion of geologic context of soils of NE Sumatra. With simple map showing boundary between 'high-red soils' and 'low-white soils')


('Contribution to the knowledge of the Tertiary flora of Sumatra')

(Discussion of gas in E Miocene Gumai Fm sandstones) in area of NE Betara Field, Jabung Block, S Sumatra)

(Outcrops of Eocene synrift, alluvial- fluvial Brani Fm of Ombilin Basin useful analogue for subsurface rift-fill of C Sumatra Basin)

(On fractures in Merbau field, a 1975 gas discovery in Baturaja Limestone buildup in S Sumatra basin)

('Geochemical study and maturation model of the Talangakar Formation rocks from the Tungkal Block, South Sumatera basin'. Talang Akar Fm sediments with immature - late mature organic matter. Dominated by mixed
Widayat, A.H. (2011)- Paleoenvironmental and paleoecological changes during deposition of the Late Eocene Kiliran oil shale, Central Sumatra Basin, Indonesia. Ph.D. Thesis, Johann Wolfgang Goethe University, Frankfurt am Main, p. 1-143. (online at: https://core.ac.uk/download/pdf/18325618.pdf) (Palynofacies and geochemical study of samples from 102m core in Late Eocene Kiliran oil shale ('Brown Shale', Pematang Gp). Represents ~240,000 years of lacustrine deposition in warm-humid climate)


(Up to 300m thick Eo-Oligocene alluvial fan sandstones identified in Anggor and Secanggang Fields and Gebang Block wells in N Sumatra basin. Gas tested in Anggor and GB-04 wells. Risk of overpressure)
II.3. Sumatra - Offshore forearc and islands (36)


(Description of active gas seep on seafloor in Simeulue- Siberut forearc basin: seismic expression, carbonate hardground cementation of seafloor. Seep vent fauna of white crabs, mytilid bivalves, Vestimentifera polychaete tube worms, etc.)


(The Tabuan- Panaitan Ridge, trace of the Sumatran fault in Sunda Strait, based on geophysical data analysis'. Semangko pull-apart basin in Sunda Straits two sub-basins separated by NW-SE to N-S trending Tabuan-Panaitan Ridge, part of main Sumatra Fault zone in Sunda Strait. With likely magmatic intrusion activity)


(Bathymetry data and local seismicity in Sunda Strait suggest existence of extension segment of Sumatran Fault Zone S of Ujung Kulon towards Sunda Trench, and is active fault)


(At Sumatran oblique convergent margin Mentawai and Sumatran Fault right-lateral fault zones accommodate most of trench- parallel component of strain and bound Mentawai forearc sliver that extends from Sunda Strait to Nicobar Islands. Set of wrench faults obliquely connect two major fault zones, separating at least four horses of regional strike-slip duplex forming forearc sliver, each comprising individual basin in forearc. Duplex formation started in M-L Miocene SW of Sunda Strait, then propagated N-wards over 2000 km until E Pliocene)


(Two large intra-oceanic earthquakes in NE Indian Ocean on 11 April 2012 largest strike-slip events in historical times. Triggered large aftershocks worldwide. Along fossil fabric of extinct Wharton basin and part of intraplate deformation between India and Australia that followed Aceh 2004 and Nias 2005 megathrust earthquakes. Australian plate, driven by slab-pull forces at the Sunda trench, is detaching from Indian plate, which is subjected to resisting forces at Himalayan front)


(Literature review of Sumatra accretionary prism. High-risk frontier exploration area)


(online at: https://repositories.lib.utexas.edu/handle/2152/45947)
(Incl. study of accretionary prism offshore N Sumatra between 1-7°N. Steep outer slope (5-12°), plateau ~100-120 km wide, and steep inner slope adjacent to Aceh Basin. Predominantly landward vergence from deformation front for ~70 km landward. Prism toe region prominent mass failures. Etc.)

(Bathymetric and seismic surveys across accretionary prism off NW Sumatra. Accretionary wedge in study area up to~180 km wide, narrowing to 125km to S, near Simeulue island. Seafloor depths ~4.5 km near Sunda Trench to <1 km on fore-arc high near fore-arc basin. Wedge consists of steep outer slope (5-12°), plateau ~100-120 km wide with anticlinal folds spaced 2-15km apart, and steep inner slope adjacent to Aceh forearc Basin. Mainly landward-vergent folds at trench side, mainly seaward vergent folds at landward side)

(online at: http://onlinelibrary.wiley.com/doi/10.1029/2012GC004122/epdf)
(High-res bathymetry shows NW offshore extension of Great Sumatra FZ near Banda Aceh into young SW transpressional Breuch and NE transtensional Weh basins, with Sumatran volcanic arc passing through Weh basin)

(The tectonic development of the Sunda Strait forearc area and its relationship to the Sumatran Fault Zone'. Sunda Strait forearc interpreted as ongoing separation of area as Sumatra forearc plate moved NW, bounded by Sumatra Fault. Sumatra Fault can be viewed to extend across fore arc to trench as several graben systems)


(Biotite from granodiorite in Siumayam Complex in Barisan Mts K-Ar age of ~98.6 Ma; biotites from Meuko River granodiorite ~56.2 and 53.2 Ma, compatible with Cretaceous- E Paleogene granitic activity recorded elsewhere in N Sumatra. Gabbro from E Simeulue ophiolite 35.4± 3.6 and 40.1 ± 2.7 Ma (Late Eocene), possibly representing formation as part of Indian Ocean floor. Basaltic- andesitic volcanics from Barisan Mts on E margin of Sibolga Basin 16- 9 Ma (M-L Miocene). Start of volcanic activity in M Miocene coincided with uplift of Barisan Mts along E margin of Sibolga Basin (E- M Miocene sediments only minor evidence of contemporaneous volcanic activity))

(2004 Sumatra earthquake initiated at ~ 30km depth and ruptured 1300km of Indo-Australian- Sunda plate boundary. Seismic velocity model from tomography and forward modeling shows deep structure of earthquake
source region. 4-5 km of sediments on oceanic crust at trench. Crystalline backstop 120 km from trench axis, below fore-arc basin. Shallow continental Moho (22 km depth), 170 km from trench. Seismogenic zone begins 5-30 km from trench. Deeper part of rupture along contact between mantle wedge and downgoing plate)

(online at: https://www.solid-earth-discuss.net/se-2017-128/se-2017-128.pdf)
(Tomographic model of C Sumatra subduction zone suggests thinned continental crust below basin E of forearc islands (Nias, Pulau Batu, Siberut) at ~180 km from trench. Reduced vp velocities beneath forearc region between Mentawai Islands and Sumatra mainland possibly reflect reduced thickness of overriding crust)

(online at: http://jurnal.unpad.ac.id/bsc/article/view/8377/3893)
('Indications of tsunami deposits by subfossils in the swamp of the Simeulue area'. Presumed tsunami deposit with mixed marine foraminifera from middle (Elphidium, Pararotalia) and outer neritic (Heterolepa subhaidingeri) environments)

(online at: https://www.sciencedirect.com/science/article/pii/S0012821X17303977)
(First sampling of full sedimentary section of Bengal-Nicobar Fan W of N Sumatra by IODP Expedition 362. Sources for Nicobar Fan mainly Himalayan-derived Ganges-Brahmaputra and Indo-Burman Ranges/W Burma, with minor contributions from Sunda forearc and arc and Ninetyeast Ridge. Bengal-Nicobar Fan clearly developing before Late Miocene, but distinct increase in sediment accumulation rate at ~9.5 Ma suggests restructurering of sediment routing in submarine fan system, coinciding with inversion of E Himalayan Shillong Plateau and encroachment of W-propagating Indo-Burmese wedge)

(Slab-tear fault within subducting Indian plate ruptured in 2005 across W Sunda Trench within marginal intra-plate region)

('Structures, evolution and tectonics of the forearc region in the western Sundaland active margin')


('Geodynamics of Sunda Strait forearc area based on seismic reflection data'. Sunda Strait transition zone between Java frontal subduction and Sumatra oblique convergence. Disappearance of forearc basin off Sumatra and presence of horsts and grabens. Young faults formed in sediments formerly part of forearc. Horsts and grabens not only related to pull-apart system, but also connected to volcanic-magmatic activities)

(Brief review)


('Extension tectonics of Sunda Straits'. Sunda Straits pull-apart basin at SE termination of Great Sumatra Fault Zone, with main opening in Pliocene- Recent. Clearly expressed by bathymetry. Associated with magmatism, with N20°E-trending, S-ward younging volcanic line from Sukadana in N (1.2 Ma) to Krakatau (1 Ma) and Panjaitan(0.5 Ma) in S)


(Large uplifts and tilts on Sumatran outer arc islands between 0.5°- 3.3°S during great historical earthquakes in 1797 and 1833)

Noda, A. & A. Miyakawa (2017)- Deposition and deformation of modern accretionary type forearc basins: linking basin formation and accretionary wedge growth. In: Y. Itoh (ed.) Evolutionary models of convergent margins: origin of their diversity, Intech, Japan, Chapter 1, p. 3-27. (online at: http://repository.osaka-fu-u.ac.jp/dspace/bitstream/10466/15058/103/Chapter01.pdf)

(Includes brief review of Sumatra- Java forearc basins, classified as doubly-vergent 'two-wedge' accretionary-type forearc basins)


(In Aceh basin frequency of turbidite mud decreased as sea level rose during Pleistocene- Holocene deglaciation. Terrigenous organic carbon content high at end of Last Glacial period, but during deglaciation most organic carbon of marine origin. In Sunda trench Holocene turbidites consisted of remobilized slope sediments from two sources: (1) old Bengal/Nicobar fan with thermally matured organic fragments, whereas those derived from trench slope contained little terrigenous carbon)


(At least five discrete uplift events identified at raised coral reef sites around Siberut, Sipora, Pagai islands in about 1597, 1613, 1631, 1658, and 1703, likely corresponding to large megathrust ruptures)


(Seven deep-sea turbidite layers identified in Indian Ocean core off Sumatra, corresponding to events that occurred at 128-130, 105-107, 98-100, 86-87, 50-53, 37-41 and 20-29 ka. Possible triggering mechanisms for turbidite events include tsunamis, earthquakes, volcanic eruptions and sea-level changes)


'Sunda Megathrust' is name for 1600km long seismogenic subduction zone off Myanmar-Andaman- Sumatra- Java, which runs from deep trench on ocean floor under continental margins. Slippage events in 2004 and 2005 caused major earthquakes and tsunamis)


(Cold methane seep in forearc basin off Sumatra, with methane-seep adapted microbial community)


(Fault plane solutions of 2005 and 2009 earthquakes in Mentawai offshore area suggest 'back-thrust' sequences occurred on steeply landward-dipping fault. Interpreted as ‘unsticking’ of Sumatran accretionary wedge along backstop fault that separates accreted material from stronger Sunda forearc lithosphere, or as reactivation of pre-Miocene normal fault under forearc basin)

II.4. Sunda Shelf (incl. 'Tin islands', Singkep, Karimata) (38)


(Wolframite/ tungsten is most common mineral associated with tin deposits all over Bangka. Traditionally viewed as uneconomic, but may have value. Genetic origin similar to tin. Most common as late hydrothermal deposit in cracks and fractures of quartz veins in Triassic Tanjung Genting Fm sandstones)

(Bangka Island and surrounding areas major tin producer (cassiterite), but also heavy mineral placers (magnetite, ilmenite, zircon, apatite, monazite) and potential REE producer (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, etc.). Tectonic environment of Toboali granitoid of S Bangka continental magmatic arc)

(online at: www.ccop.or.th/download/as/52as2.pdf)
(Presence of REE minerals in sand and tin mining tailings in S Bangka island. Bangka granites subdivided in Klabat batholith in N (10 plutons; S-type, Late Triassic-M. Jurassic; comparable to Main granite belt of Malay Peninsula) and Bebulu batholith in S (5 plutons; S and IS-types))

(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/121/111)
(‘I-type Kelumpang Granite at Balok beach, Belitung’. In Bangka- Belitung region biotite-granites associated with cassiterite; no cassiterite mineralisation in hornblende granites. Kelumpang granite of SE Belitung hornblende granite, rich in K-feldspar megacrystic minerals, of I-type, and no cassiterite. Age E Jurassic?)

(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/95/85)
(The relationship between Rare Earth Elements and heavy minerals ilmenite and rutile in waters off Gundi Beach, West Bangka’. Niobium (Nb) and Tantalum (Ta) occur in association with ilmenite (FeTiO2) and rutile (TiO2) in near-coastal sands off SW Bangka)

(online at: http://iopscience.iop.org/article/10.1088/1755-1315/118/1/012053/pdf)
(Sunda Shelf epicontinental shallow shelf since Pliocene. Sedimentation and erosion cycles follow glacial-interglacial sea level variation cycles that periodically changed area to open land. During eustatic lowstands important river drainage systems from SE Asia in N (Gulf of Thailand) and system from Malay Peninsula, Sumatra, Bangka-Belitung and Kalimantan, named Palaeo Sunda River)

(‘Records of transgression and regression events of Holocene P. Belitung and the rise in temperature of the Earth surface today’. Around Belitung island Holocene transgression from -65m at 11000 BP to +7.5m at 3700 BP, followed by regression until today. Ancient beach ridges and coral at +5.75m)

(‘Interaction of tectonic, sea-level and climate change factors in the Klabat Bay area, Bangka Regency, Bangka’. Study of depositional facies/ thickness of Quaternary deposits off N Bangka island)

(‘Discussion of Belitung glass tektites, found on top of bedrock (‘kong’), below tin-bearing alluvial deposits. Mainly critique of Wing Easton (1921) suggestion that billitonites formed from colloidal solutions. Many billitonites have fragile small ‘tables’ on a stem, suggesting limited or no transport)

(online at: https://repository.ugm.ac.id/273552/

"Mineralogy and geochemistry of Baginda Hill granitoid, Belitung Island'. Granitoids widespread on Belitung: in NW associated with tin deposits, in SW, at Baginda Hill, extremely low Sn content. Magmatic affinity of granitoid calc-alkaline, high K alkaline/ shoshonite, I-type metaluminous. Rb versus Y+Nb and Nb versus Y suggest Baginda Hill granitoid is Volcanic Arc Granite, associated with subduction)


(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/268/229)

(Late Triassic Karimun Granite on Karimun island S of Singapore differs from other felsic intrusive rocks in Malay Peninsula because of A-type affinity, although it is classified as part of Tin Islands)


(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/238/290)

('Rare Earth Element content in pinkish granite of the Lagoi area and its comparison with similar rocks of other regions'. Triassic granite intrusions on Bintan Island part of Main Range Granite belt of SE Asia. Different colours of granite. Granite in Lagoi area of N Bintan (226 ± 8 Ma) pink color, with high REE content (av. 295 ppm)


(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1986/5083...)

(Tebrong area of E Belitung underlain by Triassic granite plutons and metasediments with low-grade Sn mineralization in swarms of subvertical quartz-tourmaline-cassiterite veins. Overlain by Quaternary cassiterite 'kaka' placers)


(Sediments in Malacca Strait largely derived from adjacent land provinces of Sumatra and Malay Peninsula, with highly variable provenance. Dominant NW current due to movement of water into strait from S China and Java Seas and to lesser extent from Andaman Sea)


(online at: http://ejournal.mgi.esdm.go.id/index.php/bong/article/view/26/26)

(Sunda shelf off W Kalimantan with Pleistocene incised valleys seen on shallow seismic lines may contain gold placer accumulations, derived from Sintang Intrusives)


(online at: http://jurnal.tekmira.esdm.go.id/index.php/imj/article/view/592/454)
(Marine magnetic anomalies over Belitung waters, where zone of <50 nT total magnetic anomaly interpreted to reflect submerged Belitung granite. Correlation between magnetic susceptibility and type of granites indicated submerged Belitung intrusive is biotite-granite, associated with cassiterite minerals)


(SE Asian Tin Belt tied to arc-related Eastern granite province and collision-related Main Range granite provinces, running across Thailand, Singapore and Indonesia, and separated by Paleo-Tethys sutures. E Province usually granites with biotite ± hornblende; Main Range granites sometimes characterised by biotite ± muscovite. On Indonesian Tin Islands both hornblende-bearing (previously I-type) and hornblende-barren (previously S-type), apparently randomly distributed. Bangka granites geochemically similar to Malaysian Main Range granites, with zircon U-Pb ages of ~225 Ma and ~220 Ma, within time of Main Range magmatism (~226-201 Ma) in Malay Peninsula. This suggests Paleo-Tethyan suture lies E of Bangka island)


(online at: http://buletinsdg.geologi.esdm.go.id/index.php/bsdg/issue/archive)

('Characteristics of primary tin reserves in the area of Parit Tebu, East Belitung Regency'. Primary tin mineralisation in quartz veins, hosted by quartz-arenite sandstone and metaclaystone, intruded by aplitic granite. Tin mineral cassiterite associated with realgar, molybdenite, pyrite, sphalerite, galena, etc.)


(online at: www.pnas.org/content/111/47/16790.full.pdf)

(Climate of C Sundaland during Late Pleistocene Last Glacial Maximum suitable to sustain Dipterocarp rainforest; presence of previously suggested transequatorial savannah corridor at that time unlikely. Dipterocarp species richness lower at LGM, and areas of high species richness mostly off current islands and on emergent Sunda Shelf)


(online at: https://gsmpubl.files.wordpress.com/2017/04/bgsm2016007.pdf)

(Shallow acoustic profiles across paleo-incised valleys in Penyu Basin, S China Sea, formed during several phases of Late Pleistocene regression and subsequent Last Glacial Maximum when sea level was ~123 m lower than present-day. Valleys filled during lowstand and subsequent post-glacial marine transgression. Holocene shallow-marine cover (3-10m thick) healed ravinement surface. Average late-Pleistocene surface 53-64m below present-day MSL, with ~16-50m of valley incision)


(Pahang River paleovalleys in S China Sea formed during regressive phase of last glacial cycle, and submerged and filled during postglacial marine transgression. Valley fills overlain by marine transgressive ravinement surface and 5-10m thick Holocene shallow marine deposits. Low-sinuosity lowstand valley system changed to
high-sinuosity meander belt and eventually into deltaic distributary channel system, before submergence. Average Late Pleistocene surface between 53-64m below sea level, with ~16-50 m of valley incision)


Rueb, J. (1915)- Ontstaan der alluviale tinerts afzettingen van Banka en Billiton. De Ingenieur 1915, 5, p. ('The origin of the alluvial tin ore deposits of Bangka and Belitung'. Discussion origin of two types of alluvial tin ore: 'koelit' (rel. in place weathered granite material; mainly formed in period of dry-warm climate) and 'laksa' (erosional products transported by rivers))


forests and lower montane rainforests, suggesting exposed shelf covered with humid vegetation. Marshy vegetation in valley along N Sunda River. Climate during LGM inferred from vegetation cooler today, but no significant decrease in humidity recorded.


('Characteristics of trace elements in granitoid magmatism discrimination on Bangka Island'. Klubat granitoids on Bangka Island studied for trace elements. Granitoids in E (Belinyu) and C Bangka display crust-mantle mixing with calc-alkaline affinity, characteristic of I type (= 'Eastern Province'?). In S and W Bangka granitoids high K calc-alkaline and of S type (= 'Main Range'?))


('Rare Earth Elements profile of Klubat Granitoid in Bangka Island by neutron activation analysis')


(Boomer shallow seismic survey off S coast of Bangka to determine Quaternary sediment thickness (5-20ms))

II.5. Natuna, Anambas (10)


(Play assessment of Eo-Oligocene early syn-rift Lama Fm quartz-rich fluvio-lacustrine clastics in Natuna A Block. Due to deep burial, reservoir effectiveness critical risk (especially due to quartz cementation. Two main erosion events: (1) base Miocene (Base Arang shale; ~25 Ma); (2)M Miocene unconformity (~16-11 Ma). Sweet spots for Lama Play at rift flexural margin)


(Pliocene-Recent Muda interval in W Natuna Basin contains five 3rd-order sequences, with depositional environments confined to shelf and consisting mainly of fluvial elements)


(Examples of reional seismic lines across East Natuna basin rifts and highs with carbonate buildups)


('Basement' outcrops on Natuna Islands Jurassic- E Cretaceous ophiolite (peridotite-gabbro- basalt) and (NE-dipping)?) ?Cretaceous melange/ subduction complex of Bunguran Fm in SW, with intensely folded deep marine pelagic siltstones, radiolarian cherts and tuffs, and sandstones in scaly clay matrix. In NE and E intruded by Late Cretaceous granodiorites (~71-73 Ma) in Ranai area. Pre-Tertiary overlain by Tertiary fluvial-shallow marine basal conglomerates, stacked sandstones and interbedded siltstone-claystone. Sandstones mostly sub-litharenites, dominated by quartz, chert and metamorphic fragments, of good potential reservoir quality)


Ozza, T., M. Mazied, F.H. Korah, M. Arisandy, H.I. Darmawan, I W.A. Darma, B.P. Putra & W.N. Farida (2018)- Geochemistry analysis and petroleum system modeling for "X" Block, West Natuna Basin. Proc. 42nd Ann. Conv. Indon. Petroleum Assoc. (IPA), Jakarta, IPA18-417-G, 18p. *(Geochemistry and hydrocarbon charge/ entrapment model for “X” Block close to NW tip of West Natuna Basin and with several inverted half-grabens (Anoa, Gajah, Kakap, Kambing) that delivered hydrocarbon charge. Inversion structures started at ~21 Ma; M Miocene erosion up to 1000m. Oil biomarkers indicate (Paleogene) lacustrine source facies. In deep grabens hydrocarbon expulsion started at 37, 31 Ma)*


III. JAVA, MADURA, JAVA SEA  (379)

III.1. Java - General, Onshore geology, Forearc  (273)


(Sedimentological study of M Miocene Jatiluhur Fm in N Bogor Trough, NE of Bogor. Lower and M Jatiluhur Fm interpreted as M Miocene S-ward prograding slope-shelf system, derived from Sundaland. Late Miocene deposits also suggest additional supply of volcanicogenic sediments from volcanic terranes to S. Klapanunggal Limestone in middle part of formation with Katacycloclpeus and coral)


(On Late Miocene shelf-margin carbonate reef up to 240m thick, well exposed in Cibinong area, NE of Bogor, named Klapanunggal Fm. Thick and massive reefal limestone with large foraminifera. Interpreted a S-prograding shelf margin, facing Bogor Trough in S (with picture of Katacycloclpeus annulatus, suggesting Middle Miocene age; HvG))


(450m thick section of M-L Miocene Halang Fm exposed along Cijurey River. Lithofacies interpreted as mass transport deposits (no maps and not much other detail))


(E Miocene carbonates of Tuban Fm in Sukowati Field, NE Java basin, produced oil and gas since 2004. Two carbonate build ups, with different productivity rates. Highest productivity in N of field, with better-developed secondary porosity)


(2011 Alas Tua W1 well in E Java Basin discovered gas in ~300m Early Oligocene platform carbonates overlain by ~200m of Late Oligocene deeper water marls)


('Petrogenesis of igneous rock intrusions in the West and East Jiwo hills, Bayat District, Klaten, Central Java'. Three types of igneous rocks in Jiwo Hills: olivine gabbro (in SW), micro gabbro(W and E) and diorite (Gunung Pendul in W and Gunung Dowo, Butak and Desa Drajet in W Jiwo))


('Stratigraphy and biostratigraphy of the Upper Sentolo Formation'. U Sentolo in section near Kaliagung Village, SW of Sentolo, C Java, 24m thick, mainly calcareous sandstone. Age Late Pliocene (N20-N21))


(online at: https://repository.ugm.ac.id/274228/1/PSP-10.pdf)

('Preliminary study of abundance of fossil molluscs in the upper Sentolo Formation'. Molluscs in Late Pliocene (N20-N21) part of Sentolo Fm NW of Kaliagung village, Kulon Progo, C Java: 10 species of gastropods (incl. Corbicula gerthi, Conus spp., Amnicola, Sulcospira, Cypraea) and 5 species of pelecypoda (incl. Anomia boettgeri, Paphia cheribonensis, Meretrix, Pallium, Anadara). Most species shallow marine and transitional)


(online at: https://repository.ugm.ac.id/135168/1/874-885%20M4P-0.pdf)

('Age of the Kebo Butak Formation based on calcareous nanofossils in the Bayat area, Klaten District, C Java'. Kebo Butak Fm of S Mountains of E Miocene age. Tegalrejo-Cermo section with Cyclicargolithus floridanus, Sphenolithus ciproensis and Dictyococcales bisecta (zone NN1, earliest Miocene) and Discoaster druggii (zone NN2). Basal Karangnongko section with Sphenolithus heteromorphs and S. belemnos (NN4))


(online at: https://journal.ugm.ac.id/jag/article/view/26964/16605)

('Eocene shale at Nanggulan, south C Java, potential shale gas source. Deposited in estuarine to shallow marine environments. Core samples show TOC 0.36-1.0 % for shales and 12.8 % for coaly shales. Estuarine E Eocene higher TOC. Volcanic activity in M Eocene caused lower organic content)


(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/327/233)

('Gases from surface seeps in W Kendeng zone SE of Semarang and NE of Salatiga thermogenic gases with 53-85% methane, 10-35% N2, etc. Possibly derived from humic (coaly) organic matter))


(online at: http://www.eri.u-tokyo.ac.jp/people/yaoki/2017GSLSP.pdf)

('LUSI mud volcano in Sidoarjo, E Java, started to erupt on 29 May 2006, 200 m from drilling Lapindo oil-gas well, and continues to erupt. Ground deformation data from GPS monitoring do not support triggering of LUSI eruption by reactivation of underlying fault due to Yogyakarta earthquake)


(online at: http://adsabs.harvard.edu/abs/2016AGUFMEP21D0911A)

('Four Quaternary marine terraces identified along S coast of Java: T1 0-.05m, T2 2m, T3 17m, T4 22 m, suggest late Quaternary uplift of 0.17 mm/yr)


Ansori, A.Z.A. & D.H. Amijaya (201)- Proses pengendapan dan lingkungan pengendapan serpih Formasi Nanggulan, Kulon Progo, Yogyakarta, berdasarkan data batuan inti. Proc. 7th Seminar Nasional Kebumian, Dept. Teknik Geologi, Gadjah Mada University, Yogyakarta, p. 708-720. (online at: https://repository.ugm.ac.id/135165/1/708-720%20MAO-03.pdf) (Depositional processes and setting of shales of the Nanggulan Formation, Kulon Progo, Yogyakarta, based on core data'. Depositional environment of Nanggulan Fm upward deepening, from fluvial to tide-dominant estuarine to shallow marine)


Ariani, N.P., Akmaluddin & W. Rahardjo (2017)- Paleoclimatic change during Late Miocene based on planktonic foraminifera in the Sentolo Formation- Kulon Progo. Proc. Joint Conv. HAGI-IAGI-IAFMI-IATMI (JCM 2017), Malang, 5p. (Planktonic foraminifera assemblages in Late Miocene (N16-N17; ~8.6-6.1 Ma) part of Sentolo Fm in Jurang-Banjharjo and Kalibawang sections, W Progo Hills, C Java, suggest paleoclimate fluctuations: Zone I warm (~8.6Ma); zone II cooling around ~7-8.6 Ma (cold peak at ~8 Ma); Zone III warming around ~6-7 Ma (warm peak ~8 Ma) and Zone IV re-warmed to cool down at ~6.1 Ma. Pattern comparable to observations in Kepek Fm (S Mountains) on, Kerek Fm (Kendeng Zone) and ODP 806 in Pacific Ocean)


Molluscan evidence for slow subsidence in the Bobotsari Basin during the Plio-Pleistocene, and implications for petroleum maturity. J. Mathem. Fundamental Sciences (ITB) 47, 2, p. 185-204.
Bibliography of Indonesia Geology, New for Ed. 7.

(online at: http://journals.itb.ac.id/index.php/jmfs/article/view/469/911)

(BDeposition under marine conditions until E Pleistocene in Bobotsari Basin, S of Mt Slamet, C Java, while adjacent Bogor and N Serayu basins have fluvial deposits in Pleistocene)

('Atlas of sedimentary basins of Indonesia: Serayu Basin')

('Stratigraphy and sedimentology of tidal flat deposits at Kali Tulis, Banjarnegara' Merawu Fm in Kali Tulis. Lower part mainly mudstone, interpreted as mud flat, and reportedly with E-M Miocene (N8-N14) planktonic foraminifera (= open marine; do not support mud flat facies interpretation; JTvG). Upper part sand-rich, interpreted as sand flat and with common volcanic rock fragments, suggesting provenance from volcanic arc)

(Unpublished report in Geological Survey-Bandung library, presumably by Stanvac geologist in 1930's)

('Geology of ancient volcanoes'. Also as 2013 second edition. Introductory text on volcano geology based on examples from Indonesia)

('Mud volcanoes in Cengklik and surrounding areas, Boyolali District, Central Java Province'. In Boyolali district mud volcanoes in E-W zone 20km long/3-5 km wide from Lake Cengklik to Solo River. With andesite basalt skoria in Gununglondo)

(online at: https://digital.library.adelaide.edu.au/dspace/bitstream/2440/110285/2/02whole.pdf)

('Tectonics and rate of sedimentation effect in mud volcano generation in the Kendeng and Rembang zones, East Java Basin'. Mud volcanoes are surface expressions of extruding overpressured formations or shale diapirs. E Java mud volcanoes grouped into four models, i.e. Kiuwu, Crewek Medang and Lusi. Mud volcanoes caused by contractional tectonic deformation, sedimentation rate (>280m/My), deep burial (>1000m) and dominance of shale (>85%). If mud volcano system is at critical pressure phase, drilling will cause rapid explosion of mud volcano. If mud volcano system is in near critical phase, explosion will start when drill pipe is deepened. Overpressured mud zone has potential for unconventional gas reservoir with high gas storage capacity)


(Tugu Barat A is oil field in onshore NW Java basin, in Parigi reefal limestone reservoir. Initially view as single pool, but composed of multiple reservoir layers with different Gas-Oil and Oil-Water contacts. Porosities 7-44%. Revised oil reserve estimate 11 MBO)


(Paleogeographic maps of M Eocene Ngimbang Fm clastics source rock and Oligo-Miocene Kujung Fm carbonate reservoir facies in NE Java basin. Ngimbang clastics in series of NE-SW trending grabens)


(1:250,000 scale map of soils in part of Central Java, from Muria volcano in N to Solo, Yogyakarta, Southern Mountains region in S)


(Plio-Pleistocene Pucangan Fm volcanoclastic reservoirs in 1994 Wunut gas discovery, E Java. Sediments derived from volcanic arc in S)


(online at: https://journal.sttnas.ac.id/Retii/article/view/161/130)

('Determination of age and depositional environment of the Kepek Formation at Kepek village, Gunung Kidul'. Kepek Fm marls overlie Wonosari Lst and are youngest sediments in Southern Mountains of C Java. Relatively gentle slope (<10°), thickness <200m. With common open marine foraminifera, incl. planktonic species Globorotalia dehiscens, Globorotalia plesiotumida (indicating zone N17, Late Miocene))


(Commentary of Mauri et al. 2017 paper that fails to mention gas well drilling as possible trigger of mud volcano eruption)


(online at: http://iopscience.iop.org/article/10.1088/1755-1315/118/1/012009/pdf)

Bibliography of Indonesia Geology, New for Ed. 7.
(Eocene Lower Ngimbang carbonaceous shales from Kujung-1 and Ngimbang-1 wells in Cepu area. C-13 isotope data suggest transitional/ deltaic source facies in Kujung-1 to marginal marine in Ngimbang-1)

(Oils from Kujung Fm reservoirs in Mudi and Sukowati fields, NE Java, from one oil family with deltaic-marginal marine source facies. Oils correlated to Eocene Lower Ngimbang shales. Mixed deltaic (vitrinite macerals type III) and marginal marine (liptinite and alganite macerals type II). Source richness fair- excellent. Top oil window (Ro 0.6) between 1900-2850m depth)

(Samples from of E Tertiary Jatibarang Fm shale of unnamed wells dominantly type III kerogen)

Ediyanto & A. Subandrio (2002)- Perbandingan keterdapat an antara foraminifera (plankton dan bentos) dan moluska pada lingkungan pengendapan laut dangkal, studi kasus pada Formasi Cimandiri, Sukabumi, Jawa Barat. Proc. 31st Ann. Conv. Indon. Assoc. Geol. (IAGI), Surabaya, p. 807-817. (online at: http://repository.upnyk.ac.id/5602/1/PERBANDINGAN_KETERDAPATAN_ANTARA_FORAMINIFERA.pdf) ('Comparison between content of foraminifera (plankton and benthos) and mollusks in shallow marine depositional environments, Case study on the Cimandiri Formation, Sukabumi, West Java`. Shallow marine Cimandiri Fm sediments of late Middle Miocene age (N12-N13). Locally abundant molluscs (Turritella angulata assemblage of Oostingh 1938), particularly infaunal species)


(Ambient seismic noise data from area of Lusi mud eruption shows hydrothermal plume, rooted at minimum 6 km depth and reaching surface at Lusi site)

('Age analysis of limestone of the Bojonglopan formation and stratigraphic relationship between the Bojonglopan limestone and the Jampang Formation breccia')

(Tumpangpitu porphyry and high-sulfidation epithermal deposit in Tujuh Bukit district, SE Java. Porphyry resource 1.9 billion tonnes @ 0.45% Cu and 0.45 g/t Au, with additional resource in epithermal mineralization. At least 8 discrete intrusions. Tujuh Bukit district floored by Miocene sedimentary and andesitic volcanic rocks. Volcanic-hydrothermal activity at Tujuh Bukit began with formation of weakly altered Tanjung Jahe diatreme complex (U-Pb zircon ages ~8.8-8.5 Ma). Mineralization preceded by large, equigranular dioritic batholith (~5.8-5.1 Ma). Syn- to late-mineralization porphyries emplaced in E Pliocene (~5.40-3.9 Ma). High-sulfidation Au-Ag ± Cu lithocap Cu deposit: evidence for pre-mineralization porphyries')

('Diabase in the Karangsambung area, Luk Ulo, Kebumen, Central Java: What formed the basaltic rock group in the form of intrusive bodies?. Diabase at Karangsambung village exposed as isolated hill surrounded by clay and clay breccias of Karangsambung and Togog Formation. Late Eocene-Oligocene K/Ar ages (~26-38 Ma, island-arc tholeitic affinity and product of submarine volcanism. Now tectonic slice in SSW verging thrust systems, deformed in Oligo-Miocene')

(Luk Ulo melange is tectonic melange as result of Cretaceous- Paleocene? subduction, and with younger melange resulting from Eo-Oligocene collision event of E Java microcontinent. Blocks of ultramafic rocks, schists, pillow basalts, pelagic sediments, granodiorites, limestones and sandstones in matrix of claystones often with scaly and phyllitic texture suggestive of diagenesis at depths up to 4-8 km)

(online at: www.bgl.esdm.go.id/publication/index.php/dir/article_detail/843)
('Volcanism and distribution of non-biologic resources in Southern Mountains of Yogyakarta and Wonogiri, C Java'. S Mountains of C Java consists of Oligocene- E Miocene volcanic rock, with Baturagung Volcano High in W and Gajahmungkur Volcano in E. Paleovolcanic eruption centres at Parangtritis, Imogiri, Ptlang, Karangdowo, Patuk, Bayat, Tenong, Panggung, and Wedombo. Non-economic metal and nonmetal deposits)

('Volcanism and distribution of non-biological materials in the Southern Mountains, Yogyakarta')

(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/373/239)


(Hlate Miocene of Kali Pasir outcrop section, Banyumas, C Java, with abundant Discoaster (D. brouweri) and large Reticulofenestra in muddy facies of early Late Miocene (NN8-NN10a) representing deep thermocline. Decreasing Discoaster and small Reticulofenestra in turbiditic section of later part of Late Miocene (NN10b-NN11) indicate shallow thermocline/ nutricline. Strong eutrophication in Kali Pasir section probably driven by increased nutrient-rich terrestrial material, related to onset of Indian monsoon in Late Miocene/8-9 Ma)


(Age of Karangsambung Fm olistostrome deposits in C Java Oligocene, based calcareous nannofossils from matrix. Older reported ages (M-L Eocene, etc.) probably reworked)


('Stratigraphic control and gravity structure at the Sijenggung hydrocarbon seepage, North Serayu Basin’. N Serayu basin of C Java with many oil and gas seeps, indicative of active petroleum system. In Sijenggung Village (Banjarmangu District) surface seepage in outcrop of E-M Miocene Rambatan Fm. Dominant deformation of Rambatan Fm is gravity sliding to NNE in extensional regime)

Husein, S., M. Sakur & A. Setianto (2016)- Sebaran perlipatan en echelon pada antiklinorium Rembang. In: R. Hidayat et al. (eds.) Proc. 9th Seminar Nasional Kebumian, Dept. Teknik Geologi, Gadjah Mada University, Yogyakarta, p. 70-82. (online at: https://repository.ugm.ac.id/273465/)

('Distribution of en echelon folding on the Rembang anticlinorium’. N Rembang anticlinorium of NE Java composed of E-W trending inverted folds arranged in ENE-WSW en echelon pattern, indicating reactivation of ENE-WSW trending basement fault. Two tectonic phases: (1) N-S compression (Pliocene), causing en-echelon folds and NE-SW sinistral shear; (2) NW-SE directed extension, causing formation of normal faults)


(Senepo epithermal mineralization prospect in Southern Ms of C Java. Low sulphidation epithermal quartz vein, hosted by Oligo-Miocene andesite. Veins N-S-trending, 1-2m thick, with low Au, Ag, chalcopyrite, sphalerite, galena, hematite, covellite and malachite, etc.. Probably originated at 300-425m paleodepth)


(‘Geochemical characteristics of source rocks of the Walat Formation, Sukabumi Regency, West Java’. On hydrocarbon source potential of Late Eocene- E Oligocene Walat Fm. Formation currently in mature stage (Tmax 439-458 °C), with fair-very good organic matter richness (TOC up to 3.7%) and mainly Type III gas-prone kerogen)


(Summary of biostratigraphic correlation project around Rembang-Madura- Kangean- Sakala wrench fault zone. Not much detail)


(Five planktonic foraminiferal biodatums identified in sections at Ciherang, Cikeo, Cigajah, etc. rivers and Jatiluhur reservoir: Orbula suturalis (E-M Miocene boundary; N9); Top Globigerinoides subquadratus (M Miocene; near top N13); Base Globorotalia acostaensis (near base Late Miocene; N16); Base Globorotalia plesi o tumida (Late Miocene; N17); and B Globorotalia marginatae (Miocene-Pliocene boundary; N18))


(In Lulut area N of Bogor, W Java, M Miocene shallow marine Jatiluhur Fm clastics interfingers with Klapanunggal Fm limestone, rich in corals and algae. Planktonic foraminifera of Jatiluhur Fm zones N9-N14. Little detail: no sample localities, distribution charts, etc.)
(online at: http://seminar.fgeologi.unpad.ac.id/wp-content/uploads/2015/03/Middle-Miocene-to-Early-Pliocene-Nannofossil-Biostratigraphy.pdf)
(Upper Cibulakan, Parigi and Cisubuh Fms exposed near Jatiluhur reservoir dated as M Miocene-E Pliocene (NN3/CN4- NN13-CN10)

(Geology and mineralogy of common 6-25mm diameter hexagonal dipymidal quartz crystals in dacite from Ciemias Village, SE of Pelabuhan Ratu, Jampang Plateau, W Java)

(online at: http://seminar.ftgeologi.unpad.ac.id/wp-content/uploads/2015/03/ANALISIS-FACIES-DAN-SEJARAH-DIAGENESA-BATUAN-KARBONAT-FORMASI.pdf)
('Facies analysis and diagenetic history of carbonate rock formations Rajamandala, Padalarang, West Java'. Reef, back-reef, fore-reef and open shelf facies in Latest Oligocene Rajamandala Lst. Early and late diagenesis resulted in relatively tight rock, suitable for exploitation as marble)

(online at: www.trijurnal.lemlit.trisakti.ac.id/index.php/mindagi/article/view/73/73
('Fossils and paleoecological associations of carbonate rocks of the Rajamandala Formation, Padalarang, West Java')

(online at: http://jurnal.unpad.ac.id/bsc/article/view/8117/3693)
('Paleoecology of the claystone member of the Jatiluhur Formation, Cileungsi area, Bogor District, West Java'. Late E- early M Miocene (N8-N9) claystone in Cikarang and Cilegok River sections. With 20-31 species of shallow marine benthic foraminifera, dominated by Rotaliina. Interpretation of paleoecology using Diversity Index Fisher a index, etc., suggest Normal marine lagoons, Hyposaline lagoons and Hypersaline lagoons)

(online at: http://jurnal.unpad.ac.id/bsc/article/view/10965/pdf)
('Depositional environment of the Kalibeng Formation at the end of the Miocene in Demak and Semarang regencies, Central Java, based on planktonic/benthic foraminifera ratios'. Late Miocene Lower Kalibeng Fm in Jrangung River section with P/B ratios from 50- 99.4%, showing outer neritic- bathyal marine paleoenvironments)

(online at: http://jurnal.unpad.ac.id/bsc/article/view/11742/pdf)
('Change in paleobathometry in the Late Miocene- Early Pliocene based on a collection of small benthic foraminifera from the Jrangung Kali section, Demak regency, Central Java'. Four outer shelf- middle bathyal biofacies in Banyak Mb/ Kalibeng Fm of Jrangung River section, reflecting eight fluctuations from bathyal to outer shelf paleobathmetry in Late Miocene- E Pliocene (N16-N19))
(online at: http://file.scirp.org/pdf/OJG_201705111291575.pdf)  
(Study of reservoir characteristics of M Miocene Ngrayong Sandstone from outcrops N of Blora, Rembang zone. Ngrayong single transgressive-regressive cycle, with foreshore and tide-dominated shoreface facies. Sands f-m grained, subangular- poorly rounded, well-sorted, mainly composed of quartz, also orthoclase, plagioclase and micas. Texturally mature. Porosity 26- 40%, permeability 95- 3385 mD. Eight lithofacies)


('Determination of depositional environment of the Penosogan Formation based on trace fossil analysis in the Kali Jaya section, Karangsambung, Kebumen, Central Java'. Outer neritic- upper bathyal environment of turbiditic clastic series)

(Mineable magnetite-bearing iron sand deposits in Cilacap, S coast of C Java. Coastal area successive sandy beach ridges separated by marshy valleys, typical of prograded coasts. Iron sand deposits derived mainly from denudation of Oligocene- E Miocene 'Old Andesite Fm' in hinterland. Serayu River main agent of sediment supply to coast (see also Sarmili et al. 1999))

(E-M Miocene shallow marine clastic play in Tuban (Burdigalian) and Tawun Fms (Langhian) in Alas Dara Kemuning PSC (NW part of Cepu Block), NE Java basin. Coarsening-upward packages. Oil and gas-condensate in recent N-1 well (inversion structure?) and nearby NU-2 and NU-4 wells. Reservoirs moderate-good porosity, low permeability (carbonate cement), except in Ngrayong sands)

(online at: https://ejournal2.undip.ac.id/index.php/jgt/article/view/2503/1494)  
('Petrogenesis of metamorphic rocks in the West Jiwo Hills, Klaten, Central Java')  
(Bayah Complex metamorphic rocks low grade greenschist facies, associated with Eocene Nummulites limestones, serpentinite/gabbro. Schist-phyllite from protolith of continental origin (siltstone, claystone))

(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/154/151)  
('Pematang Pantai Purba as a biogenic gas trap on the coast of Indramayu West Java Province a preliminary study'. Biogenic gas seepage at beach sands along N coast of Java near Indramayu)

('Characteristic of Indramayu Beach with presence of biogenic gas'. Indramayu coast at N coast of W Java with sandy coastal dunes between mangroves. Biogenic gas from mangroves may accumulate in dune sands)

(E Java Basin in back-arc geological setting onshore and offshore E Java. 380 exploration wells drilled, with ~90 discoveries. Seven main charge cells identified: Muriah, Cepu, Central Deep, N Madura, S Madura, Kangean and Southern Basin. Etc.)


('Facies and petrography of Nanggulan formation coal of the Kalisonggo area, Girimulyo Subdistrict, Kulon Progo Regency, Special Region of Yogyakarta'. Coal bed 0.53m thick in M-L Eocene Nanggulan FmW of Yogy. Vitrinit 57-69%, lignite grade (vitrinite Rv max 0.34-0.44%)


(Review of hydrocarbon plays in onshore and offshore NW Java sub-basins and 125 years of exploration history)


(Ambient Noise Tomography used to image upper crustal structure under E Java- Bali. Main is thickness of sediment cover. Kendeng basin dominated by very low velocities)


(Ambient Noise Tomography method used to detect structure under E Java. N Rembang zone and most of S Mountains zone areas of high gravity anomaly and high velocity zones. Kendeng zone and most of basin in Rembang zone associated with low velocity zones)


('Brief review of the geology and oil occurrence in the Kawengan field. Cross-section from this report in Situmorang (1985), shows asymmetric faulted anticline with M Miocene Ngrayong Sst main reservoir)


(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/88/82)

('Relationship between the Sadeng Valley, Baturetno Basin and Solo River terraces, Central Java')


Miller, S.A. & A. Mazzini (2017)- More than ten years of Lusi: a review of facts, coincidences, and past and future studies. Marine Petroleum Geol., p. (in press) (Lusi mud eruption in E Java continued unabated for >10 years, continuously erupting mud breccia, gas, steam, and water. Suggested drilling trigger cannot explain subsequent observations; more likely volcanically-linked hydrothermal system)


(Offshore S Java displays extensional structures in fore-arc position, with structures trending mainly NE-SW to ENE-WSW. NE-SW structural trends continue into onshore S Java (unlike N-S faults in N Java))


(online at: http://journal.uir.ac.id/index.php/JGEET/article/download/1039/784)

(Tumanggipitu epithermal Cu-Au-Ag deposit at S coast of SE Java, in area with Late Oligocene- M Miocene low-K calc-alkaline to alkaline andesitic volcanics and volcanioclastics and with low-K intermediate intrusions. Mineralization style high-sulfidation epithermal gold-copper system typically associated with deeper gold-rich porphyry copper system. Paleodepth of mineralization determined from fluid inclusions 650m- 1220m)


('Stratigraphy of the late Paleogene- early Neogene in the Tuban, Paciran and Panceng areas, East Java')


(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/265/245)

(Sub-surface structure of Semarang and surroundings from gravity and magnetic methods'. Semarang area mainly covered by young volcanic rocks. Cipaku oil field, S of Kendal already closed in 1930. Structures in area mainly E-W and N-S directions)


('Sub-surface geological structures of Pekalongan and surrounding areas based on gravity and magnetic anomaly analysis')


(Java fewer major earthquakes than Sumatra, and focused along many smaller active faults (left-lateral Lembang fault, Cimandiri reverse fault, Barolis everse fault, Opak fault, Lasem fault and others)


(geologic studies and earthquake records suggest E-W trending Baribis (W Java) and Kendeng (C-E Java) thrust belts in back-arc zone are connected and still active fold-thrust belt. Connects E to Flores back thrust)


(Summary of Oligocene- M Miocene (bio-)stratigraphy of Padalarang area, W of Bandung. Oldest rocks deep marine M Oligocene (N2) Batuasih Fm shale. Overlain by Late Oligocene (N3-N4)Rajamandala Lst, overlain by E Miocene outer neritic- bathyal clastics (N5-N13), etc. (No references to many earlier papers on this area))

(Tujuh Bukit group of telescoped epithermal and porphyry copper-gold-silver deposits in E Java, ~205 km SE of Surabaya. Cluster of deposits, including Tumpangpitu, Candrian, Katak and Gunung Manis in area of ~5 km diameter. Tumpangpitu comprises high sulphidation Cu-Au-Ag epithermal mineralisation that is telescoped onto large underlying Au-rich porphyry Cu-Au-Mo system, associate with young tonalite intrusives)

(Cikotok gold-silver deposits discovered in 1936 in Bayah Dome of S Banten, ~200 km SW of Jakarta. Total production from 1940-1992 ~7704 kg of gold and 218,853 kg of silver. Pliocene-age mineralization in quartz veins infill brittle fractures, formed at low T, in Oligo-Miocene felsic volcanics('Old Andesite Fm') host rocks. Small andesitic and granodioritic intrusive rocks emplaced in M-L Miocene. Cikotok ore typified by high silver content which occurs as fine-grained argentite and possible as electrum. Ore minerals in large sulphide (chalcopyrite, sphalerite and galena)-bearing quartz veins and in hydrothermal breccias. Three zones. Epithermal origin, with average formation T 245°C. Depth below surface ~200 m at time of formation)

(Cikotok high-silver/ minor gold mineralization in SW Java large epithermal sulphide-quartz veins and in hydrothermal breccias. Host rocks Oligo-Miocene 'Old Andesite' volcanics. Ag-Au in sulphide minerals sphalerite, galena and chalcopyrite. Formed at 200m below surface (exploited from 1936-2008))


(online at: https://repository.ugm.ac.id/137862/1/DOB-01.pdf)
('Characteristics of structural deformation in the complex Terombo horizontal fault system in Sumberan village, Ngawen sub-district, Gunung Kidul regency'. Trembono fault complex NE-SW trending strike-slip faults in Tertiary rocks in S Mountains near Sumberan, deforming Kebo-Butak submarine volcanioclastic rocks)


('Evolution of Oligo-Miocene Rajamandala Formation limestone in the Padalarang area, West Java')

(Ongoing seismic events events in E Java mainly nucleate at 8-13 km depths below Arjuno-Welirang volcanic complex. Practically no seismicity in sedimentary basin hosting Lusi mud eruption. Focal mechanisms indicate mainly sinistral strike-slip faulting SW of Lusi and suggesting Watukosek fault system extends from volcanic complex towards NE of Java)

Dryobalanoxylon sp.: a fossil wood preserved in the Genteng Formation from Lebak Regency, Banten, and its paleophytogeography in Indonesia. E Pliocene fossilized wood of dipterocarp family in Genteng Fm tuff in Sindangsari Village, W Java. Genus known from Miocene- Pleistocene of Sumatra, W Java and Kalimantan.


(Petroleum potential of Ngimbang Formation in the Nglipar Region)


(Depositional environment of the Sambipitu Formation based on trace fossils in the Nglipar Region)


(‘Neogene molluscan paleontology of the genus Turritella from Java as basis for development of a Turritella biozonation’)


(S well tested gas in Late Oligocene limestone in 2013 (In W Tuban block? Not real well name? Should be Lower Kujung Fm?; JTvG)


(Application of gravity methods for identification of hydrocarbon potential in the Jakarta basin and beyond'.)


('Study of the oil and gas potential off the north coast of Jakarta with gravity methods'. N-S normal faults and E-W reverse faults shown on gravity model)


(Sequence stratigraphic analysis for identification of carbonate reservoir compartmentalization of the Ngimbang Formation in the Suci Block, NE Java Basin’. Study of wells and seismic sections indicates Ngimbang carbonate reservoirs deposited in Late Eocene- E Oligocene in inner neritic-upper bathyal environments, shallow in W (KMI-1) to deeper in E (Suci- 2). Three separate units, including Late Eocene carbonate platform facies around Suci-2, Eocene- basal Oligocene carbonate platform facies around KMI-1 and Suci 2 and upper E Oligocene reef facies around Suci 1 well. Gas accumulation only in Suci-1)


('Study of foraminifera biofacies in the Middle Miocene carbonate formations in the Southern Mountains, Wonosari area, D.I.Yogyakarta')


Pfeiffer, J.P. & F.C. van Heurn (1928)- Eenige tot dusver niet beschreven fossiele houtsoorten van Java: Verslag vergadering Afd. Natuurkunde, Kon. Academie van Wetenschappen Amsterdam 37, 5, p. 469-475. ('Some previously undescribed fossil wood species from Java'. Silicified wood from Bolang, 35km W of Bogor, dominated by Dipterocarpoxylon and Dryobalanoxylon, also Sapindoxylon and Parinarioxylon)


Pott, G. (1942)- Summaries of the coal fields of (a) Bajah and Tjimandiri (South Bantam) and (b) Bodjongmanik (Bantam). Report Geological Survey, Bandung, p. (Unpublished)


Praptisih (2016)- Fasies, lingkungan pengendapan dan sifat fisik (kesarakan dan kelulusan) batuan karbonat Formasi Parigi di daerah Pangkalan Karawang, Jawa Barat. J. Geologi Sumatera Mineral 17, 4, p. 205-215. (online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/13/6) ('Facies, depositional environment and physical properties (porosity and permeability) of the Parigi Formation carbonate rocks in area Pangkalan Karawang area, West Java'. Facies and facies distribution of M-L Miocene Parigi Fm limestones in Pangkalan area, NW Java. Porosity up to 25.8%, permeability up to 21.2 mD)

('Facies of carbonate rocks in Bojongmangu area, Bekasi, West Java'. M Miocene Parigi Fm outcrops in Bojongmangu- Bekasi area. With Lepidocyclina (Tryblolepidina) rutteni, and N17 planktonics. Four reef slope facies)


Praptisih (2017)- Geokimia batuan induk hidrokarbon Formasi Cinambo di daerah Sumedang, Jawa Barat. Bul. Sumber Daya Geologi 12, 3, p. 144-153. (online at: http://buletinsdg.geologi.esdm.go.id/index.php/2016/01/20/prosiding_geoteknikologi_2016) (Geochemistry of the Cinambo Formation hydrocarbon rocks in the Sumedang area, West Java'. 16 samples of claystone from Miocene Cinambo Fm with TOC 0.32-1.5% (low hydrocarbon potential). Organic matter mainly gas-prone Type III kerogen. Biomarkers suggest no correlation with oil seepage in Majalengka area)


(Fieldtrip guide S of Yogyarta)


(Rembang-Madura-Kangean-Sakala (RMKS) Fault zone in NE Java and further East is sinistral slip fault which started to develop in M Miocene. E-W trending)


(online at: https://repository.ugm.ac.id/273596/)

(Ciletuh Cretaceous subduction complex in SW Java. Metamorphic rocks in Gunung Badak area consist of Gt-Ms-Qz schist, Ms phyllite, quartzite and serpentinite. In Tegal Pamidangan area Ms-Qz phyllite and slate (greenschist-facies). Protoliths of metamorphic rocks pelitic, ultramafic and quartz-rich rocks. No blueschist or eclogite-facies rocks recognized (but reported by endaang suhaeli et al. 1977). Presence of serpentinite among low-grade metamorphic rocks indicates metamorphic environment associated with oceanic crust/ mantle. Similar to Jiwo Hills, C Java, metamorphics)


('Changes in depositional environment in some areas of Java during the Plio-Pleistocene based on paleontological studies of mollusks'. Three areas studied in W and C Java (in Bogor, N Serayu and Bobotsari Basins), all showing transition from shallow marine facies (with Turritella) in Late Pliocene to marginal marine (with Melanoides, Sulcospira, Tellina, Paphia) and non-marine (no molluscs) in Pleistocene (also as U.P. Wibowo ITB S2 Masters Thesis, 2009))


(Late Early Miocene (N7-N8) U Cibulakan Fm in S Pamanukan gas field, onshore NW Java basin, 190m thick, with 3 sandstone reservoir zones 3-9m thick. Possible stratigraphic traps)


(P1 (2015) and P2 (2016) wells on Plio-Pleistocene Pakel anticline in Rembang zone, NE Java, with gas-condensate in poorly consolidated late E Miocene Tuban and early M Miocene Ngrayong Fm tidal sandstones. Gas samples from P2 well from mixed of biogenic (40%) and thermogenic sources)


('The regional tectonic and stratigraphic framework of Java Island and its relation to hydrocarbon potential'. Java tectonics three main phases: (1) Eocene-Oligocene extensional rifting; (2) Neogene compressional wrench faulting, with shear faults reactivation of Paleogene normal faults; (3) Plio-Pleistocene compressional thrust-folding, creating E-W oriented antilines)

Putra, P.S. & E. Yulianto (2016)- Sedimentological and micropaleontological characteristics of the Black Clay deposit of the Baturetno Formation, Wonogiri, Central Java. Indonesian J. Geoscience 3, 3, p. 163-171. (online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/218/217) (Quaternary Baturetno Fm black clay with freshwater diatoms, but mostly barren of palynomorphs and low TOC. Unlikely to be lacustrine, probably mud-flow deposit. Carbon dating ages ~7000 yrs BP, i.e. much younger than Late Pliocene tilting in S Java)


(Pliocene marine Kaliwangu Fm (N19) locally over lain by E Pleistocene black clay with freshwater molluscs and vertebrate fossils (cervids, proboscideans and crocodiles). Over lain by Pleistocene fluvial Citalang Fm, also with bone and tooth fragments in conglomerates (= Von Koenigswald 1935 fossil locality))


(Three paleo-tsunami deposits identified along Cilacap coast of S Java, dated and tied to earthquakes of 1883, 1982 and 2006. Three more older layers. Paleo-tsunami layer characterized by light sands on top of paleo-soil, with common mud clasts and marine benthic foraminifera)


(M Miocene- E Pliocene Halang Fm in Pangkalan river, Banyumas Basin, with five turbiditic facies associations: proximal channel, distal levee, frontal splay 1, crevasse splay, and frontal splay 2. Mud rich system. ~400m thick Late Miocene Kumbang Fm andesitic volcanic breccia reflects sediment supply change)


(Sedimentation of E Pliocene part of Cantayan Fm along Cibeet River in Bogor Trough in Sirnasari area, SE of Bandung. Classic turbidite facies)


(SE-most Java Cu-Au prospects in Bukit Tujuh District, explored since 2007. Main prospects Tumpangpitu Cu-Au-Mo porphyry system and overlying cap of Tumpangpitu Au-Ag oxide System)


(‘Neogene paleogeographic study of the limits of Kendeng-Serayu basin: challenges and implications for oil and gas exploration concepts at the Semarang regional high, north Central Java’. N-S trending Semarang High at W side of Kendeng zone surrounded by oil seeps and possibly migration focus)

(Summary of biostratigraphy work on M-L Miocene (N13-N17) of Cipamingkis and Cileungrs sections. Klapanunggal Lst of uppermost Jatiluhur Fm with Lepidocyclina spp., Katanycloclypeus annulatus and Flosculinella (equivalent of plankton zones N14-N16'))


(Modeling of propagation of seismic waves beneath Lusi mud eruption (E Java) suggests no significant amplification of incident seismic energy in U Kalibeng Fm (source of erupting solids). Hypothesis that Lusi mud eruption was triggered by clay liquefaction after earthquake unlikely. Also other constraints favor nearby drilling activity as trigger of mud eruption)

(Ground deformation around Lusi mud volcano, E Java, decaying exponentially. Discharge predicted to decrease to 10% of present rate in 5 years)

Samankassou, E., A. Mazzini, M. Chiaradia, S. Spezzaferri, A. Moscariello & D. Do Couto (2018)- Origin and age of carbonate clasts from the Lusi eruption, Java, Indonesia. Marine Petroleum Geol. 90, p. 138-148. (Carbonate clasts from Lusi feeder conduit brecciated and mobilized to the surface carbonate lithologies buried as deep as possibly ∼3.8 km. Since deeper carbonate samples erupted in 2006 belong to typically not overpressured Kujung Fm, an additional overpressure may be generated from deeper units (Ngimbang Fm) (dating mainly by Sr-isotopes)).

(MT survey supports presence of three Kujung Fm carbonate build-ups in area of Kawengan oilfield and Banyuasin area, C Java)

(Gravity measurements show low density structure beneath dormant Mt. Pandan volcano in E Java. May be interpreted as subsurface magma body, and suggest possibility of magmatic activity below Mt. Pandan)


(Fault Seal Analysis study in Rajamandala limestone near Bandung. Faults in carbonates generally leaking)


(online at: https://repository.ugm.ac.id/135460/)

('Calcereous nanofossil biostratigraphy of the Lower Nanggulan Formation based on core from Girimulyo and Nanggulan, Kulon Progo District, DI Yogyakarta'. 175m of UGM-cored section of Songo Beds and Watupuru Beds zones NP15-NP17, Middle Eocene)


(online at: https://repository.ugm.ac.id/273555/)

(Study of the petrology and geochemistry of metamorphic rocks of the Muncar River, Seboro Village, Sadang District, Kebumen, C. Java'. Metamorphic rocks from Muncar River in Lok Ulo complex low P to high P facies (increasing to N?): greenschist, amphibolite, glaucophane blueschist and eclogite. Reflect orogenic metamorphism in subduction environment. Tourmaline-bearing facies probably derived from MORB basalt, eclogite phengite from oceanic intra-plate basalt (OIB). Also presence of serpentine, marble)


(East Cepu High NE-SW trending Paleogene paleo-high, with several oil-gas fields in Oligo-Miocene carbonate build-ups. Hydrocarbons from Paleogene Ngimbang Fm source rocks, but from different environments. Hydrocarbons in SE from fluvo-deltaic deposits, in NW from deltaic-shelf deposits)


(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/272/262)

('The formation of accretionary prisms at Ciletuh Bay in relation to the Cimandiri Fault, West Java'. Series of thrust faults interpreted on (shallow) seismic profiles at Ciletuh Bay, interpreted as accretionary prism)


(online at: https://repository.ugm.ac.id/273761/1/C-11.pdf)

('Study of tectonic setting, provenance and paleoclimate of the Nanggulan Formation sandstone based on petrographic analysis'. Petrography of Eocene Nanggulan Fm str of Kulon Progo Dome, C Java, suggests changes in provenance from lower sands from continental block (granitic rock of E Java microcontinent) followed by recycled orogen (low-grade metamorphics; folding-uplift of E Java microcontinent) to undissected magmatic arc in upper Nanggulan Fm (onset of magmatic arc activity). Climate humid-subhumid)

(Calcareous nannofossil biostratigraphy of NE Java basin well DDR (Dander)-1, interval 110- 2241m (= shale above Ngimbang Lst). Age E Miocene- latest E Pliocene (NN3-NN15). Four unconformities: (1) 1100m (10.54-10.79 Ma); (2) 720m (9.56- 9.67 Ma); (3) 560m (8.52- 8.76 Ma); and (4) 380m (4.0- 7.17Ma). Sedimentation rates 20-40cm/ 1000 years with unconformities. Unconformities correlated to global climatic events such as Asian monsoons intensification (8 -10Ma) and Messinian salinity crisis (5.5Ma) and may be related to global eustacy changes)


('Geochemical Atlas of West Java'. Distribution maps of 30 elements in stream samples from W Java: Ag, Al, As, Ba, Ca, Ce, Cl, Co, Cr, Cu, Fe, Hg, etc.)


(Gravity data from Banyumas Basin, C Java, suggest six sub-basins with depocenter of 5.5 km, SE-NW strike-slip fault and E-W trending basement highs)


('Structural pattern and subsurface geological configuration of the North West Java Basin based on gravity analysis'. Gravity analysis suggests average basement depth in NW Java basin is 3.3 km and five subbasins: Bekasi, Rengasdengklok, Cikampek, Subang and Majalengka subbasins)


('Petrology, geochemistry and age of granitoid rocks in the Luk-Ulo Complex, Karangsambung, Kebumen, Central Java'. Granitoid blocks along upstream Luk-Ulo River four groups, all calc-alkaline, metaluminous types. Zircon ages of granite with graphic texture and hornblende granite all latest Cretaceous (~66-70 Ma); foliated granodiorite and garnet granite / granodiorite with zircon melting ages ~100-120 Ma, with inherited zircons as old as 437± 13 Ma. Cordilleran-type granitoids of Karangsambung normal volcanic arc products, with possibility of post-tectonic collisional granite from partial melting of continental crust)


(Unpublished)

('Petrology of basement in the Rengasdengklok area, West Java and implications for tectonics and hydrocarbon reservoirs potential'. NW Java basin N-S trending horsts and grabens. Basement penetrations show fracture porosity and hydrocarbon shows. Pondok Makmur Field in NE Ciputat Basin with basal dolomitic limestone that is fractured and of Eocene- Late Oligocene age)


(online at: http://adsabs.harvard.edu/abs/2007AGUSM.V23B..08S)

('Distinct volcanic belts related to Java trench subduction only since Oligocene. Metalic deposits in porphyry, high-sulfidation and low-sulfidation epithermal systems, all tied to subaerial volcanism and subvolcanic plutonism. Some volcanicogenic massive sulfides deposits show mineralization in submarine environment. Most mineral deposits related to volcanic centers of Tertiary arcs; no mineralization associated with backarc magmatism. Major metalic deposits tied to deep, old crustal structures (strike-slip faults) . Existing mines in

('Climate change bioprediction method using fossil pollen and spores of Pliocene age in Banyumas'. Pollen and spores in Tapak Fm of indicate Podocarpus imbricatus zone age (Late Pliocene; with Podocarpus imbricatus and Stenochlaenidites papuanus) and 3 hot-cold-hot climate change events)


('Oil characteristics in Wonosegoro and surrounding areas, Boyolali, Central Java, based on biomarker data'. Biomarkers from oil seeps in Kerek Fm in W Kendeng Zone near Wonosegoro (Gunung Sari, Repaking and Kemusu villages). Oils °API 15.8, 29.8, and 18.8, and biodegraded. Probable source rock Ngimbang Fm)


('Inverse modeling of surface deformation at Lusi mud eruption in E Java suggests volume changes occur in two regions beneath Lusi, at 0.3-2.0 km and at 3.5-4.75 km. Shallow mud source supply ~2-3 times larger than deep source, but additional fluids ascend from >4 km)


('Evaluation of the geology of a gas seep in the Merapi region, Purwodadi, Central Java'. Natural gas seep in Merapi area, on W side of Godong High)


('Oil-gas production in Cepu area from upper Tuban (Ngrayong Sand) and Kawengan Fms. Rel.high total organic content (av. 0.75%) in Tuban Fm; low TOC in Kawengan Fm. Thermal maturity confined to Tuban Fm. Kerogen mainly Type III, with limited Type II. Source probably in Tuban Fm and/or deeper section)


(Zircon FT data from W Java: SW Java melange and NW Java basin basement: ~88-110 and 191-220 Ma; Eo-Oligocene sediments of Ciletuh, Walat, Jatibarang: ~61-65 and 128-161 Ma, etc. All rocks strong Late Cretaceous signals, replaced by E Miocene component by E Miocene)


('Planktonic foraminifera biozonation in Cipamingkis River section, Jonggol, West Java Province'. Jatiluhur Fm in Cipamingkis River with M-L Miocene planktonic foraminifera of zones N13-N16)


(Zeolite- and greenschist-facies metamorphic rocks in Karangsambung area widespread in N part of Luk UloMelange Complex, especially in Gebang River, Kaliwiro area, incl. scaly clay, mica schist, zeolitic rocks and basaltic lava. (S part of complex with higher-grade metamorphics))


('Gemstones of West Java: the potential and its problems'. Brief review of presence of agate, silicified wood, jasper, opal, etc., in S Mountains of west Java)


(Dominant stress direction remains similar (N100E/ ~E-W strike azimuths) from M Eocene to Pliocene-Quaternary. U Miocene and younger strata same strike direction but generally more gentle dips. Ideal Java geomorphologic zonation from S to N: rel. undeformed plateau in S (Jampang)- (volcanic arc)- intensely folded ridges in middle-thin skin overthrusting in N)


(Summary of paleomagnetic study of Plio-Pleistocene volcanics in Bandung area)


(online at: http://jurnal.unpad.ac.id/bionatura/article/view/7212/3311)

(Sedimentology and paleohydrology of fluvial sediments of the Oligocene Walat Formation, Sukabumi, West Java'. Fluvial Walat Fm outcrops show upward decrease of fluvial sinuosity, and rivers becoming more braided, with wider and deeper channels upsection, with more coarse-grained facies Represents relative sediment supply increases beyond capacity of accommodation, possibly related to sea level drop through Paleogene, and global climate change from greenhouse to icehouse conditions in Eocene-Oligocene time (NB: age of Walat Fm more likely Late Eocene?; Lunt 2013))


(Plio-Pleistocene magnetic polarity stratigraphy supplemented with K-Ar dating, etc., for lava flows and dykes around Bandung Basin. 15 volcanic units assigned to paleomagnetic zones Gilbert (Selacau - Paseban volcanic unit, with a mean age of 4.1 Ma and having reversed polarity), Gauss (calc-alkalic series of Cipicung, Kromong E and W; 3.3, 3.1 and 2.9 Ma), Matuyama (Cicadas tholeiitic lavas; 1.7 Ma) and Brunhes. Etc.)


('The Semilir Formation in the Southern Mountains of Central Java, a result of an enormous eruption of a Miocene volcano'. Early Miocene volcanics with zircon ages of ~19-20 Ma)


(online at: https://jurnal.ugm.ac.id/jag/article/view/26982/16620)

(Randu Kuning prospect at Selogiri, ~40 km SE of Solo. Many Tertiary dioritic rocks in Randu Kuning area, with related porphyry Cu-Au and epithermal Au-base metal-bearing veins. Most porphyry veins cross cut by epithermal-type veins. Two type of hydrothermal breccias)


Taufik, M. (2007)- Studi detail foraminifera bentonik besar di Formasi Baturaja. Proc. Joint Conv. 32nd HAGI, 36th IAGI and 29th IATMI, Bali 2007, p. 720-728. (‘Detail study of larger benthic foraminifera in the Baturaja Fm’. Larger foraminifera from E Miocene reefal limestones of Baturaja Fm in 3 wells in West Java basin (no real well names or locations given; onshore?). Incl. Lepidocyclina, Austrotirillina, Spirolypeus, Miogyspsina, Miogysnoides, Borelis, etc. (zone Te5). Seven ecozones based on LBF clusters. Equivalent of nannoplankton zones NN1-NN2)
Thayib, E.S. (1977)- The status of the melange complex in Ciletuh Area, South-West Java. Lemigas Scientific Contr. 1, 2, p. (Same as Thayib et al. 1977, below)

Tingay, M. (2015)- Initial pore pressures under the Lusi mud volcano, Indonesia. Interpretation (SEG)3, 1, p. SE33-SE49. (Lusi mud volcano at Porong, E Java erupted continuously since May 2006. Analysis of pore pressures immediately prior to Lusi eruption from nearby (150m) Banjar Panji-1 well indicate all sequences >350m below Lusi overpressured, and follow approximately lithostat-parallel pore pressure increase through Pleistocene clastics, Plio-Pleistocene volcanics (1870-2833 m) and Miocene Tuban Fm carbonates, with pore pressure gradients of 17.2-18.4 MPa/km. Pore pressures in basal carbonates ~23.0 MPa above hydrostatic. 'Textbook disequilibrium compaction overpressure')

Tingay, M. M. Manga, M.L. Rudolph & R. Davies (2018)- An alternative review of facts, coincidences and past and future studies of the Lusi eruption. Marine Petroleum geology, p. (in press) (Review of likely causes of Lusi mud eruption in E Java. Drilling reports and data confirm wellbore was not intact, there was subsurface blowout, and there was connection between well and eruption. Yogyakarta earthquake too far away to have initiated new eruption. Strongly favor initiation of eruption by oil well drilling)

Titisi, A. D. (2014)- Geochronology and geochemistry of Cenozoic volcanism in relation to epithermal gold mineralisation in western Java, Indonesia. Ph.D. Thesis, School of Earth Sciences, University of Melbourne, p. 1-297. (Unpublished) (W Java hosts low-sulphidation epithermal gold deposits, with most important deposits in Pongkor, Cibaliung, Cikotok and Papandayan districts. Most volcanics with enriched LILE and LREE compositions characteristic of calc-alkaline arcs, but Papandayan basalts depleted LREE contents typical of island arc tholeiites. 40Ar/39Ar ages volcanic host rocks: Papandayan district ~18 Ma; Cibaliung district ~11 to ~9.5 Ma, Cikotok district ~18 - ~4.5 Ma, Pongkor district 2.7-~2 Ma. Adularia crystallisation ages similar. Magmatic arc across W Java likely linked to SE Asia tectonic evolution, from E Miocene CCW rotation of Kalimantan to Late Miocene-Pliocene subduction. Three main events: E Miocene primitive tholeiite arc (20-18 Ma), M Miocene mature calc-alkaline arc (13-9 Ma) and Late Miocene-Pliocene evolved high-K calc-alkaline and shoshonitic arc (7-2 Ma). E Miocene Papandayan basement thinned island arc crust. Miocene- Pliocene mineralisation of Cibaliung, Cikotok and Pongkor associated with calc-alkaline arc built on Sundaland continental crust)


Bibliography of Indonesia Geology, New for Ed. 7. 111 www.vangorselslist.com 8/6/18
Tuakia, M.Z., B. Sapiie & A.H. Harsolumakso (2015)- Karakteristik dan deformasi pada Satuan Larangan, Banjarneagra, Jawa Tengah. Buletin Geologi (ITB) 42, 1, p. 41-57. ('Deformation characteristics of the Larangan Unit, Banjarneagra, Central Java')


Cijulang prospect in Garut District, W Java, high-sulfidation epithermal system in andesite lava and lapilli tuff. Mineralization characterized by pyrite-enargite-gold and associated acid sulfate alteration. Two stages: early Fe-As-S stage (with Au) and later Cu-Fe-As-S stage)


('Petrogenesis of iron sand deposits at Panggul beach, Trenggalek'. Magnetite-rich sands along S coast of Java derived mainly from outcrops of Oligo-Miocene Mandalika Fm volcanics (Old Andesites) in S Mountains)


(Marly soil on Upper Kalibeng Fm on NE Java with 90% of heavy mineral fraction composed of small idiomorphic crystals of celestine (celestite; SrSO4) (origin not clear))


Van Regteren Altena, C.O. & C. Beets (1945)- Beschouwingen over de toekomst van het onderzoek der Caenozoische mollusken van Nederlandsch-Indie. Geologie en Mijnbouw 7, 5-6, p. 45-50. ('Remarks on the future of research of the Cenozoic molluscs of the Netherlands Indies')


Widagdo, A. (2008)- Fase-fase tektonik pembentuk ruang mineralisasi emas di daerah Selogiri- Wonogiri. Dinamika Rekayasa 4, 1, p. 23-29. ('Tectonic phases of gold mineralisation in the Selogiri- Wonogiri area'. Selogiri prospect with metallic minerals pyrite, chalcopyrite, galena, sphalerite, magnetite, ilmenite, gold, etc. Four extensional tectonic phases in the study area, with metal mineralization generated by epithermal processes filling ~N-S trending fractures formed during extensional phase II (E Miocene))


Widarto, D.S., E. Widianto, Sardjito, E. Purnomo & E. Bianctoro (2009)- Gravity and magnetotelluric studies of the South Losari oil prospect, Central Java, Indonesia. Proc. 9th SEGJ Int. Symposium Imaging and interpretation, Sapporo, 4p. (Gravity anomaly patterns suggest S Losari basement configuration controlled NW-SE trending Riedel shears and step-over splays, which subdivided study area in two depressions)


(P- and S-wave tomography velocity model under Java from ambient seismic noise. Area of low gravity beneath Kendeng zone associated with low velocity zone. Southern Mountain range high gravity anomaly related to high velocity zone)


(online at: http://journal.upn.ac.id/bsc/article/view/9813/pdf) 

('Provenance of the Jatiluhur and Cantayan Fm sandstones in the Tanjungsari and surrounding area, Cariu district, Bogor, W Java'. M-L Miocene sandstones in Bogor Trough: (1) Jatiluhur Fm (feldspatic wacke, derived from plutonic igneous rock, from Dissected Arc terrane) and Cantayan Fm (lithic arenite, derived from volcanic rock, from Transitional Arc- Undissected Arc terrane). Both units derived from magmatic arc terrane)


(Low-metamorphic marble and phyllite form basement outcrop in Jok Tuo area, E Jiwo Hills, C Java. Presence of marble blocks and well-preserved mid-Cretaceous larger foram Orbitolina sp. in foliated chlorite-biotite-graphite)


(online at: http://journal.upn.ac.id/bsc/article/view/9813/pdf) 


(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/246/206) 

(Ore mineralogy of westernmost part of W Java (Pongkor, Cibaltung, Cikidang, Cikotok and Cirotan) characterized by dominance of silver-arsenic-antimony sulfosalts with silver selenides and rarely tellurides over argentite, whereas E part of W Java (Arinem and Cineam) deposits dominated by silver-gold tellurides)


(online at: https://repository.ugm.ac.id/135459/1/...) 

('Calcareaous nanofossil biostratigraphy of the Kepek Formation in the Sungai Rambutan section, Kec. Paliyan, Gunungkidul, Yogyakarta Special Area'. Kepek Fm 55m thick and youngest formation of Java Southern Mountains stratigraphy. First appearances of Discoaster asymmetricus and Pseudoemiliana lacunosa allow subdivision into 3 biozones: Sphenolithus neoabies (NN 13), Discoaster asymmetricus (NN 14) and Pseudoemiliana lacunosa (NN 15), of E Pliocene age (~5.1- 3.8 Ma). Equivalent to N19 planktonic foram zone)


(online at: https://repository.ugm.ac.id/273483/) 

('The relationship of oils from the Gabus anticline in Grobogan and Kawengan anticline in the Bojonegoro area, NE Java Basin based on biomarker data'. Oils from Gabus (Ledok Fm) and Kawengan (Wonocolo Fm
and Ngryong Fm) anticlines are related. API Gravity 24-30 °API, viscosity 2034-71 mm2/ s. Pr /Ph ratio 5.48-11.54, suggesting non-marine rocks with terrestial Type III kerogen (high land plants. Some biodegradation)

(Updated geologic model of Oligo-Miocene carbonate and clastic reservoirs of Banyu Urip oil-gas field, Cepu Block, E Java. 46 wells drilled. Permeability from logs higher than core-based (matrix) permeability. Best quality reservoir in platform-interior zones (av. porosity 26%). Drowning-cap dominated by deeper water facies with av. porosity ~15%. Margin zones cemented, recrystallized and rel. tight (av. porosity 9%))

(Two volcanic belts in West Java: (1) late Miocene- Pliocene belt, generating Pliocene-Pleistocene epithermal deposits; (2) late Eocene- E Miocene belt generating Miocene epithermal deposits. Data from Ciemias gold deposit E of Ciletuh Bay (hosted in 'Old Andesites') indicate mixing of magmatic fluid with meteoric water. Miocene epithermal ore deposits in S part of West Java more affected by magmatic fluids and higher degree of sulfidation than those of Pliocene-Pleistocene)

III.2. Java Sea (incl. Sunda-Asri Basins, offshore NW Java basin) (40)
(online at: http://ejournal.mgi.esdm.go.id/index.php/bomg/article/view/373/287)
(Sparkler seismic profiles in SE Java Sea around Bawean show widespread Pleistocene incised lowstand paleo-channels, with late Pleistocene-Holocene (partial) fill. Older paleo-channels buried by up to 50m sediments. Width of main paleo-channels ~4 km. Two channel types: U-shaped channels in W part and V-shaped channels in E. Internal structure of incised-channels consist of chaotic reflectors at bottom, overlain by parallel-subparallel and almost reflection-free, homogenous sediments)

(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/166/156)
('Fault zones in the waters S of Kalimantan'. Shallow seismic data indicate young NE-SW fault structures in Java Sea NE of Bawean, now probably inactive. Directions coincide with Muria-Meratus Tectonic Zone)

(Deeper play potential in stratigraphic traps in early rift sediments onlapping against basement highs in Talang Akar Fm, Arjuna basin, offshore NW Java)

(Large E-W trending pre-Cenozoic faulted synform of 200x50 km in Kangean area below base Cenozoic unconformity nucleated Paleogene extensional features, inverted in late Neogene to form Central High. Three thermal domains, controlled by burial depth of basement: in N and S, where basement near base Cenozoic unconformity, heat flows of 70-80 mW/m2. In C domain, where basement is deeper, heatflows <70 mW/m2, in
(Petroleum system of Kangean area, E Java Sea, controlled by heat flow distribution, overpressure occurrence, and Late Neogene erosion. Charging of Sepanjang Field from late Neogene depocenter that formed in W-G part of Southern Basin as result of uplift and erosion of Central High. Depocenter activated E-ward oil expulsion ring of Paleogene Ngimbang source rock, already overmature to W. Oil remains contained in Ngimbang reservoir complex, thanks to thick overpressured overburden and absence of vertical conduits)

(Presence of oil and gas fields in N Madura Platform attributed to long distance migration from Central Deep and Madura Basin kitchen areas. In Bukit Tua and Jenggolo Field complex, oils initially trapped in lowest part of N Madura Platform (Ngimbang Fm, CD Carbonate). As charging of oil continued, top seal breached and oil filled overlying Kujung II clastics and carbonates. Later gas generation was able to breach Kujung II)


(South Saubi well S of Kangean island in E Java Sea surprisingly drilled >3500’ of Miocene? volcanics/ volcanoclastics, just below top of Kujung Limestone. Exact age of volcanics unknown)

(online at: https://buletingeologi.com/index.php/buletin-geologi/issue/view/4/Paper-1%20vol.%202%20no.%201)
(‘Seal analysis and fault characteristics in the Kujung Reef Formation at the KE Field Complex, East Java basin: implications for hydrocarbon migration’. Geologic modeling and fault seal analysis of Kujung Reef formation at JS-1 ridge, E Java Sea)

(online at: https://www.jstage.jst.go.jp/article/japt/80/1/80_19/_pdf/-char/en)
(In Japanese, with English summary. Review of prospectivity of Kangee PSC block in E Java Sea. Two petroleum systems: (1) thermogenic oil-gas with pre-Ngimbang and Ngimbang Fm source rocks; (2) biogenic dry gas in shallow horizons. Terang-Sirasun gas field started production in 2012. S Saubi prospect large reef buildup of Kujung Lst, similar to Banyu Urip oilfield in NE Java (but mainly volcanics; Harsian 2018))

(Main producer in Krisna field is Baturaja Fm carbonate reservoir. Also production from some wells from poor-quality 200' thick Krisna Sand of Miocene Air Benakat Fm (270 MBO cumulative production ?))

(Play evaluation of E Miocene Baturaja Lst Formation in Sunda Basin)


(JS-1 Ridge in Java Sea is NE-tending horst-like structure, formed in Eocene or before, flanked by East Bawean Trough in W and Central Deep in E. Well basement penetrations in N part dominated by basic plutonic rocks (gabbro, basalt, and serpentinitie in one well with ~81 Ma Ar/Ar age). Center of JS-1 Ridge composed of metamorphic rocks. In South diorite, volcano-clastics, to altered andesite (Ar/Ar age ~71 Ma). Southernmost area dominated by (meta-)volcanics, also possible Pretertiary sediments. JS1 rocks possibly represent E-M Cretaceous melange)

(online at: http://jurnal.unpad.ac.id/gsag/article/view/15619/7346)

(Shallow gas in Pliocene Cisubuh Fm sandstones in offshore NW Java basin formerly viewed as shallow drilling hazards, now potential targets (e.g. over ANP, Lima fields). Biogenic gas)

(Hydrocarbon indications in Pretertiary basement of offshore NW Java Basin mainly in metamorphic rocks (schist, gneiss, marble, quartzite))

(Thermal modeling of hydrocarbon source potential of coals and carbargillites in Eocene Ngimbang clastics of E Java Sea suggests large areas of basin are at maximum burial and thermal stress today. Due to high oil expulsion temperature (140° C at 5° C/Ma) and relatively limited post-rift deposition areas of effective kitchen severely limited)

(Seismic evidence of undrilled N-S oriented incised valley in mid-Oligocene at Top Lower Ngimbang Fm carbonate-dominated section on JS-1 Ridge in E Java Sea)


('Tectonostratigraphy of the North Bali III area, NE Java basin'. Tectonostratigraphy study based on 43 seismic lines and 6 wells around the North Bali III Area, offshore NE Java basin. Four tectonostratigraphic units: Pre Tertiary pre-rift, Eocene rifting, Late Eocene-Oligocene post-rift and E Miocene and younger syn-inversion)

(Evidence of compression in Late Oligocene- mid E Miocene of E Java Sea (E-W RMKS fault zone inversion?))

(U Field in Offshore NW Java Basin produces from E-M Miocene shelf sand ridge reservoirs of Main and Massive intervals of U Cibulakan Fm. Mainly N-S trending sand bodies)

(Study of Jatibarang sub-basin of NW Java, N of Cirebon. NW-SE trending border fault of Jatibarang sub-basin (OO-Brebes Fault) likely right-lateral transtensional fault and probably part of Pamanukan-Cilacap Fault Zone. Paleogeography maps of Oligocene Talang Akar Fm syn-rift intervals show alluvial fans and fan delta, sourced from N and E)

(Fluvial- lacustrine Lake Singkarak deposits compared to Late Oligocene Talangakar Fm in Jatibarang basin)

(Gas tested from fractured'Eocene pre-rift limestone in Kencanaloka Field, KLD Block, S Arjuna sub-basin, NW Java. (NB: Eocene limestones not known from NW Java, and no evidence for age reported here; HvG))

(N Madura Platform hydrocarbon producing area between two mature kitchens: Madura subbasin in S and Central Deep N and W. Hydrocarbon migration from Madura sub-Basin before inversion at ~7 Ma, but hydrocarbon migration from Central Deep in question, due to steep border fault and predicted poor reservoir quality of syn-rift deposits along fault. Oil geochemistry and basin modeling indicate N Madura Platform oils charged by both kitchens: mixed terrigenous-algal organofacies source from Ngimbang shale in Central Deep (expulsion since 22 Ma) and mainly terrigenous organofacies source in S part of platform)

(Most of secondary porosity in carbonates results from subaerial exposure and meteoric diagenesis, but Oligo-Miocene carbonate in N Madura Platform also evidence of late dissolution during burial diagenesis.)
(Oligo-Miocene carbonates (CD and Kujung formations) in N Madura Platform developed as rimmed carbonate platform complex. Four growth stages. Complex diagenetic history; most porosity is formed by dissolution of some grains, micrites and cements. Several undrilled patch reef complexes in study area)  

(Examples of 2D seismic section showing Oligocene carbonate platform and post- E Pliocene inversion of normal faults)  

(online at: http://jurnal.unpad.ac.id/bsc/article/view/11739/pdf)  
('The relationship between geochemistry of oils and source rocks in the Central Arjuna sub-basin, NW Java Basin'. Source rock in Talang Akar Fm in offshore wells YZD-1, YY-1 and DZN-1 with kerogen types II-III, from terrestrial and algal sources. Oil samples suggest deep and shallow lake depositional environments, with mixture of higher plants and algae. Burial history modeling suggests oil generation in basal Talang Akar Fm began in E Miocene, deltaic Talang Akar in M Miocene)  

(Banwati Fm, Zelda and Gita Members in Oligocene of Sunda and Asri Basins divided into six 3rd-order sequences. Sedimentary evolution consistent with tectonic evolution)
III.3. Java - Quaternary Volcanism (50)
Abdurrahman, M., E. Suparka, R. Chrysant, H. Handley, D.P. Adli & J.N. Indriyanto (2017)- Subducted components and lithospheric contributions to arc magmatism in Java: insight from the distribution of major and trace elements of Quaternary volcanic rocks. Proc. Joint HAGI-IAGI-IAFMI-IATMI Conv. (JCM 2017), Malang. p. (Major and trace elements of Papandayan and Merapi volcanoes are significantly above other Java volcanoes of similar depth above Wadati-Benioff zone)

Abdurrahman, M. & M. Yamamoto (2011)- Geochemistry of Papandayan and Cikuray volcanoes: mapping the extent of Gondwana continental fragment beneath Java, Indonesia. American Geophys. Union (GSA), Fall Meeting 2011, Abstract V43C-2599, 1p. (Poster presentation) (Geochemistry of contiguous volcanoes Papandayan (medium-K basaltic andesite (Early Stage), andesite (Middle Stage) and dacite (Late Stage); high 87Sr/86Sr and Cikuray (low-K, low 87Sr/86Sr, etc.) suggests mixing of low-K Cikuray-type magma with Gondwanan continental fragment material (Pre-Cambrian-Devonian Australian granites) at Papandayan. Two volcanoes reflect change in underlying basement type in West Java: Sundaland in N, Gondwana continent fragment in S. Papandayan volcano probably only Quaternary volcano underlain by Gondwana continental fragment)


Erdmann, S., C. Martel, M. Pichavant, J.L. Bourdier, R. Champallier, J.C. Komorowski & N. Cholik (2016)- Constraints from phase equilibrium experiments on pre-eruptive storage conditions in mixed magma systems: a case study on crystal-rich basaltic andesites from Mount Merapi, Indonesia. J. Petrology 57, 3, p. 535-560. (online at: https://academic.oup.com/petrology/article/57/3/535/1752840) (Experiments on Merapi volcano basaltic andesites suggests pre-eruptive reservoir partially crystallizes at ~100-200 MPa (4.5-9 km). Magmas are stored at ~925-950°C with melt H2O content of ~3-4 wt %. Pre-eruptive recharge magmas T 950-1000°C, and higher melt H2O content of ~4.5 wt %)


Francis, P. W. (1985)- The origin of the 1883 Krakatau tsunamis. J. Volcanology Geothermal Research 25, 3-4, p. 349-363. (Three hypotheses proposed to explain causes of 1883 Krakatau tsunami: (1) collapse of N part of Krakatau island (Verbeek, 1884); (2) submarine explosion (Yokoyama, 1981), and (3) emplacement of pyroclastic flows (Latter, 1981). Most likely mechanism Mt. St. Helens-like scenario, close to hypothesis of Verbeek, in which collapse of part of original volcanic edifice propagated major explosion)

Handini, E., T. Hasenaka, A. Harijoko & Y. Mori (2017)- Variation of slab component in ancient and modern Merapi products: a detailed look into slab derived fluid fluctuation over the living span of one of the most active volcanoes in Sunda Arc. J. Applied Geology (UGM) 2, 1, p. 1-14. (online at: https://journal.ugm.ac.id/jag/article/view/30253/18263) (Holocene eruptions of Merapi medium-K calc alkaline before 1900 years ago and high-K after that. Change attributed to increasing sediment input as volcano matures. Ancient Merapi sample higher input of slab derived fluid (1.5 % of sediment derived fluid) than 2006 eruption of Modern Merapi, opposite of suggested trend)


Harijoko, A., R. Uruma, Wibowo, E. Haryo, L.D. Setijadji, A. Imai, K. Yonezu & K. Watanabe (2016)- Geochronology and magmatic evolution of the Dieng volcanic complex, central Java, Indonesia and their relationships to geothermal resources. J. Volcanology Geothermal Res. 310, p. 209-224. (Dieng volcanic complex three volcanic episodes: pre-caldera (>1 Ma), second (0.3-0.4 Ma) and youngest (after 0.27 M). Each episode distinct differentiation trends, indicating multiple shallow magma chambers)

Hartono, U. (1994)- The olivine, pyroxene and amphibole chemistry from the Wilis volcano complex, East Java: implications for temperatures and pressures of the magma. J. Geologi Sumberdaya Mineral 4, 37, p. 7-19. (Pyroxenes from Wilis basalt and andesite crystallized at T of 1150°C and 947°C respectively. Amphiboles from Wilis dacite crystallized at pressure of ~5 kb)


of volcanioclastic deposits and (2) anomaly at ~4–8 km (possible magma reservoir). Under Merapi summit, low-velocity anomaly at~ 8 km, possibly active magma reservoir that feeds eruptive activity of Merapi.


('The lahars of Merapi Volcano, Central Java, Indonesia: triggering, sediment budget, dynamics and zoning of associated risks')


(online at: http://journals.ums.ac.id/index.php/fg/article/view/1822/1274)

(Lahar term for rapidly flowing, high-concentration, poorly sorted sediment-laden mixtures of rock debris and water from a volcano. Resulting deposits poorly sorted, massive, made up of elasts (mainly volcanics) in mud-poor matrix Lahars may be direct result of eruptive activity or not temporally related to eruptions. Etc.)


(online at: https://www.sciencedirect.com/science/article/pii/S0377027317301385)

(Reconstruction of 2014 Kelud eruption sequence. Plinian phase preceded by destruction of earlier lava dome)


('Four periods of major eruption disasters at S side of Merapi: 8th, 10th (1006, demise of 'Old Mataram'?), 13th and 16th (1587) centuries')


('Borobudur temple 27 km W of Merapi volcano built in area surrounded by former lake, possibly formed by damming of Progo River by Merapi eruption deposits around 1710 BC. Lake deposits ~13m thick')


(online at: http://journal.akprind.ac.id/index.php/snast/article/view/757/484)

('Identification of eruption characteristics of Merbabu volcano based on the stratigraphy and mineralogy of volcanic rocks')


(online at: https://www.jstage.jst.go.jp/article/grsj1979/26/3/26_3_285/_pdf)

(Three main episodes of volcanic activity in Mt. Sunda volcanic complex (Sunda, Burangrang and Tangkuban Parahu volcanoes): (1) Batunyusun Andesite (1.1 Ma), which unconformably overlies Neogene sediments; (2) Sunda Volcanics (0.56 and 0.18 Ma; Sunda Andesite and huge volume of pyroclastics covering area of 200 km2)
and with caldera-forming eruption between 0.205-0.18 Ma; (3) Tangkuban Parahu andesite and pyroclastics (62-22 ka). Younger craters at 9880-1440 yrs BP. No magmatic eruption since 1600)

(online at: http://natuurtijdschriften.nl/download?type=document;docid=511015)
('Krakatau, then and now. Popular review of development of Krakatau volcano, 50 years after 1883 eruption)

(online at: https://babel.hathitrust.org/cgi/pt?id=mdp.39015077870965;view=1up;seq=771)
('The Ijen volcano in Besoeki')

(Three models previously proposed for large tsunami generated by 1883 eruption of Krakatau: (1) large-scale caldera collapse of N part of Krakatau Island; (2) emplacement of pyroclastic flow deposits; (3) submarine explosion. Modeling suggests all three models displace same volume of water (11.5 km³), but in different ways. Submarine explosion model of 1-5 min duration best explains generation of largest tsunami)

(online at: http://ir.kagoshima-u.ac.jp/bitstream/10232/5937/1/AN00040884_1983_001.pdf)
(Volcanic products og 1982 Galunggung eruptions range in chemical composition from basaltic andesite to basalt. Silica-contentof first stage (April 5-8 of 1982) ~55 wt. %, later stages ~50%)

('The large caldera systems of Central Indonesia'. Popular review of calderas of E Java (Tengger-Semeru, Ijen) and Bali (Batur))

(Metastable calcic amphibole megacrysts in basaltic andesites of Merapi volcano, C Java, crystallised at pressures of >500 MPa (mid- to lower crust))

(Sundoro volcano 65 km NW of Yogyakarta, with 12 eruptive groups)

(online at: https://www.mdpi.com/2076-3263/8/5/183/pdf)
(Rock magnetic studies of basaltic- andesitic lavas from Ijen Volcanic Complex, East Java)


(New tomographic imaging higher resolution at shallow depths (<35 km) below Merapi volcano, C Java. Magma reservoirs detected at ~27 km and 12 km depth. Dipping low velocity material rises from ~100 km depth)
('The eruption of Mt. Ringgit on Java in the year 1593'. Historic records of significant volcanic activity above Panarukan, with possibly 10,000 people killed)

(online at: www.annalsofgeophysics.eu/index.php/annals/article/view/6404/6384)

(online at: www.annalsofgeophysics.eu/index.php/annals/article/view/6529/6509)
(Verbeek (1886) estimate of 12 km3 volume of Krakatau 1883 eruption ejecta revised to 19 km3, much more than volume of disrupted volcano edifice (8 km3). Does not support hypothesis that calderas formed by collapses of volcano edifices into magma reservoirs)


('Tektogenesis, gravity and magmatic cycles along the Ungaran-Merapi volcano row in Central Java')

(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/178/168)  
('Mud diapirs in waters south of Madura Island'. Shallow seismic reflection lines show 10 mud diapirs and gas-bearing sediments in N Madura Straits, S of E Madura Island from Sampang to Kalianget)

(Hydrocarbons in latest Miocene- Pliocene Mundu Fm bioclastic limestone reservoir of Madura Strait mainly formed of Globigerina planktonic foraminifera. Seismic inversion study shows W part of Mundis (=Maleo?) field more fractured, due to more fragile, cleaner facies. More porous reservoir in upper part of Mundu Fm. Two flat spots on seismic: lower at paleo oil-water contact, upper flat spot at present oil-water contact)

(Pliocene Mundu Globigerina limestone one of main gas producers in E Java Basin. Reservoir winnowed planktonic foraminifera pelagic rains on crests of anticlines; with excellent porosity (28-47%). Gases in Oyong, Wunut and Kepodang fields mixed thermogenic (from Ngimbang Fm) and biogenic (from Plio- Pleistocene sequences. Paciran Fm claystone seal for Mundu reservoir, supporting gas column of >200m in nearby fields)

(Depositional model of Pliocene Globigerina grainstone reservoirs ('Mundu play'). Best reservoir quality on crests of highs/ terraces (28-47% porosity; maximum winnowing, less dilution with fine clastics)

(Diapiric structures below the surface of the seabed in the southern coastal region of Sampang - Pamekasan Regency, East Java'. Shallow seismic profiles in N Madura Straits show Quaternary sediments undisturbed by folding/faulting, but Tertiary sediments off S coast of Pamekasan area tightly folded and with shale diapirs)

(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/142/132)  
('Migration pathway and biogenic gas accumulation based on seismic profiles of shallow sandstones in Sumenep waters and correlation with BH-2 core hole, East Java'. SE Madura offshore . In BH-2 core ~30m of Holocene-Recent black clay rests on the Pleistocene Pamekasan Fm. Minor biogenic gas)

(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/111/101)  
('Biogenic and thermogenic gas content of marine sediments in Madura Straits waters (their effect on physical properties and engineering)')

GLX structure in NW Madura Strait with 2 wells drilled. Reservoir rock Pliocene Mundu-Selorejo Globigerina Limestones. Two types of Globigerina Lst: (1) planktonic foram 'drifts', winnowed by bottom currents, and (2) planktonic foram 'turbidites'. Mundu sequence deep marine pelagic rock with <1% detrital clay, affected by bottom currents (upwelling?). Overlying Selorejo Fm with significant clay content, mainly reworked Mundu Fm)


Mansyur, M., L. G. Wooley & Nurhasan (2017)- Controlling factor in Pliocene carbonate reservoir quality as key to evaluate play chances: case study from Mundu carbonate from South Madura Strait- East Java Basin. AAPG Asia Pacific Region Technical Symposium, Bandung 2017, Search and Discovery Art. 11007, 7p. (online at: www.searchanddiscovery.com/documents/2017/11007mansyur/ndx_mansyur.pdf and www.searchanddiscovery.com/documents/2017/11007mansyur/slides.pdf) (Pliocene Mundu carbonate reservoir of E Java Basin (Madura Straits) consist of >85% planktonic and deep marine benthic foraminifera bioclasts. Contains 3.5 TCF gas. Average porosities >40% (up to 60%), permeability 100- >4000 mD. Sr isotope age 5.1- 5.8 Ma, older than suggested in previous publications. Reservoir quality controlled by marine sorting processes and diagenesis shutdown)


Nurhasan (2017)- Seismic DHI flat spot characteristic and statistic of the Pliocene Globigerina bioclastic limestones reservoir in Madura Strait area, East Java basin. Proc. Joint Conv. HAGI-IAGI-IAFMI-IATMI (JCM 2017), Malang, 5p. (All anticlinal structures drilled in Madura Straits with bright seismic flat spot at level of Mundu Fm Globigerina Limestone reservoir are commercial gas discoveries)


IV. BORNEO (KALIMANTAN & NORTH BORNEO) (308)

IV.1. Kalimantan/ Borneo General (51)


(Basement outcrops in Siung Malopot area in N part of Barito basin (277km NE of Palangkaraya) Cretaceous? low-metamorphic andesite and granodiorite. Also boulders of Early Tertiary limestone and presumably reworked latest Carboniferous - E Permian fusulinid foraminifera (Schwagerina))


(Similar to Aryanto et al. (2013) paper above on Singkawang granite-granodiorite 145km N of Pontianak (no age info))


(M Eocene- Oligocene Melawi Basin in NW Kalimantan 300km long and 100km wide and formerly classified as intra-continental rift, sag basin and strike slip basin. Sedimentation thicker in N, as result of thrust fault-controlled sediment deposition. N of basin subduction and collision-related rocks include M Eocene Piaybung arc volcanics and Boyan and Lubok Antu melanges. Further N lies Sarawak Basin, classified as Eocene-Oligocene foreland basin. Oil seeps around Kedukul-1 well, gas shows in Kayan-1 and Kedukul-1 wells. Melawi basin is retroarc foreland basin, with hydrocarbon migration pathways from foredeep in N to forebulge area in S part of basin)


(Melawi Basin in NW Kalimantan with oil seeps at surface, but two wells (Kayan 1, Elf 1986 and Kedukul 1, CanadianOxy 1995) only gas shows. Both wells E Oligocene beds at surface. In Kayan-1 E Miocene Sintang intrusions intruded Eocene Ingar and Dangkan Fms; Kedukul-1 TD in Sintang Intrusion. Reservoir sandstones poor porosity (av. 8-10%). Oil maturation window at surface in E Melawi basin due to Miocene regional uplift)

(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/147/143)
(same as Baharuddin 2011, above)


(‘The diamond terranes of Kasan’, SE Kalimantan. Report on natives’ diamond digging for diamonds in alluvial deposits in Kusan area (E of Meratus Range?): Sungei Dana/ Sungei Bakarang. No maps or figures)

(North Kalimantan orogen formed by collision between Luconia continental block and N margin of Sundaland. Complicated history from interior orogen to peripheral orogen and to interior orogen again. Imbricate thrusting during late Oligocene- M Miocene interior orogen was most important epoch of regional metallogenesis in Kalimantan)

(online at: https://repository.ugm.ac.id/137902/1/MOB-03.pdf)
('Study of the characteristics and petrogenesis of 'Beku rocks in the regions of Singkawang and surroundings, W Kalimantan Province'. On NW Kalimantan volcanic and intrusive rocks: (1) Permo- Triassic calc-alkaline subduction- and collision-related series with intrusions of S-type granite (2) Cretaceous calc-alkali to high-K subduction and collision series with I- and S-type granites; (3) Eocene-Miocene calc-alkaline subduction series with I-type granitoids and (4) Pliocene tholeitic series formed in continental rift zones)

(Kalimantan located far from active subduction zones with few seismic stations. SS precursors show discontinuity at ~690 km depth and weaker discontinuity at ~290 km depth)

(Exploration over past 15 years by Kalimantan Gold Corporation identified >30 copper and/or gold prospects. Porphyry copper-gold systems are viable exploration targets in central regions of Kalimantan)

(online at: https://eprints.utas.edu.au/19986/1/whole_HarahapBhaktiHamonangan1988_thesis.pdf)
(Petrography and chemistry of Tertiary volcanic rocks from C and W West Kalimantan (mainly subduction-related arc volcanics) and Quaternary basaltic andesites from Mt. Niut (intra-plate volcanism not related to subduction). K-Ar ages of intrusions near Sintang: in South 23.0-30.4 Ma, in North 16.4-17.9 Ma (similar to intrusives in nearby Sarawak))

Harrison, T. (1975)- Tektites as "date markers" in Borneo and elsewhere. Asian Perspectives 18, 1, p. 61-63.
(The only place in North Borneo with tektites is NW coastal region 20 miles from Brunei city, at base of Jerudong Beds, and K-Ar dated as 730,000 BP by Zahringer (1963). However, associated wood much younger, so tektites may be reworked)

(online at: http://searg.rhul.ac.uk/pubs/hennig_etal_2017%20Paleo-Pacific%20margin%20West%20Borneo.pdf)
(Metamorphic and magmatic rocks in NW part of Schwaner Mountains of W Kalimantan with mainly Cretaceous U-Pb zircon ages (~80-130 Ma). Triassic metatonalite near Pontianak with Triassic and Jurassic zircons formed at Paleo-Pacific margin of subduction under Indochina- E Malaya block. Geochronologically similar Triassic rocks in Embuoi Complex to N and Jagoi Granodiorite in W Sarawak formed part of SE margin of Triassic Sundaland. One S-type granitoid (118.6 Ma) with inherited Carboniferous, Triassic and Jurassic zircons, indicating Sundaland basement. Two I-type granitoids with Cretaceous ages of 101.5 and 81.1 Ma. All three record Cretaceous magmatism at Paleo-Pacific subduction margin. Cretaceous zircons of metamorphic origin indicate recrystallisation at ~90 Ma, possibly related to collision of Argo block with Sundaland. Subduction ceased at that time, followed by post-collisional magmatism in Pueh (77.2 Ma) and Gading Intrusions (80 Ma) of W Sarawak (NB: West Borneo here viewed as part of Triassic Sundaland, extending to NW Schwaner zone and possibly further South; not SW Borneo block as previously assigned by Hall, etc.).)
Hovig, P. (1930)- De oorsprong van de Borneo diamanten. Geologie en Mijnbouw 8, 12, p. 157-161. (online at: https://drive.google.com/file/d/1IsA9sp2MEHaeqL_IHPOyMvILVrkM08Tm/view) ('The origin of the Borneo diamonds'. Brief review, largely based on Krol (1922). Quaternary diamond placers probably formed through multiple stages, from primary deposits (here believed to be contact zones of acid intrusions) into Lower Cenomanian clastics, then reworked into progressively younger sediments. No figures)


Kamiludin, U., I Wayan Lurga & S. Hakim (2003)- Sedimen permukaan dan kandungan mineralnya di perairan Pontianak, Kalimantan Barat. J. Geologi Sumberdaya Mineral 13, 143, p. 57-66. ('Surface sediment and mineral content in the waters of Pontianak, West Kalimantan'. Recent sediments off Pontianak dominated by quartz (from Sukadana granite and Kempari Sst Fm?). Heavy minerals include magnetite, hematite, cassiterite, pyrite, etc.)


Panggabean, H. (2005)- The occurrence of methane gas seepages in the Upper Ketungau area, West Kalimantan. Indonesian Mining J. 8, 1, p. 1-8. (online at: http://jurnal.tekmira.esdm.go.id/index.php/imj/article/view/205/122) ('Flammable methane gas seepages at Peturau River, N of Upper Ketungau River, Ketungau Basin, N of Semitau High (Boyan Melange), NW Kalimantan. Near outcrop of Sekalau coal seam and probably coalbed methane gas, leaking through NW-SE trending faults. Coals present in Eocene Kantu (Silantek) Fm and Miocene Late Oligocene-Miocene (?) Ketungau Fm (Sekalau and Malintang seams, 0.10-0.95m thick, vitrinite Ro 0.66-0.70%). Kantu Fm coal vitrinite Ro 0.68-0.82%)


('Gold occurrences of Borneo'. Early report on distribution of gold in Kalimantan. Many of the alluvial and fluvial gold occurrences already mined by locals. Less common gold disseminated in metamorphic rocks, granites and quartz veins)


('Geological notes from Borneo: 1. Coal occurrences in Borneo, 2. Geological notes from Central Borneo')


('Type of "massive sulphide" Pb-Zn deposit in Riam Kusik, Ketapang District, West Kalimantan'. Massive sulphide mineralization with galena, chalcopyrite, sphalerite, etc., following E-W structural grain)


('Assessment of porphyry copper deposits in C Kalimantan- N Borneo dispersed belt of late Oligocene- Pliocene intermediate intrusives and volcanics. Relation of these intrusive rocks to subduction unclear, and tectonic setting for porphyry copper deposits in this tract likely post-subduction. All porphyry copper prospects likely of Miocene-Pliocene age. Only one known porphyry copper deposit: Mamut (Sabah; 1966)


(W Kalimantan map sheet with oldest rocks pre-Cretaceous Pinoh Metamorphics, Cretaceous granitoids and volcanics. In Kapuas River area in N overlain by E Oligocene clastics of Melawi Basin. Youngest rocks Oligo-Miocene Sintang Intrusives)


('Crustal evolution of the Meratus Mts and implications of aspects of mineralization')


('On some oils from Borneo'. Old chemical analyses of 15 crude oil samples from Sanga Sanga and Louise fields, E Kalimantan)


('Kelian and Magerang andesites 250km W of Samarinda, with short age range. Magmatism and mineralization within 0.5- 1.0 Myrs around 19.4 Ma (E Miocene). Produced two types of eithermal deposits. Detrital zircons in nearby rivers Tertiary populations of 1.7-2.8 Ma and 15.8-21.7 Ma; large Cretaceous peak at ~105 Ma))

('E Miocene calc-alkaline arc volcanics of Kelian region two magmatic differentiation trends. Part of Central Kalimantan continental arc of andesitic- trachyandesitic rocks')


('Case study of three contaminated granitic bodies in the Longlaai area, Berau district, East-Kalimantan'. E Miocene Mamak, Gupak and Segah granitoids in NE Kalimantan with 'calcic' contamination)


(online at: http://jgsj.geologi.esdm.go.id/index.php/JGSM/article/view/15/13)

('Configuration of basement of geological sedimentary basin area of Longbia-MuaraWahau, East Kalimantan, based on gravity analysis'. Bouguer anomalies in NE Kutai basin suggest basement composed of granitic and ophiolitic fragments)


(online at: http://jgsj.geologi.esdm.go.id/index.php/JGSM/article/view/258/238)

('Subsurface geology model of the Muara Wahau area from gravity anomaly analysis and depth estimation with the spectral analysis method')


('Study of heavy placers of Kendawangan coastal and adjacent offshore area, W Kalimantan. Cassiterite (0.3-15%) and zircon (1-26%) found at all locations and have potential to be further developed. High content of cassiterite (Sn) generally linked to sediment of Kendawangan River')


(online at: www.igc-gemmology.org/)

('Diamonds found in 4 main areas of Kalimantan (Landak, Puruk Cahu, Martapura, Kelian), mainly in Quaternary alluvial deposits, some in Cretaceous and Eocene conglomerates. Landak diamond deposits along lower terrace of Landak river')


(online at: https://www.gsj.jp/data/bull-gsj/15-08_01.pdf)

('Main minerals in laterite ores from Sebuku goethite, gibbsite, magnetite, chromite, spinel, hematite, quartz. No location data or geologic background info')


('Character and chemical age of uranium mineralization in Remaja and Tanah Merah, Kalan, Kalimantan'. Uranium mineralization in Kalan area, N margin of Schwanev Mtss, NW Kalimantan. In Remaja mainly uraninite and brannerite; in Tanah Merah mainly uraninite and monazite. Chemical ages of Remaja 145-150 Ma (or 125-130 Ma); Tanah Merah 145-150 Ma (or 135-145 Ma))
(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/236/226)
('Bouguer anomaly patterns and magnetic anomalies and their relation with mineral and energy prospects of Pulau Laut, Sebuku Island and Sebuku Strait, South Kalimantan'. Circular pattern of Bouguer gravity anomalies of 45-64 mGals reflect ultramafic rocks close to surface; exposed ultrabasic rocks indicated by high magnetic anomalies. Parallel Bouguer patterns reflect thrust and normal faults)

(English edition of 1989 report on expedition to study Devonian limestone/fossils(oldest known rocks from W Indonesia), initially reported by Witkamp (1925) and Rutten (1940) in area of Telen River (tributary of Mahakam Delta). Oldest unit pre-Permian? dark schist. Overlain by ?Permian turbiditic metasandstones of Telen Unit, with black Devonian limestone boulders with Heliolites corals (up to 10's of m; debris flows?) and with common Permian fusulinid foraminifera (Neoschwagerinidae; similar to fusulinids from Danau Kapuas regions?; Krekeler 1932, 1933) in calcareous sandstone matrix. Sediments are thrusted toward East, but no evidence of 'melange'. Mesozoic and older metasediments unconformably overlain by Eocene quartz sandstones. With reverse faults and post-Eocene diorite intrusions.)

(Bauxite deposits in Tayan, E of Pontianak, W Kalimantan, formed by lateritization of E Cretaceous gabbro (high-iron type) and Late Cretaceous diorite (high-silica type))

('Detailed geology and economic mineral prospecting in Muara Luhung (Permata Intan) area, Muara-Tewe sheet, Central Kalimantan')

(Fe-Ni-Cu sulphides, Co, Au and Platinum Group Elements minerals, associated with cumulus ultramafic zone of Late Triassic- E Cretaceous ophiolite complex in Sebuku Island)

(online at: www.bgl.esdm.go.id/publication/index.php/dir/article_detail/659)
('Silat shale in the Nanga-Serawai area, Sintang District, and its shale gas potential'. Late Eocene Silat shale in Melawi Basin, C Kalimantan, deposited in lacustrine and delta environment. Organic material vitrinite (from plants) and liptinite (from plant fats or sea algae). TOC 0.54-1.15%, vitrinite reflectance 0.29-0.45%)


(online at: http://jurnal.tekmira.esdm.go.id/index.php/imj/article/view/342)
('Busang prospect in Kalimantan Volcanic belt, ~150 km SW of Kelian mine. Hosted within volcanic rocks intruded by Oligo-Miocene Atan Diorite. Hydrothermal alteration with gold, minor chalcopyrite, lead, sphalerite, pyrite and marcasite. Low sulfidation epithermal type)

(Pinang Dome coal deposit in Kutai Basin, 90km N of Samarinda, 10km long in N-S direction and 2-6km wide. Six main seams 1-14m thick and 17 thin coal seams in 950m interval of Miocene fluvio-deltaic sequence. High-quality coal with rel. low moisture (4-12%), low ash (<3%), low sulfur (0.2-1.4%) and high rank (VR 0.51-0.67%; burial 2000-3000m). Also some lower quality Eocene coal in area of higher rank (VR 0.65-0.75%))


('The geological-mining investigation of part of Borneo's West coast No. 9: Investigation of gold veins near Melassan'. Report on 1884 survey of area formerly mined for gold by Chinese kongsi's, now abandoned. Presence of quartz vein(s) in weathered 'old clay-shales' with pyrite and minor amounts of gold (0.0005%). Further exploitation deemed uneconomic)


(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/266/283)

('Petrology and geochemistry characteristics of the Late Oligocene - Miocene volcanic rocks in the Gunung Muro Region, C Kalimantan'. Mt Muro calc-alkaline magmatic (part of Sintang Arc volcanics))
**IV.2. East Kalimantan Cenozoic Basins, (bio-)stratigraphy (114)**

(Seismic stratigraphy study of Pliocene- Pleistocene deep water clastics at Kutai Basin slope and basin floor of Makassar Straits. Six sequences identified, with lowstand features submarine canyons, channels and fan lobes)

(Review of Mahakam Delta depositional system and depositional cycles)

(Fault seal analysis of fields in S Mahakam offshore, with Jempang-Metulang, Mandu and Stupa gas fields along N side of Sepinggan Fault (parallel to Adang FZ). Gas reservoirs in M Miocene Sepinggan deltaic sands. High shale content leads to shale smear and high seal capacity of all faults)

(Unpublished)  
('Microscopic and organic-geochemical investigations on coals from Indonesia, a contribution to the genesis and facies of various coal basins')

(Coalbed methane CBM evaluation of two Indonesian coals, Sambaliung (Berau/Tarakan, NE Kalimantan, E-M Miocene Lateith Fm) and Sawahlunto, W Sumatra, Late Oligocene Lower Ombilin Fm). Gas storage capacity of Sambaliung 113-269 scf/ton; Sawahlunto coals 486-561 scf/ton. Adsorption capacity related to coal rank: low at Sambaliung area (vitrinite Rr ~0.38%) and higher at Sawahlunto (Rr ~0.72%)

(Maceral petrography of E (M?) Miocene upper Muara Wahu Fm coal from three drill cores. Two main seams 8-40m thick. Huminite macerals 73- 88%. Liptinite 0.7-6.7%, inertinite 4.3-34%. Coal developed from herbaceous plants in ombrotrophic type of peat. Preservation low and peat relatively wet or limnic)

(Palynofacies study of M-L Miocene in wells from Louise Field, Sanga-Sanga anticlinorium, Kutai Basin)

(Successful CBM exploration program in coals in Balikpapan Fm of Sangatta II block)


Arifullah, E., Y. Zaim, Aswan, Djuhaeni, D. Arwibowo, Y. Eriawan & M. Ilham (2016)- The significance of ichnofabric analysis for sedimentological interpretation: an outcrop study at Palaran, Samarinda Area, Kutai

(Trace fossils in Miocene deltaic Palaran Sst (Balikpapan Fm) in Samarinda area, Mahakam Delta onshore)

(online at: http://journal.akprind.ac.id/index.php/snast/article/view/756/483)
('Ancient volcano of Nunukan Island, Nunukan district, N Kalimantan. Several andesite-basalt volcanoes on Mio-Pliocene deltaic clastic deposits of Nunukan Island)

(online at: www.searchanddiscovery.com/documents/2010/50363bachtiar/ndx_bachtiar.pdf)


('The Misedor well- synthesis of geologic studies'. Misedor shallow cored well in Handil Field area of Mahakam Delta penetraded Quaternary (0-400m) and Late Pliocene clastic sediments (400- 638.6m). Four transgressive- regressive sequences in deltaic setting)

(online at: http://www.publish.csiro.au/ex/pdf/ASEG2018aB77_3B)
(Pelorang Anticline part of NNE-SSW-trending Samarinda Anticlinorium in detached fold-thrust belt of onshore Kutai basin. Detachment fold, ~30km long, with steeply dipping flanks. Airborne gravity shows anticline associated with strong positive gravity anomaly, possibly from ~2000m high, high-pressured shale core. Two commercial hydrocarbon accumulations, Sambutan and Mutiara)

(online at: www.searchanddiscovery.com/abstracts/pdf/2003/intl/extend/ndx_82692.pdf)
(Review of Late Pleistocene- Holocene of Mahakam Delta , showing complete cycle of lowstand (incised valleys and prograding lowstand delta)- transgressive (up to 40m thick Halimeda carbonate buildups on interfluves of incised valleys on shelf)- highstand sequence tracts (prograding clastics of modern delta))

(During period of continuous sea level fall Mahakan Delta distributive channels converted into incised valleys with adjacent dendritic tributary channels. Main incised valleys reached shelf break, transporting sediments beyond shelf break. During sea levelrise incised valleys flood and remain largely underfilled)

Bibliography of Indonesia Geology, New for Ed. 7. 137 www.vangorselslist.com 8/6/18
(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/222/212)
('Biogenic gas and mineral elements in Kapuas delta sediments, West Kalimantan'. Bacterial-origin biogenic gas in Quaternary clastic sediments of shallow boreholes in Kapuas Delta)

(Tarakan Basin initiated simultaneously with formation of Celebes Sea in M-L Eocene until end of E Miocene. Deltaic sedimentation from W in M Miocene- Pliocene, with significant growth faulting. Latest tectonic phase latest Pliocene- Recent transform movement along 3 major (Semporna, Maratua, N Mangkalihat) and several smaller sinistral wrench faults crossing Makassar Straits, causing up to 1000m of local inversion uplift)

(online at: www.iagi.or.id/jost/files/2017/03/BS37-03032017.pdf)
(Review of East Kalimantan Barito, Kutei and Tarakan basins, all with M Eocene - U Oligocene Paleogene sediments. M Eocene dominated by fluvial settings, U Eocene common coastal to shallow shelf deposits. Carbonates developed in Oligocene in N and S; in Kutei Basin mainly shelf to bathyal clastics)

(online at: https://cseg.ca/assets/files/resources/abstracts/2002/Walia_R_Reinterpretation_of_the_Sembakung_CAS-1.pdf)
(Sembakung field 1975 ARCO discovery onshore Tarakan (Tidung) basin, 80km N of Tarakan island, NE Kalimantan. 19 wells drilled until recent redevelopment. Producing since 1977 from stacked Miocene- Pliocene deltaic sands of Tabul Fm, in structurally controlled traps)


(Kutai Basin mature basin, with high success rates drilling on surface anticlines, many of which are inversions of growth faults in delta systems. Two main remaining play types are stratigraphic traps along flanks of structural highs (e.g. Tunu) and drilling for isolated pressure compartments in overpressure zone)

(online at: https://buletingeologi.com/index.php/buletin-geologi/issue/view/4/Paper-4%20vol.%202%20no.%201)
('Sequence stratigraphy analysis of the Pliocene interval at Bunyu Tapa field, North Kalimantan'. Pliocene Tarakan Fm in Bunyu Tapa oil field in N Kalimantan can be subdivided in 5 delta plain-dominated sequences)

(online at: http://buletingeologi.com/index.php/buletin-geologi/issue/view/2/09_BG201621)
('Study of rock types and modeling in Block X, Barito Basin'. Interpretation of fluvial depositional facies of (Eocene) Lower Tanjung Fm in wells of Tanjung Field, Barito Basin, SE Kalimantan. Highest porosity-permeability in channel and point bar sands)


Hamdani, A.H., E. Sunardi & Y.A. Sanjaya (2014)- The Coalbed Methane potential from Sajau coal in eastern part of Berau Basin, East Kalimantan. Int. J. Science and Research (IJSR) 3, 3, p. 104-107. (online at: https://www.ijsr.net/archive/v3i3/MDIwMTMxMDc5.pdf) (Pliocene coal seams of Sajau Fm in Berau basin, lignite- subbituminous grade and categorized as high gaseous seams. with good CBM development potential)


Husein, S. (2017)- Lithostratigraphy of Tabul Formation and onshore geology of Nunukan Island, North Kalimantan. J. Applied Geology (UGM) 2, 1, p. 25-35. (online at: https://journal.ugm.ac.id/jag/article/view/30255/18265) (Nunukan Island, in Tidung sub-basin N of Tarakan, built mainly by Late Miocene Tabul Fm clastics, deposited in transitional environment. Apparent coarsening upward sequence (but biostrat suggesting inverted section?; JTvG). E coast Pliocene Tarakan Fm fluvi-deltaic conglomerates unconformable over Tabul Fm clastics, suggesting Pliocene and younger deformation/ uplift of paleo-Simengaris Delta (sinistral movement of NW-SE Semporna Fault?), contemporaneous with common basaltic volcanism over NE Borneo, including basaltic intrusions in N Nunukan)


('Mapping of parasequence sets: a way of adjusting the resolution of geological models using seismic stratigraphy interpretation of deltaic sediments'. With examples and facies maps of Sangatta field, E Kalimantan)


(online at: http://seep.paleo.pan.pl/AHS_5.html)

(Late Miocene methane-seep deposit and associated fauna in Kutai Basin. Dominated by large, globular lucinid bivalve Meganodonta sp. nov. (up to 12.4 cm), and elongate bathymodiolin mussel, Gigantidias sp. nov.(up to 8.7 cm long). Also common small lucinid Cardiolucina aff. quadrata and Isorropodon sp., rare lucinid Lucinoma sp. and gastropods Bathymbembix, Naticarius, Profundinassa, etc. Probably upper bathyal environment (400-500m). Close affinities to Recent tropical W Pacific seep faunas)


(online at: http://iopscience.iop.org/article/10.1088/1755-1315/29/1/012022/pdf)

(Outcrops in Siung Malopot area in N part of Barito basin (277km NE of Palangkaraya) show Late Cretaceous basement of Pitap Fm andesites and granites, unconformably overlain by M-L Eocene Tanjung Fm clastics with intercalations of coal and thin limestones. Palynomorphs: Proxapertites cursus, Meyeripollis naharkotensis, Cicatricosisporites eocenicus, C. dorogensis and Palmaepollenites kutchensis indicate Late Eocene Proxapertites opeculatus zone. Increasingly more humid climate with age. Depositional environment mainly back-mangrove (abundant Acrosticium aeurum), with increasing marine influx in upper parts of Tanjung Fm)


('Acoustic characteristics and geological phenomena of Quaternary sedimentary deposits of the Mahakam Delta - East Kalimantan'. Mahakam delta offshore shallow seismic profiles indicate at least four acoustic intervals (depositional sequences), separated by unconformities)


('Significant portion of Paleo-Mahakam Delta succession deposited during transgressive phases, either from extensive major transgressions or short-lived transgressions within mainly progradational phases. Sandstone facies with significant reservoir potential in transgressive successions: (1) backfilled distributary sandstones (coastline-perpendicular 10-20 m thick sand bodies, fining-upward channel sands, becoming more marine upwards; (2) shoreline-parallel, transgressive shoreline sandstones)


(Gas well W Kerendan-1 (2013) core and log analysis shows Oligocene carbonate reservoir of interlayered reservoir-quality grainstone and wacke-packstone units. Persistent presence of clastic materials suggest land-attached setting. Diagenetic events generated secondary porosity during intermediate-deep burial and uplift)


(Unpublished, pioneering report on geological survey and micropaleontology of large parts of NE Kalimantan. Copy of typescript reportedly in archive of Netherlands Centrum for Biodiversiteit (Naturalis), Leiden, as 'Verslag Boeloengen-Beraoe. Arch. 55 30031 (larger foraminifera from Leupold NE Kalimantan collection described in several papers by Van der Vlerk (1925, 1929))


(South Sesulu Block at S margin of offshore Kutai Basin, with structural traps formed during end- Early Miocene inversion along left-lateral faults of Adang flexure zone. SIS-A1 well (2015) penetrated good quality M-L Miocene deltaic and upper slope sandstones and tested dry gas from Late Miocene sandstone. Late Oligocene-Miocene coals and shales in S Sesulu area good source rock potential)


(online at: https://dspace.library.uu.nl/bitstream/1874/334448/1/Marshall.pdf)

_COLLECTION of studies on Miocene of E Kalimantan (paleoenvironmental reconstruction, magnetostratigraphy, strontium isotope stratigraphy, cyclostratigraphy and paleomagnetic rotations). Mahakam Delta cyclic sediment alternations match Earth’s orbital oscillations (20, 40 and 100 kyr cyclicity in M Miocene, 15-11Ma). Paleomag work on Eocene- Miocene sediments indicates Borneo island probably did not rotate drastically since at least ~40 Ma, Late Eocene, but data from Cretaceous basalts do suggest ~40° CCW rotation)


(Paleo-Mahakam delta of E Kalimantan, Borneo developed during globally warm M Miocene in equatorial setting. Statistical analysis of sandstone/shale alternations show distinct pattern of cycles with thicknesses of ~90, ~30, and ~17m, translating into periods of ~100, 40, and 20 kyr, matching orbital eccentricity, obliquity and precession cycles. Proximal paleo-Mahakam sedimentation dominantly controlled by allogenic orbital forcing, probably as consequence of glacioeustasy (also in Marshall 2016 thesis))


(online at: http://jurnal.unpad.ac.id/bsc/article/view/8237/3785)

('Diagenesis and source of sandstone of the Lati formation in the Berau Region, East Kalimantan, based on petrographic data'. MMiocene Lati Fm sandstones of NE Kalimantan classified as litharenites and wackes. Provenance mainly from granitic rocks, with transport to SE (see also Maryanto 2013))


Depositional environment of Warukin Formation coal based on organic petrographic analysis in the Paringin area, Barito Basin, S Kalimantan. Macerals in Miocene Warukin coals suggest deposition in a palaeomire in wet forest swamp.


Coral patch reefs in Miocene Mahakam delta in E Kalimantan developed in shallow marine turbid waters, in delta front-prodelta environment. Langhian patch reefs in limestone quarries of Air Puth area near Samarinda with two types of microbial carbonates: low-relief domes and large nodules ('megaoncoids') around nuclei of coral fragments. Slope of patch reef flank favored falling and rolling of encrusted corals, with continued growth of microbial crusts on all sides of nodules. Both types near base of reef slope.


Two main structural styles in offshore Tarakan sub-basin: (1) proximal-shelf deformation dominated by normal-growth faults and (2) distal-slope deformation dominated by toe-thrusts, both result of gravitational sliding on upper E Miocene shale detachment surface. Top overpressure created by fluid expulsion predicted at depth of 2000-3500m TVDss in M-L Miocene shale. Decrease of overpressure in distal direction.


Modeling of six producing sandstone layers and dolerite sill in E-M Eocene Lower Tanjung Fm reservoir interval in Tanjung Field.


(Interpretation of overpressure from sonic and density wireline logs in oil-gas field off Mahakam Delta)


(Example of cyclostratigraphy interpretation of outcrops of Miocene near Samarinda area, E Kalimantan)


(online at: www.geo.sc.chula.ac.th/BEST/volume6/number2/BEST-13Ridha%20Santika%20Riadi-Vol6No2-pp115-121.pdf)


(online at: https://dspace.library.uu.nl/handle/1874/300545)

(Study of Miocene corals from patch reefs in E Kalimantan; collection of manuscripts. Incl. revision of fossil record of Acropora (31 species) and Isopora in Indo-Pacific. Platy coral assemblages common up to M Miocene (Serravallian), branching coral assemblages become dominant in Late Miocene (Tortonian) and first occurrence of entirely massive coral assemblage (similar to modern) in Messinian)

(Corals from E Kalimantan outcrops contain 79 genera and 234 species. Three different coral assemblages in small patch reefs, developed under influence of high siliciclastic input from Mahakam Delta. Platy coral assemblages(Porites, Leptoseris, etc.) common until Serravallian, branching corals became abundant in Tortonian. By Late Tortonian massive coral assemblages dominated, similar to modern-style coral framework)


(online at: https://academic.oup.com/zoolinnean/article/175/4/677/2449809)

(Extensive collections of Miocene corals from E Kalimantan, Indonesia, with 31 species of Acropora and 2 of Isopora, in E Miocene (max. age 18-20 Ma). 12 extant species already present in E Miocene. Most corals associated with shallow turbid habitats)


(In Asem-Asem Basin average mineral content of Miocene coals (3.9%) lower than Eocene coals (6.7%). Miocene coals bright lithotypes/ vitrinite-rich coal with fewer clay partings; Eocene coals dull lithotypes/vitrinite-poor)


(online at: http://jurnal.tekmira.esdm.go.id/index.php/imj/article/view/494/358)

(Coals in Asem-Asem Basin, SE Kalimantan, in Eocene Tanjung and M Miocene Warukin Fms. Eocene(?)) coals from Satui area dominated by bright-banded and banded types. Vitrinite and liptinite dominant macerals, minor inertinite. Mineral content relatively high. Brighter coal more vitrinite-rich. Vitrinite reflectance 0.48-0.54%)


(Coals from Eocene Kuaro Fm in Pasir area in s-most Kutai Basin. Maceral composition similar to most SE Kaliman.coals. Presence of common pyrite and calcite reflects marine incursion. Vitrinite reflectance (Rvmax%) 0.53-0.71% (subbituminous A- high volatile bituminous C))


(E and S Kalimantan Eocene and Miocene coals dominated by vitrinite, common exinite and rare inertinite. Paleogene coals sub-bituminous to high volatile bituminous rank (Rv max. 0.53-0.67%), Miocene coals brown to sub-bituminous rank (Rv max 0.30-0.57%)

Santoso, B. & N.S. Ningrum (2010)- Characteristics of selected Mangkalihat coals according to petrographic and proximate analyses. Indonesian Mining J. 13, 3. p. 128-134.


(Coals in Eocene Kuaro Fm in Mangkalihat area of E Kalimantan, below Oligocene and younger limestone section. Three seams 1.5-4.0m thick. Coals with very thin claystone-sandstone laminae and rel. common pyrite, suggesting marine influence during deposition. High moisture (15-19%). Vitrinite reflectance 0.46-0.49% (subbituminous A and B rank))


(online at: http://journals.itb.ac.id/index.php/jets/article/view/3510/2961)
(Late Eocene Tanjung Fm and E-M Miocene Warukin Fm coals in Barito Basin with cleats (micro-fractures) predominantly oriented in WNW-ESE and NNE-SSW directions. Cleat density increases with structural position like fold hinges and fault zones. Cleats form during coalification (shrinkage), and are superimposed by later processes like fluid pressure and tectonic stresses and also affected by composition of the coal)

(In Tarakan Basin much of Eocene- E Miocene in marine facies. Common Oligocene limestones. Late M Miocene huge sediment influx came into into Tarakan basin and deltaic sedimentation began)

(online at: http://www.iagi.or.id/fosi/berita-sedimentologi-no-40.html)
(Stratigraphic succession in onshore Tarakan Basin two major depositional environments: Eocene-E Miocene marine and upper M Miocene-Pliocene deltaic depositional environment)

(Summary of gravity field of Kutei Basin and surrounding areas. Onshore Bouguer anomalies generally from +10 to +50 mGal; in Balikpapan area depocenter ~75 mGal. Assuming 9000m of sediment and underlying continental crust, anomalies here should be ~ -115 mGal. One possible explanation is rise in Moho)

(Barito Basin M Eocene synrift- postrift Lower Tanjung Fm clastics 7 sequences. Coals in three sequences of postrift phase. Most widespread and thickest coal seams in transition between synrift- postrift phases. Coals deposited in paralic to upper deltaic settings in various systems tracts. Coals TOC 44-73%, hydrogen index (HI) 285-567 mgHC/gTOC and hydrogen to carbon ratio (H/C) of 0.87-1.18, showing coals are liptinitic and can generate oil. Carbon isotopes and biomarkers show Tanjung Fm coals sourced Tanjung field oil)


(online at: http://widyaniset pusbindiklat.lipi.go.id/index.php/widyaniset/article/view/205/198)
('Palynological Study of the Mentawir Formation, Lower Kutai subbasin, E Kalimantan'. Palynology of interval 100'-4140' in well 'X' of 'DNA' field. Age mainly M Miocene (F. trilobata zone), 100-850' Late Miocene)


(online at: www.iagi.or.id/fosi/files/2017/12/FOSI_BeritaSedimentologi_No39_Dec2017.pdf)
(Discussion of Miocene-age Sangatta Delta system (Balikpapan and Kampung Baru Fms) in NE Kutai Basin. Development controlled by Rantau Pulung- Mangkupa paleohigh, bound by NE-SW and N-S strike slip faults that represent Neogene reactivations of old basement faults. Delta development started with small proto-
Sangatta Delta in E Miocene and became larger during M-L Miocene after inversion/ uplift at Kuching High to W. More than 10 stacked, E-ward prograding fluvial-deltaic parasequence sets)

(N Kutai Sangatta delta (Balikpapan and Kampung Baru Fms) development started in E Miocene with at least two fluvial-deltaic parasequence sets prograding to E. Delta became larger in M-L Late Miocene as regional inversion and uplift took place at Kuching High to W of delta. >10 stacked fluvial- deltaic parasequence sets identified, all showing progradation to E)

(Gravity mag survey in upper Kutai Basin, in area with Kerendan and West Kerendan gas fields in Oligocene carbonates. NE-SW trending surface antilies are mainly (M Miocene?) inversions of M-L Eocene extensional structures)

(Five proven and potential types of petroleum source rocks identified in Kutai basin. Most oils tied to deltaic coaly shales. Coaly materials significant role in hydrocarbon generation, conventional and unconventional)

(Tarakan Basin with E-ward prograding fluvio-deltaic sedimentation since E Miocene, sourced from multiple feeder rivers (Sesayap, Sesanip and others). Deltaics at and E of Bunyu Island deposited on oceanic crust of Celebes Sea. Tarakan sub-basin bounded by left-lateral strike slip faults Sampoerna (in N; Celebes Sea transform fault?) and Maratua and Mangkalihat FZs (in S; continuation of Palu-Koro fault of Sulawest?). Major tectonic event at end of Late Miocene (end of Santul Fm), which uplifted part of area E of Kucing High. Second major tectonic event in Pleistocene, forming present-day Bunyu, Tarakan and Ahus structures)

(Distributions of cleat orientation, spacing, and aperture in Pliocene Sajau Fm lignite seams controlled by main tectonic structures in area)

(Palynostratigraphic study on core samples from Miocene reservoirs 28- 4 in 22 wells in Handil Field, Mahakam Delta. Palynoflora composition: 224 species of fungal spores, 88 species of pollen grains and 14 species of spores. Four E Miocene- E Pliocene informal stratigraphic assemblages distinguished, based on subzones of Florschuetzia meridionalis Zone)

(online at: https://www.ijsr.net/archive/v3i4/MDtwMTMxNTcy.pdf)
(Brief review. Kutai Basin basement slickensided serpentinites (Kuaro, Muru River) and deep marine turbiditic metasediments with polymict conglomerate, and pelagic sediments (Tewe River), interpreted as Jurassic ultramafic complex. Overlain by E Miocene(?) and younger beds with numerous repetitions of prograding patterns (fluvial-deltaic and shallow marine facies, with transgressive carbonate build ups). In Late Miocene retrograding patterns and progressively deeper facies)


('Geochemistry of the organic matter of the Misedor well'. Geochemical analyses of organic matter in Late Pliocene- Recent sediments of interval 0-640m in the Misedor well, SW Mahakam Delta. Organic matter all Type III, and derived from same higher land plants as organic matter in deeper water deltaic sediments)

(online at: www.iagi.or.id/fosi/files/2016/01/BS34-01142016_FINAL.pdf)

(online at: www.zobodat.at/pdf/SBAWW_88_0372-0384.pdf)

('On the Tertiary flora of Borneo')

(Mahakam Delta Complex may be small scale aulacogen showing associated delta depocenters. Sedimentary prism underlain by oceanic crust. Interplay of basin development, deltaic sedimentation and intrabasin deformation displayed in E Kalimantan favors large petroleum prospects)

(E Miocene deltaic-shelfal clastic play in onshore Upper Kutai basin only partly explored. Sandstone reservoir quality linked to deep burial main risk. QFL plots show E Miocene sandstone sub-litharenite to litharenite, with lithics mainly metamorphic and sediment fragments (less quartz than M Miocene sandstones))

(online at: https://buletingeologi.com/index.php/buletin-geologi/issue/view/4/Paper-2%20vol.%202%20no.%201)

('Relationship of coal ranking to Coal Methane Gas content of Middle Warukin Formation at Well BSCBM-01, Paser Regency, East Kalimantan Province'. M Warukin Fm coals from 116-389m in N Barito basin well subbituminous, Type II kerogen, with total biogenic gas content 3-121 scf/ton, percentage methane 12-96%)

(online at: http://www.trijurnal.lemlit.trisakti.ac.id/index.php/mindagi/article/view/96/96)

('Study of depositional facies of coal in utilization of coaled methane gas potential in the Balikpapan, East Kalimantan area, based on proximate analysis and petrography'. Core from 130m deep EPL 01 well in Miocene Balikpapan Fm in Penajam area. 11 coal layers 0.2-3.1m thick, lignite- sub-bituminous rank (Rv 0.28-0.38%), up to 84% vitrinite. Environment wet forest swamp, dominated by woody plants, in lower delta plain)
(Late Eocene coals in Tanjung Fm inMuara Teweh area, N Barito Basin, formed in, in upper delta plain swamp environment with marine influence. Palynomorphs grouped into six types: fresh water and lowland (42%), brackish water swamp (30%), peat and freshwater swamp (18%), marine (8%), backmarshove (1.5%) and upland (1%). Palmae pollen dominant (Dicolcopollis, Proxapertites cursus, P. operculatus, Longapertites and Palmaepollenites kutchensis). Also with Magnastriatites howardi Verrucatosporites usmensis, Retistephanoclopites and Ixonantes, indicative of Late Eocene age)

('Microfossils in the coal-bearing formation in the Perian region, Muntai District, Kutai Regency, East Kalimantan'. Palynomorphs from 4 samples from Perian River in Kutai Basin include Stenochlaenidites papuanus, Florschuetzia meridionalis and F. levipoli, suggesting most likely M Miocene age. Foraminifera rare Miocene forms only. Mainly mangrove and swamp environments)


(On Eocene Tanjung Fm coal potential in Lipon-Gendang area, Sungai Durian District, E of Kandangan Meratus Mts front, SE Kalimantan. Four outcropping coal seams mapped, 0.2- 3m thick. Predicted resources 1,403,550 ton with average caloric value of ~5400 cal/gr and average sulfur 1.47%)

(Paleontological zonation of the Lower Kutai Basin, Balikpapan and surrounding area, East Kalimantan’. Brief general discussion of Miocene- Recent foraminifera, calcareous nannoplankton and palynology biozonations. No details on Kutai Basin)

('Chronostratigraphic of the lower Kutai Basin in Balikpapan and surrounding area, East Kalimantan’. Brief review of latest Oligocene- Pliocene biozones in outcrops of Kutai basin. Little location/stratigraphy detail)

(Pliocene age lignites from Lower Sajau seam in borehole in Kasai Coal Field, Berau Basin. Lignite-grade coal with abundant terpenoid biomarkers including lupane and oleanane indicate angiosperm-dominated vegetation. Also hopanoid biomarkers indicating acidic depositional environment)

(‘Late Oligocene shales of coal-bearing Pamaluan Fm in Gunung Bayan area of upper/NW Kutai Basin poor-good quality source rock with gas-prone Type III kerogen. Maturity level mainly immature)

IV.3. North Borneo (Sarawak, Sabah, Brunei) (127)


(online at: https://gsmpubl.files.wordpress.com/2014/09/ngsm1987002.pdf)

(Youngest Globotruncana species at top of Pedawan Fm in Penrissen area (S of Kuching) Marginotruncana coronata, Marginotruncana angusticarinata and Discarinella carinata, signifying U Santonian age)


(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1993/..)

(In Batu Gading are off Baram River, Sarawak, S of Brunei, , massive U Eocene limestone, disconformably overlain by Late Oligocene limestone breccia with mixed Late Eocene and Late Oligocene taxa, suggesting post-Late Eocene emergence. With abundant Eocene larger foraminifer, incl. Nummulites javanus, N. pengaronensis, Discocyclina, Asterocyclina. Limestones overlain by deep marine beds with earliest Miocene Globigerina sellii- G. binaiensis planktonic foraminifera)


(online at: www.gsm.org.my/products/702001-101706-PDF.pdf)

(Comparison of two completely different oil source rocks, Jurassic of Yemen and Oligo-Miocene of Sarawak)


(Organic facies in outcrops around Miri, Sarawak. M Miocene Miri Fm with organic-rich sandstone intervals with coal clasts and carbonaceous laminae. Early mature (Vitrinite reflectance Ro 0.35- 0.50%))


(Extended Abstract)

(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1993/..)

(Organic matter present in all formations studied mainly of terrigenous origin and gas prone (Type III and Type III-IV kerogen), except for minor occurrence of mixed oil-gas prone Type II-III kerogen in Miocene Belait Fm and in slump mass transport deposits of West Crocker Fm)


(In Late Miocene to Recent deep water thrust belt off NW Borneo up to 50% of sediments large-scale remobilized mass-transport deposits. MTD's 10-200m thick, composed mainly of claystone. Intercalated with turbidites, which form sandstone reservoirs of petroleum discoveries. Thickest sands often immediately overlying MTDs. MTD lithofacies continuum from debrisitic claystones to more simply folded claystones)

(Comprehensive analysis of Cenozoic carbonates from Sarawak Basin, both onshore (4 Late Eocene -E Miocene units) and offshore (4 M-L Miocene build-ups in offshore C Luconia). Carbonate growth mainly controlled by paleo-baseament structures: some carbonates on flat rift blocks show flat-top morphology; on tilted sub-blocks often conical shapes. Eustacy probably main controlling mechanism for carbonate growth. Late Eocene Lower Batu Gading Lst massive nummulitic facies with Pellatispira; E Miocene U Batu Gading Lst on disconformity and composed of finely bedded and brecciated limestones. Suai Lst (Te5?) fining-upward parasequences of larger foraminifera dominated by large Eulepidina spp. E Miocene Subis Lst (Te5) rich in corals, foraminifera and algae. Bekenu Lst laminated marls-shale calci-turbidites. Luconia offshore carbonates greater similarity in facies and sequences. Ten stages of calcite cementation/ dolomitisation. Presence of high T minerals indicate late stage corrosive fluids of hydrothermal origin, responsible for porosity- permeability enhancement of reservoirs)


(Darvel Bay Ophiolite Complex of SE Sabah withperidotite, gabbro, pillow basalt and reddish-brown chert. Cherts along Kunak-Semporna road with 56 species of radiolaria, of 3 assemblages: I: Aptian-Albian, with Sticomitra simplex, Crucella bossoensis, etc.; II: Albian-Cenomanian, with Xitus mclaughlini, Pseudoaulophacus sculptus, Dictyomitra gracilis, etc.; III: Turonian, with Pseudotheocampe tina, Crucella cahensis, Dictyomitra multicoastata, etc. Bedded chert with abundant radiolarians indicates high plankton productivity, possibly related to upwelling. Absence of limestone suggests deposition below CCD depth)


(Samples of Kalumpang Fm/ Sipit Mb reefal limestone in 46m thick section at Teck Guan Quarry, 50km E of Tawau, SE Sabah. Formation faulted and thrusted against Cretaceous Darvel Bay Ophiolite Complex at Darvel Bay area. 17 species of larger foraminifera, in two assemblages: (1) Lepidocyclina (N) parva, L. (Eulepidina) formosa (Te5, Aquitanian-Burdigalian; E Miocene); (2) Lepidocyclina (N) sumatrensis, Lepidocyclina (N) angulosa, Lepidocyclina spp., Miogypsinia sp., Katacyclopyeus annulatus, Cyclochyeus spp., Flosculinella bontangensis, etc. (Tjf1-2; M Miocene))


(On Cenozoic coals and associated black shales in Peninsular Malaysia (Eocene- Oligocene coals in small basins on West coast), Sarawak (Late Oligocene- Miocene coals in Nyalau, Liang, Begrih and Balingian Fms) and S Sabah (M Miocene coals in Tanjong Fm). All have mixed Type II-III kerogens and hydrogen index suggesting potential for gas and oil generation. Coals and black shales from M Miocene Tanjong Fm formed under wetter climate conditions than others)

Nippon 'T-I' exploration well, with ~770m thick M Pleistocene and almost 1000m Late Pleistocene- Holocene. New Late Pleistocene- Holocene cycle (cycle IX) proposed for Shell 'NW Borneo cycle scheme')


(In offshore NW Sabah gas hydrates, with Bottom-Simulating Reflector on seismic, mainly in zone of coast-parallel ridges (top of imbricated thrust anticlines). Minimum water depth for BSR 600m, and 250-350m below seafloor)


(Reservoir quality of M-U Miocene sandstones on offshore W Baram Delta wells. Average porosity 25 %, permeability 1911 mD for coarse grained sandstones, 5.7 % and 1.4 mD for very fine grained sandstones, 16.5% and 23 mD for bioturbated sandstone, etc. Excellent reservoir rock quality in coarse sandstones attributed to lack of cement between grains, good intergranular porosity and pore connectivity)


(Geochemistry, provenance, tectonic setting, etc., of offshore Miocene clastics in W Baram Delta Sandstones provenance mainly felsic-intermediate igneous with minor mafic contribution. Passive margin tectonic setting after continental collision and rifting stages of foreland basin. Paleoclimate warm and humid, enhancing chemical weathering)


(Geochemical indications of thermogenic gas and non-biodegraded oil seepage in 6 of 10 piston cores from Amerada Hess Block F, off Sarawak)


(34 taxa of agglutinated forams in Miocene of Brunei and Sarawak and paleoenvironmental interpretation)

Breitfeld, H.T. & R. Hall (2018)- The eastern Sundaland margin in the latest Cretaceous to Late Eocene: Sediment provenance and depositional setting of the Kuching and Sibu Zones of Borneo. Gondwana Research 63, p. 34-64.

(Kuching Zone in Borneo several large sedimentary basins of Late Cretaceous- Late Eocene age. W Sarawak Kayan Basin with U Cretaceous- Lower Eocene Kayan and Penrissen Sandstones (Late Cretaceous- Paleocene with abundant Cretaceous, Permian-Triassic and Precambrian zircons; Paleocene- E Eocene mainly Cretaceous zircons from Schwaner granites of SW Borneo). In Kuching Zone Ketungau Basin with unconformably overlying M-U Eocene Ketungau Group, with oldest sediments derived from nearby sources, probably Triassic Sadong and Kuching Fms. Kuching sediments can be correlated with deep marine Rajang Gp. Some magmatism but scarcity of contemporaneous zircons indicates it was very minor)


(Metamorphic rocks in W Sarawak previously assumed to be pre-Carboniferous basement but new Ar/Ar ages from quartz-mica schists show Late Triassic metamorphism (~216-220 Ma; Norian). Metamorphics associated with Triassic acid and basic igneous rocks. Late Triassic Sadong Fm with youngest zircon ages of ~205, 212 Ma and inherited age peaks of 240-270 Ma and 1.8 Ga. Zircon ages from Jagot Granodiorite ~208 Ma with inherited ages of 240 Ma, reflecting M-L Triassic subduction in W Sarawak (most likely W-directed Paleo-Pacific subduction). W Sarawak and NW Kalimantan underlain by continental crust that was already part of Sundaland in Triassic. Detrital zircon ages in Cretaceous volcanoclastic Pedawan Fm with major peaks 110-120, 150-160, 220-240, 250-260 Ma, 1.8-1.9 Ga), similar to ages of Schwaner granites of SW Kalimantan plus additional sources; interpreted as Cretaceous forearc basin with material eroded from magmatic arc that extended from Vietnam to W Borneo. Youngest ages from zircons in tuff layer from uppermost Pedawan Fm indicate end of volcanic activity/ subduction at ~86-88 Ma. Cretaceous metamorphism of Serabang, Sejingkat, Sebangan Fms and Lubok Antu- Kapuas (and Boyan?) melange associated with Cretaceous subduction zone. Results of study cast doubt on existence of separate 'Semitau block')


(Kuching Zone in W Sarawak two sedimentary basins (Kayan, Ketungau) that extend into Kalimantan. Uppermost Cretaceous (Maastrichtian)- Lower Eocene Kayan Gp above Pedawan Unconformity, marking end of Paleo-Pacific subduction-related magmatism (above Cretaceous Pedawan Fm forearc sediments). Kayan and Penrissen Sst mainly fluvial- alluvial fan deposits. In late E or early M Eocene, sedimentation in basin ceased and Ketungau Basin developed to E. Change marked by Kayan Unconformity. Sedimentation resumed in M Eocene (Lutetian) with marginal marine Ngili Sst and fluvial Silantek Fm. Top of Ketungau Gp fluvial-dominated Tutoop Sst. Paleo-current measurements show dominant southern source, suggesting uplift of S Borneo in region of Schwaner Mountains from latest Cretaceous onwards. Ketungau Gp also with reworked Kayan Gp. Kuching Supergroup predominantly horizontal or low dips, with steep dips restricted to faults)


(Detrital zircon age distributions suggest major change in provenance at unconformity between E-M Eocene deepwater Belaga- Bawang Fms and fluvo-deltaic Oligo-Miocene Tatau-Nyalau Fms. Unconformity previously interpreted as Late Eocene orogeny, but no evidence for subduction or collision event at this time in Sarawak;
possibly marks late M Eocene plate reorganisation. Borneo main source of Cretaceous (~120-150 Ma peak?) zircons (Schwaner Mts, W Sarawak). Dominant Triassic (~220-240 Ma peak?) zircon age population in Nyalau Fm indicates either provenance from Malay Peninsula tin belt or Indochina (SE Vietnam). (or unidentified Triassic granites on Borneo. Persistent ~1800 Ma age peak; HvG))


(Composite granitic intrusion of Mt Kenabalu in Sabah emplaced in upper-middle crust in Late Miocene over 0.8 Myrs, at contact between ultramafic basement and sedimentary cover. Emplacement during regional NNW-SSE-oriented extension. Six major units, oldest tonalite/granodiorite and two final porphyritic granites. Preferential emplacement of successive units along granite-country rock contact of previous units rather than basement-cover rock contact exploited by initial units)


(Seismic attribute interpretation applied to Greater Samarang sub-block, E Baram Delta, offshore Sabah)


(Extended Abstract. Sandakan Fm of Segama Group exposed across Sandakan Peninsula, ESabah. U Miocene part of Segama Group three lithofacies: 1) brackish mudstone, 2) shallow marine sandstone and mudstone and 3) cross-bedded estuarine sandstone)


(Sedimentology of Late Miocene Sandakan Fm, exposed across Sandakan Peninsula in E Sabah. Unconformably overlies Garinono Fm. Seven lithofacies in estuary and shallow marine facies)


(Growth timing of studied Miocene carbonate platform at C Luconia Province ~ 4 Myrs, governed by third-order sea-level fluctuations and syndepositional tectonics. First karstification during Burdigalian sea-level drop, over complex horst-graben setting, configured by seafloor expansion of S China Sea, before carbonate initiation. Second major subaerial exposure/karstification in Langhian. Third subaerial exposure minor karstification. Final drowning in Serravallian without subaerial exposure)


(Miocene carbonate platform development of Southern Field High of C Luconia Province. Initial patchy growth during Burdigalian, followed by build-out and backstepping. Four 3rd order Burdigalian-Serravallian eustatic cycles prior to platform drowning and rapid proto-Borneo clastic influx. With extensive karst development by sub-aerial exposure and re-submergence of carbonate platforms. Karstification mainly along fractures and faults. Final drowning correlated to surge of sea level rise in Serravallian)


(All Neogene deformation across N Borneo is result of uplift and erosion of detached, gravity-driven collapse system and shale diapirism, not product of multi-phase basement tectonics. Deep Regional Unconformity may
not be unconformity, rather diachronous mechanical boundary of different responses of overpressured shale and more competent sandy sediments to gravity-driven collapse)

(In C Luconia province off Sarawak 60 TCF gas in-place discovered, majority in Late Miocene carbonate buildups play. Many carbonate buildups underfilled, probably due to 'thief beds'. Since 2015 paper two more discoveries made in SK408 PSC, including accumulation with gas column height >900m)

(online at: www.searchanddiscovery.com/documents/2015/51133collins/ndx_collins.pdf)

(Comparison of outcrop analyses of facies and stratigraphic architecture in M Miocene Belait Fm with process-based geomorphological and sedimentological analyses of coastal-deltaic depositional environments in present-day Baram Delta Province)

 manusc (Manuscript online at: https://core.ac.uk/download/pdf/77017250.pdf)
(Miocene -Recent Baram Delta Province 9-12 km of coastal-deltaic to shelf sediments over past 15 Myr. Facies analysis of outcrops suggests 'storm-flood' depositional model, with two distinct periods: (1) fair-weather periods dominated by longshore sediment reworking and coastal sand accumulation; and (2) monsoon-driven storm periods characterised by increased wave energy and offshore-directed downwelling storm flow that occur simultaneously with peak fluvial discharge caused by 'storm-floods')

(online at: https://seacarledu.files.wordpress.com/2016/06/2015_12_10_dedeche_niah_outcrop-analogs.pdf)
(Gunung Subis large flat-topped limestone hill in Sarawak still represents shape of original E Miocene backstepping isolated carbonate platform. Similar to S China Sea/ Luconia carbonate buildups in terms of growth history, but different diagenetic history)

(presentation online at: https://seacarledu.files.wordpress.com/2016/06/2015_12_10_dedeche_niah_outcrop-analogs.pdf)
(Subis Limestone onshore Sarawak (with Niah cave) 2 main sequences: (1) U Oligocene lower sequence, deep marine; (2) Lower Miocene upper sequence; reefal, and forming spectacular limestone hill that reflects original carbonate platform. Good analogue to Sarawak offshore carbonate platforms)

(online at: http://english.gyi.cas.cn/pu/papers_CJG/201608/P020160809534849297876.pdf)
(Paleocene- Miocene sandstones from SW Sarawak (Kayan Sst, Plateau Sst, Silantek Fm) sublitharenites, dominantly composed of quartz with minor mica, feldspar and volcanic fragments. Derived from quartz-rich recycled orogenic sources. Felsic igneous source suggested by a low TiO2 compared to CIA, etc.)


(Summary of Shell commemorative volume of same title. Main event was Miri oilfield discovery by Royal Dutch/Shell subsidiary in 1910. Miri 1 producing mainly from ~1000’ depth)


(online at: https://www.slb.com/~media/Files/technical_papers/130/13162.pdf)

(Samarang field 35-year-old oilfield in E part of Baram Delta. Initially developed by Shell in 1975. Petronas currently operating and reducing production decline rates Large rollover anticline, producing from Late Miocene- E Pliocene deltaic- marine sandstones. Not much on geology)


(online at: http://searg.rhul.ac.uk/pubs/galin_etal_2017%20Rajang%20provenance%20Sarawak.pdf)

(Rajang Gp clastics in N Borneo thick, large deep-water submarine fan complex. In Sarawak Lupar and Belaga Fms deposited fom latest Cretaceous (Maastrichtian)- late M Eocene. Borneo one of the few places in SE Asia with sediments of this age preserved. Main source regions Schwaner Mts in SW Borneo, and W Borneo/Malay Tin Belt. Heavy mineral assemblages and detrital zircon U-Pb dating show 3 units: (1) Late Cretaceous- E Eocene age zircon-tourmaline-dominated (2) Early to M Eocene zircon-dominated, abundant Cretaceous zircons and few Precambrian zircons derived primarily from Schwaner Mts; (3)M Eocene zircon-tourmaline-dominated. Limited contemporaneous magmatism during Rajang Gp deposition, inconsistent with subduction/arc setting. Rajang Gp deposited N of shelf edge formed by Lupar Line strike-slip fault)


(Examples of seismic velocity building technologies to generate accurate models for imaging and depth conversion in offshore Brunei)


(Sabah structure and tectonic history dominated by Late Oligocene- M Miocene S China Sea seafloor spreading and Sulu Sea subduction. Sabah tectonics started in E Cretaceous. S China Sea subducted under N Borneo margin, forming M Eocene- E Miocene basin sediments. Celebes Sea subducting N-ward under Dent Peninsula in Late Oligocene. Circular basins in E part of Sabah formed in E-M Miocene, thought to be related to SE Sulu Sea Basin rifiting. Volcanic arc in Dent Peninsula also formed during this time, due to S-ward subduction of Sulu Sea. In Late Miocene SE Sulu Sea Basin rifiting ceased)


(Brief note on presence of Late Eocene (Tb) larger foraminifera Actinocyclina and Nummulites at base of Kantu Beds (lowest part of Plateau Series), proving Late Eocene or older age of 'Plateau Series transgression' over Pretertiary- Lower Eocene rocks)


(Sandakan Peninsula outcrops. Oldest exposed unit is M Miocene Garinono Fm, widely distributed in E Sabah, with lower sequence of sedimentary melange/oolistostrome and volcanics-dominated upper sequence, part of M Miocene Cagayan Volcanic Arc. Volcanic facies andesite- dacite and tuff- tuffaceous sandstone. Unconformity between volcanics and base of overlying Sandakan Fm also M Miocene age (Globorotalia fohsi fohsi), Sandakan Fm 12km thick mudstones and cross-bedded sandstones. Common lignite seams, fossilized wood and consolidated quartz pebble lenses)


(Tectonic events affected growth of Miocene carbonates in C Luconia. Three stages: pre-carbonate (Late Oligocene- E Miocene), syn-carbonate (M-L Miocene) and post-carbonate (Pliocene). Rifting of S China Sea and subduction of proto-South China Sea responsible for pre-carbonate faulting; movement of ancient Baram Line controls strike directions of normal faults in syn-carbonate stage. Subsidence and compaction due to overburden of clastics from prograding deltas main reason for gravitational tectonics in post-carbonate stage)


(online at: https://umexpert.um.edu.my/file/publication/00006513_154787_66167.pdf)


(Blocking 2 F in Bunguran Trough, deepwater Rajang Delta area, off Sarawak in S China Sea. Trough evolved as tectonically-induced sag basin. Oldest known rocks shelfal clastics of E Miocene Cycles I/II, now buried >6000m. Late Miocene Cycle V ~3000m of slope and toe-of-slope deposits, overlain by Plio-Pleistocene sediments with turbiditic fairways forming main objectives in current exploration campaign)


(online at: https://drive.google.com/file/d/0B35lLH-Cki2N01LNEYCcG12Z2M/view)

(Deepwater Bunguran Trough off Sarawak is intra-continental pull-apart basin in deepwater Rajang/West Luconia Delta province. Oldest stratigraphy shelf clastic deposits Late Oligocene Cycle I (= Gabus Fm of Natuna Basin), now buried to >7000m. Sediments sourced from: (1) Natuna Arch in Oligocene- E Miocene and Late Pliocene- Pleistocene (feldspatic and quartz-rich) turbidites); (2) Rajang/ W Luconia Delta (Neogene) and (3) minor contributions from Dangerous Grounds/ N Luconia and C Luconia Platform areas to N and E)


(online at: www.gsm.org.my/products/702001-101705-PDF.pdf)

(Review of onshore Baram Delta province in N Sarawak, with M Eocene- Holocene succession and 1910 Miri oilfield discovery. Three episodes of deformation: (1) Late Cretaceous- Eocene (79.5-36 Ma) block faulting, (2) Late Oligocene- M Miocene (30-20.5 Ma) wrench movement and folding; (3) M Pliocene (4 Ma)- Holocene uplift and compressional folding. Two major anticlinal trends: Engkabang-Karap in S, M-Asam Paya in N. Two distinct petroleum systems: (1) overmature gas in S, sourced from deep Eo-Oligocene basinal shales with reworked terrestrial organic matter. Earlier oil charge probably in Oligocene before late basin reversal; (2) oil and gas system from peak-mature M-L Miocene carbonaceous shales and coals in synclines, charging inversion compressional structures along N M-Asam Paya anticlinal trend, and Miocene at Engkabang-Karap Anticline. Expulsion and charge started in Late Miocene and is continuing to present-day. Exploration results of Eo-Oligocene carbonate play disappointing. Onshore Baram Delta still contains attractive plays)


(online at: www.iagi.or.id/fosi/files/2016/01/BS34-01142016_FINAL.pdf)

(400 km2 large Eocene- Oligocene carbonate body of Engkabang-Karap Anticline, onshore Sarawak (equivalent of Melinau Lst). Tight reservoir facies encountered in two Engkabang wells)


(online at: www.gsm.org.my/products/702001-101676-PDF.pdf)

(Incised Pleistocene gravel beds and conglomerates common feature of Baram, Limbang and Temburong drainage systems in NW Sarawak and Brunei. Incision from 9-76 m likely result of strong precipitation, combined with ongoing uplift. Conglomerates almost exclusively from Lower Miocene Meligan Sst, and deposited in nested fluvial terraces. Uplift may be ongoing present day)
(online at: https://gsmpub.files.wordpress.com/2016/03/warta41_3-4.pdf)
(~1000m thick outcrop section along 3-4 km of new Miri- Long Lama road (NW Sarawak), with two major regional unconformities: (1) M Miocene Unconformity (MMU) between U Setup Shale and Lambir Fm, and (2) Mio-Pliocene angular unconformity between folded Lambir rocks and unfolded Tukau Fm)

(online at: https://gsmpub.files.wordpress.com/2016/08/warta42_1_2.pdf)
(After Paleocene-E Eocene Sarawak Orogeny (~40-36 Ma) shallow shelf developed in NW Sarawak, which included Luconia/Tinjar terranes and rimmed recently emerged Rajang Gp hinterlands. Late Eocene benthic foraminiferal limestone banks and ramps developed on sheltered shools. By E-M Oligocene carbonate deposition slowed. Second episode of carbonate deposition in E-M Miocene, with small coral-algal bioherms)

(online at: www.gsm.org.my/products/702001-101701-PDF.pdf)
(Good correlation between normal fault throw and fault gouge thickness)

(online at: www.gsm.org.my/products/702001-101710-PDF.pdf)
(In NW Sarawak two independent carbonate systems: Late Eocene-Oligocene foraminiferal limestone banks and E-M Miocene coral-algal buildups. No outcrop or well shows continuity of carbonate deposits from Late Eocene to M Miocene. Eo-Oligocene carbonate system formed during deepening of NW Borneo foredeep after Paleocene- E Eocene Sarawak Orogeny; E-M Miocene carbonates originated as foredeep shallowed and eventually disappeared with establishment of shallow, clastic shelf)

(Neogene sequence of greater Miri area in NW Sarawak with up to four Neogene unconformities: well-established Mid-Miocene Unconformity (MMU; ~15.5 Ma?) and less well-defined Shallow Regional Unconformity (SRU; ~10 Ma), Intra-Pliocene Unconformity (IPU; 3.6 Ma) and Lower Pleistocene Unconformity (LPU; ~1.6-1.8 Ma). Timings yet-to-be fully established)

(online at: www.iagi.or.id/fosi/files/2017/12/FOSI_BeritaSedimentologi_No39_Dec2017.pdf)
(Fault zones with clay gouge in outcrops and shallow boreholes of Late Miocene- E Pliocene deltaic clastics show no fault sealing capability. Probably due to weathering)

(online at: http://www.iagi.or.id/fosi/berita-sedimentologi-no-40.html)
(Hydrocarbon column length offshore Sarawak, Brunei and NW Sabah mainly controlled by effective and laterally continuous top seal. Seal capacity affected by mineralogy, grain size, diagenesis and lateral continuity. Hydrocarbon columns tend to be longer in clay-prone environments, like outer shelf and deepwater turbidite environments (av. ~250m), and shorter in sand rich shallow marine-deltaic settings (av. 30m))

(SW Sarawak basin S-ward sloping basement characterized by passive margin tectonics: Triassic extension, Cretaceous transpression and Oligo-Miocene compression. Deeper basin zone between Schwaner Mts block to S and SW Sarawak basin to N. E-W trending Cretaceous carbonate platform in SW Sarawak basin signify shelf zone where shallow marine sedimentation progressed during Cretaceous transpression. Late Cretaceous- E Eocene Kayan Sst unconformable on Cretaceous Pedawan Fm. NW-SE trending Oligo-Miocene continental volcanic arc. Back-arc extension prevailed in Oligo-Miocene. SW Sarawak basin two sub-basins (Senibong in W, Kuching in E), with wide range of transpressive features. Sri Aman marginal sea-basin characterized by oceanic assemblages, ophiolite, serpentinite and pillow basalt)


(Outcrops of sandstones-clays at Ambug Hill in NE Brunei with layers rich in marine fossils. Calcareous nannoplankton of Late Tortonian- E Messinian (NN11) age, confirmed by Sr-isotope age from bivalves (8.3- 6.2 Ma). Overlain by emersion surface, possibly tied to Me1 (7.25 My) or Me2 (5.73 My) sequence boundary)

(Offshore Sabah subjected to tectonic and gravity deformation since E Tertiary. E Miocene event led to crustal overthickening and uplift of former deep marine thick shale (Setap Fm) to shallow water environment. Relief prepared initial conditions for delta-related sequence in M Miocene time. Differential loading triggered mobile shale, forming mini-basins and shale ridges. Late Miocene more shale-prone prograding system. Gravity faults with rollovers and associated outboard, Late Miocene- Pliocene toe-thrusts, linked along shallow detachment. Further offshore imbricate thrust system rooted in deeper detachment)

(oldest fossiliferous rocks of Sabah are E Cretaceous limestone and chert, but older metamorphic rocks and granite and tonalite (minimum age E Jurassic or Triassic) also present)

(Sabah granites often viewed in literature as Cretaceous in age and related to ophiolites, but radiometric ages of 210 and 185 Ma suggest it predates ophiolites and more likely represents Pre-Cretaceous continental basement that originated from continental margin of E Asia during of Proto-South China Sea Basin)

(Major review of Late Eocene-Pleistocene depositional cycles I-VIII, used by Shell since 1960's for Sarawak/Brunei Tertiary. Cycles originally defined by initial transgression changing to regression, and probably reflect interplays between tectonic and eustatic events. Initial (unpublished) definitions updated through time, but most biostrat support data unpublished. Cycles I-II boundary close to Oligocene- Miocene boundary, coinciding with Top Crocker Unconformity in Sabah and onset of seafloor spreading in W South China Sea. Base Cycle IV transgression at ~15.5 Ma called 'break-up unconformity' by Hutchison (2004), based on strongly rifted topography called 'M Miocene Unconformity' (MMU); followed by accelerated sediment supply. Base Cycle V at ~12-13 Ma. Etc.)

(online at: www.gsm.org.my/products/702001-101714-PDF.pdf)

(Review of Oligocene - Pleistocene stratigraphy of N Borneo, with emphasis on dating regional unconformities: Top Crocker Unconformity (TCU: Oligo-Miocene boundary, ~23 Ma); Deep Regional Unconformity (DRU, late M Miocene, ~12 Ma; 'Sabah Orogeny' (around E-M Miocene boundary, with uplift in C Borneo and accelerated progradation of deltaic deposits to N))

(Batu Gading Limestone isolated outcrops along Baram River, ~80 km SE of Miri, Sarawak, and part of Melinau Limestone Fm. Unconformably overlies Cretaceous turbiditic Kelalan Fm. Basal transgressive sequence 40m thick with Late Eocene larger foraminifera Pellatispira, Discocyclina and Nummulites (probably deepening-upward series), overlain by 10m thick limestone breccia with mixed clasts of Late Eocene and Late Oligocene age (Tel-4; with Heterostegina borneensis and Miogypsinoïdes), overlain by deep marine Miocene beds. Breccia formation probably in submarine slope setting)

(online at: http://topscience.iop.org/article/10.1088/1755-1315/88/1/012023/pdf)

(Outcrop study in Sandakan, NE Sabah, of Miocene shallow marine sandstone of Sandakan Fm. Shoreface to offshore transitional environments, with common Hummocky Cross Stratified sandstone)

(online at: https://gsmpubl/files.wordpress.com/2017/09/ngsm2017_032.pdf)

(Tajau Sst Member of Kudat Peninsula, Sabah, gently folded thick pebbly coarse sandstones with Late Oligocene (Te1-4) larger foram assemblage (Heterostegina borneensis, Eulepidina, etc.))

(online at: www.theses.fr/2016LORIS408.pdf)

(Collection of papers on geomorphology and morphotectonic analysis of Rajang and Baram drainage basins of Sarawak. Characterized by high denudation rates since Miocene. At end of Miocene rapid uplift of possibly whole Interior Highlands and coastal areas of Sarawak. Enhanced post 5 Ma erosion rates led to rapid progradation of deltas and Plio-Quaternary sediments that reach thicknesses of >6 km)

(online at: www.gsm.org.my/products/702001-101686-PDF.pdf)

(Seismic profiles and maps description of 500m diameter mud volcano caldera at 1100m water depth offshore Sabah. Mud volcano overlies toe-thrust anticline and has well-defined caldera)


Morley, C.K. & M. Burhannudinmur (1997)- Anatomy of growth fault zones in poorly lithified sandstones and shales: implications for reservoir studies and seismic interpretation: part 2, Seismic reflection geometries. Petroleum Geoscience 3, 3, p. 225-231. (Seismic reflection data across growth faults off NW Borneo show many of small-scale fault geometries recognized in outcrop can also be interpreted on seismic data. Some fault zones single fault plane; others up to 1km wide bundles of overlapping fault planes connected by hard and soft linkage geometries)

Mueller, F.P. (1915)- Tekrite from British Borneo. Geol. Magazine, ser. 6, 2, 5, p. 206-211. (Four black lustrous tektites 1.5-3 cm in diameter, found in 1913 near Tutong Station, SW of Brunei town, washed out of white quartz sand 1-2' below surface, in terrace deposit ~40' above sea level. With first map of distribution of billitonite/ tektite of Malaysia- Indonesian region?)


Mustafar, M.A., W.J.F. Simons, F. Tongkul, C. Satirapod, K.M. Omar & P.N.A.M. Visser (2017)- Quantifying deformation in North Borneo with GPS. J. Geodesy, p. 1-19. (online at: https://link.springer.com/content/pdf/10.1007%2Fs00190-017-1024-z.pdf) (GPS survey results indicates extension along coastal regions of Sarawak and Brunei (5-9 mm/year W-directed movement) but strain rate tensors in Sabah reveal only insignificant extension, while compression occurs throughout NW Borneo. CW (microblock) rotation of N part of North Borneo. Low subsidence rates along W coast of Sabah, but inconsistent trends between Crocker and Trusmadi Mts. Unable to confirm hypothesis of
gravity sliding as main driving force. Ongoing Sundaland- Philippine Sea plate convergence may still play role in present-day deformation)


(Coals in mangrove sediments of Sandakan Fm of Sandakan Peninsula with vitrinite reflectance (Ro) 0.31-0.49%, indicating immature- very early mature for hydrocarbon generation. Dominated by Type III kerogen, with some Type II/III. Presence of dinoflagellate cysts and offshore mudstones consistent with rel. high sulphur content from marine inundations. Palynomorphs with abundant mangrove and freshwater pollen Presence of Florschuetzia levipoli, F. meridionalis and F. semilobata suggests E-M Miocene age)


(Petrography and geochemistry suggest Miocene Lambir and Sibuti Fms clastics derived from recycled sedimentary/metasedimentary sources in an evolving passive-to-active continental margin setting)


(later at: https://gsmpubl.files.wordpress.com/2017/09/ngsm2017_032.pdf)

(Miocene quartz-rich clastics of Tukau and Belait Fms sourced from area comparable to Rajang-Crocker mountain belt in Borneo hinterland. Tukau Fm supplied from moderately-weathered continental hinterland composed of acidic igneous and/or metamorphic lithologies, and older sediments. Miocene Belait Fm reflects stronger weathering and significant input of mafic minerals (i.e. biotite, Mg-chromites))


(Late Miocene or younger (‘10–2.6 Ma) Tukau Fm of Sarawak formation unconformably overlies M Miocene Lambir Fm. Clastics highly mature and recycled from weathered sedimentary- metasedimentary sources, with granitoids and mafic-ultramafic rocks. Cretaceous and Triassic-age detrital zircons from felsic rock, tie to granitoids of Schwaner Mts (Kalimantan) and Tin Belt granites, but probably recycled via Rajang Group, uplifted and eroded in Neogene. Chromian spinels indicate minor influence of mafic- ultramafic rocks. Deposited in passive margin with passive collisional and rift settings)


(Airborne gravity survey database for land and marine areas compiled to update geological map of Sabah)


(Bunguran Trough intra-continental basin in deepwater setting of Rajang Delta, off Sarawak. Characterised by deepwater clastic deposition of post-M Miocene Unconformity sediments. Pre-MMU sediments now buried to >6000m One potential source rock intervals currently mature for hydrocarbon generation in post-MMU sequences is Lower Pliocene section)


(later at: https://gsmpubl.files.wordpress.com/2017/09/ngsm2017_032.pdf)
Brief review of geologic model of 3x5km M-L Miocene carbonate buildup of TX Field, 170km N of Bintulu, offshore Sarawak

(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/333/228)
(Facets and permeability changes in outcrops of M Miocene Belait Fm in Berakas Syncline, Brunei)

(Lithological-structural mapping with remote sensing of mineralized zones in Bau gold field in W Sarawak with Carlin style gold deposits. Late Triassic Serian Volcanics overlain by Late Jurassic- Cretaceous sediments. E Jurassic deformation event, with 190 Ma Jagoi granodiorite. M Miocene Bau Trend porphyritic granodiorites with porphyry-copper style mineralization, skarn, limestone polymetallic replacement, epithermal precious metal, disseminated gold, and Ba-Hg deposits)

(online at: www.gsm.org.my/products/702001-101713-PDF.pdf)
(Four geological terranes make up Kudat Peninsula: (1) N Sabah exotic Terrane (Eocene sandstones with M-L Eocene Suang Pai Lst with Discocyclina, Pellatispira, etc.), separated by (2) Kudat Fault Zone (up to 6 km wide horst with E Cretaceous ophiolite and oceanic crust) from (3) Slump Terrane (wide area from Sikuati to Kota Marudu, consisting of mainly lower slope turbidites with slump intervals). S-most terrane is (4) Mengaris Duplex (latest Eocene to Oligocene West Crocker Fm turbidites)

(Oligocene- E Miocene deep marine Crocker Fm in SW Sabah deformed by M Miocene faulting-folding, under NW-SE compression)

(Zircon dating of 6cm thick tephra layer in thick coal near Mukah, Sarawak, suggests latest M Miocene volcanic event (main zircon age group ~11.4- 11.8 Ma). Also older inherited zircons)

('Giant amber from Sarawak'. Large (up to 3.5m long, >10cm thick)slabs of fossil resin (amber), associated with coaly beds in Miocene Nyala Fm)


(online at: www.sciencedirect.com/science/article/pii/S1674987118301087)
(Digital imaging and reservoir quality analysis of 750m outcrop of Late Miocene or younger, shallow marine-deltaic Sandakan Fm, Sabah)

(online at: www.jurnalteknologi.utm.my/index.php/jurnalteknologi/article/view/3677/3373)

(online at: www.arpnjournals.org/jeas/research_papers/rp_2016/jeas_0216_3513.pdf)
(Crustal profile model across Deepwater Fold and Thrust Belt, Sabah Trough, Dangerous Grounds Province and Thrust Sheet Zone. Formation of half-grabens and normal faults in Dangerous Grounds which subducted beneath Sabah Trough. Moho depth (top upper mantle) range 26-33km)

(1910 oil discovery in U Miocene Miri Fm of N Sarawak by Anglo-Saxon Petroleum (Royal Dutch/Shell Group) in area of oil seeps. Peak production reached 15,211 BOPD in 1929. Total production by end-1940 ~7 MBO; 597 wells had been drilled in the field. Field closed in 1972)

(online at: http://theses.whiterose.ac.uk/18877/1/Sulaiman_NB_%20Earth%20and%20Environment_PhD_2017.pdf)
(On the offshore NW Sabah gravity-driven extensional-compressional system. Pulses of M Miocene- Recent proximal uplift started in E (now onshore) part of NW Borneo and increased slope elevation and sediment supply to basin. Shortening resulted in response to gravity spreading of uplifted continental interior)

(On diagenesis of elevated Quaternary reef limestone in Celebes Sea, E of Sabah)

(online at: www.gsm.org.my/products/702001-101680-PDF.pdf)
(Eocene- E Miocene Crocker Fm of Sabah with large sole markings near Kaung Village on mid-slope of Mount Kinabalu, incl. >10m long groove casts. Effects of turbulent flow. Nereites-Zoophycos ichnofacies with Paleodictyon confirm bathyal-abyssal depth of deposition. In other localities of Crocker Fm in Sabah, paleocurrents ran N-ward, exception near Kaung Village where S-directed)

(online at: http://www.gsm.org.my/products/702001-101721-PDF.pdf)
(Sabah under WNW-ELSE compressive stress due W-ward movements of Philippine-Pacific plate against SE-moving Eurasian plate, causing NE-SW trending active thrust faults and NW-SE trending strike-slip faults. Resultant regional folding/ warping of upper crust produced uplifted NE-SW belt in W Sabah (Crocker-Trumadi Range) and is thought to be driving extensional tectonics, creating 6 elongate Quaternary graben-like basins (Tenom, Keningau, Tambunan, Ranau, Timbua and Marak-Parak))

(online at: jurnal.batan.go.id/index.php/eksplorium/article/download/2814/2586)
(Outcrop facies study of M-L Miri Fm in Miri Field area, Sarawak. Two main facies associations: (1) tide-dominated estuary; and (2) wave and storm-dominated facies)


Wang, P.C., S.Z. Li, L.L. Guo, S.H. Jiang, I.D. Somerville, S.J. Zhao, B.D. Zhu, J. Chen, L.M. Dai, Y.H. Suo & B. Han (2016)- Mesozoic and Cenozoic accretionary orogenic processes in Borneo and their mechanisms. In: Evolution of West Pacific Ocean, South China Sea and Indian Ocean, Geological J. 51, Suppl. S1, p. 464-489. (Borneo Accretionary Orogen Mesozoic- Cenozoic accretionary orogeny, with intensely deformed Rajang-Crocker Gp Accretionary prism, ophiolites and calc-alkaline igneous rocks. Four episodes of Sabah deformation: (D1) displacement foliation (S1) and NNE-trending thrusts (Sabah Orogeny; 23-16 Ma); (D2) WNW- or NW-striking thrusts (formation of Deep Regional Unconformity at 16 Ma), followed by NNW-SSE-trending thrusts and folds; (D3) Shallow Regional Unconformity at 10 Ma; (D4) NNE-trending sinistral strike-slip faults and WNW-trending dextral thrusts (NW-SE-trending extension after multi-stage collisional events). Accretionary orogen related to evolution of Proto-S China Sea, which continuously subducted under Borneo Block and closed in Late Eocene- E Miocene. BAO still active, as thrusting and subduction of Dangerous Grounds under Borneo Block. NNE-trending faults considered as transform faults, rotating to present-day NW-trending faults due to CCW rotation of entire Borneo Block. Previous NNE-trending Tinjar Fault major boundary, with Oligocene- E Miocene strata and igneous rocks to NE, and Cretaceous-Late Eocene to SW)

Wolfenden, E.B. (1961)- Molluscs from the Bau Formation of the Tebakang area, First Division. Geol. Survey Department British Territories in Borneo, Annual Report 1960, p. 47- (Brief note on Late Jurassic fauna in conglomeratic shale of Bau Lst Fm of W Sarawak: ammonites (Lithacoceras or Subplanites), bivalves (Nuculana, Cucullaea, Astare, Corbula). No figures)

Wong, Y.L. (2012)- Stratigraphy of the Ransi Member of the Middle Eocene to Oligocene Tatau Formation in the Tatau-Bintulu area, Sarawak, East Malaysia. M.Sc. Thesis, University Malaya, Kuala Lumpur, p. 1-256. (online at: http://studentsrepo.um.edu.my/3871/) (Ransi conglomerate-sandstone originally dated as U Miocene-Pliocene, but basal part of U Eocene- Oligocene Tatau Fm. Separated from underlying more tightly folded Belaga Fm by angular unconformity. Conglomerate mainly angular- subangular clasts of chert, quartz, igneous and metamorphic fragments. Igneous clasts rhyolite similar to M Eocene igneous intrusion at Bukit Piring in Tatau Area. Source of Ransi beds mainly from chert and metamorphic rocks of older Rajang Fp to S, as indicated by paleocurrent determinations. Volcanic clasts suggest volcanic source in hinterland during deposition. Arip Lst (equivalent to or younger than Ransi Mb) in Tatau Formation to SW with M-L Eocene microfossils such as Discocyclina, Nummulites, Pellatispira)


(online at: www.kahaku.go.jp/research/publication/geology/download/41/L_BNMNS_C41_29-43.pdf)

(Tinjar-West Baram Line is NW-trending trans-lithospheric fault in N Borneo; its NW extension into S China Sea is W Baram Line. Originated as NE/NNE-trending transform fault during spreading of Proto-South China Sea before 35 Ma and before NW trending strike-slip movement since Oligocene)
IV.A. Makassar Straits (17)


(Review of E-M Eocene synrift sediments of Makassar Straits wells and proto-Barito and Kutai and W Sulawesi basins, areas with similar Eocene stratigraphies. Non-marine syn-rift deposition likely initiated in M Eocene, in peripheral foreland, with widespread marine shales by Late Eocene. Area of well-developed lacustrine M Eocene in E part of S Makassar Basin)


(Makassar Straits formed by M Eocene extension, typical Sundaland, grabens and half-grabens. With top syn-rift unconformity of Late Eocene (38-40 Ma) age. Basement is stretched continental crust. Deepwater sediments deposited in response to tectonic events in adjacent Borneo and Sulawesi in Late Eocene- Neogene. M Miocene pulse of E-directed quartzose turbidites deposited in deepwater. All petroleum system elements present)


(West Seno in Makassar Strait PSC in 2400- 3400’ of water on slope of N Mahakam Delta discovered in 1998 and is Indonesia’s first deepwater oil-gas field. First production in 2003. U Miocene reservoir sands series of deepwater amalgamated channel and channel-levee deposits (see also Redhead et al. 2000))


(online at: http://archimer.ifremer.fr/doc/00268/37924/36005.pdf)

(Variations in sediment sources in Makassar Straits (Indonesia) in the late Quaternary: the role of morphostructural and eustatic factors'. Mineralogy of sediments from Makassar Straits show differences between sediments supplied from Kalimantan in W and Sulawesi in E. Kalimantan source quartzitic sand, with rare feldspars. Heavy minerals mainly pyroxene (hypersthene) and amphibole, clays mainly illite-kaolinite. Sulawesi source abundant feldspars, lithioclase and mica, with amphibole and pyroxene (augite) and illite-chlorite clay minerals. During Late-Pleistocene of sealevel lowstand Mahakam River discharged directly on shelf edge, dominating sediment supply. Rising sealevel in Holocene trapped river sediments in delta, so most sediment supplied to Makassar Straits from steep Sulawesi margin)


('Eocene palynomorphs from C Makassar Straits'. Interval 8100'-11850' of Well O’ in Makassar Straits with Eocene age palynomorphs, incl. Proxapertites operculatus, P. cursus, Palmaepollenites kutchensis, Cicatricosisporites eocenicus, etc. Lower abundance/diversity than in Nanggulan Fm of C Java, probably due to Late Eocene age. Appearance of moderate Restioniidites punctulosus pollen indicates dry climate)

('The development of porosity and permeability of deep marine detrital limestones marine sediment in the area of the Paternoster Platform, South Makassar Basin')


(Ruby Field gas discovery in Late Oligocene Berai Fm deep marine, re-deposited carbonate debris reservoir near Paternoster Platform. Limestone clasts range from pebble-size to boulders in matrix of micrite and fine bioclasts. Matrix-supported facies better porosity-permeability than clast-supported facies. Porosity generally moldic and vuggy, resulting from dissolution, and controlled by deep-burial diageneis by dewatering of underlying Lower Berai Fm bathyal shales and overlying Lower Warukin shales during burial)


(Comparisons of submarine fan lobe dimensions from six different systems, including Pleistocene fan of Kutai basin/ W Makassar Straits (mainly from data in Saller et al. 2004, 2008). Pleistocene basin floor fan 22x22 km across, deposited during period of low sea level that ended at ~240 ka, fed by paleo-Santan River, N of Mahakam river. Main depocentre of fan located where seabed gradient decreases from 2.1° (slope) to 0.3° (basin floor), basinward of toe-trust belt)


(online at: www.searchanddiscovery.com/documents/2013/50847saller/ndx_saller.pdf)

(3D seismic data y of Pleistocene shelf margin, slope and basin offshore E Kalimantan/ Makassar Straits. Clastic sequences on shelf dominated by progradational packages deposited during highstands and falling eustatic sea level. During last two sea level lowstands (~18 and ~130 ka), coarse lastics generally not deposited in deep-water because lowstand deltas did not prograde over underlying shelf margin. During lowstand of ~240 ka, deltas prograded over previous shelf edge, and sand-rich sediments spilled onto slope. Channel levee complexes on slopes where deltaic sediment supply was large (paleo-Mahakam River); incised valleys/canyons on slopes with limited clastic input. Basin floor deposits dominated by mass-transport complexes, suggesting slope valleys and canyons formed by mass failures of slope, not erosion associated with turbidite sands)


(online at: www.searchanddiscovery.com/documents/2017/51393saller/ndx_saller.pdf)

(For last 7 My carbonates mixed with siliciclastics N of Mahakam delta. Modern carbonates deposited locally N of delta while large amounts of clastics coming out of delta. Late Pleistocene carbonate mounds(on upthrown side of faults) and shelf margin carbonates (on underlying shelf margins) repeatedly grew during transgressions. During sea level highstands siliciclastics prograded across shelf, covering many carbonates. During last 7 My shelf margins generally backstepping landward N of Mahakam delta. Shales covering carbonates are downlapping packages, generally not effective seals)


(N and S Makassar basins originated as continental rift in triple-junction rift-system. Classified as marginal sea, flanked in W by Asian continental margin and by volcanic arc of Sulawesi in E. Strongly positive gravity anomalies suggest it is underlain by oceanic crust. Melawi-Ketungau basins of Kalimantan possible third arm of triple junction rift system. Possible presence of turbiditic reservoir rocks, and favorable conditions for accumulation of organic matter during initial rifting stage of seafloor spreading suggest Makassar basins may be highly prospective)


(S Makassar Straits 'M' gas field (= Ruby/ Makassar Straits) developed in Oligocene- E Miocene Berai Fm carbonate slope debris reservoirs. With multistage diagenetic and tectonic evolution, incl. phase of late deep burial leaching)


('The geotectonic views of the North Makassar Straits, its implications for the potential of marine hydrocarbons in the Kutai basin, East Kalimantan'. Literature review of geotectonic evolution of Makassar Straits and potential for hydrocarbons in deepwater Makassar Straits in toe thrusts around Mahakam Delta. Seismic character, water depths, gravity modeling, etc. suggest much of Makassar Straits, including the Mahakam Delta, underlain by oceanic crust, as continuation of Eocene spreading in Celebes Sea)
V. SULAWESI (113)

V.1. Sulawesi (108)


(online at: http://searg.rhul.ac.uk/pubs/advokaat_etul_2017%20Extension%20North%20Sulawesi.pdf)
(Malino Metamorphic Complex (MMC) in W part of N Arm of Sulawesi previously suggested to be metamorphic complex exhumed in E-M Miocene. New data suggest MMC metamorphic core complex which underwent extension during E-M Miocene, but no exhumation at this time: (1) Pliocene undeformed granitoids intrude MMC indicating complex still at depth and (2) Pliocene- Pleistocene cover sequences do not contain metamorphic detritus. Second phase of extensional uplift with brittle faulting from Late Miocene-Pliocene onwards, with MMC exhumation (synchronous exhumation of adjacent Palu Metamorphic Complex in W Sulawesi, and rapid offshore subsidence in Gorontalo Bay). Linked to N-ward slab rollback of S-subducting Celebes Sea since Pliocene, and ongoing at present day)

(online at: www.bgl.esdm.go.id/publication/index.php/dir/article_detail/732)
(Same paper as Budiman et al. 2011). Totopo West gold prospect, W of Gorontalo, probable Miocene andesitic volcanics unconformably overlain by Pliocene-Pleistocene dacitic volcanics, all intruded by are intruded by contemporaneous diorite and dacite porphyry dykes. Additional exploration required)

(Discussion of historical Bugis accounts (La Galigo) suggesting expansion of Tempe, Sidinreng and Buaya lakes in SW Sulawesi and possible seaway across SW Arm of Sulawesi)


(High seismic activity rates, both along fast-slipping crustal faults(Palu-Koro-Matano Fault) and in regions of distributed deformation, contribute moderate-high earthquake hazard over all but the SW part of Sulawesi)

('Quaternary geodynamics of the Sulawesi region'. Collection of papers on Quaternary of Sulawesi)

(online at: http://archive-ouverte.unige.ch/unige:4764)
(E-M Jurassic (Toarcian- Bathonian) calcareous nannoplankton above Late Triassic limestones in dismembered succession in Kolonodale-Beteleme area of W margin of E Sulawesi Zone)

(Sediment geochemistry of cores from Lake Towuti in C Sulawesi records paleoclimate changes over last 60 ka. During Last Glacial Maximum no changes in sediment provenance, despite drier climate, but trace elements suggest decrease in weathering intensity, likely in response to decreased precipitation and temperature)

(online at: http://www.bgl.esdm.go.id/images/stories/warta_geologi/pdf/warta201003.pdf)

('Ophiolite in the East Arm of Sulawesi'. Brief review)


(Senoro gas field in E Sulawesi divided into two carbonate reservoir areas: (1) N Senoro with Mentawa carbonate buildup facies, and (2) S Senoro with Minahaki platform carbonate facies)


(Awak Mas gold deposit in metamorphic belt of Sulawesi. Hosted by low-metamorphic Cretaceous Latimojong Fm flysch sequence locally intruded by diorite dykes. Believed to have formed by hydrothermal fluids sourced from metamorphic dewatering reactions of marine sediments (mesothermal orogenic gold deposit))


(Kabaena island off SE Sulawesi contains ultramafic rocks (peridotite), Pommpangeo Complex low-medium grade metamorphics (amphibilite, schist) and metamorphosed, fractured Matano Fm limestone and some black shale. Ultramafic rocks thrust over microcontinental rocks. Gas seepage in limestone unit tied to strike slip fault. Not much new)

(online at: http://repository.unhas.ac.id/bitstream/handle/123456789/15298/ )

('Depositional environment of the marl unit of the Tonasa Formation based on benthic foraminifera, case studies: Camming River and River Palakka Barru, S Sulawesi Province'. Mainly middle-outter neritic facies ('30.48- 182.88m'), concluded from nodosarids-dominated benthic foram assemblages in Early-Late Eocene of Tonasa Marls in two outcrop sections)

Farida, M., Pratiwi & R. Husain (2014)- Paleotemperature of Middle Eocene Tonasa Limestone based on foraminifera at Palakka Area South Sulawesi. Int. J. Engineering and Science Applications (UNHAS) 1, 1, p. 77-84.
(online at: http://pasca.unhas.ac.id/ojs/index.php/ijesca/article/view/137/93)

(Interbedded marl/limestone at Palakka section, Barru area (presumably basal Tonasa Lst) with lower M Eocene (P11) planktonic foraminifera and middle? neritic small benthic forams ('warm water= 0-27°C'))

(Zircon ages from Banggai-Sula and E Sulawesi. Granites from Banggai-Sula region with mainly Permo-Triassic age zircons. Also one Banggai-Sula granitoid with 23-26 Ma zircons. Banggai and Taliabu metamorphics mainly Proterozoic zircon ages. Sulabesi metasediments with Permo-Triassic zircons. SE
Sulawesi Mekongga Fm metamorphics with Mesozoic-Paleozoic and Mesozo-Paleoproterozoic zircons, but youngest zircon ~170 Ma (M Jurassic) (similar zircon distribution in Triassic-Jurassic Meluhu clastics)

(Paleogeographical reconstructions with genetic and morphometric datasets from Sulawesi's three largest mammals (babirusa, anoa, Sulawesi warly pig) indicate these likely colonized Sulawesi at different times (14 Ma to 2-3 Ma), and experienced near-synchronous expansion from central part of island at ~1-2 Ma. Endemic fauna of Sulawesi driven by geological events over last few million years)

(On genesis of garnierite nickel ore, mainly in veins in lower saprolite of serpentinite-derived regolith. Ni preferentially enriched in talc-like phases rather than serpentinite-like phases)

(Awak Mas and Salu Bullo gold deposits in Latimojong Metamorphic Complex, S Sulawesi. Latimojong MC part of Late Cretaceous accretionary complex with high-P metamorphics, W of obducted Lamasi Complex (= E Sulawesi Ophiolite?). Gold hosted in quartz veins in pumpellyite- to greenschist-facies metasedimentary and metavolcanic rocks. Metamorphic reactions in metasedimentary rocks during retrogression stage considered main source of ascending fluids forming Au-mineralization)

(Gold deposits in Latimojong Metamorphic Complex, S Sulawesi (Awak Mas, Salu Bulo), in pumpellyite- greenschist facies metasedimentary and metavolcanic rocks. Gold in quartz veins in N-S normal faults and extensional fractures. Minerals dominated by pyrite, chalcopyrite, galena, minor tetrahedrite and sphalerite; gold is electrum with low silver content. Gold bearing fluids trapped in quartz at ~180-250 °C at depths <5 km. Isothermal decompression during retrogression stage mobilized large volumes of fluids, leading to significant gold mineralization)

(Awak Mas metasedimentary-hosted gold deposit in Cretaceous metamorphic Latimojong Fm, S Sulawesi. Hosted by phyllite-schists representing metamorphosed shales derived from acidic arc volcanic rocks in continental island arc setting, and metamorphosed under low P-T conditions (greenschist-facies). Obduction and thrusting of Lamasi Ophiolite Complex onto Latimojong Metamorphic Complex in Miocene led to ductile deformation, followed by crustal thickening that caused melting at base of crust and granitic magmatism at 5.8-1 Ma. Granodiorites of calc-alkaline magmatic affinity emplaced in transition between volcanic-arc and syn-collisional granite tectonic setting. Extensional collapse caused brittle deformation (normal faulting/ fracturing) and formation of veins controlled gold mineralization. Awak Mas epigenetic, orogenic gold deposit)

(Awak Mas one of metamorphic-rock hosted gold deposits in C Sulawesi metamorphic belt. Dominant lithologies slate, phyllite and mica schist. Mineral assemblage reflects high P/ low T environment or greenschist facies metamorphic rocks. Extensional faults, shears and fractures control gold mineralization)
(online at: http://journal.uir.ac.id/index.php/JGEET/article/view/434/376)
(On 'orogenic gold' in gold-bearing quartz veins in Pompangeo Metamorphic Complex of Permo-Carboniferous metasediments and mica schists at Rumbia Mountains, SE Sulawesi. Veins sheared/deformed and brecciated. 1- 15.7 cm thick. Associated with pyrite, chalcopyrite, hematite, cinnabar, stibnite and goethite. Gold also in derived placer deposits)

(online at: http://searg.rhul.ac.uk/pubs/hennig_etal_2017%20Rapid%20cooling%20Palu%20Sulawesi.pdf)
(Metamorphic complexes form 1.5- 2km high mountains in W Sulawesi, and younger than previously thought. Some have Eocene sedimentary protoliths. Palu Metamorphic Complex strongly deformed and partially melted to migmatites. 40Ar/39Ar dating shows cooling in E Pliocene (~5.3-4.8 Ma) in N, and Late Pliocene (~3.1-2.7 Ma) in S. Intruded S-type granites similar Pliocene ages. Fast cooling and rapid exhumation in very young orogenic belt. Contemporaneous magmatism and deformation interpreted as consequence of decompressional melting due to extension. I-type magmatic rocks, separated from PMC by Palu-Koro Fault exhumed from upper crustal levels at moderate rates)

(online at: https://journal.ugm.ac.id/jag/article/view/26962)
(Quartz ± gold veins in Rampi block prospect mainly hosted by metamorphic and metasedimentary rocks of Latimojong Fm and Pompangeo metamorphic complex. Orientation and distribution of veins controlled by NW-SE and NE-SW trending structures. Orogenic/mesothermal gold type, with similarities to Awak Mas mesothermal prospect in Luwu district)

(Examples of metamorphic rock-hosted 'orogenic' gold mineralization in Bombana (Rumbia Ms, SE Sulawesi: gold-bearing quartz veins in Pompangeo metamorphics) and NE Buru Island (quartz veins in Permo-Carboniferous Waulhua mica schists))

(online at: http://journal.uir.ac.id/index.php/JGEET/article/view/291/130)
(same as Idrus et al. 2016)

(Modeling of N-content suggests that highest grade zones are concentrated below slopes in 5-19° range)

(online at: http://pasca.unhas.ac.id/ojs/index.php/ijesca/article/view/163/118)
(Pleistocene raised reef terrace with reef front, reef core and back reef facies in Bira area at SE tip of S Arm Sulawesi. Part of complex of four seaward-young narrow terraces of U Miocene-Pleistocene 'Selayar Limestone', reflecting uplift of area (Bone Bay rift shoulder?; JTvG))

('Lithofacies analysis of Pare-Pare volcanic rocks in the Lumpue area of South Sulawesi'. Rock types of latest Miocene-earliest Pliocene (~4-7 Ma) Pare-Pare volcanic deposits)

(online at: http://buletinsdg.geologi.esdm.go.id/index.php/bsdg/issue/archive)
('Heavy metal enrichment of Mn, Co, and Cr in nickel laterite in North Konawe Regency, SE Sulawesi'. Weathering of ultramafic rock causes Mn, Co and Cr enrichment mostly in laterite, whilst Ni concentrated in transitional bedrock. Highest REE concentrations in lateritic horizon)

(Geochemistry of N Konawe ultramafic rocks suggest origin in arc tholeiitic tectonic environment setting. SiO2 38.5- 41%, etc. Emplaced in E Cretaceous, unconformably overlain by Late Cretaceous Matano Fm)


(online at: http://repository.unhas.ac.id/handle/123456789/16802)
('Study of the macrostructure (mesoscale structure) of metamorphic rocks in the Barru region, S Sulawesi'. Barru metamorphic block composed of low- moderate grade metamorphic rocks, with foliation generally NE-trending and tilting to SE. Two main stretching directions i.e., SE-NW-trending and NE-SW-trending, both plunging to W. Fault low angle dip-slip or thrust and horizontal movement or strike-slip. Locally high angle dip-slip faults. Folds formed earlier than faults)

(online at: http://repository.unhas.ac.id/handle/123456789/16801)
('Structure and deformation of metamorphic rocks in the Poboya region of Central Sulawesi province'. Poboya/E Palu District in 'neck' of Sulawesi with outcrops of molasse sediments, gneiss and biotite schist. Folding and post-Tertiary horizontal faulting.Quartz crystal orientations and porphyroblasts in amphibolite-greenschist facies indicate formation at low-medium T (300-700°C) and P <1 Gpa, during syn-tectonic sinistral shear, related to Palu-Koro regional fault)

(online at: http://repository.unhas.ac.id/bitstream/ ...)
'Olistostrome and precious stones in the Bantimala tectonic complex, Pangkajene District, S. Sulawesi'. Bantimala Complex composed of metamorphic rocks such as glauconphane schist, hornblende mica schist, eclogite, granulate, phyllite and metaquartzite of Triassic age. Olistostrome components schist, quartzite, metachert, jadeite, Jurassic-Cretaceous metamophidolite and Cretaceous sediments (flysch, shale, sandstone, mudstone and radiolarian chert). Basement contains precious stones like agate, jade, turquoise, etc.)

('Morphology and hydrography of the Toili plain (East Sulawesi). Geographic description of East Arm of Sulawesi. With 1: 200,000 topographic map of SE coast of East Arm)

(Seismic suggestive of carbonate duplex structure under ophiolite in Banggai-Sula foreland basin imbricate thrust zone (Batu Thrust belt), E Sulawesi)

(Banggai-Sula Foreland Basin in Matindok Block, E Sulawesi, is product of Late Miocene- E Pliocene collision between Banggai Sula microcontinent and E Sulawesi Ophiolite-magmatic arc of Sundaland. Onshore wells Matindok-7 and Penyu-1, and discovered gas-condensate in M-52 carbonate layer of Plio-Pleistocene Celebes Molasse. M-52 turbiditic carbonate 3 layers, with (reworked?) Miocene Lepidocyclina, poosity 10-20%)


(Pomalaa nickel mine/prospect in SE Arm of Sulawesi, 30km S of Kolaka, in N-Co laterite on East Sulawesi Ophiolite. Typical laterite profile: weathered, serpentinized ultramafic bedrock overlain by 2-7m thick saprolite layer with average 1.7-2.3% nickel (mainly garnierite), overlain by 3-7m thick yellow and red limonite zone with 0.4-1.2% nickel)

(Re-description of Trygon vorstmani De Beaufort 1926, an E Miocene stingray from fish-bearing limestones of Tonasa Fm near Patoneoang Asoe E in Maros District of SW Sulawesi. Assigned to new genus Protohimantura. First holomorphic stingray specimen from Neogene)

(online at: https://archive-ouverte.unige.ch/unige:4766)
(Widely outcropping Late Triassic reefal carbonate platform between Kolonodale and Tomata on W margin of Ophiolitic Zone of E and SE arms of Sulawesi. Late Norian-Rhaetian age based on rich benthic foraminifera, and also on youngest Mesozoic conodont Missikella posthemsteini. Two foraminiferal associations, lagoonal (Triasina hantkeni and other Autotortidae) and reefal (porcelaneous foraminifers incl. Galeanella). Main
(Study of granitic rocks from 11 areas in W and N Sulawesi. Plutons classified as (1) high-K /shoshonitic (HK), mainly in S and CW part of W Sulawesi; (2) high-K calc-alkaline (CAK) in C and NW part of province; (3) low K- tholeiitic, dominant in N Sulawesi. Most granitoids metaluminous I-type granitic rocks. HK and CAK granitic rocks derived from partial melting of lower crustal sources with arc signature; low-K /tholeiitic granites from oceanic crust. Crystallization depths ~4-12 km. Rapid exhumations of granites in W Sulawesi triggered by Late Miocene- Pliocene collision of Banggai- Sula microcontinent with E Sulawesi (Ar-Ar cooling ages 9.5.1 Ma. Exhumation of granites in N Sulawesi attributed to Celebes Sea subduction)

(Chromite occurs in chromitite as podiform lenses or layers 10-40 cm thick in depleted lherzolite and dunite from Bantimala and Barru blocks, S Sulawesi. Also other differences in mineral chemistry, suggesting chromitites originated in different settings, Bantimala from parental melt in island arc environment, Barru from boninitic lava)

Maulana, A. (2014)- Iron ore occurrence in Balanalu area Limbong District North Lhuwu South Sulawesi. J. Penelitian Geosains (Hasanuddin University) 10, 1, p. 38-49. (online at: http://repository.unhas.ac.id/) (C Sulawesi magnetite and hematite mineralization in weathered and brecciated andesitic-dacitic tuff)


(Lateritic soil of ultramafic rocks of Sulawesi may be potential source of scandium, while weathered I-type granitic rocks could be potential source of rare earth elements (but no actual data to support this?))


Maulana, A., K. Watanabe and K. Yonezu (2016)- Petrology and geochemistry of granitoid from South Sulawesi, Indonesia: implication for Rare Earth Element (REE) occurrences. Int. J. Engineering and Science Applications (UNHAS) 3, 1, p. 79-86. (online at: http://pasca.unhas.ac.id/ojs/index.php/ijesca/article/view/280/164) (Late Miocene- Pliocene calc-alkaline I-type granitoids at Polewali and Masamba, 300-400 km N of Makassar, W Sulawesi, with average REE content 249 and 194 ppm. REE-bearing minerals zircon, monazite and apatite)

Maulana, A., K. Watanabe, K. Yonezu, G. Zhang & T. van Leeuwen (2016)- Exhumation and tectonomagmatic process of granitic rock from Sulawesi. Proc. GEOSEA XIV and 45th Ann. Conv. Indon. Assoc. Geologists (IAGI) (GIC 2016), Bandung, p. 362-364. (In C and N parts of W Sulawesi Late Miocene- Pliocene granite plutons rise to 3000m altitude. P-T data suggest increasing depth of emplacement of plutons from CW to NW Sulawesi (~2.1 to ~11km) and more rapid exhumation (0.37- 2.7 mm/year. Most rapid uplift tied to Palu-Koro fault activity)


(NW-SE trending Lawanopo fault of SE Sulawesi considered as active left-lateral strike-slip fault. Exposures of fault are clear, and it serves as tectonic boundary between different rock assemblages. Young fault, but no evidence of recent activity, consistent with lack of seismicity on fault)


(Celebes Molasse in SE Sulawesi unconformable over pre-Miocene rocks, post dating E Miocene Sula Spur collision. Three units: (1) serpentine-rich clastic unit (pre-Latest Miocene), (2) limestone unit (Latest Miocene-Holocene) and (3) quartz-rich clastic unit (Late Miocene-Pliocene).


(New paleogeographic maps from E Miocene-Pleistocene (20-1 Ma), after Sula Spur- N Sulawesi volcanic arc collision. For most of Neogene Sulawesi shallow marine area with small islands surrounded by deeper marine areas. Onset of extension at ~15 Ma. Deep inter-arm bays began to form in Late Miocene and islands became larger. Pliocene increase in land area and elevation accompanied by major subsidence of inter-arm bays. Separate islands coalesced in Pleistocene to form distinctive K-shaped island known today)


(online at: https://agu.confex.com/agu/fm17/meetingapp.cgi/Paper/219367)

(Neogene sediments of Celebes Molasse in SE Arm of Sulawesi show unroofing series: (1) U Miocene Pandua Fm dominated by serpentinite and chrome spinel, less polycrystalline quartz and metamorphic, etc. lithics (mainly sourced from ultramafic rocks) and (2) latest Miocene-earliest Pleistocene Langkowala Fms poor in serpentinite and increasing metamorphic detritus including glaucophane/lawsonite (from exhumation of HP-LT metamorphic complexes). Two formations separated by angular unconformity)


(Neogene stratigraphy of Sulawesi with five regional unconformities: (1) E Miocene (~23 Ma), (2) M Miocene (~15 Ma), (3) latest Miocene-earliest Pliocene (~ 6-5.3 Ma), (4) E Pleistocene (~1.8 Ma), and (5) M Pleistocene (~1 Ma). E Miocene collision between promontory of Sula Spur and N Sulawesi volcanic arc, causing ophiolite emplacement in E Sulawesi. M Pliocene unconformity in some areas of N Sulawesi. With 10 paleogeographic maps)


(Bakan gold mine 200km SW of Manado in N Arm of Sulawesi operational since 2013. Cluster of epithermal high-sulphidation gold occurrences hosted by Plio-Pleistocene dacitic tuffs that are unconformable over Miocene andesitic lavas and sandstones. Mineralization similar to North Lanut mine)


(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/151/141)

(Volcanoes and subsea hydrothermal activities in North Sulawesi waters: mineralization and tectonic implications'. IASSHA 2003 expedition in Sangihe islands waters identified the submarine volcano of Kawio Barat and observed hydrothermal activities at Roa, Naung and Banoa Wuhu. At Kawio Barat volcano polychaeta 'tube worms' colony growth on rock at methane gas seep)

(online at: www.bgl.esdm.go.id/publication/index.php/dir/article_detail/736)
(Awak Mas gold project in S part of C Sulawesi Metamorphic Belt, SSW of Palopo, explored since 1987. Hosted in intensely folded (WSW to SW-directed thrusting?, generally 15-50°N-dipping) Late Cretaceous Latimojong Fm flysch-type phyllites, slates, volcanics, limestones and schists, overlying basement metamorphic rocks and intruded by late diorite-monzonite plugs and stocks. T-P regime suggests either subduction or massive thrusting environment. ~N-S trending oblique normal faults and extensional fractures local controls to mineralization)

(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/238/228)
('Geologic structure of Bone Bay, South Sulawesi'. Bone Bay water depth 50-2000m. Seafloor morphology strongly influenced by active faults, incl. flower structures)

('Contribution to the petrography of the Minahassa, North Sulawesi'. Petrographic description of volcanics and plutonic rocks of NE Sulawesi: diorite, diabase, dacites, andesites, basalt. Also granite near Gorontalo)

(Se-bearing Au-Ag low-intermediate sulphidation epithermal mineralisation in River Reef Zone of Poboya prospect, 12 km NE of Palu, C Sulawesi. Hosted in metamorphic and igneous rocks)

(online at: http://pubs.usgs.gov/sir/2010/5090/d/sir2010-5090d_text.pdf)
(W Sulawesi magmatic arc part of 1200-km-long Sulawesi- Sangihe magmatic arc, active since M Miocene-Pliocene. W-dipping subduction zone. Displacement of W Sulawesi arc system over Makassar Straits/ Celebes Sea in response to Banggai-Sula microcontinent collision, resulting in Pliocene-Pleistocene uplift of composite arc system. No known porphyry copper deposits, but Malala porphyry molybdenum (4.14 Ma) in N)

(online at: http://pubs.usgs.gov/sir/2010/5090/d/sir2010-5090d_text.pdf)
(Two known porphyry copper-gold deposits in S-C part of N Sulawesi tract: Tapadaa (3.75 Ma) and Tombulilato (3.0 Ma))

(Sulawesi North Arm more than simple oceanic arc. Paleogene granites suggest basement evolved arc crust or continental crust, but few inherited zircon ages. Neogene granites with Paleozoic and Proterozoic inherited zircon cores, suggesting melting of Australian continental crust. Two periods of sedimentation: M Miocene and Late Miocene-Pliocene. Two major fault trends: E-W Neogene basin-bounding faults and young NW-SE strike-slip faults. Record indicates arc-continent collision and underthrusting of Australian crust in E Miocene (~22 Ma), with later extensional episodes. Metamorphic core complex formed on land in M Miocene (~15 Ma), and later extension linked to initiation of S-ward subduction of Celebes Sea in latest Miocene- E Pliocene (~5 Ma))
Planktonic foraminifera biostratigraphy of the sandstone unit of the Pasangkayu Formation, Lariang Basin, West Sulawesi. (online at: http://repository.unhas.ac.id/handle/123456789/16805)

'Planktonic foraminifera biostratigraphy of the sandstone unit of the Pasangkayu Formation, Lariang Basin, West Sulawesi'. Pasangkayu Fm in Pasangkayu area of W Sulawesi with upper M Miocene- E Pliocene planktonic foraminifera (N14-N19; G. nepenthes-Gr siakensis to Gr tumida- Sphaeroidinellopsis subdehiscens zones)


'Tomori Basin at S side of East arm of Sulawesi is Miocene foreland basin in collision zone between Sundaland/ E Sulawesi Ophiolite and Banggai-Sula microcontinent. Source rock analysis of onshore E Sulawesi Mesozoic Tokala, Nanaka and Tetambahu shales show hydrocarbon source potential: TOC 0.32- 3.46% and mainly type III kerogen. Rock-eval Tmax measurements suggests immature to marginally mature (428- 432°C), but vitrinite reflectance Ro 0.56- 0.76%) and TAI data (2-2.5) suggest sediments early mature to peak mature


'Prediction of chromite minerals using Induced Polarization (Ip) method in the area of North Kabae na, Bombana, SE Sulawesi'. In N Kabae na island chromite present in Cretaceous ultramafic peridotites and as alluvial deposits. Electric methods used to predict distribution


'Analysis of fractures in Pre-Tertiary melange complex of Bantimala area South Sulawesi, Indonesia. Common fracture orientations NW-SE, W-E, NNE-SSW and ENE-WSW, different in each lithology. Fracture intensity in schists higher than other lithologies'


'Causes and sources of high-K in volcanic and plutonic rocks in Tana Toraja, N part of South Sulawesi: associated crust, magma evolution and tectonic regime'. Mio-Pliocene high-K volcanics and plutonics in Tana Toraja area, S Sulawesi, formed in post-subduction tectonic regime, with magma interacting with crust, creating 'continental affinity'


'Sedimentation processes in Bone Basin, based on interpretation of seismic reflection in waters of Bone Bay, South Sulawesi'. Deep marine Bone Basin between S and SE arms of Sulawesi formed in Paleogene-Neogene. Initial Bone Basin formed by Cretaceous subduction, then developed as intra-montane basin. May be underlain by oceanic crust in Paleogene. Quaternary deposits influenced by reactivation of Walanae Fault. Six main seismic sequences A-F. Unit B Oligocene limestone, Unit C Late Oligocene- E Miocene volcanics, etc.)

(New GPS velocity observations in agreement with previous results: CW rotation of North Arm, Tomini Gulf opening and left-lateral strike slip of Palu-Koro fault. SW Sulawesi moves as part of Eurasian-Sunda Block with some compression at Makassar Straits (6.25 mm/yr to W). Palu-Koro Fault rapid strike slip faulting)

(Sulawesi characterized by rapid rotation in several different domains and compression-strain pattern varies depending on type and boundary conditions of microplate)

(Review of E Sulawesi stratigraphy and early tectonic scenario for Sulawesi. Accepts presence of Permo-Carboniferous rocks in E Sulawesi. Pretectonic rocks in E Sulawesi (with ophiolite) and Banggai Sula (with pink granites) similar age range, but seem to be of different origin. Several tectonic melange complexes (incl. Cretaceous) and olistostromes)

('Eocene-Lower Miocene gravity sedimentation in Tana Toraja, South Sulawesi (Indonesia)')

(Unpublished)
('Petrology and geochemistry of volcanic rocks in Togean Islands, Tomini Bay, Central Sulawesi: implications for the tectonic structure of Sulawesi'. Volcanic rocks from Togean Islands 3 types: (1) Una Una (adakitic subduction volcanics from partial melting of Celebes Sea slab at 70-85 km depth), (2) Togean (both adakites, basaltic-trachyandesite and result of partial melting of Sulawesi Sea slab in amphibole-eclogite zone) and (3) Walea (tholeitic basaltic-andesite and tholeite basalt, interpreted as upper part of ophiolite, formed around 6 Ma from seafloor spreading due to rollback of oceanic crust of Banggai-Sula microcontinent)

(online at: https://www.jstage.jst.go.jp/article/jmps/111/3/111_150907/-/pdf)
(Evolution of high-P metamorphic rocks from Bantimala Complex, S Sulawesi))

(online at: www.seed-net.org/wp-content/uploads/2015/12/GEOCHEMICAL-CHARACTERISTIC...)
(same paper as Setiawan et al. 2013)

(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/344/226)
(Adang Volcanics ~400m thick series of (ultra-) potassic- sodic lavas and tuffs of mainly trachytic composition, part of widespread Late Cenozoic (latest Miocene- E Pliocene) high-K volcanics in W Sulawesi. Tectonic setting and origin debated. Major rock forming minerals leucite, diopside/aegirine and high T phlogopite. Geochemistry suggests formation in post-subduction, continental rift tectonic setting)

(online at: www.cocop.or.th/download/as/52as2.pdf)


('Geology of the Palu valley, Central Sulawesi, using remote sensing techniques'. Palu-Koro Valley 250 km long, is reflection of sinistral Palu-Koro strike slip fault, with active movement estimated at 2-3.5mm to 14-17 mm/year, totaling 3.25 km. Palu-Koro fault separates two different terranes)

(online at: https://journal.ugm.ac.id/jag/article/viewFile/7178/5618)


('Very thin layers (up to 15cm thick) and lenses of Late Miocene coals in Mandar Fm in Polaman Regency, westernmost Sulawesi. Mainly vitrinite (93.4-98.6 %), followed by inertinite (1.2- 3.0 %). Vitrinite reflectance Rmax 0.56-0.60%, indicating high volatile bituminous coal rank)


('Tectonic setting of Adang Volcanic Complex in Mamuju Region, West Sulawesi Province '. Adang volcanic complex in W Sulawesi subdivided into seven complexes. K-Ar ages ~3.4 (sandine)- 2.4 Ma (biotite). Basic-intermediate alkaline volcanics with high radioactivity. Volcanic center and several lava domes, composed of phonolite to dacite rock, with ultrapotassic affinity, formed in active continental margin and influenced by SW Sulawesi micro-continental crust (see also Shaban et al. 2016, suggesting rift volcanism))


('High concentrations of radiometric U and Th in Mamuju area, W Sulawesi, in ultrapotassic, leucite-bearing (Pliocene?) basaltic-intermediate Adang Volcanics. Three volcanic domes, probably submarine volcanism; submarine flanks of volcano dominated by erosive-depositional and mass-wasting features)

(online at: www.lemigas.esdm.go.id/publikasi/read/scientific/1)

(Tolo Bay E of East Sulawesi, with water depth of up to 3500m. Part of Banggai Basin and within Late Cretaceous - M Miocene collision zone between Banggai-Sula Microcontinent and E Sulawesi. Drift phase sediment at front of Banggai-Sula Microcontinent is potential source and reservoir rock. Hydrocarbon exploration very risky)
Oldest omarkers indicate, but n3.4.

Bibliography of Indonesia Geology, New for Ed. 7.

Complexes upper plate plates marked by breaks (N Arm of Sulawesi (NAoS), Indonesia, to Szentpeteri (Gold mineralization hosted (online at: www.mdpi.com/2075

Central Sulawesi, l Syafri, I. (200

of oil seeps is Eocene Toraja or Kalumpang Fm. Maturities at generation equivalent with Ro 0.8-1.0 %)


('The chemical composition of eclogite and garnet-glaucophane rocks of the Bantimala complex, S Sulawesi, Indonesia and their possible origin')


('Characterization of mineralogy of a lateritic nickel deposit in the Tinanggea area, South Konawe Regency, Southeast Sulawesi': Lateritic nickel from advanced weathering of Ni-silicate bearing ultramafic rock)


(Gold mineralization hosted in granite, biotite gneiss and biotite schist of Palu Metamorphic Complex)


(N Arm of Sulawesi with 4 active gold mines. Three oceanic plates subducting under N Arm. Molluca andCelebes plates dip opposite to each other, Sangihe plate at right angles to other two. Variations in subducting plates marked by breaks in morphology and earthquake intensity, corresponding to arc-transform structures in upper plate. N Arm and Tomini and Gorontalo Bays in extensional regime (incl. uplifts of metamorphic core complexes), possibly tied to slab detachment and/or rollback of Sulawesi Trench. Young (5-1 Ma) Au-Cu


('Depositional environment of Tonasa carbonate rock formations in the Karama area, District of Bangkala, Jeneponto, South Sulawesi Province'. Outcrop of M Eocene Tonasa Fm marl dominated section with limestone interbeds at S-most tip of S Sulawesi deemed to be deposited in middle shelf environment)
mineralized districts in N Arm related to extensional features and intersections with transtensional arc normal faults (which may extend as tear faults on lower, opening window to mantle))

(Three small NE Gondwanan blocks from E or SE collided with W and N Arms of Sulawesi, at W-dipping subduction zone(s): (1) Late Oligocene- E Miocene ‘Kolonodale Block’, tectonically capped by large ophiolite; (2) M Miocene ‘Lucipara Block’ collision with Kolonodale Block; (3) M Pliocene ‘Banggai-Sula Block’. Kolonodale Block strikingly similar to Timor; Lucipara and Banggai-Sula blocks similar to Birds Head)


(Latimojong Metamorphic Complex in C-W Sulawesi is accretionary complex of metamorphic rocks tectonically mixed with cherts and ophiolitic rocks, overlain(?) by unmetamorphosed U Cretaceous Latimojong Fm distal turbidites (accretionary complex). Aptian-Albian radiolaria in chert float sample in Latimojong Metamorphic Complex. Foraminifera ages from Toraja Group (56-23 Ma), Makale Fm (20.5-11.5 Ma) and Enrekang Volcanic Series (8.0-3.6 Ma). Magmatic zircons record ~38, ~25 and 8.0-3.6 Ma phases of volcanism. Late Miocene E Pliocene high-K Enrekang Volcanics (~ 3.9-7.5 Ma) and Palopo Granite (6.6-4.9 Ma) may be tied to crustal extension/ slab rollback. Miocene-Proterozoic inherited zircons in Pliocene igneous rocks support Proterozoic-Phanerozoic (193, 38-34 Ma) basement or sediments derived from these. Little evidence for Oligocene-Pliocene thrusting in Latimojong region)

(Nickel grades reach maximum in saprolite zones. Fracture density in ultramafic bedrocks played important roles during laterisation. In Sorowako ultramafic complex of East Sulawesi Ophiolite Complex high-medium fractured types of bedrock tied to thick saprolite zone)

SW Sulawesi coal deposits at Paluda, Padanglampe, Lamuru and Tondongkura. Lower moisture of Paluda coal might be affected by igneous intrusion. Coal samples generally high ash (29%) and sulfur(3.74.%). No vertical distribution trend for ash and sulfur)

(Gold-copper mineralization associated with granodiorite of Sungei Mak in Gorontalo similar to other porphyry copper deposit(s) in Tombolilato District (>3400m thick Late Miocene- Pleistocene island arc-type volcano-sedimentary pile)

(Chromite from S and SE Arms of Sulawesi varies from Cr-rich to Al-rich. Small platinum-group minerals (PGM) in chromitites mainly laurite. Accumulation of Cr-rich chromitites probably at deep mantle level, Al-rich chromitites close or above Moho-transition zone. All laurites considered to be magmatic in origin)
(Tiaka offshore oil field and Matindok, Minahaki, Donggi and Senoro onshore gas fields Banggai Basin, E Sulawesi, sourced from Tertiary (high oleanane). Two oil types, A and B, generated from marine carbonate and shale source rocks. Senoro gas thermogenic, formed from secondary cracking. Matindok gas thermogenic, generated from mixed gas source and the most mature gas)

V.2. Buton, Tukang Besi (5)
(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/269/259)
('Geological structure south of Buton island'. Shallow reflection seismic lines in waters S of Buton and Muna)

(Bitumen content of 'Asbuton' 10-40%. Geoelectrical resistivity survey and x-ray fluorescence shows Ca is dominant element in asphalt rock (40-90%), indicating limestone (surprise!))

(Bitumen from Pasar Wajo, Buton island classified as asphalt. Low concentrations of sulfur and trace elements and lack of normal-chain hydrocarbons)

(Late Cenozoic coral reef terraces identified on 23 islands of Tukang Besi and Buton archipelagos. Reef terrace sequences from Wangi-Wangi (Buton) and islands of Ular, Siumpu and Kadatua with terraces from last interglacial maximum (MIS 5e; ~122 ka) at elevations <20m, at 34m on W Kadatua. On SE Buton reef terraces up to 650m, with >40 undated strandlines. On Sampolawa Peninsula 18 strandlines up to 430m, possibly as old as 3.8 ± 0.6 Ma)

VI. NORTH MOLUCCAS  (39)

VI.1. Halmahera, Bacan, Waigeo, Molucca Sea  (16)


volcanics. Potential Miocene carbonate buildups now interpreted to be Oligocene thrust complexes. Clastic reservoir provenance likely dominated by volcanic rocks. No indications of active hydrocarbon system)

(Molucca Sea subduction zone in NE Indonesia in SE Asia is unique Cenozoic example of 'divergent double subduction' (DDS). Asymmetrical shape. DDS probably associated with closure of narrow and short oceanic plate; large-scale double subduction is rare in nature)
VI.2. Banggai, Sula, Taliabu, Obi (6)

(online at: www.cagsbulletin.com/dqxbcn/ch/reader/create_pdf.aspx?file...)
(Large Sn-Fe polymetallic deposit in C Taliabu, Banggai-Sula islands, sourced from Triassic monzogranite derived from partial crustal melting. Mineralization in contact zone between granite and Carboniferous metasediments, including skarn type iron ore in contact with Carboniferous marble. Ore deposit belongs to E Australia metallogenic belt that moved to SE Asia)

(online at: http://jurnal.unpad.ac.id/bsc/article/view/8266/3813)
('Survey of nickel in Soligi area. South Obi, North Maluku'. Pretertiary ophiolite and metamorphics are oldest rock in W and S Obi Island. Nickel and cobalt-bearing laterite weathering zones at tops of hills)

(Gravity modeling of E Sula basin area suggests E Sula (Taliabu) island on continental crust, with oceanic crust to N and S. Basement depth in block from -954 to -10245m, gradually deepening to S. E-M Jurassic rift fill clastics (Bobong Fm) in N-S trending grabens)

('Geological, radiometrical and geochemical studies of Banggai granites and Bobong Formation to determine potential uranium areas in Taliabu Island, North Maluku'. Late Permian-Triassic Banggai granite is potential uranium source, E-M Jurassic fluvial-deltaic sandstone of Bobong Fm is potential host rock)

('Gravity anomaly pattern of Taliabu- Mangole area and surrounding seas, related to oil and gas prospectivity')

(Seismic data in deepwater basin between Obi and Bacaan/ S Halmahera, formed as pull-apart basin along Sorong fault zone. Indications of Miocene Kais carbonate buildups and potential gas chimneys)

VI.3. Seram, Buru, Ambon (17)

(Brief review, showing highly variable porosity and TOC in Triassic Kanikeh Fm outcrop samples)

(online at: https://spiral.imperial.ac.uk/handle/10044/1/36159)
(Planktonic Foraminifera of Nief Beds indicate deposition during Cretaceous, Paleocene, Eocene and Miocene in deep bathyal environment. Corroded radiolaria in U Jurassic- Lower Cretaceous part of Nief Beds indicate deposition close to compensation depth for silica at ~4000 m. Fine grain-size and radiolaria-dominated
microfauna of Saman Saman Lst indicate deposition in very deep marine water. Microfaunas of Late Triassic Asinepe Lst reveal deposition during Norian in reefal- sublagoonal environment)

('Marble on Ambon Island'. Brief note on samples of light grey, grey and black marble. Age unknown)

(Seram Trough began to form in Late Pliocene due to loading by Seram fold-thrust belt. Tanimbar Trough originated in Late Miocene as elongate extensional structure within Australian continental margin. Weber deep is major young extensional feature. None of troughs are subduction zones. Etc.)

(online at: http://pubs.usgs.gov/sir/2010/5090/d/sir2010-5090d_text.pdf)
(Assessment of porphyry copper deposits in Pliocene-Quaternary Ambon island arc. Two suites of island-arc magmas: (1) 5- 3.2 Ma, low-K calc-alkaline basalts, andesites, dacites and rhyolites, evolved from basaltic magmatism from mantle melting above W Irian Jaya Plate as it subducts along Seram Trough; (2) 2.3-1 Ma, high-K calc-alkaline basalts, andesites, rhyolites and granites (incl. ambonites= cordierite-bearing dacites) and granites, representing magmas that assimilated continental crust. Hila porphyry Cu-Au prospect on Ambon Island (3.6 Ma))

(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/22/22)
(Seismic profiles at Seram Trough show avalanches of Pliocene- Quaternary base-of slopes material in front of Seram accretionary prism)

(online at: www.biodiversitylibrary.org/item/196149#page/379/mode/1up)
('Travel results from the Moluccas'. Summary of geological observations on Seram. No figures. More detail in Martin (1903))

(online at: http://pasca.unhas.ac.id/ojs/index.php/ijesca/article/view/276/160)
(Gold-bearing quartz veins in greenschist facies metamorphic rocks (muscovite schist and phyllite; probably metasediments) at Gunung Botak, Buru, reflect epithermal- high sulphidation gold mineralization)

(Seram Trough commonly interpreted as accretionary wedge/ subduction zone beneath Seram, but is shallower than typical subduction zone and marks deformation front of fold-thrust belt resulting from young oblique convergence between Outer Banda arc and Birds Head. Fold-thrust belt zone narrower in W (with thrusting ceasing thrusting ceases at E edge of Buru oceanic basin) and widens to SE. Thrusting at the trough started in Late Pleistocene)


Pownall, J.M., M.A. Forster, R. Hall & I.M. Watkinson (2017) - Tectonometamorphic evolution of Seram and Ambon, eastern Indonesia: insights from 40Ar/39Ar geochronology. Gondwana Research 44, p. 35-53. (Two main phases in Seram Neogene tectonic evolution: (1) 16 Ma episode of extreme extension that exhumed hot lherzolites from subcontinental lithospheric mantle and drove UHT metamorphism and melting of adjacent continental crust (kyanite-grade metamorphic event of Tehoru Fm across W and C Seram); and (2) 5.7, 4.5 and 3.4 Ma episodes of extensional detachment faulting and strike-slip faulting that further exhumed granulites and mantle rocks across Seram and Ambon. Events interpreted to be result of W Seram ripping off from SE Sulawesi, extended, and dragged E by Banda Slab subduction rollback)

Pownall, J.M., R. Hall & R.A. Armstrong (2017) - Hot lherzolite exhumation, UHT migmatite formation, and acid volcanism driven by Miocene rollback of the Banda Arc, eastern Indonesia. Gondwana Research 51, p. 92-117. (N Banda Arc (Seram) exposes upper mantle lherzolites and lower crust granulite facies migmatites of 'Kobipoto Complex'. Granulites experienced ultrahigh-T (> 900°C) at 16 Ma due to heat supplied by lherzolites exhumed during slab rollback in Banda Arc. Ages of detrital zircons from Kobipoto Complex 3.4 Ga- 216 Ma, suggesting W Papua/ W Australian Archean protolith and post-Late Triassic metamorphism. Zircons in granulites 3 later growth episodes: 215-173 Ma (= subduction beneath Birds Head and Sula Spur?), 25-20 Ma (collision between Sula Spur and N Sulawesi?), and ~16 Ma. 16 Ma zircon rims grew during M Miocene metamorphism and melting of Kobipoto complex rocks beneath Seram under HT-UHT conditions. Extension during continued slab rollback exhumed both lherzolites and adjacent granulites beneath extensional detachment faults in W Seram at 6.0-5.5 Ma, and on Ambon at 3.5 Ma. Ambonites and dacites sourced mainly from melts generated in Kobipoto Complex migmatites erupted on Ambon from 3.0-1.9 Ma.)


'The Wawani on Ambon and its reported eruptions, part 3'. Wawani mountain on Ambon with diabase and porphyric igneous rock, but is not a volcano

(N Seram Basin evolution interpreted as four stages: E Triassic initial rifting, M Triassic- M Jurassic rifting, Late Jurassic- M Miocene passive continental margin and Late Miocene-Quaternary thrusting of foreland foldbelt (Seram and Birds Head viewed here as part of same continental block; no subduction/collision))
VII. BANDA SEA, LESSER SUNDA ISLANDS (78)

VII.1. Banda Sea, East Banda Arc (incl. Tanimbar, Kai, Aru) (7)


(Late Cretaceous (Campanian-Maastrichtian) progradational package in Barakan-Tanimbar (W Aru) margin. Late Cretaceous ('Ekmat') delta top sands without hydrocarbons penetrated by Barakan-I and Koba-I wells. Potential new hydrocarbon play)


(Lakuwahu cluster of mineral deposits hosted by andesitic Lakuwahi Volcanics on S Romang near Wetar. Formed in shallow submarine caldera, subsequently covered by reefal limestones. Dominant Pb-Zn mineralization. Uplift in past 1-2Myr caused emergence of Romang Island)


(On hydrocarbon prospectivity in accretionary prism thrust structures in Timor Sea S of Babar)


(Weber Deep 7.2-km-deep forearc basin in Banda Sea is deepest point of Earth's oceans not within trench. Formed by forearc extension driven by E-ward subduction rollback. Lithospheric extension in upper plate accommodated by major low-angle normal fault system named 'Banda detachment'. Bathymetry data reveal Banda detachment is exposed underwater over much of 120 km downdip and 450 km lateral extent)


(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/14)

('Delineation of sedimentary basin and subsurface geological interpretation of the Tanimbar basin based on analysis of gravity data'. Gravity survey on and around Yamdena Island suggest six sub-basins. NE-SW trending basement high)


(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/181/177)

('Gravity field and geodynamic models around the Kai and Aru Islands, Moluccas'. Kai- Aru area underlain by continental crust. Kai islands formed by thrusting. Aru islands by rifting)


('The Banda dilemma': Discussion of nature and age of crust below Banda Sea)

VII.2. Lesser Sunda- West Banda volcanic Arc (Bali-Lombok- Flores- Wetar) (24)


(online at: https://link.springer.com/content/pdf/10.1007%2Fs11589-017-0179-2.pdf)


(HALBACH P. I cruise in 2001 examined SE trending submarine ridge in tectonically active Flores-Wetar Basin, extending to Komba (Batu Tara) volcano. Seamount cross-cut by left-lateral NW-SE faults, with intervening z-shaped plain (pull-apart structure). Rock samples K-rich porphyritic volcanics (trachyandesites, trachydacites), locally impregnated with sulphides (epithermal low-sulphidation metal deposits)


(In Flores-Wetar basin N of Lomblen NW-SE trending submarine hills extending to Komba Island (Batu Tara). Hills cut by several NW-SE faults. Samples mainly porphyritic K-rich basaltic trachyandesite and trachydacite. With epithermal-type mineralization halo)


(Same paper as Harahap et al. 2014, above)


(Elang large porphyry Cu-Au deposit ~70 km E of Batu Hijau on SE Sumbawa. Associated with tonalite porphyry intrusions hosted by andesitic volcanics. Elang typical of number of Cu-Au porphyry systems where magnetite associated with mineralisation and produces strong magnetic anomaly)


('Petrography of submarine volcanic rocks of the Mount Komba complex, Flores Sea, Indonesia'. Dredge samples from water depths 130-900m of Gunung Komba submarine volcano complex, NE of Flores, composed of andesite-basaltic lava flows. Varying degrees of propylitic or sericitic alteration)


(On magmatic and hydrothermal biotite in Batu Hijau porphyry copper-gold deposit, Sumbawa)


(On hydrothermal micas in alteration zone of Batu Hijau porphyry copper-gold deposit, Sumbawa)


(E Sunda arc major porphyry metallogenic belt (Tumpangpitu/ Tujuh Bukit Au-Ag-Cu deposit in E Java, Batu Hijau and Elang on Sumbawa). Porphyry mineralization confined to E segment (E Java to Sumbawa), where Roo Rise subducting island arc. Subeconimic porphyry prospects at Selogiri, Ciemens, Cihurip with low sulfidation epithermal deposits (Pongkor, Cikotok, Cibaliung, Cikondang, Arinem) along W segment of Sunda arc, developed on thick continental crust on S Sundaland margin, associated with 'normal' Indian oceanic crust subduction. Porphyry deposits typically with large lithocaps (>20 km2), with high sulfidation epithermal gold-silver veins within lithocaps at Elang, Selodong, Brambang and Tumpangpitu)


(E Sunda arc hosts three premier porphyry Cu-Au deposits between E Java and Sumbawa: Batu Hijau, Elang, and Tumpangpitu. Built on island-arc crust where Roo Rise is being subducted. Along W segment of arc (W Java), major epithermal deposits associated with poorly endowed porphyry prospects, on thick continental crust of S margin of Sundaland, associated with subduction of thin Indian oceanic crust. Porphyry Cu-Au deposits associated with small, nested, dioritic-tonalitic intrusive complexes, with mineralization during three main events. Large (>20 km2) lithocaps with high-sulfidation epithermal systems. Porphyry deposits formed between 2-2.5 Ma, suggesting important change in metallogeny of arc at this time)


(On exploration techniques of large Cu-Au porphyry deposits under barren or mineralized lithocaps. Five major discoveries in last 15 years in E Java and Sumbawa)


(Mineralogy and chemistry of magmas erupted over last ~12 kyr at Rinjani-Samalas volcanic complex on Lombok. Calc-alkaline series, moderately rich in K2O. Pre-caldera stage bimodality of magmas (basalt-trachydacite); post-caldera magmatism basaltic andesites. Possibly result of mixing between basalt and trachydacite melts. AD 1257 caldera-forming eruption large volume of trachydacitic magma)


(Mineral alteration on Abang Komba submarine volcano, Flores Basin, caused by hydrothermal solutions)

(Three submarine ridges off NE Flores waters: Baruna Komba (S of Komba/Batutara active volcano), Abang and Ibu. Magnetic data suggest Baruna Komba Ridge not volcanic, but possibly volcanic detritus. Abang and Ibu Komba ridges related to submarine magmatism)

('Subsurface structure interpretation based on magnetic anomaly attributes of Wetar waters, East Nusa Tenggara'. Identification of back-arc frontal thrust and submarine volcano edifices from magnetic and shallow seismic data in E Flores Sea/ S Banda Sea, N of Banda Arc islands Alor- Wetar)

(Shallow seismic lines in S Banda Sea, N of Alor- Wetar, in zone of back-arc thrusting. Delineation of Alor Thrust and Wetar Thrust, offset by N-S left-lateral strike-slip fault. Also possible submarine volcano structures)

(GPS campaign shows horizontal displacements between 1.9 and 22.5 mm/yr, dominantly to NE. Deformation in Bali mostly controlled by subduction in S and East Flores back-arc thrust in N)


(Iron isotope values of andesite and quartz diorite and coeval hypogene ore minerals from Batu Hijau porphyry copper-gold deposit in Sumbawa)

Yeh, H., F. Imamura, C. Synolakis, Y.Tsuiji, P. Liu & S. Shi (1993)- The Flores Island tsunamis. EOS Transactions American Geophys. Union (AGU) 74, 33, p. 369, 371-373. (December 12, 1992 Ms 7.5 earthquake and tsunami off N Flores with epicenter 50km NW of Maumere, hypocenter depth 15km. Considered to reflect activity in N Flores backarc thrust zone. Tsunami runup height up to 26m, inundation distance ~600m)

VII.3. Sumba, Savu, Savu Sea (2)


('Joint study of the drainage systems and uplifted Pliocene-Quaternary paleocoasts: examples from Indonesia and the Gulf of Normandy-Brittany'. In French. With chapters on raised coral reef terraces of Sumba (E Indonesia) and Huon Peninsula (PNG))


VII.4. Timor, Roti, Leti, Kisar (incl. Timor Leste) (34)


(Metamorphic age of highest-grade rocks formed in Timor arc-collision collision remains controversial. U-Th-Pb dating of monazite from Aileu Fm amphibolite-grade schists suggests peak metamorphism at 5.5-4.7 Ma)


(Detrital zircon U-Pb age data from Aileu Complex and 'Gondwana Sequence' of Timor, indicate both derived from common source with 200-600 Ma, 900-1250 Ma and 1450-1900 Ma zircons. Most significant age population ~260 Ma. Similar spectrum of ages along E active margin of Pangea, today best exposed along NE coast of Australia. Mudstones of Aileu Complex more siliceous and other chemical differences from 'Gondwana Sequence', so possibly eroded from different sections of margin and deposited in separate basins. Present proximity result of Pliocene- Recent collision between N Australia plate and Banda Arc)


('New finds of rocks of the alkali series on Timor' - Part 2. Brief note on reddish alkalirhyolites SW of Sufa collected during Molengraaff West Timor Expedition. (No figures or details on geologic setting))


(Onshore block in SW part of Timor Leste now held by national oil company Timor Gap EP. 18 exploration wells drilled between 1960-1973: ten with hydrocarbons, two (Matai-l/-1A and Cota Taci-l) tested oil in subcommercial quantities. At least 37 surface hydrocarbon seeps (14 oil, 23 gas) across block. Gas from seeps both high-mature thermogenic (from Permian?) and biogenic. Triassic calcareous restricted marine shale likely source for all Timor oils. Likely subthrust inversion anticlines of Permo-Triassic rifts)

(Five phases of oil-gas exploration in Timor Leste since 1893)

(Uppermost Gzhelian (possibly lowermost Asselian) 9-24m thick bioherm on basalt near Kalau, 6 km WNW of Maubisse, in highlands of Timor Leste. With abundant foraminifera belonging to 17 genera (incl. fusulinids Ozawainellidae, Schubertellidae, Schwagerinidae, etc. Two new Schwagerina species: S. timorensis and S. maubissensis in oldest carbonate unit recorded from Maubisse Fm. Also Eostaffella spp., Schellwienia spp. Timor was in N part of N-S East Gondwana rift system along which W margin of Australia later developed. Timor fauna most closely related to faunas from S China and Changning-Menlian region of Yunnan)


(A crinoid pluricolumnal from Noil Simaam, Timor, identified as Barycrinus? sp., youngest member of this otherwise E Carboniferous genus)

(Along Timor sector of Banda Arc synorogenic piggy-back basins formed above melange unit, exhumed to sea floor in latest Messinian. Following deep marine marl sedimentation, increasingly muddy sediment flux indicates emergence of Timor 4.5 Ma. Sediment source probably 50-60 km to N. Sedimentation between 4.5-3.2 Ma probably derived from mudstone-dominated landscape with geochemical affinities to the Triassic-mudstone-rich synorogenic melange, which overlies and surrounds Banda Terrane. After 3.2 Ma, sedimentation dominated by hard rock lithologies of Banda Terrane, and accompanied by rapid uplift)

(online at: http://www.publish.csiro.au/ex/pdf/ASEG2018abP031)
(Review of Mesozoic of W Timor and comparisons to Australian NW Shelf, suggesting similar hydrocarbon plays)

(online at: http://www.dwc.knaw.nl/DL/publications/PU00016941.pdf)
(Crinoid Dinocrinus cornutu, described from E Permian of Timor by Wanner, probably junior synonym of Calceolispongia hindei Etheridge known from W Australia (not from India, but Netherlands Indies; JTvG))

(online at: www.journal.lemigas.esdm.go.id/index.php/LPMGB/article/view/428)
"The oil and gas seepages in West Timor. Many oil and gas seeps in W Timor, generally associated with mud volcanoes. Gas seeps in all mud volcanoes in W Timor; oil seeps only at mud volcanoes in S part of W Timor. Gas mainly methane (CH4) and minor ethane (C2H6) with high N2 content. Gas Chromatography of oil seeps suggest oil probably originated from lacustrine or marine-transition environments"


(U Artinskian- Kungurian deposits in Timor-Leste and Canning, S Carnarvon and N Perth basins of W Australia formed between 35- 55°S paleolatitude in East Gondwana interior rift, a precursor to rift that 100 My later formed Indian Ocean in region. Timor lay near main axis of E Gondwana rift. Main depocentres developed by faulting initiated in latest Carboniferous. Cool conditions in early Late Artinskian (water T 0-4 °C), followed by rapid warming in late Artinskian and maximum marine flooding near Artinskian-Kungurian boundary. Carbonate mounds, with larger fusulines and algae developed in N part of rift; Tubiphytes, conodonts, and brachiopods with Tethyan affinities to migrate into marginal-rift basins. Bua-bai Lst (= 'upper Maubisse Gp) locally rich in Late Artinskian? fusulinid Praeskinnerella. Similar pattern of climate change in Carboniferous- E Permian between E Gondwana rift and Lhasa and Sibumasu terranes)

(Hili Manu peridotites in Manatuto District on N coast of Timor Leste, ∼50 km E of Dili with ultramafic rocks(serpentinised dunites, harzburgites and lherzolites associated with rare rodingites and gabbros) in two massifs, separated by amphibolite block. With chromitite bodies and Platinum-Group Mineralisation. Preliminary PGM Re-Os ages from 0.05 Ga (Subao Highway) to 0.21 Ga (Kerogeol Hill))

(Ultramafic rocks at Hili Manu, ∼50 km E of Dili, two ultramafic massifs separated by amphibolite. Chromitite bodies at Hili Manu small lenses few m in size. Chromites both high-Cr and high-Al types. Platinum-group minerals (laurite, etc.) as inclusions and in fractures in chromite or serpentine matrix. Peridotite geochemistry and chemistry of chrome-spinels suggest formation of Hili Manu peridotite in upper mantle in supra-subduction zone setting, part of young oceanic lithosphere from Banda Arc)

(Permian Bisane Fm of W Timor dominated by calcareous sandstone with abundant marine crinoid fossils. Intercalation of non-calcareous dark shale-siltstone with papery structure, 5m thick, with Permian striate-bisaccate pollen, incl. Protohaploxypinus samoilovichii and other species (associated with Glossopteris flora), Striatopodocarpidades phaleratus, Pinuspollenites globosaccus, Lunatisporites pellucidus, etc. and lack marine dinoflagellate. Possibly synrift lacustrine deposit)

Lelono, E.B., D. Kurniadi, K.D. Anggriyta & Saidah (2017)- Palynological review of the Permian lacustrine sediment in the West Timor. Proc. Joint Conv. HAGI-IAGI-IAFMI-IATMI (JCM 2017), Malang, 6p. (Palynology of new locality of 4m thick non-calcareous black 'paper shale' in central W Timor interpreted as Late Permian lacustrine deposit. High abundance but low diversity of palynomorphs. Tasmanites-green algae >80% of pollen assemblage; rest assemblage striate and non-striate bisaccate and trilete spore, characterising Permian age. Tasmanites blooms interpreted as lake supplied with meltwater from surrounding glaciers. Tasmanites algae potential hydrocarbon source (NB: Tasmanites commonly viewed as pelagic marine algae,
common in higher latitudes? (e.g. Barentsz Sea M Triassic marine oil shales with Tasmanites blooms and common Daonella bivalves; Vigran et al. 2008; JTvG). No details on locality)

(Bisane Fm sandstones-shales in W Timor outcrops with mica and abundant crinoids and up to 5m thick non-calcareous dark shale-siltstone with paperpenny structure and rich in sulfur. Permo-Triassic ages indicated by striate-bisaccate pollen, incl. Protopalynopsis samoilovichii, P. fuscus, P. goraiensis (= from Glossopteris plants), Striatopodocarpidites phaleratus, Pinuspollenites globosaccus, Lunatisporites pellucidus, also non-striate Falcisporites auratus, Samarapollenites speciosus, etc. Trilete-monosaccate spores of Plicatipollenites malabarensis and Cannoanopollis janakii in non-calcareous shale samples Permian or older age. Marine dinoflagellates in calcareous samples (incl. Dapsilidinium langii, Dingodinium jurassicum) suggest marine influence, and not present in non-calcareous samples. Possibly new petroleum system in Paleozoic of W Timor? (NB: dinoflagellates are latest Triassic-Jurassic species?; JTvG))


('Hydrocarbon potential of Pre-Tertiary sediments of the Atambua area, West Timor'. Atambua area with many hydrocarbon seeps. Permian shale of Bisane Fm and Triassic clay of Aitutu Fm are considered to be source rocks, Permian and Jurassic sandstone potential reservoirs, Jurassic of Wulaili Fm clay potential seal)

(U Triassic Carnian- U Carnian/Rhaetian basinal carbonate series with radiolaria, ammonites and conodonts. 6 lithostratigraphic units: A-B Carnian; C Norian with Gliscopollis meyeriana and Granulatoperculatipollis rudis; E with U Norian Monotis salinaria, etc. Adherance of Allochthonous of Timor to Australian margin highly questionable)

('Aspects of the petrography of limestones in the South Central Timor Area'. Petrography of limestones from N and E of Soe: Triassic Aitutu Fm (rich in phylloid algae (= Halobia-type bivalves?; HvG)), E Cretaceous Nakfunu Fm (rich in radiolaria), Late Cretaceous Menu Fm (with planktonic foraminifera) and Paleogene Ofu Fm (with benthic foraminifera and terrigenous material))

(Review of15 species of blastoid genus Deltoblastus, with introduction of 3 new species, based on material from Basleo, etc. (now in Waco and London museum collections))

(Hili Manu peridotite body in Timor Leste is spinel lherzolite peridotite with mylonitic structures. Geothermobarometry from exsolution lamellae of pyroxenes indicate peridotite formed at 1190°C and 8.5 kb (850 MPa). Rocks mylonitized at 964-1092°C and 4.9-5.7 kb (490-570 MPa). Metamorphism of underlying Permian Aileu Fm increases toward base of peridotite; sole metamorphism during peridotite emplacement)

Munasri & K. Sashida (2018)- Tethyan and non-Tethyan Early Cretaceous radiolarian faunas from West Timor, Indonesia: paleogeographic and tectonic significance. Earth Evolution Sciences (University of Tsukuba) 12, p. 3-12.

(Abundant and well-preserved E Cretaceous radiolaria in calcilutites and shales of Nakjunu Fm, Kolbano area, southern W Timor, in part of accretional complex. Radiolarian faunas similar to ODP Leg 123- Site 785 from Argo Abyssal Plain. Four assemblages of Berriasian- E Aptian age, with trend from non-Tethyan to Tethyan affinities in progressively younger strata. Frequent and random repetition of radiolarian assemblages reflect imbrication of beds. Faunas derived from S paleolatitude origin, influenced by Circum-Antarctic current)


(online at: http://ocean.kisti.re.kr/downfile/volume/kseeg/JOHGB2/2014/v47n1/JOHGB2_2014_v47n1_1.pdf)

(In Korean, with English title. Bobonaro melange syn-collisional melanges formed during collision between Australian continental margin and Banda arc. In Siuai area melange matrix of unmetamorphosed red-green clay with scaly texture, with allochthonous blocks. Melange classified into 1) diapiric; 2) tectonic; and 3) broken formation. Melange intruded all pre-collisional units including lower Australian margin unit (Gondwanan megasequence) and Banda arc unit. Interpreted to be mainly formed as diapiric melange originated from Gondwana megasequence)


('Comparison of provenance of the Babulu and Oebaat Formations of Savu Island, NTT'. Sandstone petrography of (1) Late Triassic Babulu Fm (quartz 21-54%, feldspar 3-18%, and mainly metamorphic rock fragments 1-28%; recycled orogen) and earliest Cretaceous Oe Baat Fm (quartz 72-99%, feldspar 1-4%, rock fragments 0-5%; craton interior))


(New constraints on history of uplift, exhumation and shortening of W Timor. Foreland thrust stack of Jurassic-Miocene Australian continental strata and hinterland antiformal stack of Permo-Triassic Australian continental units duplexed below Banda Arc lithosphere. Piggyback Central Basin with deepwater synorogenic deposition from 3.57-5.53 Ma, uplift from lower-m bathyal depths at 3.35-2.58 Ma, and uplift from m-a bathyal at 2.58-1.30 Ma. Hinterland Permo-Triassic with apatite (U-Th)/He ages of 0.33-2.76 Ma, apatite FT ages of 2.19-3.53 Ma. Youngest or most reset in center of antiformal stack. Minimum of 300km of shortening including 210km of Australian continental subduction below Banda forearc. Timor-Leste similar timing of collision, etc.)


('Quaternary tectonic activity on Timor')


(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/24/21)

('Geochemistry of the volcanic rocks of West Timor and its tectonic implications'. Geochemistry of basaltic rocks from Fatu River (interfinger with Permian Maubisse Fm limestone) suggests Oceanic Island Basalt. Oligo-Miocene metabasalt from Mutis Complex calc-alkaline, island arc volcanics. Metan River and Atauro Island (Banda Arc) subalkaline/ tholeitic volcanics)
Webster, G.D. & S.K. Donovan (2012)- Before the extinction- Permian platyceratid gastropods attached to platycrinid camerate crinoids and an abnormal four-rayed Platycriites s.s. wachsmuthi (Wanner) from West Timor. Palaeoworld 21, 3-4, p. 153-159.
(Examples of gastropods attached to Permian platycrinid camerate crinoids from W Timor)

(26 species of crinoid Graphiocrinus described from Permian of Timor by Wanner (1916-1949), but 12 belong to other genera, many others considered indeterminate members of several families. New taxa introduced)

(Biomarker compositions of oils from Masin Lulik mud volcano seep and surface sediments from the Atambua area, onshore Timor, show signatures of marine source facies (Pr/Ph 1.30- 1.83, absence of land plant biomarker signatures such as bicadinanes and oleananes). Low thermal maturity of oils (early mature) and surface sediments (immature). No information on sample locations or ages of rocks)

VII.5. Timor Sea, Indonesian Sahul Platform (11)

(SHmax stress direction NE-SW to N-S, subparallels convergence direction between Australia and Indonesia)


(online at: www.searchanddiscovery.com/abstracts/pdf/2002/hedberg_australia/images/ndx_gartrell.pdf)
(Fault reactivation related to late Tertiary collision of Australian continent with Banda Arc responsible for common occurrence of breached hydrocarbon traps in Timor Sea. Two stages of collision at Timor: (1) Late Miocene (8 Ma) when transitional Australian continental crust reached subduction system; (2) true continental crust entered subduction system in M Pliocene, and Timor Trough evolved as foredeep basin in response to imbricate thrust loading on Australian margin)

(Includes early Gulf Oil seismic profiles across Timor Sea showing frontal thrusting/ scraping off of sediment cover and piled on smaller surface to form S Timor- Tanimbar accretionary prism. Etc.)

(Probable Miocene carbonate pinnacle reef on 3D seismic of Babar Selaru Block, Timor Sea off SW Tanimbar)


Saqab, M.M. & J. Bourget (2016)- Seismic geomorphology and evolution of early-mid Miocene isolated carbonate build-ups in the Timor Sea, North West Shelf of Australia. Marine Geology 379, p. 224-245. (Seismic data show ~60 isolated carbonate build-ups of E-M Miocene age over wide area of NE Bonaparte Basin. Individual build-ups ~100m thick with average diameter of 3 km. Typical stratigraphic architecture: (1) M Burdigalian initiation (Tf1/CN2), (2) late Burdigalian lateral expansion (CN3), and (3) Langhian (Tf2/CN4) backstepping and drowning. Followed by (3) sub-aerial exposure during major Serravallian sea-level fall. Only small patch reefs developed afterwards during Late Miocene. Observed growth phases correlate with global sea-level fluctuations and major changes in global climate/oceanography; role of local tectonics minimal)

Saqab, M.M., J. Bourget, J. Trotter & M. Keep (2017)- New constraints on the timing of flexural deformation along the northern Australian margin: implications for arc-continent collision and the development of the Timor Trough. Tectonophysics 696-697, p. 14-36. (Numerous extensional faults in passive margin strata of N Bonaparte Basin, related to lithospheric flexure of descending Australian Plate in convergent setting, coincident with creation of Timor Trough as foreland basin and Cartier Trough. Onset of extensional deformation in latest Miocene (~6 Ma), coincident with onset of arc-continent collision in Timor Sea and development of Timor Trough. Second episode of increased tectonic activity around Pliocene- Quaternary boundary (~3 Ma), continuing intermittently to today)

Surjono, S.S. & I. Arifianto (2016)- Petrophysics analysis for reservoir characterization of Upper Plover Formation in the Field  않고, Bonaparte Basin, offshore Timor, Maluku, Indonesia. J. Applied Geol. (UGM) 1, 1, p. 43-52. (online at: https://journal.ugm.ac.id/jag/article/view/26959/16601) (Upper Plover Fin in Abadi Field not produced due to reservoir issues. Seven parasequences, in transgressive systems in coastal environments with coarsening upward patterns during M-L Jurassic. Porosity 1-19%, permeability 0.01- 1300 mD)


VIII. WEST PAPUA (WEST NEW GUINEA) (74)

VIII.1. New Guinea General and West Papua (67)


(Adi Basin narrow, deep water (1-3.5km) offshore basin E of Seram accretionary complex, N of Kai Island and Aru basin and SW of Lengguru foldbelt. Basin formation started in Late Miocene (after deposition of New Guinea Limestone; no wells?) and still active today. Adi-Aru Basin structures dominated by normal faults with NNE-SSW strike direction. Multiple episodes of subsidence, marked by unconformities in syn-extension units. Basin development influenced by sinistral movement of Tarera-Aiduna Fault, visible at N side of basin showing normal fault offset. Subsidence driven by slab pull of Australian subducting plate)


(Kumawa and Aru basins part of narrow N-S trending extensional system in Aru Trough, E of Kai Besar island-Kai Arch and E of Seram accretionary prism. Basin formation started in Late Miocene, with several periods of subsidence, marked by unconformities within syn-extension units. Tarera-Aiduna fault zone dies out to W, S of Lengguru fold belt)


(Area covered by perennial ice and snow in Carstenz (Puncak Jaya) area 6.9 km2 at end 1972)


(Permian sediments penetrated by several wells in Bintuni area mainly non-marine and deltaic facies, with gas in Vorwata-I and Mogoi Deep-I wells. Chemo-stratigraphy aids in stratigraphic correlation. Sediments likely sourced from acid-intermediate provenance)


(Brief review of under-explored fold-thrust belt of West Papua. Not much new. Proven hydrocarbon system, but, unlike in adjacent Papua New Guinea, no commercial discoveries)


(Review of E Cretaceous Woniwogi and Toro Sst and Late Jurassic Kopai Sst as crucial hydrocarbon reservoir targets. All are products of regression pulses during E Triassic- Late Cretaceous overall transgression. Valanginian Woniwogi (Alene) Sst well-developed in Birds Body and extends E into PNG. Berriasian Toro Sst only present in Digul region and PNG. Sediment provenance from Kemum and Arafura landmasses)


(Review of Mesozoic hydrocarbon plays in Central Range foldbelt and foreland of eastern West Papua and Papua New Guinea. No commercial oil in Indonesian part of main New Guinea island, but oil shows in Cross Catalina 1 and oil and gas in Kau 2 foreland basin well prove working Mesozoic petroleum system)

(Kawista I well (2013) in W Salawati basin tested oil in Eocene Faunai Lst different from oils in shallower horizons; very low in oleane, and probably derived from Pre-Tertiary source (e.g. Fusulina-bearing Permian in Orba I, Jurassic- Cretaceous in Sele 39 and Klamogun 1)


(Study of ichnofossils in neritic Jurassic and deep marine Paleocene reservoir sandstones of unnamed wells in Bintuni basin)


(Cenderawasih Bay contains >8 km thick series undated sediments. Suggest sediments started to accumulate in Cenderawasih Bay and onshore Waiapoga Basin in Late Miocene since inception of growth of Central Range (12 Ma), resulting in up to 12.2 km sediment accumulation. Basin fill probably mainly siliciclastics from Ruffle Metamorphic Belt and equivalent in Weyland Overthrust, with minor contributions from ophiolites, volcanic arc rocks and diorites. Local transtensional tectonics may explain unusually high rates of sedimentation in overall sinistral oblique convergence setting)


(Gajah Tidur prospect is deepest explored part of Grasberg Igneous Complex at elevation 1600-3000m, almost 2.5 km below pre-mining surface. Bottom of Grasberg Cu-Au porphyry ore body seems to terminate at ~2750m elevation)


(Walio oil field 1973 discovery in Salawati Basin, mainly producing from Miocene-Kais reefal limestone. Producing since 1975 from >300 wells, with oil production peak at 57,800 BOPD in 1977-1978. Current oil production ~2200 BOPD with >99% water-cut. Oil API 33.1°. Strong aquifer support contributed to rel. high reservoir recovery factor (~44%). Poor-quality reservoir intervals may still be untapped)


(online at: tao.wordpedia.com/pdf_down.aspx?filename=JO00001053_8_22-42)

Taiwan and New Guinea collisional belts represent comparable continental platform- foldbelt- arc (ocean) successions. Sutures on both islands are zone of ophiolitic melange)


(Bintuni Bay area with Tangguh gas fields with 3-way and 4-way closures formed by strike-slip movement. Long tectonic history: (1) Permian extension generated NW-SE grabens; (2) Inversions in Late Triassic, causing truncations at Base Jurassic unconformity and onlapping E-M Jurassic, thickening to S and E; (3) ?M-L Eocene-Oligocene ENE-WSW left-lateral strike-slip faults, with ~2 km or more displacement, and truncation at
Base Oligocene unconformity (base Kais carbonate); (4) Late Miocene- E Pliocene tilting due to flexural loading of Lengguru FB, and (5) Late Pliocene-Pleistocene left-lateral strike slip after Lengguru FB lockup, with several 100m of displacement)

Collier, B., N. Sabirin; S. Sirait, F.B. Widoto et al. (eds.) (2011)- Tembagapura: the mining community, the uniqueness, and the natural beauty of our surroundings. PT Freeport Indonesia, p.

(online at: http://journal.unpad.ac.id/bsc/article/view/8150/3723)
('Lateritic nickel in the Tanah Merah, Tablasufa and Ormo regions, Jayapura Regency, Papua Province'. Up to 6% nickel (associated with Fe, Co and Cr) in laterites on weathered ultramafic rocks around Jayapura. Pretetrary ultramafic and metamorphic rocks of uplifted and exposed since E Miocene- present tectonics)

(Lengguru fold-thrust wedge of W Papua younger than 10Ma and result of oblique and fast subduction of Birds Head under Melanesian Arc. High P rocks in core of wedge in Wandamen peninsula, with metabasic eclogites and amphibolites observed as sheared 'knockers' in Mesozoic metasediments. Metasediments HP (~13-17 kbar; burial depth ~32-44 km); metabasic rocks peak pressure 17-23 kbar and 700-800 °C (burial depth 43-66 km?). U-Pb dating of zircons shows some magmatic cores with ages >300 Ma (= Australian eraton margin volcanic arc). Most zircons metamorphic origin and Late Miocene age (5.6± 0.04 Ma- 8.1± 1.1Ma). N- S normal faults cross cut limb of anticline associated with present-day E-W extension. Young metamorphic ages suggest rapid subduction and exhumation event)


(Neogene carbonate units that extend offshore into Biak Basin SW of Biak and Sapiori islands, with pockmarks, headless canyons and semi-circular collapse structures, identified in multibeam bathymetric imagery)

(online at: https://link.springer.com/content/pdf/10.1007%2Fs10347-017-0506-z.pdf)
(Anggrisi River section in E Birds Head of W Papua shows E Miocene (Te) Kais Lst platform carbonates overlain by ~20m thick heterolitic Burdigalian- Serravallian drowning sequence of progressively upward-deepening marine units. Uppermost brown packstone bed with Kataclyclocyles annulatus and Miogypsina antillea. Drowning sequence overlain by Tortonian Klasafet/ Klamogun marine elastics. Cause of platform drowning attributed to reduction in rates of carbonate accumulation due to excess nutrients. Duration of drowning event across Birds Head region ~9.5 My (18.0- 8.6 Ma))

(Paleogeography of W New Guinea from Carboniferous- Present. Biostratigraphic data suggests two major transgressive-regressive cycles in regional relative sea-level, with highest sea levels in Late Cretaceous and Late Miocene and terrestrial deposition prevalent in Late Paleozoic and E Mesozoic. Sea levels dropped between Late Cretaceous and Paleogene, with widespread shallow water carbonate platform development in the M-L Eocene. Minor transgressive event in Oligocene. E Miocene collision marked by regional unconformity. Carbonate drowning event in M Miocene, etc.)
Gunawan, I., R. Hall & B. Sapiie (2014)- Triassic reservoir characteristics of the Bird's Head, New Guinea, Indonesia: new insight from provenance study. Int. Petroleum Techn. Conference (IPTC), Kuala Lumpur, 9p. (Triassic- Jurassic Tipuma Fm sandstones and conglomerates sourced from acid volcanic, metamorphic and recycled sedimentary rocks to N and from N Australian Craton. Quartz provenance dominated by low-T metamorphics and volcanics with little plutonic origin. Youngest zircon ages indicate deposition in Triassic. Recycled zircon populations Permo-Triassic (205-275 Ma) and Proterozoic (~975 Ma, 1.4-1.6 Ga and 1.8-2.0 Ga) populations, with few grains of Archean age (2.8-3.2 Ga). Tipuma Fm probably not deposited in simple continental setting. Decline of volcanic quartz and increase in Carboniferous-Proterozoic zircons in Middle Member indicate reduced contribution of sediment from arc and increased contribution from N Australia)


Harrington, L., S. Zahirovic, N. Flament & D. Muller (2017)- The role of deep Earth dynamics in driving the flooding and emergence of New Guinea since the Jurassic. Earth Planetary Sci. Letters 479, p. 273-283. (In New Guinea area periods of flooding and emergence since Jurassic inconsistent with magnitudes of global sea level changes, and suggest long-wavelength dynamic topography changes driven by subduction-driven mantle flow. Subduction at E Gondwana margin locally enhanced high eustatic sea levels from E Cretaceous (~145 Ma) to generate long-term regional flooding. Miocene dynamic subsidence associated with subduction of Maramuni Arc caused long-term inundation of New Guinea during period of global sea level fall)

Henley, R.W., F.J. Brink, P.L. King, C. Leys, J. Ganguly, T. Mernagh, J. Middleton, C.J. Renggli et al. (2017)- High temperature gas-solid reactions in calc-silicate Cu-Au skarn formation; Ertsberg, Papua Province, Indonesia. Contrib. Mineralogy Petrology 172, 11-12, 106, 19p. (On 2.7-3.0 Ma Ertsberg East Skarn System, adjacent to Grasberg diorite intrusion and 2.5 km from giant 3.3 Ma Grasberg porphyry copper deposit. Formed through flux of magma-derived fluid through carbonate rock sequences at T> 600° C and P<50 MPa (~2 km depth))


Ikhwandunin, F. & C.I. Abdullah (2016)- The connection between ophiolite occurrence and Yapen-Sorong Fault Zone (YSFZ), Papua, Indonesia. In: 78th EAGE Conf. Exh., Vienna 2016, Th P5 08, 5p. (Sheared and brecciated ophiolitic rocks on NE Yapen island, unconformable over Wurui Limestone Fm (M Miocene?). Drifted and brecciated mainly in Late Miocene-Pliocene. Ophiolite is carried by Yapen-Sorong Fault Zone in strike-slip compressional regime)

Jost, B.M., M. Webb & L.T. White (2018)- The Mesozoic and Palaeozoic granitoids of north-western New Guinea. Lithos 312-313, p. 223-243. (Late Paleozoic and E Mesozoic granitoids of NE Birds Head mainly small-medium size intrusions of Late Devonian- E Carboniferous (363-328 Ma) and latest Permian-Triassic (257-223 Ma) ages, intruding Silurian-Devonian Kemum Fm metasediments. Most peraluminous and derived from partial melts of metasedimentary continental crust. Minor mantle-derived material, especially in Permian-Triassic. Devonian-Carboniferous granitoids (Mariam Ngemona, Wasiani, etc. granites/granodiorites) and volcanics locally restricted. Late Permian-Triassic intrusions (Sorong, Anggi, Maransabadi, Kwatisore, Netoni, Sorong, etc.) likely part of long active continental margin subduction system spanning length of New Guinea, E Australia and Antarctica)


rocks of oceanic origin with highs (terranes) and lows (basins). Deep SE-NW trending Waigeo Trough with up to 1000m of (Plioene- Quaternary?) sediment is tectonic contact between island-terrane of Waigeo and Ayu islands and Pacific Oceanic crust


rocks in Pliocene-Pleistocene Memberamo Fm turbidites. Source rocks include shale of Miocene Makats Fm. Area high potential of hydrocarbons, thermogenic or biogenic)


(Offshore Semai area S of Bird’s Head, Irian Jaya, with interaction of Australian, Pacific and Eurasian Plates. Some compressional events in Oligocene-Miocene, ending with Misool-Onin-Kumawa Ridge uplift in M Pliocene. New seismic generated three regional exploration plays, but 7 dry exploration wells in 2010-2012)


(Textures in vein quartz from Grasberg Igneous Complex allow interpretation of history of fracture opening and infilling)


('The potential of the Sirga Formation as a source rock in the Salawati Basin, Papua'. SF-1X well (2007) in Salawati Basin with oil and gas shows in Late Oligocene Sirga Fm sandstones, in SAR-1X well (2008) oil in pre-Kais sandstones, making M-Miocene Klasafet source rock unlikely. Oils from both wells waxy (3.6 wt%) with very low sulphur, heavy carbon isotopes (-22 to -23), pristane/phytane ratio 1.33- 2.61, with oleanane as biomarker of Tertiary land plants and diahopane/ neohopane as biomarker of shallow lacustrine source. Most likely source E Tertiary lacustrine rocks, possibly Sirga Fm deposited in extensional-graben system)


(Waigeo island NW of Birds Head. 14C dating of marginal marine Ostrea mollusc fossils from uplifted Miocene(?)) Waigeo Fm limestone along S part of island gave ages of ~8200 and 11000 years at 110 and 70m above sea level, suggesting recent uplift rates of ~6.3- 13.4 mm/year)


(Late Miocene-Pliocene Steenkool Fm thickens to E (by progressive onlap to W onto Top Late Miocene Top Kais Lst and thickening to E). Kais Lst drowned by influx of clastic material into rapidly evolving E-dipping foreland basin in-front of Lengguru foldbelt. Shallow marine Lower Steenkool Fm with shallow gas in W part of area. Fluvial-deltaic Upper Steenkool Fm with stacked coal beds in E of area. Shortening in Lengguru fold-thrust belt stopped in Pleistocene. Faulting in Steenkool formation by Plio-Pleistocene strike-slip tectonics, creating E-W faults. Upper Steenkool Fm eroded by Pleistocene unconformity E of Tangguh field)


(Change in deformation style in Central Range from regional folding to localized strike-slip between ~4-2 Ma interpreted to be manifestation of short-lived change in relative plate motion between Australian and Pacific plates at 4 Ma (transform movement between Australian plate and short-lived Caroline plate).
(Jurassic-Cretaceous Kopai Fm in NE part of Lengguru foldbelt rel. high organic richness (TOC up to 1.2-17.7%). Most samples Type III kerogen. High thermal maturity in samples from NE area (overmature). Hydrocarbon seeps)

(Biak Island and Supiori Islands interpreted as series of extensional fault blocks with >2000m of Neogene sediments, overlying Eocene arc volcanics)

(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/169/159)
('Occurrence of zircon minerals and their relationship to metamorphic rocks in Wondama Bay, Papua' (= Wandamen Bay). Zircon-bearing metamorphic schist and amphibolite of Roon Island along Wandamen Bay point to granitoid, continental crust composition of precursor rock)

(Since 2006 oil companies invested $600MM in unsuccessful exploration of Semai basin between Onin Peninsula/ Birds Head and Seram Trench (Trench). Tight Lower Jurassic sandstone penetrated in Lengkuas-1 well at 6500m TVDSS (63m gross, but not fully penetrated; porosity <1-2%), i.e. older than M Jurassic main reservoirs in Tangguh fields. Probably part of W-E (or SW to NE?) backstepping pattern in E-M Jurassic deltaic sandstones. Same age reservoir much shallower at Bawang Putih-1 and Serai-1 wells to E; also poor reservoir quality. Reduced porosity in E Jurassic sandstones due to deep burial (quartz overgrowth) and >3km of late structural uplift and inversion. With paleogeographic maps for E Jurassic, Paleocene, Miocene)

(Kucing Liar 1992 discovery of multistage Cu-Au skarn/ replacement deposit from fluids emanating from W-SW side of Grasberg porphyry intrusive. Mainly in U Cretaceous Ekmai Fm and Paleogene Waripi Fm, along WNW-ENE reverse fault, at depth of 500-1500m below surface elevation of 3700m asl))

(online at: www.lemigas.esdm.go.id/public/publikasi/lembar/14554130711989243592.pdf)
('Pre-Tertiary pollen of the Birds Head area, Papua'. Palynology of samples from Ainin River shows Late Permian Ainim Fm (Protohaploxypinus microcorpus zone, with Falciisporites australis, Lunatisporites novialensis, etc.), overlain by Late Cretaceous Jass Fm (Tricolporites apoxyexinus zone, also with Coniacian-Campanian planktonic foraminifera and nannofossils in samples G3-G7), overlain by Eocene (Florschuetzia trilobata zone). Permo-Triassic sediments deposited in terrestrial environment with some marine influence, Cretaceous mainly marine)


(3D seismic surveys in Walio and Arar areas of Birds Head. Closures identified in deeper horizons below Kais carbonates, possibly Paleogene Waripi Fm or Jurassic Kembangan Gp)


('Indications of a porphyry-type gold deposit in the Mamberamo area, Papua Province')


(online at: https://repositories.lib.utexas.edu/handle/2152/61523)

(Novel U/Pb depth profiling technique shows Grasberg Igneous Complex intrusive magmatism active from 3.6-3.1 Ma. Cu-Au mineralization started after intrusion of MGI (3.22 Ma) and predates EKI (3.20 Ma) and LKI (3.09 Ma). High grade core of the Grasberg deposit formed in <100 to 220 kyr. Ertsberg pluton (3.1-2.8 Ma) and other minor intrusions shows magmatism in district took less than 1 Myr. Rapid cooling of surface samples precludes presence of 2 km volcanic edifice overlying orebody. Garnets from Big Gossan skarn show skarn formed between 2.9–2.7 Ma)


(Big Gossan Cu-Au skarn formed near contact between Cretaceous Ekmai limestone and Paleocene Waripi dolomitic limestone, adjacent to 3.1-2.8 Ma Ertsberg diorite. Andradite garnets dated as 2.9-2.7 Ma, compatible with district-wide zircon U-Pb geochronology and single 2.82 Ma phlogopite 40Ar/39Ar age for skarn. Confirm that Big Gossan was one of last ore-forming events in Ertsberg-Grasberg district)


(online at: https://agu.confex.com/agu/fm17/meetingapp.cgi/Paper/222305)

(Wandaman Peninsula at W side of Cenderawash Bay almost entirely composed of metamorphic rocks, associated with Late Mio-Pliocene metamorphic core complex. Multiple phases of deformation, all within last few Myrs: (1) crustal extension and partial melting at 5-7 Ma according to new U-Pb data from metamorphic zircons; (2) extensional phase followed by two phases of folding; (3) overprinted by brittle extensional faults and uplift, continuing today)


(Distribution of Pre-Tertiary reservoir and source rock facies in E Indonesia influenced by old tectonic grains such as Paleozoic-Mesozoic grabens. New plays identified in Birds Head of W Papua (Triassic and Early Jurassic reservoir and Paleocene Daram Sandstone)
(online at: http://buletinsdg.geologi.esdm.go.id/index.php/bsdg/issue/archive)
('Potential of lateritic chromite deposits in the Dosay area, Jayapura Regency, Papua'. Presence of chromite in weathered ultramafic rocks of Cycloop Mountain Range. Chromite content in saprolite 1.3- 4.7%)

(Maturity of Ainim Fm Permian source rocks in wells of Bintuni Basin varies from Ro 0,63% - 1.59%, and increases to NE, towards Lengguru fold-thrust belt (Ro 1.5% onshore Bintuni Bay). Gas in Bintuni fields likely came from NE (no details on wells, samples, uncontrolled maps))

(online at: http://jurnal.unpad.ac.id/bsc/article/view/15101/pdf)
('The relationship between phyllic alteration and rock strength value in the Grasberg mine Block Cave Undercut Level'. Grasberg Block Cave underground mine with three intrusion stages: Dalam (3.51 Ma), Main Grasberg (3.21 Ma) and Kali (3.1 Ma). Mineral alterations affect rock strength)
VIII. 2. Misool (0)

VIII. 3. Arafura Shelf (7)
('Cenozoic deformation period in the Aru Islands, Wokam Basin, Moluccas'. Three periods of Cenozoic deformation on Aru island, all with strike slip faulting: Late Miocene NW-SE stress (SW-NE folds), Late Pleistocene extension, and late N-S lineations)

Kaswandi, A.A., F. Ferdian & D. Setiawan (2017)- Tectonostratigraphy of NW Edge Arafura platform. Proc. Joint Conv. HAGI-IAGI-IAFMI-IATMI (JCM 2017), Malang. 5p. (Tectonostratigraphy of NW edge of Arafura Platform divided into (1) Prekinematic 1 and 2 (Proterozoic-Devonian), Syn-kinematic 1 (Permian- E-Triassic rifting; thickening towards NNE-SSW trending normal faults; ASM 1), Base-Jurassic unconformity, Post-kinematic 1 (backstepping M-L Jurassic- Cretaceous, thickening to W), Post-kinematic 2 (Paleogene- Miocene New Guinea Lst), Syn-kinematic 2 (E Pliocene extension at W platform edge) and Syn-kinematic 3 (Late Pliocene and younger Akimeugah foreland basin, thickening to NE; Aru Trough opening)

(Core ARU-3 from seafloor of Aru Trough W of Aru Islands at water depth of 3543m, 2.26m long. Mainly greenish clay. One thin possible ash layer)


Subroto, E.A. & D. Noeradi (2008)- Petroleum system of the Paleozoic and Mesozoic formation intervals in the northern Arafura Sea, Papua, Indonesia. 8th Middle-East Geoscience Conf. Exh. (GEO 2008), Bahrein, 1p. (Abstract only) (Geochemical analyses and modeling of outcrop and well samples (mainly W Papua; JTvg) suggest wo oil and gas source rocks: (1) Permian Aiduna Fm (TOC=1.3-6.6%, Ro 0.55%); (1) Jurassic-Cretaceous Kembelangan Gp. Basal Lower Kembelangan entered late maturity for hydrocarbon generation (Ro = 1.2%) at ~2 Ma and reached maturity at ~5-10 Ma. Paleozoic formations reached maturation during Mesozoic. Possible reservoirs porosity 5-15% and permeability 10-20 mD)
IX. CIRCUM-INDONESIA (1340)

IX.1. Andaman Sea Region (74)

(online at: https://www.ias.ac.in/article/fulltext/jess/113/04/0715-0721)
(Quaternary volcanics of Barren Island (Andaman Sea, Indian Ocean) evolved from source similar to that of Sunda Arc lavas of Sumatra/Java and is part of the same Neogene Inner Volcanic Arc)

(online at: www.currentscience.ac.in/Volumes/108/02/0205.pdf)
(Mile Tilek Tuff ~40m thick bedded dacitic-rhyolitic tuff deposit on S Andaman is one of several volcanic ash deposits in Andaman- Nicobar Islands that are evidence of large-scale volcanic eruption in SE Asia. Assumed ages Mio-Pliocene (~25-2 Ma), but new 40Ar-39Ar age for whole rock 0.73± 0.16 Ma. Chemically typical of subduction zone magmatism. Sr-Nd isotopes (87Sr/86Sr = 0.7073 and d Nd <0.9) suggest continental crustal contamination of magma, pointing to source volcano in Sumatra, possibly Ranau volcano in S Sumatra)

(Minutes after M9.0 Sumatra-Andaman earthquake in 2004, mud volcanoes erupted on Diglipur Island in N Andaman. Eruptions activity linked to hydrocarbons)

(7 types of ?Cretaceous algae in calcareous sst in Baratang Gp, most of them new: Cayeuxia, Ethelia, Baratangia, Peyssonella, Permocalculus, Halimeda, etc. (possibly Paleogene?))


(Distichoplax biserialis algae in Lower Eocene-Oligocene calcareous sst of Port Blair Gp, Baratang Island)

(Calcareous sst in Baratang Gp (Lw Paleocene- Lw Eocene) and Port Blair Group (M Eocene- Oligocene) yielded 4 dasyclad algae: Broeckella, Dissocladella, Neomeris and Trinocladus. Tethyan affinities)

(Barren and Narcondam young volcanic islands of volcanic belt that extends from Java in E to Burma in N. Below Narcondam probably continental or transitional crust, below Barren Island oceanic lithosphere)

(online at: http://mem.lyellcollection.org/content/memoirs/47/1/9.full.pdf)
(Introduction to Andaman islands in NE Indian Ocean are segment of tectonically active accretionary wedge of Sunda subduction system, with dismembered ophiolites, volcanic arc rocks, trench-slope deposits, submarine fan turbidites, pelagic sediments, etc.)

(Andaman-Nicobar archipelago at W margin of Andaman Sea is sediment-dominated accretionary wedge (outer-arc). Andaman accretionary ridge two distinct terranes, juxtaposed and telescoped into N-S trending fold-thrust belt along E margin of Indo-Australian oceanic plate. Pre-Cretaceous meta-sedimentary rocks, U Cretaceous ophiolites and Paleogene- Neogene sediments indicate rapid changes in lithology, sedimentology, environments and paleogeographic setting)


(Mithakhari Melange composed of conglomerates, sandstones, andesitic tuff, siltstone, mudstones, shale, carbonaceous shale and limestones. Coherent and chaotic units with olistoliths of pre-ophiolite metasediments, ophiolitic ultramafics and basalts and pelagic-hemipelagic sediments. Active andesite volcanism on arc massif E of Andaman arc on W margin of Burma-Thai-Malaya peninsula in Eocene- Oligocene, before opening of Andaman Sea in M Miocene)


(Andaman Flysch of Oligocene age marine turbidites from axially fed submarine fan. Intermittently exposed across entire chain of Andaman- Nicobar Islands)


(Neogene Archipelago Group overlies Oligocene and older turbidites and tectonic melanges of ophiolite and Mithakhari rocks. Deposited in intertidal and subtidal, nearshore and offshore shelfal environments)


(online at: www.ias.ac.in/article/fulltext/jess/124/05/1019-1037)
(Oligocene turbidites of Andaman Flysch along E coast of S Andaman Island. Geochemistry of av. 71% SiO2, etc., close to granite field. Combined geochemical, petrographic and paleocurrent data indicate mainly plutonic-metamorphic provenance, possibly Shan-Thai continental block of NE and E Myanmar)


(Baratang Fm of Middle Andaman Isles with mixed of Tertiary and Upper Cretaceous forms, the latter being more common (see also Mandal et al. 2003))


(Seismicity across Andaman-Nicobar island arc and Andaman Sea. Magnitudes of displacements varied from dip-slip on S (Sumatran) segment to dip-slip and strike-slip on Andaman-Nicobar segment. Andaman section more steeply dipping slab and thicker sediment cover compared to Sumatra where coupling with overlying plate is stronger. Seismicity in Andaman Sea spreading centre consistent with normal faulting and dyke injection)


(On radiolarian species from Late Miocene of Neil Island, Andaman Islands. Previous records of *A. disolenia* mainly from DSDP/ODP cores of Pacific Ocean and South China Sea)


(Late Miocene (Tortonian) diatoms in outcrop samples from Neil Island with 82 taxa/35 genera. Two distinct groups, dominated by (1) Thalassionema nitzschioides and *T. longissima* and (2) *Actinocyclus ellipticus*, *Azpeitia nodulifera*, *Coscinodiscus asteromphalus* and *C. radiatus*. Dominance of upwelling diatom taxon Thalassionema nitzschioides confirms strong Late Miocene monsoonal activity in study area)


(Andaman- Nicobar accretionary ridge along N extension of Java-Sumatra convergent margin is forming by accretion and underplating of sediments off-scraped from obliquely colliding Bengal Fan. Net accretion low (~28%; rest subducted mostly into upper mantle). Subduction initiated at ~95 Ma, but large-scale subduction accretion likely accelerated in E Miocene)


(online at: https://www.spgindia.org/2010/126.pdf)

(On hydrocarbon prospectivity in three tectonic settings of Andaman basin (fore arc, volcanic arc, back arc))


(online at: https://www.biodiversitylibrary.org/item/41527#page/482/mode/1up)

('On an extensive rock formation composed of siliceous Polycystina on the Nicobar Islands, etc.'. Brief note on Islands Car Nicobar and Comarta with core of syenitic and serpentiniferous gabbro, covered by (?) marls-calcareous siltstones rich in Polycystina (= radiolaria). Over 100 species (one of first reports of radiolaria-rich (Miocene?) rocks from Andaman-Nicobar Islands))

(GPS measurements across Sagaing fault suggest ~20 mm/yr of relative plate motion of ~36 mm/yr between India and Sunda plates accommodated at Sagaing fault through dextral strike-slip motion. Steeply dipping Churachandpur-Mao fault in Indo-Burmese Wedge accommodates remaining ~18 mm/yr through dextral strike-slip)


(online at: www.sciencedirect.com/science/article/pii/S1674987113000285)

Piacenzian (late Pliocene) Guitar Fm carbonates in Car Nicobar Island (S of Andaman Islands) rich in coralline algae. Deposited in shallow marine, reefal setting)


(Andaman- Nicobar ophiolites discontinuous bodies along E margin of Andaman- Nicobar Islands. Composed of mantle rocks overlain by crustal rocks with thin transition zone. Mantle peridotites and volcanic rocks great variability, demonstrating influence of subduction-related magmatism and origin in supra-subduction zone. Final emplacement unlike typical Tethyan-type ophiolites because, before final emplacement over Indo-Burma-Andaman microcontinent subduction margin charged with thick sediments from delta systems to N that accreted at leading age of overriding plate)


(Four Neotethyan Cretaceous ophiolite bodies (Nagaland, Manipur, Andaman island and Rutland island) along E margin of Indian plate, all belonging to W ophiolite belt of Indo-Burman Ranges (continuation of Sumatran fore-arc). Gross similarities with Philippine Sea samples. Geotectonic setting between Mid-ocean ridge and back-arc affinity. Plagiogranites of arc affinity suggest later arc event or back-arc origin of ophiolites)


(Late Miocene radiolarian zones Stichocorys peregrina, Didymocyrtis penultima and D antepenultima in mudstones of Sawai Bay Fm, Neill Island, Andamans. Cluster analysis of 45 taxa suggest colder and warmer periods due to monsoonal upwelling during warmer periods (5.0-6.3 and 8.5-7.7 Ma). Basinal shallowing during Late Miocene)


(Coccoliths from mud volcanoes in W Baratang Island with mixed coccolith assemblages, with latest Eocene as youngest elements. Also common complete Campanian- Danian section suggested present in subsurface)


(online at: https://www.spgindia.org/2010/261.pdf)

(Recent ENI exploration activities in deepwater East Andaman Basin revealed presence of unexplored rift setup, on trend with North Sumatra and Mergui rift basins)

Jha, P., D. Ros & M. Kishore (2012)- Seismic and sequence stratigraphic framework and depositional architecture of shallow and deepwater postrift sediments in East Andaman Basin: an overview. GEO India Conf. 2011, New Delhi, 10p. (Extended Abstract)


Malik, J.N., C. Banerjee, A. Khan, F.C. Johnson, M. Shishikura, K. Satake & A.K. Singhi (2015)- Stratigraphic evidence for earthquakes and tsunamis on the west coast of South Andaman Island, India during the past 1000 years. Tectonophysics 661, p. 49-65. (Stratigraphic records from W coast of S Andaman Island with evidence of three historical transoceanic tsunamis during past 1000 yrs: (I) predating AD 800, 35-40 cm t fine gravel to coarse sands with broken shell fragments; (II) ~AD 660-800, 20-25cm coarse sand and broken shell fragments; (III) ~AD 1120-1300, 50 cm thick sand. December 2004 tsunami resulted in deposition of 15cm m-c sand)


(online at: www.searchanddiscovery.com/documents/2012/50566jha/ndx_jha.pdf)
(Deepwater East Andaman Basin along W flank of NE-SW trending Mergui Ridge with Eo-Oligocene rift section overlain by up to 2500m of M Miocene and younger post-rift with typical deepwater depositional architecture. NE-SW trending sea-floor spreading centre came into existence at C Andaman Basin area)
India coupled with W Myanmar, margin became dominated by dextral strike-slip and NNW–SSE transtensional deformation during Miocene)


(Andaman Sea evolved from near-pure extension (WNW-ESE) in Late Palaeogene, to oblique extension (NNW-SSE) in Neogene, to strike-slip-dominated deformation in Late Miocene-Recent, probably reflecting switch from slab rollback-driven extension to India coupling with Myanmar. Possible revisions to traditional models for Andaman Sea: (1) Alcock and Sewell rises may be hyperextended continental or island arc crust, not Miocene oceanic crust; (2) E Andaman Basin mainly underlain by strongly necked to hyper-extended continental crust, not oceanic crust; or (3) C Andaman Basin oceanic crust of Miocene, not Pliocene-Recent age)


(Proposed model for Cretaceous- Cenozoic development of Sumatra-Andaman-Myanmar region suggests continuity of single continental mass between Myanmar and Sumatra during Cenozoic. E Cenozoic ophiolite emplacement as imbricate slices in accretionary complex and no emplacement of a major overthrusting oceanic slab. Subsequent collisional deformation further dismembered ophiolites. ~30° CW rotation of SE Asia occurred following Asia- India collision, accompanied by transition from paired Andean-type magmatic belt to regional oblique-slip and strike-slip tectonics. In Neogene Andaman sea region became dominantly transtensional, while Myanmar in Late Neogene became transpressional)


(online at: www.tandfonline.com/doi/full/10.1080/19475705.2015.1011242)

(Multiple transverse slab tear faults and longitudinal trench-parallel extensional faults on top part of Benioff zone in Sunda-Andaman arc)


(online at: https://www.j-micropalaeontol.net/25/37/2006/jm-25-37-2006.pdf)

(Rare siliceous spicules of endoskeletal dinoflagellates (Actiniscus spp.) in Late Miocene Sawai Bay Fm on Neill Island (E of South Andaman Island). Associated with calcareous nannofossils of Discoaster berggrenii subzone (CN9A/ NN11))


(Geologic evidence along N part of 2004 Aceh-Andaman rupture suggests region generated five tsunamis in prior 2000 years. 2004 tsunami deposits mainly organic debris, sand sheets, coral debris and boulder deposits. Distant and geomorphologically sheltered sites higher potential for tsunami deposit preservation)


(Direction of maximum compression in Burma- Andaman- Nicobar region NE-SW to N-S, compatible with postulated motion of Indian Plate)

(online at: www.ias.ac.in/article/fulltext/jess/125/02/0359-0368)

(Regional magnetic survey over Andaman Islands shows intermediate-high amplitude magnetic anomalies over areas of exposed ophiolite rocks along E coast of North, Middle and South Andaman Islands. 2D modelling along E-W profiles indicate ophiolite bodies extend to ~5-8 km depth and correlate with mapped fault zones)

(online at: www.currentscience.ac.in/Volumes/102/04/0605.pdf)
(Trace element ratios of arc lavas from Barren and Narcondam volcanoes of Andaman Islands group: Narcondam lavas (mostly andesitic) with subduction component of sediment fluid and melt. Barren Island lavas (mostly basaltic) ratios, indicative of subduction component from altered ocean crust)

(online at: www.currentscience.ac.in/Volumes/104/07/0934.pdf)

(Barren Island of Andaman Sea is only active volcano in Indian territory. Tephra (ash) layers in Andaman Sea sediment core, 32 km to SE, with tephra layers as old as ~70 ka, and with plagioclase separates as old as 1.8 ± 0.4 Ma, possibly represents age of older rocks in plumbing system of volcano)


(Great Nicobar island ophiolite restricted to E coast, as small isolated outcrops in Oligocene sediments terrain. Only upper part of ophiolite suite, with pillow basalts, massive andesite and pyroclastic andesite. In Andaman Islands dismembered ophiolite with complete ophiolite stratigraphy within Eocene sediments. Ophiolitic rocks in Great Nicobar island similar to Sunda outer arc ridge)

(online at: https://www.sciencedirect.com/science/article/pii/S167498711830032X)
(Serpentinized Cretaceous- Paleocene peridotites (dunites) exposed in S Andaman representing tectonized mantle section of ophiolite suite. Geochemical features suggest contributions from boninitic mantle melts and substantiate subduction initiation process by rapid slab roll-back with extension/ seafloor spreading in intra-oceanic forearc regime)

(Paleoevolution of coralline algae in Serravallian Long Fm reefal carbonates of SE Little Andaman Island (Hut Bay). Nine genera, incl. Lithothamnium, Lithoporella, Corallina, etc.)

(online at: http://www.igu.in/18-4-3-paper.pdf)
(Seismic data in Andaman offshore E of Andaman islands shows prominent bottom-simulating reflector (BSR) at ~575m below seafloor, indicating presence of zone of gas hydrates and free gas below BSR)

(Late M Miocene calcareous algae assemblage from limestone unit of Hut Bay Fm of Little Andaman Island with 13 species of coralline red algae (Lithophyllum, Lithothamnion, Amphiroa, etc.) and Halimeda-type green algae)


(Two intervals of faunal turnover suggested by E-M Miocene radiolarians from Andaman-Nicobar, in Stichocorys wolffii -Calocycletta costata -Dorcodospyris alata zones: (1) latest E Miocene (upward increase in cold water species and decreasing diversity; (2) in M Miocene Dorcodospyris alata Zone at ~14.8-12.7 Ma, faunal turnover correlated with M Miocene cooling)


(11 radiolarian events identified in Late Miocene - E Pliocene of Andaman-Nicobar islands)


(online at: http://www.mantleplumes.org/WebDocuments/shethetal2009-bv.pdf)

(Barren Island little known volcano in Andaman Sea, and northernmost active volcano of Great Indonesian arc. Recent eruptions (1991, 1994-95, 2005-06) produced aa lava flows of basalt and basaltic andesite and tephra)


(Volcanic ash/ glass shards widely distributed in E Miocene marine succession of Andaman-Nicobar Islands, also few records from early M Miocene (~21-15 Ma). Range in composition from basalt to rhyolite. Andesite/ basalt-andesite most common, implying island arc tectono-magmatic setting, possibly in Indonesian region)


(21 species of Late Miocene discoasters from Sawai Bay Fm. Discoster berggrenii and D quinqueramus common forms. Calcareous nannofossil subzone CN9A = lower NN11)


(Brief paper listing 86 species of benthal (probably >600m water depth) small benthic and 25 species of planktonic forams(70% of fauna) in Late Miocene (Tortonian) of Little Andaman Island)


(Active Barren Island and Pleistocene Narcondam volcanoes are only two subaerially exposed Andaman arc volcanoes, rising from 1000- 2300m deep seafloor of Andaman Sea, and associated with subduction of Indian plate beneath Burma plate. Lavas at Barren Island basalt to andesite, Narcondam volcano andesite to silicic andesite/dacite. Isotopic values from Barren Island likely caused by assimilation of extended continental crust and/or sediments from Irrrawaddy Delta fan at Myanmar continental margin)


(online at: www.ias.ac.in/article/fulltext/jess/125/02/0359-0368)

(Andaman Islands part of outer-arc accretionary complex of Andaman-Sumatra active subduction zone. Regional magnetic survey revealed intermediate-high amplitude magnetic anomalies, correlatable with areas of exposed ophiolite rocks along E coast of N, M and S Andaman Islands. Modelling indicates ophiolite bodies extend to depth of ~5-8 km and spatially correlate with mapped fault/thrust zones)


(Series of 11 previously published seismic profiles across Sunda subduction thrench- accretionary prism- forearc from North Sumatra- Andaman Islands- Myanmar. Plate margin changes from subduction margin in S to transform margin in N. May have been wholly subduction margin until ~25Ma)


(online at: www.searchanddiscovery.com/documents/2011/10343wang/ndx_wang.pdf)

(Many shallow biogenic gas reservoirs in Miocene-Pleistocene strata in Andaman offshore area. Large biogenic gas field Zawtika 1A in Block M09 discovered in 2007, with >2 TCF proven gas reserves. Reservoirs Miocene-Pliocene delta front sandstonesat 750-1580m depth, and shallower biogenic gas reservoirs in Pleistocene with burial depths <500m)

Zhang, P., L. Mei, P. Xiong, X. Hu, R. Li & H. Qiu (2017)- Structural features and proto-type basin reconstructions of the Bay of Bengal basin: a remnant ocean basin model. J. Earth Science 28, 4, p. 666-682.

(online at: http://en.earth-science.net/PDF/20170721112257.pdf)

(Bay of Bengal Basin remnant ocean basin between E continental margin of India to W and Sunda trench-arc system to E. Prominent down flexure structures caused by huge amount of Bengal fan turbidite sediments accumulation. Transition from ocean basin to remnant ocean basin in Late Oligocene)
IX.2. Malay Peninsula, Singapore (93)


Azman, A.G. (2000) - The Western Belt granite of Peninsular Malaysia: some emergent problems on granite classification and its implication. Geosciences J. 4, 4, p. 283-293. (Western Belt granites of Malay Peninsula considered as exclusively ‘S’ type granites, but consists of mixed ‘I’ and ‘S’ type features. This implies W Belt granites not solely derived from metasediments, but mixed origin of crustal material such as metapelites, greywackes and meta-igneous rocks)

Baioumy, H. & Y. Ulfa (2016) - Facies analysis of the Semanggol Formation, South Kedah, Malaysia: a possible Permian-Triassic boundary section. Arabian J. Geosciences 9, 8, 530, p. 1-16. (NW Malay Peninsula outcrop sections of deep-marine Late Permian- Triassic Semanggol Fm. Common volcanogenic material in Late Permian, probably from E China)


(U-Pb geochronology of detrital zircons in continental Late Jurassic or older formations of Peninsular Malaysia (E Malaya Terrane). Bertangga Fm zircon populations Jurassic (139-194 Ma), Permo-Triassic (226-274 Ma), Ordovician-D Devonian (372-459 Ma), Neoproterozoic (631-876 Ma), and Mesoproterozoic-Palaeoproterozoic (1.5- 2.6 Ga). Gerek Fm significant Carboniferous grains. Detrital zircons correlate well with regional tectonic uplift and erosion to tectonic stability of East Malaya Terrane basin in Mesozoic)

(Sulfur isotope data from E Permian volcanic-hosted massive sulfide deposits of Tasik Chini district in Central Belt of Malay Peninsula suggest source of ore fluids is seawater-dominated with minor magmatic input)

(Tasik Chini district in C Belt of Malay Peninsula hosts Bukit Botol and Bukit Ketaya VHMS deposits. Hosted by Permian felsic volcanics. Four mineralization zones: (1) stringer sulphide; (2) massive sulphide; (3) barite; and (4) Fe-Mn and Fe-Si zones. U-Pb zircon dating of rhyolites E Permian ages (~286-292 Ma). Differences between E Permian host and later Triassic igneous rocks due to tectonic progression from volcanic arc to collisional setting)

(Lead isotopes of sulfides and host volcanic rocks of Permian Tasik Chini volcanic-hosted massive sulfide deposit. Range of lead isotopic compositions reflect mixing of bulk crust/juvenile arc and minor mantle sources, are typical for VHMS deposits in island arc- back arc setting)

(online at: www.gsm.org.my/products/702001-101674-PDF.pdf)
(Review of Late Pliocene-Quaternary alluvial deposits that overlie M Pliocene 'Sundaland Regiolith' red-yellow lateritic soil development in Malay Peninsula. Old Alluvium/Simpang Fm older than 775 ka, supported by presence of tektites (~785ka) within tin-bearing beds of Gambium tinfield in Pahang)

(online at: https://gsmpubfiles.wordpress.com/2014/09/ngsm1994003.pdf)
(E and W blocks of Peninsular Malaysia were not separated by vast oceanic Palaeotethys. If vestiges of oceanic crust can be seen in serpentinites of Bentong-Raub suture zone, then linearity and persistent narrowness (< 15km in most places) of zone point to no more than very narrow seaway)

(Polyphase deformation of thin-bedded Devonian or basal Carboniferous limestone-shale in Raub Gp, S of Raub. Conodont Color Alteration Index 5 (= 300-480°; low metamorphic))


E Maastrichtian extensional detachment, associated with crustal melting, emplacement of syn-kinematic plutons and widespread migmatisation. Formation of detachment and first phase of Late Cretaceous cooling followed by renewed Eocene - Oligocene exhumation (see also Ali et al. 2016))


(Notices of Indonesia Geology, New for Ed. 7.


(Paragenetic tin mineralisation sequence and relation to host rocks and structures at two main hypogene tin deposits in Eastern Belt of SE Asian Tin Province in Malay Peninsula (Hantu and Gawak Mines at Sungai Lembing, Pahang, and Waterfall Mine at Pelapah Kanan, Johore. Mineralization preferentially in brittle calcarceous Carboniferous-Permian metasediments)


(Kinta Limestone important Silurian-Permian unit in W Belt of Malay Peninsula. Diagenesis obscured many primary sedimentary and geochemical features. Nearly pure limestones have rel. low Mn/Sr values (1.83-3.14), suggesting minor postdepositional alteration and likely preservation of original marine compositions)


(Old Alluvium of Singapore mainly matrix-supported pebbly sand and appears to be proximal braided river alluvium of possible Pleistocene age. Mixed provenance of granitic and low-grade metamorphic origin. Believed to be deposited during low sea levels, in environment of high relief, seasonal rainfall and active erosion. Such conditions may have prevailed over much of SE Asia at time of deposition of Old Alluvium)

(Review of former relative sea levels in Malay Peninsula and adjacent marine areas. Well established Holocene level of ~ +6 m. Levels down to -100m shown by depths of fluvial alluvium and erosional submarine morphology. No convincing evidence for former levels higher than + 6 m)

(online at: https://gsmpubl.files.wordpress.com/2017/09/ngsm2017_032.pdf)
(Kubang Pasu Fm near Pokok Sena, Kedah, thick interbedded marine shale-sandstone. Shale intervals with trilobite Chilupacula (previously known as Macrobole kedadensis), bivalve Posidonia/Posidononya becheri, etc., indicating E Carboniferous age. Locally abundant plant fossils, incl. leaves identified as Sphenophyllum cf. miravallis. Possibly oldest plant fossils from W Belt of Malay Peninsula)

(online at: www.gsm.org.my/products/702001-100826-PDF.pdf)
(Strike-slip fault in area of Paleozoic sediments in NW Malay Peninsula)

(online at: https://gsmpubl.files.wordpress.com/2014/09/hgsm2002016.pdf)
(Three types of gold mineralizations in Central Belt: in quartz veins (dominant), in massive sulphides(kuroko-type marine deposit) and in skarn. Gold-bearing quartz veins in steeply dipping N-S fault and shear zones)

(online at: www.bgs.ac.uk/research/international/dfid-kar/WC95021_col.pdf)
(Penjom area near Kuala Lipis with gold in quartz veins in shales and phyllites of Permian Padang Tenku Fm. In tract of Paleozoic continental margin sediments, between the W and E ranges of Triassic granites. Main Au-Ag vein sulphides with galena, chalcopyrite and sphalerite)

(online at: www.gsm.org.my/products/702001-101619-PDF.pdf)


Jusop, S. (2017)- Pyritization of coastal sediments in the Kelantan Plains as evidence for the sea level rise in the Malay Peninsula during the Holocene. Bull. Geol. Soc. Malaysia 64 (Geol. Soc. Malaysia 50th Anniversary Issue 2), p. 59-63. (Widespread pyritization (2-3%) of low-lying plains in Malay Peninsula linked to inundation by seawater due to sea level rise of 3-5m, ~43,000 years ago))

Khan, A.A. & M.K. Shuib (2016)- A review of the Bentong-Raub suture vis-a-vis new insight of the tectonic evolution of Malay Peninsula, South East Asia. Acta Geologica Sinica (English Ed.) 90, 5, p. 1865-1886. (Raub-Bentong suture does not fit model of subduction-related collision, but evolved from transpression tectonics after closure and exhumation of inland basin that underwent back-arc extension during Triassic)


Lim, K.K. & N.T. Abdullah (1994)- Development of Permian volcaniclastics limestone succession at Gua Bama, Pahang Darul Makmur. Warta Geologi 20, 3, p. 243-244. (Abstract only) (online at: https://gsmpubl.files.wordpress.com/2014/09/ngsm1994003.pdf) (Late Permian volcanic and volcaniclastic facies interfinger with minor limestone reported to be ubiquitous from Padang Tengku to Terengan catchment area. Limestone sequence at Gua Bama underlain by stratified volcaniclastics (crystal tuffs). With Tubiphytes and colaniellid foraminfera, indicating Late Permian age)


(Trace element geochemistry of Paleozoic- M Triassic marine black shales from central gold belt/E Malaya and Sibumasu terranes as possible sources of orogenic gold deposits)

(Paleozoic limestone of Kinta Valley narrow deformed strip between Late Triassic- E Jurassic batholiths of N Malay Peninsula. Deformation events: (1) early extension (Permian-Triassic intra-basin extension); (2) early compression indicated by conjugate strike-slip faults; (3) compression with thrusts and folds (coeval with late stages of granite emplacement); (4) ductile high temperature normal shear near contact with granites, and (5) late extension with large normal faults (Tertiary basins formation or Late Miocene-Quaternary uplift))

(First record of pelagic homocenitudententaculitoid genus Homoctenus from Malay Peninsula, in U Devonian Sanai Lst in Perlis. Closely related to Homoctenus tenuicinctus. Associated with rich Frasnian conodont assemblage, (Late Devonian; Palamotelepis linguiformis Zone)

(Late E Permian fusulinid Monodiexodina commonly as dense accumulations associated with marine siliciclastics. Monodiexodina-bearing bed of top Kubang Pasu Fm of Perlis (NW Malay Peninsula, Sibumasu terrane) 0.5-1.5m thick, above ~15m coastal marine coarsening upward succession. Composed of Monodiexodina tests, bryozoa (Rhombopora sp.), brachiopods, crinoid ossicles and 6-27% f quartz. Bed with giant symmetrical ripples and smaller ripples, interpreted as transgressive deposit overlying flooding surface, with mainly wave- and storm-generated facies formed by wave ravinement)

(Pennsylvanian conodont from Panching Limestone of Pahang, Malay Peninsula)


Metcalfe, I. (2017)- Devonian and Carboniferous stratigraphy and conodont biostratigraphy of the Malay Peninsula in a regional tectonic context. Stratigraphy 14, p. 259-283. (Devonian- Carboniferous stratigraphy of Malay Peninsula tied to Sibumasu Terrane in W and Sukhothai Arc (Indochina) block in E. Bentong-Raub Suture is former Devonian-Triassic Paleo-Tethys Ocean. Devonian-
Carboniferous sediments/ faunas of W belt support placement of Sibumasu Terrane on Paleozoic margin of Australian Gondwana until E Permian (Sakmarian). Carboniferous sediments of E Belt deposited on margin of equatorial Indochina Block, on which Sukhothai Arc was constructed

(Permian- Triassic Gua Musang Fm, Telong Fm, Aring Fm and Nilam Marble reflect lateral facies changes within newly defined Gua Musang Gp of argillites-carbonates-volcanics in Central Belt of Malay Peninsula)

(Kinta Valley near Kampar, Perak, flanked by granite ranges (Main Range to East) and Late Paleozoic sediments. Up to >100' fluvial/alluvial deposits, with basal granite wash which is main placer ore zone of tin mines in valley. Heavy mineral content average 0.59% (0.05- 3.2%), generally highest in coarsest sands)

(online at: https://umexpert.um.edu.my/file/publication/00011532_136895.pdf)
(Nine species of latest Silurian orthocerid cephalopods from U Setul Lst of Langgun, Langkawi Islands, incl. orthoceratids (Michelinoceras cf. michelini, Kopaninoceras setulense n.sp., Minogeseiconoceras? langgunense n.sp., Kionoceras?, Orthocycloceras), arionoceratids (Arionoceras mahsuri n.sp., Caliceras mempelamonge n.sp.) and geisonoceratid Murchisoniceras? sp. Assemblage belongs to newly defined Kopaninoceras Fauna, widely distributed along N margin of Gondwana and around Prototethys Ocean)


(Magnetization in Jurassic-Cretaceous red bed sandstones of Tembeling Gp indicates two-stages of tectonic movement in S Malay Peninsula: (1) CW rotation of 61° ± 12° accompanied by 13° ± 8° S-ward displacement after Cretaceous (caused by indentation of India into Asia after 55 Ma); and (2) subsequent CCW rotation of 18° ± 5° to present position (collision of Australian Plate with SE Asia after 30-20 Ma))

(Peninsular Malaysia no evidence to indicate Relative Sea Level ever higher than M Holocene maximum (~+5m at ~7 ka). RSL record of Malaysian Borneo more complex, even W Sarawak on Sundaland. Possible strandplain deposits over coarse alluvium in Kuching area could reflect last interglacial highstand deposition but more likely result of uplift. Ongoing subsidence of coastal plain from Kuching to Bintulu mainly due to sediment loading. N of Lupar Line, coast and interior from Bintulu to Bongawan, Sabah, has undergone Quaternary uplift. Geomorphic indicators and lack of emergent RSL indicators along W Sabah coast, N of Bongawan, suggest ongoing subsidence. RSL record from E Sabah very complex)
Parham, P.R., Y. Saito, N. Sapon, R. Suriadi & N.A. Mochtar (2014)- Evidence for ca. 7 ka maximum Holocene transgression on the Peninsular Malaysia east coast. J. Quaternary Science 29, 5, p. 414-422.
(Coral and shelly marine deposits up to 50cm above mean sea level in NE Peninsular Malaysia, with radiocarbon ages 7238-6909 yrs BP. Maximum transgression at ~7 ka, relative sea 1.4-3m above present)

(Limestone hills of Kinta Valley remnants of extensive Paleozoic carbonate complex. Altered by contact metamorphism of Triassic granite intrusion, but in N part of valley rel. unaltered. Mainly thin-beeded micritic limestone. Slump folds and breccias suggestive of marine slope deposition. Direction of slumping mainly to W, implying platform margin and lagoon facies should be E of Kinta Valley)

(Bentong-Raub Suture between Gondwana-derived Sibumasu terrane and Sukhothai arc genetically related to the sediment-hosted/orogenic gold deposits associated with major lineaments in Central Gold Belt of Peninsular Malaysia)

(Mafic microgranular enclaves in Late Triassic amphibole-bearing I-type Bintang granite of Main Range granite province. MMEs slightly older zircon age (224 ± 1 Ma) than granite host (216 ± 1Ma). Oldest inherited zircons 2.0 and 1.3 Ga, oldest xenocrystic zircons 2.5 and 1.5 Ga. Rocks generated from similar, ancient source in basement (E Proterozoic- Late Archean (~2.5 Ga) meta-igneous rock))

(Malay Peninsula almost entirely emergent during Cenozoic, with thin Cenozoic deposits mainly along W and E coasts. Isolated small Tertiary pull-apart basins. Batu Arang basin, Selangor, with 7-15m thick Eo-Oligocene thermally immature coal beds and lacustrine oil shale. E-M Pleistocene Simpang Fm (Old Alluvium) aggraded to 70m above s.l. Patches of up to 9m thick rhyolitic ash probably form Toba volcano, Sumatra)

(Triassic (Late Carnian; 229, 231 Ma) volcanics of SE tip of Malay Peninsula)

(online at: https://gsmpub.files.wordpress.com/2017/04/bgs2016011.pdf)
(Plutonic (hornblende diorite, biotite granite) and volcanic rocks (rhyolite-dacite; andesite on other part of island) in S part of Tioman Island, E of Pahang coast. Late Cretaceous granite (~80 Ma) intruded Tioman Volcanics (~88.9 Ma). Biotite granite formed in calc-alkaline volcanic arc setting (Neotethys subduction?))

(online at: www.ukm.my/jsm/pdf_files/SM-PDF-45-12-2016/14%20Mohamad%20Hanif%20Kamal.pdf)

(Semi-circular rim structure on Langkawi island previously identified by Tjia (2001) as possible remnant of impact crater. Gravity and magnetic surveys over ~35 km² area shows low gravity negative anomaly of ~1.5 km in diameter. Modelled as simple type crater with ~1500m of low density sedimentary fill)


(‘Influence of pre-existing structural fabric on rifting: example from the western margin of Sunda Plate’)


(Continental core of Malay Peninsula relatively undeformed after Triassic Indosinian orogeny. Thick crustal mega-horst bounded by shear zones (Ranong, Klong Marui, Main Range Batholith Fault Zones), initiated in latest Cretaceous and reactivated in Late Paleogene. Extension localized on sides with Late Cretaceous deformation. In W continental shelf three major crustal steps (crustal-scale tilted blocks bounded by deep-rooted normal faults; Mergui Basin), To E rift systems with large tilted blocks (W Thai, Songkhla, Chumphon) which may reflect large crustal boudins. Central domain extension limited to narrow N-S half grabens. Rifted basins resemble N-S en-echelon structures along large NW-SE shear bands. Deep Andaman, Malay and Pattani basins on weaker crust inherited from Gondwana continental blocks (Burma, Sibumasu, Indochina))


(online at: http://myrepository.pnm.gov.my/bitstream/123456789/2825/1/MN1100008_FAMD.pdf)


(online at: http://library.dmr.go.th/library/Proceedings-Yearbooks/M_1/1997/7641.pdf)

(‘Facies and sedimentary environment of the Singa Formation of Langkawi, Malaysia’. Depositional model of Carboniferous- E Permian shallow marine clastics of Singa Fm, widespread on Langkawi. With pebbly mudstone facies indicative of cold climate)


(Permundaria is uncommon genus confined to M- early Late Permian Tethys Sea. New species Permundaria perplexus in Wordian, Middle Permian Bera Fm, Pahang, Malay Peninsula (genus also recorded from Jambi, C Sumatra as Strophomena analoga; Meyer 1922))


(‘Permian- Triassic transition in C Malay Peninsula present in basal parts of Gua Bama and Gua Sei limestones. Conodonts Isarcicella isarcica and Hindeodus parvus indicate basal Triassic age of limestone overlying Upper Permian Colaniella-bearing limestone and lyttonoid brachiopod (Leptodus) shales’)

(Permian-Triassic boundary defined by first appearance of conodont species Hindeodus parvus, now indicated to be 252.3 Ma by zircon U-Pb dating. In Pahang, C Peninsular Malaysia, several limestone sections contain Permian-Triassic boundary, incl. Gua Bama and Gua Sei)

(Tin mineralisation in KL area may be related to fault zones, especially WNW trending faults, which may sinistrally offset primary tin lodes by ~70 km)

(White fine-grained and rhyolitic ash layer, 0.45m thick, in sequence of alluvium and peat exposed by tin mining. Correlated with ash previously reported from Perak and Pahang (= Young Toba Tuff?; JTvG))


(In Peninsular Malaysia Holocene climate optimum coincides with peak of Holocene transgression. Between ~6500-4000 years BP sea levels of >2m above present known from many localities in Peninsular Malaysia (~4m above sealevel at ~ 5 ka))

(Well preserved imprints of jellyfish occur in metasedimentary rocks of probable Carboniferous age along Cheroh River)

(Tekka deposit is hard-rock tin deposit in Kinta Valley. Cassiterite in mineralized veins (5mm-1m thick) in granites and schists, associated with Triassic Main Range biotite granite. Early high T mineralization with cassiterite, columbite/tantalite and wolframite, followed by late stage low T minerals galena and stibnite)

(Double Mahsuri Rings in S C Langkawi are impact structures. Each ring 2.4 km across, with depths of 45-107m and part of series of 4 structures, representing serial impacts of extraterrestrial projectiles arriving from SW. Age post Triassic-Jurassic granite, but could be of Neogene age)

(Kinta Limestone in C part of W Belt of Peninsular Malaysia (=Sibumasu terrane) extensively altered by diagenesis, making age determinations challenging. Three boreholes (total 360m) drilled at either end of Kinta Valley. Conodonts incl. Pseudopolygnathus triangulus and Declinognathodus noduliferus, indicate Late Devonian (Famennian)-Late Carboniferous ( Bashkirian) age)


Willbourn, E.S. (1936)- A short account of the geology of those tin-deposits of Kinta that are mined by alluvial methods. J. Engineering Assoc. Malaysia. 4, p. 255-264.


Yanagida, J. & S. Sakagami (1971)- Lower Carboniferous brachiopods from Sungei Lembing district, NW of Kuantan, Malaysia with a brief note on the bryozoans in association with brachiopods. Mem. Fac. Science Kyushu University, Ser. D (Geology), 21, p. 75-91. (also in Geology and Palaeontology of SE Asia 11?) (*Seven species of brachiopods from siltstones of Lower Carboniferous Calcareous Series of E Pahang. Assemblage strong affinity with M Visean fauna of Russian Central Asia and N America*)
IX.3. Thailand (289)


Arsairai, B., A. Wannakomol, Q. Feng & C. Chonglakmani (2016)- Paleoproduction and paleoredox condition of the Huai Hin Lat Formation in northeastern Thailand. J. Earth Science (China) 27, 3, p. 350-364. (online at: http://en.earth-science.net/PDF/20160612012847.pdf) (Lacustrine facies of Late Triassic Huai Hin Lat Fm at Khorat Plateau of NE Thailand believed to be one of main source rocks of gas. Organic matter mainly of AOM and acritarchs, with TOC of 2-7%. Mainly Type I and II kerogens with some Type III as indicated by phytoclasts, spores, and pollen)


(Pleistocene(?)) basalts of Thailand small plugs, vents and flows. Part of large NW-SE trending alkaline basalt province through Thailand, Cambodia, Laos, Vietnam, increasing in volume to SE. That basalts mainly in two groups: basanitoid (formed by partial melting in mantle at high P, followed by rapid ascent; with gem-quality corundum and zircon) and hawaiitic. Also rare tholitic basalts. Possibly related to rifting of S China Sea and associated basins (unlikely?, JTvG)


(Quaternary Lampang basalt flows in area of ~200 km2 in NW Thailand. Overlie gravels with Early Paleolithic pebble tools. Reversed-to-normal magnetic polarity change recorded within basalt series, probably Matuyama-Brunhes boundary of 0.69 Ma (now assumed to be closer to 0.78 Ma; JTvG). Pebble tools must be older)


(Nd and Sr isotopic studies of Australites tektites suggest source material derived mainly from Proterozoic crustal terrane. Sr analyses of Muong Nong-type layered indochinite tektites from NE Thailand yield isochron age of ~170 Ma, possibly time of deposition of sedimentary target rocks. Compositional layering in Muong Nong-type tektites may reflect compositional variability of Jurassic sediments. Impact site may be in area of Jurassic sedimentary bedrock, near N Cambodia, S Laos or SE Thailand)


(Incl. Petrified Forest Park in Tak Province, NW Thailand. Large silicified tree trunks, ~800,000 years old)


(Late Cenozoic (24 <~0.5 Ma) basalts in mainland SE Asia (Vietnam, China, Thailand, Malaysia) interpreted to have erupted in continental rift environments. Chanthaburi-Trat basalts transitional between trachybasalts and basanites. Magma was generated in continental rift environment, in fertile mantle at ~35 km depth.)


(Mafic volcanic rocks and hypabyssal rocks in Chon Dean-Wang Pong area possibly S extension of western Loei volcanic Sub-belt, NE Thailand. Possibly Permian-Triassic age and formed in volcanic arc setting)


(Incomplete sauropod skeleton from fluvial Late Triassic NamPhong Fm at Phu Nok Khian hill near Ban Non Thaworn village, Khorat Plateau, NE Thailand: Isanosaurus attavipachi gen. et sp. nov.)

(Record of sauropod dinosaurs from NE Thailand starts in Late Triassic (Isanosaurus attavipachi, Nam Phong Fm) and ends in M Cretaceous)


(New incomplete skeleton of large theropod from E Cretaceous (Berriasian- Barremian) Sao Khua Fm of NE Thailand described as Siamotyrannus isanensis. May be early representative of Tyrannosauridae (20 My older than earliest known tyrannosaurs))


(Remnants of new taxon of ornithomimosaur, Kinnareemimus khonkaenensis n. gen., n.sp.)

(online at: http://library.dmr.go.th/library/Proceedings-Yearbooks/M_1/1997/7641.pdf)
(New dinosaur finds in Late Jurassic- M Cretaceous of NE Thailand)


(Vertebra collected from Jurassic non-marine Khlong Min Fm of S Thailand referred to sauropod dinosaur family Euhelopodidae, apparently endemic to E Asia in Jurassic- E Cretaceous. Occurrence in Shan-Thai Block supports idea of a collision of the Shan-Thai Block with Indochina Block before Jurassic)

(see also Bunopas, Wasson et al. 1999a,b)
(Review of new Paleozoic- Cenozoic stratigraphic nomenclature in 7 stratigraphic belts of Thailand: (1) Archeotectonics- Precambrian- Lower Paleozoic Shan-Thai and Indochina part of Australian Gondwana; (2) Paleotectonics; Shan Thai and possibly Indochina rifting in Paleozoic, >180° CW rotation as it moved from S to N Hemisphere and collided with. each other near end-Triassic; (3) Mesotectonics; latest Triassic- Jurassic post-orogenic stage, with early M Cretaceous CW rotation, causing folding along W mountains and downwarping of Khorat Plateau with evaporite deposition; (4) Neotectonics; Cenozoic extension))

(Extinction of many mammals and marsupials and formerly widespread Dipterocarpxylon plant in S and E Asia, up to 10m thick structureless atmospheric sand and loess across Khorat Plateau, etc. all related to ~700,000 yr Pleistocene Australasian tektite field/ asteroid impact))

(Review of Thailand tectonic history. Seven major stratigraphic belts in Thailand (5 on Shan Thai, 2 on Indochina Block. Paleomagnetic data suggest >180° CW rotation of Shan-Thai (= Sibumasu) between Carboniferous and Triassic, after rifting from Gondwana)

(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1999/6614.pdf)  
(Quaternary sudden mass extinction of mastodons, stegodons and other mammals and reptiles, buried alive under catastroloess in sandpits of Khorat, NE Thailand. Associated with common burnt and abruptly felled trees and tied to Buntharik Impact Event, which generated widespread tektites. Caused E Quaternary extinction across >1/4 of globe. Probably multiple impact craters in NE Thailand- E Cambodia-SE Laos- Hainan)

(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1999/6611.pdf)  
(Widespread yellow fine construction sands across NE Thailand are derivatives of Pleistocene catastrophic loess that originally formed 10-50m thick blanket across Thailand (not windblown sands). With microtektites, formed at ~0.770 Ma, and tied to comet impact. Covers tektite horizons, burnt petrified trees, burnt trees, ancient elephants, etc., and also E Quaternary tin placers)

(Tertiary oil-bearing deposits of Fang Basin with freshwater molluscs Viviparus and Unio, and plant remains. Preliminary spores-pollen identifications suggest Oligocene age)


(Conodonts from radiolarian cherts in Loei Terrane, NE Thailand (W margin Indochina block), include Palmatolepis triangularis, P. minuta spp and polygnathids, indicating Famennian crepida Zone age. Cherts ~20 Myr younger than Givetian reef limestones and unlikely deposited in major ocean, but rather in deep marine basin close to volcanic arc)


(Lower Cretaceous freshwater shark fossils from Khorat Gp of Thailand, incl. Thaiodus ruchae n.sp., Thaiodus also known from Lhasa Block (Tibet) (see also Cuny et al. 2003, 2004, 2006))

Cavin, L., U. Deesri & V. Suteethorn (2013)- Osteology and relationships of Thaiichthys nov. gen.: A Gingelymodi from the Late Jurassic - Early Cretaceous of Thailand. Palaeontology 56, 1, p. 183-208

(Well-preserved freshwater fish Thaiichthys buddhabutrensis, n. gen., from Late Jurassic- E Cretaceous of Thailand)


(Ginglymodian fishes are relatively common in Mesozoic of Thailand. Two genera and three species identified so far (Thaiichthys buddhabutrensis, Isanichthys palustris), but many more taxa present. Known Isanichthys species restricted to N margin of Tethys in M Jurassic- basal Cretaceous time)


(New semionotiform freshwater fish, Isanichthys palustris, from Late Jurassic- E Cretaceous Phu Kradung Fm, NE Thailand)


(New species of freshwater dipnoi/ lungfish (Feruganceratodus martini) from Late Jurassic or basal Cretaceous upper Phu Krading Fm of Phu Nam Jun, Kalasin Province, NE Thailand (Khorat Gp). Comprises almost complete skull roof, jaws and some postcrania remains)


(Former presence of reidite (high-P polymorph of zircon) detected in zircon grains in Muong Nong-type tektites from Thailand. Preserved microstructures and dissociation of zircon to ZrO2 and SiO2 require pressure of >30 GPa and T >1673°C, the most extreme conditions reported for Australasian tektites so far)


(Permian carbonate major petroleum reservoir in Khorat Plateau. 47 wells drilled, two producing gas fields (Nam Phong and Sin Phu Horm) from reservoirs in Perm-Carboniferous carbonate platform, with thrust fault resulting in fracture development. Dong Mun Gas field in development, in carbonate reef with karst topography. 18 separate isolated carbonate platforms identified from seismic)


(In Lampang basin of C N Thailand 200-700m thick early Late Triassic shallow marine 'red bed' fan delta deposits, sourced from active magmatic arc in extensional forearc basin on Shan-Thai (Sibumasu) terrane during collision with W-dipping Indochina terrane. With marine mudstone with M Carnian ingularis fauna. Paleocurrents mainly from W and S)


(At least 70 named Tertiary intermontane and rift basins in Thailand, with many similarities. Tied to N-ward movement of India. Basins in S formed earlier than in N, in W earlier than E. Alluvial facies dominant in lower and upper parts, fluviolacustrine and swamp facies common in middle part)


(online at: www.scienceasia.org/2003.29.n3/v29_265_277.pdf)


(Rare Earth minerals in Thailand mainly monazite, and also xenotime and microlite. Primary REE deposits associated with tin granitoids of S-type affinity and mainly in Cretaceous- Tertiary Western Granitoid Belt. Alluvial placers near weathered granites may yield variable amounts of REE ores, mainly near granitoid terraces of western Gulf of Thailand, possibly also along Andaman Sea)

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(N-S trending Cenozoic basins of Thailand inferred to have developed in Late Eocene- E Oligocene as result of extrusion tectonics of SE Asian block, along major NE-SW trending fault zones. Most basins regarded as pull-apart basins. Deposition started with localized lacustrine and alluvial deposition in Oligocene, followed by fluvial and marginal marine deposits. Four main tectonic episodes: (1) pull-apart and transtensional rifting (55-30 Ma), marked at end by M Tertiary unconformity; (2) quiescent thermal subsidence event (30-15 Ma) involving widespread transpression and extensive delta progradation; (3) transpression wrenching event (15-7 Ma) due to on-going dextral shear along major NW-trending fault zones, with subsequent basin inversion and folding; end marked by late M Miocene unconformity; (4) post-rifting (7 Ma- Recent))


(Khao Kradong in Burirum national park in NE Thailand is small basaltic volcanic cone in Cenozoic basaltic terrain of ~30 km². Age from whole-rock Ar/Ar dating 1 Ma. Rocks transitional from hawaiite to alkali olivine basalt. Part of Cenozoic basalts of continental-rift origin of Laos-Cambodia-Vietnam)


(Monazite and xenotime significant rare earth minerals occurring with tin-tungsten deposits in granites and pegmatites and in Quaternary fluvial and beach deposits. Ilmenite- series granites more rare earth minerals than magnetite - series granites. Weathering crust of granites-pegmatites of important economic significance. In S Thailand highest RE metal contents 0.092%. Important secondary provinces in Songkhla and Yala of S Thailand with up to 0.045% monazite and 0.196% xenotime)


(M Miocene proboscidean fauna of NW Thailand E of Chiang Mai five taxa (4 elephantoids, 1 deinothere), dominated by Stegolophodon and Gomphotherium. Thai proboscidean assemblage mainly endemic, although Gomphotherium cf. browni denotes faunal affinities with Pakistan)


Cheneval, J., L. Ginsburg & C. Mourer-Chauvire & B. Ratanasthien (1991)- The Miocene avifauna of the Li Mae Long locality, Thailand: systematics and paleoecology. J. Southeast Asian Earth Sci. 6, 2, p. 117-126. (Miocene bird fossils from Li Mae Long includes anhinga, heron, lesser flamingo (Phoeniconaias siamensis n. sp.), etc.. Probably in large swampy depression surrounded by humid forests, under warm climate)


(Paleocurrent analysis in sandstones of E Cretaceous Sao Khua Fm of Khorat Plateau shows paleocurrent trend of sand channels dominantly NE; probabl yin braided channel environment)


Bibliography of Indonesia Geology, New for Ed. 7. 243 www.vangorsel.com 8/6/18


Chutakositkanon, V., K.I. Hisada, P. Charusiri & S. Arai (2001)- Tectonic significance of detrital chromian spinels in the Permian Nam Duk Formation, central Thailand. Geosciences J. 5, p. 89-96. (Detrital chromian spinels in turbiditic sandstones of Permian Nam Duk Fm suggest mafic- ultramafic volcanics and peridotites of arc origin were exposed in region in Permian. Loei-Phetchabun-Ko Chang volcanic belt, possible candidate for source of detrital Cr-spinels. Associated limestone beds with Pseudodoliolina pseudolepida and Verbeekina verbeeki suggest late M Permian age for Nam Duk Fm)

Claude, J., V. Suteethorn & H. Tong (2007)- Turtles from the late Eocene- early Oligocene of the Krabi Basin (Thailand). Bull. Soc. Geologique France 178, 4, p. 305-316. (Two new species of geoemydid turtles from three lignite pits in latest Eocene-earliest Oligocene of Krabi Basin in SW Peninsular Thailand; early representatives of testudinoid turtles from SE Asia. Eocene turtle assemblage from Krabi different Eocene Pondaung Fm of Myanmar, dominated by highly aquatic taxa, while Krabi fauna mostly composed of smaller aquatic or more semi-terrestrial species)


Cuny, G., V. Suteethorn, S. Kamha, E. Buffetaut & M. Philippe (2006)- A new hybodont shark assemblage from the Lower Cretaceous of Thailand. Historical Biology 18, 1, p. 21-31. (Teeth of five hybodont taxa from freshwater E Cretaceous Sao Khua Fm of Khorat Plateau. Fauna appears less endemic, with some European affinities, than fauna from younger Aptian-Albian Khok Kruat Fm)


Deesri, U. (2017) - Taxic diversity and ecology of Mesozoic bony fish assemblages from the Khorat Group, NE Thailand. Research and Knowledge 3, 2 p. 18-22. (online at: doi.nrtc.go.th/ListDoi/Download/?0413d160426beeb7c065e3cb57bc63e0?)

(Khorat Gp in NE Thailand with 5 M? Jurassic- Aptian continental formation with succession of freshwater bony fish assemblages in 15 localities)


(New skull and mandible of mid-sized rhinocerotid Aceratherium from Tha Chang sand pits in Nakhon Ratchasima Province, described as A. porpani. First discovery of Aceratherium in Thailand. Mixture of primitive and derived characters that differ from known species of Aceratherium. Probably latest Miocene)


(E-M Permian (Asselian-Capitanian) Khao Khwang carbonate platform with minor clastic sediments with well-bedded platform carbonates and massive reef complexes. After deposition platform deformed into Khao Khwang fold-thrust belt in Triassic-Lower Jurassic Indosinian Orogeny along S margin of Indochina Block)


(Km-scale thrusts affect sedimentary of Khao Khwang Platform in C Thailand (W margin of Indochina Terrane). Platform three Permian carbonate-dominated units, intercalated with clastics. Paleogeography of area prior to Triassic Indosinian Orogeny poorly known. In Saraburi area several separate carbonate platforms dominated by four major M Permian facies, dated with foraminifera (incl. verbeekinid and neoschwagerinid fusulinids) and algae)


(Pb-Zn deposits in W mountain chains of Kanchanaburi Province, W Thailand. Sulfide mineralization stratabound and related to reef-like algal crinoidal buildups in thick Ordovician limestone sequence. Mainly fine-grained galena-sphalerite-pyrite. Homogenization temperatures of fluid inclusions 107-174 °C. Origin of metal-bearing solutions is uncertain, possibly nearby igneous source)


('Biochronologic study of the continental basins of SE Asia'. Diverse mammal-reptile faunas from ~500m thick continental Upper Eocene of Krabi Basin of Peninsular Thailand and faunas of Neogene basins from NW Thailand)
(Suborder Anthropoidea (simians, simiiforms) contains New and Old World monkeys, apes and humans. Recent discovery of Eocene early primate remains allows better understanding of early evolutionary history of group of mammals from which we evolved)

(New ceratomorph (small rhinocerotoid) maxilla from Late Eocene in Wai Lek lignite pit near Krabi, Associated with diverse mammal fauna of >30 species)

(Micromammals have higher biostratigraphic resolution than large mammals. Northern rift basins (Lampang, Pong) of M Miocene age (17-14 Ma). Krabi Basin in Peninsular Thailand Late Eocene age. Vegetation of M Miocenein N Thailand already in monsoon climate with distinct dry season)


(Dental remains of earliest known helohyid artiodactyl from Late Eocene of Krabi, S Thailand (Progenitohyus thailandicus. Strong affinities with primitive anthracotheriid Siamotherium krabiense from Krabi)

(Wang Nam Khiao area, NE Thailand, with Carboniferous biotite granite (zircon U-Pb ages ~315-285 Ma), Late Permian hornblende granite (2453.4 Ma) and Triassic biotite-hornblende granite (238 Ma). All part of Eastern Granite Belt and implying multiple episodes of arc-magmatism formed by Paleo-Tethys subduction beneath Indochina Terrane)

(N Thailand is intraplate Basin and Range province, with N-S trending grabens and half-grabens, developed in E-W oriented extensional stress regime initiated in Oligocene, with main phase of extension in Late Miocene-E Pliocene. Result of India- Eurasia collision and subsequent E-ward extrusion and rotation of S China and SE Asia along large strike-slip fault systems. Still some Quaternary activity on basin-bounding faults)

(Study of Nan-Uttaradit suture and Chiang Mai Volcanic Belt. Proposes new location for Palaeotethys suture and new plate tectonic model of SE Asia, implying existence of new Orang Laut terranes (E Vietnam, W Sumatra, Kalimantan, Palawan, Taiwan) and redefined Shan-Thai terrane. Shan-Thai previously viewed as Cimmerian (when Nan-Uttaradit suture thought to be Paleotethys suture), but detached from Indochina with E Permian opening of Nan basin, which closed in M Triassic)


(Fang Basin Cenozoic rift structure in N Thailand. Fang oilfield includes Mae Soon anticline with well FAMS-48-73, with multiple oil-filled sandstone reservoirs. Organic petrography, etc., shows Type II and III kerogen, consisting mainly of telalginite (Botryococcus-type), lamalginite, etc., suggesting freshwater lacustrine environment. Vitrinite Reflectance values ~0.38-0.66% Ro, thermally immature for petroleum generation)


(Late M- early Late Miocene fluvial Chiang Muan Fm in Chiang Muan Basin of N Thailand ~300m thick and subdivided into five members, incl. two lignite members two mammalian fossil-bearing horizons)


(Intermontane Mae Sot basin, NW Thailand, with carbonate-rich oil shales. Laminated deposits with fish and plant fragments as main megafossils. Mappable oil shale sequences 10m thick, interstratified with marl-sandstone sequences 70m thick. Oil shales formed in perennial stratified lakes. Episodic deposition of oil shales reflects changes in lake level, probably due to climatic fluctuations on 24-46 kyr scale)


(Tertiary lignites of N Thailand (Khon Khaen area) two groups: Li Gp and Mae Moh Gp. Both groups associated with mammal fossils and both appear to be of Late Miocene age)


(Kathu Valley on Phuket Island two types of tin-bearing pegmatites: Sn-Ta pegmatites (or albite-muscovite pegmatites) and Sn- Rare earth element (REE) pegmatites (or orthoclase-lepidolite pegmatites). Pegmatites intruded into Late Paleozoic (meta-) sediments of Phuket Group. Sn-Ta pegmatites in areas close to granite body; more complex Sn-REE pegmatites located further (2-4 km) from source granite)

Grote P. (2007)- Studies of fruits and seeds from the Pleistocene of northeastern Thailand. Courier Forschungsinstitut Senckenberg 258, p. 171-181. (Middle (or Early?) Pleistocene fluvial deposits in Nakhol Ratchasiam province with plant remains (endocarp and dipterocarp fruits, seeds, leaves, wood, tubers, amber, pollen), suggestive of tropical mixed deciduous and dry evergreen forests. Also vertebrate fossils of fish, turtles, gavials, bovids, deer, Stegodon and hyena)

Hansen, B.T., K. Wemmer, M. Eckhardt, P. Putthapiban & S. Assavapatchara (2016)- Isotope dating of the potash and rock salt deposit at Bamnet Narong, NE Thailand. Open J. of Geology 6, p. 875-894 (online at: https://goedoc.uni-goettingen.de/handle/1/14086) (Age determination of Cretaceous evaporite (halite, anhydrite) of Maha Sarakham Fm in samples from Bamnet Narong Asian Potash Mine, at W edge of Khorat Plateau/ Basin. Multiple isotopic approaches (K/Ar, K/Ca and Sr) suggest depositional age from ~93 Ma to <76 Ma (Cenomanian- Campanian), in agreement with Aptian-Albian ages from vertebrate fossils from underlying non-marine Khok Kruat Fm)


Heggemann, H., K.W. Tietze & D. Helmcke (2003)- The river system of the Phra Wihan Formation, Thailand. In: Festschrift Behr, Gottinger Arbeiten Geologie Palaeontologie, Sonderband SB5, p. 23-32. (online at: www.geomuseum.uni-goettingen.de/museum/publications/images/GAGP/...) (Fluvial sedimentology of quartzitic sandstones of ~700m thick E Cretaceous Pra Wihan Fm, in middle part of Khorat Gp, Khorat Basin. General evolution from bed-load (braided) streams to mixed-load (meandering), to
suspended-load (meandering to anatomising) rivers. Paleocurrent measurements suggest source rock areas to N and NE of Khorat Basin. Petrified tree fragments (Dadoxylon (Araucarioxylon)) in channel-lag deposits

Hisada, K., S. Arai, K. Ueno, Y. Kamata, H. Hara, T. Charoentitirat, P. Charusiri & H. Chanthavongsa (2016)- Ultramafic rocks of Nan Suture Zone in northern Thailand and its northward extension in Laos. In: Development of the Asian Tethyan Realm: genesis, process and outcomes, 5th Int. Symposium Int. Geoscience Program (IGCP) Project 589, Yangon, p. 65. (Abstract) (online at: http://igcp589.cags.ac.cn/5th%20Symposium/Abstract%20Volume.pdf) (Nan Suture Zone was regarded as site of collision of Shan Thai (Sibumasu) and Indochina continents, but more recently accepted as oceanic materials in suture zone representing floor of marginal basin (Nan backarc basin) N extension of Nan SZ recently confirmed near Pakbeng, N Laos (serpentinites, metamorphics). Ultramafic rocks derived from supra-subduction zone)


Insamut, S. (2003)- Marine Paleozoic stratigraphy of the Betong- Than-To area, Yala Province, Peninsular Thailand. Dept. Mineral Resources, Bangkok, Techn. Report BGS 25/2003, p. 1-49. (online at: http://library.dmr.go.th/Document/DMR_Technical_Reports/2003/10536.pdf) (Folded 'Sibumasu' Paleozoic stratigraphy of N Peninsular Thailand: (1) Silurian Devonian Betong Fm clastics >100m thick with minor chert and limestones with Tentaculites, graptolites, trilobites, brachiopods, etc.; (2) 800m of E Carboniferous Yaha Fm shales and thin-bedded chert with radiolaria and conodonts; (3) 500m of Sri Paen Fm with bivalves, brachiopods and ribbon chert with Carboniferous radiolaria; (4) E Permian recrystallized crinoid limestones of Tham Krachaeng Fm with fusulinids. Intruded by Triassic biotite granites)


(Paleomagnetic study of Phu Tok Fm continental red beds of Khorat Gp of Indochina Block in NE Thailand suggest Cretaceous age, paleolatitude of 20-30°N and CW rotation during M Cretaceous)

(Paleozoic (meta-)sediments of W Thailand five Cambrian-Permian units (= Shan Thai/Sibumasu passive margin series))

(Psammomodontid fish tooth fragment in a massive Visean limestone in Ban Pak Chom area of Thailand. Tooth referred to Delodus sp., associated with teeth of 'Cladodus type, in lower Permian limestone at Ban Na Chareon (E of Loei)).

(Part of large amphibian capitosaurid skull, similar to Cyclotosaurus posthumus from U Triassic of Germany in U Huai Hin Lat Fm (basal part of Khorat Gp) near Chulabhorn Dam, consistent with presumed Norian age of formation. Supports hypothesis that this part of SE Asia was linked to Laurasia by Late Triassic)

('Discovery in Thailand of a part of a sauropod dinosaur femur (Saurischia, Reptilia). Discovery of Cretaceous dinosaur bone in Phetchabun region is first dinosaur remain found in Thailand)


(Cenozoic volcanic rocks in central Loei-Phetchabun volcanic belt in C Thailand. Composition ranging from basalt to high-silica rhyolite. Decrease in age from S to N: oldest rocks 55-57 Ma rhyolites; younger rhyolites that occur farther N (13-24 Ma). Depleted mantle source)


(online at: www.ipcbee.com/vol52/2013-ICGES2013-G014.pdf)  
(Permo-Triassic intermediate volcanic-plutonic rocks of Loei-Petchabun fold belt in Amphoe Wang Sa Phung and Maung areas, Loei Province, have calc-alkaline affinities and indicate magmatism at E-dipping subduction zone, where former ocean between Indochina-Sibumasu blocks subducted beneath Indochina block. Subduction active from at least 244-230 Ma (Middle-early Late Triassic). Subduction-derived melts probably contaminated by overlying continental crust)

(Trilobite Plagiolaria in E-M Devonian Tentaculites Shale of Peninsular Thailand. Associated with Monograptus spp.)


(online at: www.sciencedirect.com/science/article/pii/S1674987117300324) 
(Khok Kruat Fm in U Khorat Gp, with many Aptian-Albian dinosaur footprints at Huai Dam Chum near Laos border. ~600 tracks in thin mudstone layer of small theropods and crocodylomorphs. Most footprint of cf. Asianopodus, and imprinted by small theropoda)

(online at: www.dmr.go.th/download/laotai56/pdf_dat/Early%20Jurassic%20marine%20.pdf)

(Fragmentary silicified receptaculitalean material from E-M Ordovician Tha Manao Formation at Khao Tham, W- C Thailand (= Sibumasu terrane). Described as ?Fisherites sp., possibly related to Fisherites burmensis from C Myanmar (Rietschel & Nitecki 1984). One of few SE Asian records of this order)

(Layered anhydrite and massive gypsum in NE Nakhon Sawan, C Thailand, likely precipitated from Carboniferous sea water (~ 326 Ma). Intruded by andesitic dikes with M Triassic zircons (~ 240 Ma))

(online at: http://research.msu.ac.th/msu_journal/upload/journal_file/jfile_no34_44342.pdf) 
(Three new vertebrate localities in Late Triassic Huai Hin Lat Fm, N Thailand. With coprolites, hybodont shark, bony fish remains, phytosaur tooth and temnospondyl fragments)

(Oldest dinosaur assemblages of Thailand in Nam Phong Fm continental sediments. With Isanosaurus attipatchi and other species of basal sauropods. Age more likely E Jurassic than Triassic)


(12 oils from Sirikit field of onshore Phitsanulok Basin suggest all oils derived from mixture of bacterial, algal and higher plant material. Sterane contents relatively low and sterane ratios suggest oils relatively immature. Extensive strike-slip faults in basin may have led to rapid burial of sediments)


(similar to Lawwongngam & Philp, 1993)


(online at: http://research-repository.uwa.edu.au/files/3245697/Lazar_Shachar_2012.pdf)

(U Carboniferous-Permian Pha Nok Khao platform outcrops in N Loei-Phetchabun foldbelt and is outcrop analogue for coeval gas fields in nearby Khorat plateau. Part of Indochina Terrane)

Lei, Z.Q. (1993)- The discovery and significance of the Late Jurassic sporopollen assemblage in Peninsular Thailand (Phrae and Nan Provinces). In: T. Thanasuthipitak (ed.) Int. Symposium Biostratigraphy of mainland Southeast Asia: facies and paleontology, (BIOSEA), Chiang Mai, University of Chiang Mai, 2, p. 361-380

(online at: http://library.dmr.go.th/library/Proceedings-Yearbooks/M_1/1993/7489.pdf)

(Abundant and diverse sporopollen assemblages from redbeds of SW Peninsular Thailand dominated by 21 species of Classopolis (86%) and Dicheiropollis (4.3%). Indicate arid climate and Late Jurassic age, similar to Late Jurassic of dry southern zone in China. Associated with 'Estheria' fauna of conchostracans Pseudograpta, Paleoleptestheria, etc. (Alderson et al. 1994 suggest more likely Early Cretaceous age))


(First sauropod tracks in Thailand, in basal Cretaceous Phra Wihan Fm E of Khon Kaen, NE Thailand (Khorat Gp). Associated with theropod tracks)


(online at: http://rdo.psu.ac.th/sjstweb/journal/35-4/35-4-13.pdf)

(Miocene Wichian Buri basalts and basalt breccias in Loei-Phetchabun Volcanic Belt similar petrography and chemical compositions. Both formed from same continental within-plate, transitional tholeiitic magma)


(Denchai gem sapphire deposits in Phrae Province, N Thailand, closely associated with late Cenozoic high CO2/ high K alkaline basaltic rocks. Sapphires in alluvial placer deposits in paleo-channels at shallow depths)

(Tin mineralization may occur at shallow and deep levels of emplacement, but greater tendency for cassiterite-bearing pegmatites to form at depth)


(Well-preserved, three-toed dinosaur footprints with bilobed heel impressions from Cretaceous of Thailand are assigned to new ichnotaxon Siamopodus khoayiensis. Represent gracile theropods. Also theropod tracks with bulbous heel impressions from a new locality, similar to Lower Cretaceous tracks from elsewhere in Asia)


(online at: www.thaiscience.info/Article%20for%20ThaiScience/Article/61/10001833.pdf)

(Khorat Plateau erosional surface developed in two main phases: (1) E Tertiary formation of extensive plain, with deep weathering under humid tropical conditions (red Yasothon ferralsols and gravels of 'upper terrace'); (2) Pliocene or E Pleistocene relief rejuvenation after tectonic uplift, dissecting and stripping much of weathered mantle, with development of yellow sandy xanthic ferralsols on new land surfaces under more seasonal climate. Modifying factor in landform/soil development is post-depositional bioturbation by termites, capable of reworking a few m of soil profile in several 1000 yrs, transporting fine material upward and causing coarse material like tekmites to move down profile like a lag deposit)


(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1984/7249.pdf)


(Paleomag data from 179 sites in M Triassic- M Cretaceous Khorat Gp (54% of sites rejected). Paleolatitude not significantly different from today (unlike nearby S China, whose Jurassic-Cretaceous paleolatitudes N of present-day?). Clockwise rotation of ~38° after Mid-Cretaceous))


(New baluchimyine rodent, Baluchimys kraiense n. sp., from Bang Mark pit of Krabi mine (Late Eocene))


(online at: http://sciencepress.mnhn.fr/sites/default/files/articles/pdf/g2004n3a4.pdf)

(New finds of mandibles and isolated teeth of a diatomyid theropod Fallomus ladakhensis in Oligocene lignites of the Tertiary basin of Nong Ya Plong in C Thailand. Development of lophodont and moderately hypsodont teeth more likely in fairly arid environments.)


(online at: https://academic.oup.com/zoolinnean/article/158/3/608/3798456)
(Remnants of new alligatorine taxon from Late Eocene of Krabi Basin, S Thailand: Krabisuchus siamogallicus. Alligatorines widespread as early as Late Eocene across N hemisphere. Probably colonized vast territories, during periods of global warm climates)


Martin, M., E. Buffetaut, H. Tong & V. Suteethorn (1996)- New Jurassic dipnoans from Thailand. Geol. Soc. Denmark, DGF Online Series. 1. (online at: http://2dgf.dk/dgf-online-series/new-jurassic-dipnoans-from-thailand/) (Toothplates of freshwater dipnoans (lungfish) in Jurassic of S and NE Thailand assigned to Ferganaceratodus szechuanensis. Also known from S China Late Triassic- Jurassic)


Martin, V. & R. Ingavat (1982)- First record of an Upper Triassic Ceratodontid (Dipnoi, Ceratodontiformes) in Thailand and its paleogeographic significance. Geobios 15, 1, p. 111-114. (First discovered Norian continental vertebrate locality of Thailand yielded minute toothplate of ceratodontid (lungfish). Probably Ceratodus cf. szechuanensi, previously recorded from U Triassic of China, providing evidence for land connection between Thailand and China as early as Late Triassic)


Mein, P. & L. Ginsburg (1997)- Les mammifères du gisement Miocene inférieur de Li Mae Long, Thaïlande: systématique, biostratigraphie et paleoenvironnement. Geodiversitas, 19, 4, p. 783-844. ('The mammals from the Lower Miocene beds of Li Mae Long, Thailand: systematics, biostratigraphy and paleoenvironment'. Mammal fauna of Li Mae Long (Lamphun district, Thailand) 33 species, 5 Insectivora , 9 bats, 1 Scandentia, 2 primates, 8 rodents, 2 carnivores, 1 proboscidean, 1 perissodactyl and 4 artiodactyls). Age is the beginning of MN4; environment tropical forest near very shallow lake)


(online at: http://igcp589.cags.ac.cn/5th%20Symposium/Abstract%20Volume.pdf)

(Khorat Plateau and surrounding NE Thailand underlain by Permian carbonates, which host two commercial gas fields. Intense deformation of Carboniferous-Permian sections below Indosinian I Event, which may be caused by closure of back-arc basin between Sukhothai arc and Indochina terrane at end of Permian along Nan-Uttaradit suture, before (Triassic) collision between Sibumasu block and Indochina)


(Lampang area in N Thailand belongs to Sukhothai Zone island arc, developed along margin of Indochina Block during Permian-Triassic. E Permian Kiu Lom Fm ~500m thick volcanoclastics with bedded limestone rich in fusulinid foraminifera (Darvasites, Chalaroschwagerina, Praeskinnerella, Levenella, etc.). Volcanism of Sukhothai Arc active from latest Carboniferous - late E Permian (Yakhtashian), ceased, followed by major arc volcanism in M Triassic)


(Late Triassic Nam Pat Gp of Nam Pat Basin in Nan-Uttaradit Suture Zone, NW Thailand. Clastics dominated by volcanic arc detritus. Paleocurrents to SE and derived from underlying E-M Triassic Pak Pat andesitic magmatic arc volcanics. Basin best interpreted as short-lived back-arc basin rather than forearc basin)


(Rift basins of Thailand with remarkable diversity of fault displacement patterns. Oblique extension, influence of pre-existing trends and stress rotation in multi-phase rifts more comprehensive explanation than strike-slip interpretation of previous studies)


(Tertiary rift basins of Thailand form N-S trending string of depressions from Gulf of Thailand in S to hill country in N. Southern basins larger, longer and deeper. Extension primarily in Oligocene and Miocene. Li basin data shows episodic compressional or strike-slip events through its evolution, inconsistent with simple pull-apart origin and suggesting strike-slip motions more complex than simple prevalent strike-slip models indicate. Thai basins may have evolved under two separate deformation mechanisms (escape tectonics from India collision and Indian Ocean subduction rollback) that may have alternated in importance with time)


(Cenozoic Phitsanulok rift basin with igneous intrusions and lava flows. Age of youngest sills ~10 Ma; older sills inferred of M Miocene age. Well E-A01 drilled E Miocene synrift Lan Krabu Fm with 300m thick olivine dolerite sill, but without high amplitude seismic responses usually seen in intrusions.)


(Bramatherium remains from Miocene deposits at Tha Chang sand pit, NE Thailand, and from Irrawaddy sediments, C Myanmar)
(Two large rodents from M Miocene (13.0- 12.4 Ma) from Chiang Muan Coal Mine, N Thailand (1) beaver (Anchitheriomys); (2) indeterminate larger rodent)


(online at: http://en.earth-science.net/PDF/20160612012417.pdf)
(Late Cretaceous- E Tertiary Phu Khat Fm sandstone unsorted texture and common unstable volcanic lithic fragments (recycled sediments and felsic volcanic rocks from M-L Triassic arc to W). Unconformably overlies mature sandstone of Late Cretaceous Khao Ya PuK Fm (mainly recycled sedimentary rock))

(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/2557/8590.pdf)
(Phu Khat Fm is uppermost (Cretaceous) red bed in Nakhon Thai region. Alluvial fan and braided fluvial deposits overlie unconformably aeolian sandstone of Khao Ya PuK Fm. Thickness ~ 490m. Age not older than Campanian age and not younger than Ypresian)


(At least four pre-Jurassic volcanic belts in Thailand. Late Devonian C Loei volcanics part of Loei- Petchabun-Phai Sali volcanic belt, representing mid-ocean ridge basalts (MORB) and oceanic island arc lavas)


(New mustelid rodents from Late Oligocene in Nong Ya Plong lignite mine in C Thailand)

(C and N Thailand Oligocene- E Miocene rift basins with oil shales deposited in fresh-brackish lakes, with TOC up to 44%. With abundant lamalginitie and algal-derived amorphous organic matter, liptodetrinite and telalginitie (Botryococcus-type). Coals dominated by huminite and formed in freshwater mires. Exposed coals thermally immature. Steep Vitrinite Reflectance curves from oil basins reflect high geothermal gradients of

(BP1-W2 well in oil-producing Suphan Buri Basin with likely geothermal gradient of ~42°C/km. Predicts that onset of oil generation at 107°C post-dated reservoir and trap formation in M-L Miocene times)


(Oil produced from Suphan Buri (U Thong, Sang Kajai fields), Phitsanulok (Sirikit field) and Fang Basin (Fang field) in C and N Thailand. Most Cenozoic rift-basins 2-4 km deep, but Phitsanulok Basin deepest, with up to 8km basin-fill. Sirikit oil most mature. Oils highly waxy, generated from freshwater lacustrine source rocks with common algal material. Presence of cadalene, tetracyclic C24 compounds, oleanane, lupane, bicadinane, etc., indicate contributions from higher land plants, either disseminated in lacustrine facies or from associated coal seams. Thermally immature oil shales (lacustrine mudstones) and coals exposed in many Thai basins)


(Giant silicified trees in M Pleistocene gravel terraces of Ping River, 20 km N of Tak, N Thailand, with longest log 72.2m. Most trees belong to Koompassioxylon elegans. Part of >100m tall tropical- subtropical rainforest Lannathaian pebble tools (presumably from Homo erectus) from coeval beds in same area. Overlying basalts K/Ar dated at 0.6 ± 0.2 and 0.8 ±0.2 Ma)


(Large M Jurassic- E Cretaceous conifer logs from forest environments with different types of architecture)


(online at: http://sciencepress.mnhn.fr/sites/default/files/articles/pdf/g2011n1a2.pdf)

('Reappraisal of Brachyoxylon rotnaense Mathiesen, description of B. serrae n. sp. and stratigraphical implications for SE Asia Early Cretaceous stratigraphy'. Mesozoic beds of Muang Phalan basin in S Laos continuation of Thailand Khorat Gp. (Khok Kruat Fm). With wood fossils formerly assigned to Brachyoxylon rotnaense, known from E Jurassic of Denmark, but associated vertebrate fossils indicate Aptian age. Laos material not same as European species and here described as B. serrae n. sp.. In Thailand B. serrae associated with endemic SE Asian E Cretaceous flora, with indicators of tropical climate with seasonal rainfall)


(Petroleum exploration of Khorat Plateau since 1962. 41 wells drilled, only two are gas discoveries, in Permian carbonate reservoirs (Nam Phong and Sin Phu Hom fields; Esso 1981,1982). Source rocks mainly Late Carboniferous rocks)


Punpate, N., S. Pailoplee, I. Takshima & P. Charusiri (2005)- Ages of layered tektites and tektite- bearing sediments in Buntharik Area, Ubonratchathani, Northeast Thailand. Proc. Int. Conf. Geology Geotechnology and Mineral Resources of Indochina (Geo-Indo), Khon Kaen, p. 517-523. (Layered tektites from 0.7-1m thick pebble bed in Unit 4 of alluvial deposits in E-most Khorat Plateau. Size 1-5 cm, with average thermoluminescence age of ~850 ka. Younger ages of surrounding sediments suggests probable reworking of tektites)


Putthapiban, P. & C.M. Gray (1983)- Age and tin-tungsten mineralization of the Phuket granites, Thailand. Conference on Geology and mineral resources of Thailand, Bangkok, p. 30-39. (Four different granite suites at Phuket, W side of Peninsular Thailand. Rb/Sr ages ~83-94 Ma (Late Cretaceous). Age of tin-tungsten mineralization rel. late, ~84 Ma)

Qian, X., Q. Feng, Y. Wang, T. Zhao, J.W. Zi, M. Udchachon & Y. Wang (2017)- Late Triassic post-collisional granites related to Paleotethyan evolution in SE Thailand: geochronological and geochemical constraints. Lithos 286-287, p. 440-453. (Chonburi, Rayong-Bang Lamung and Chanthaburi granite plutons in SE Thailand similar crystallization ages of 222-218 Ma (Norian, Late Triassic). Geochemically classified into S-type (Group 1; mainly from ancient greywackes) and I-type (Group 2; from juvenile mafic crust with input of meta-sediments) granites. Formed in post-collisional thickened crust after assemblage of Indochina and Sibumasu blocks. Linked to N with Late Triassic granitoids in NW Thailand (Sukhothai zone), to S with East Malay Peninsula granites)

Qian, X., Y. Wang, B. Srithai, Q. Feng, Y. Zhang, J.W. Zi & H. He (2017)- Geochronological and geochemical constraints on the intermediate-acid volcanic rocks along the Chiang Khong-Lampang-Tak igneous zone in NW Thailand and their tectonic implications. Gondwana Research 45, p. 87-99. (Lampang-Den Chai area volcanic suite in NW Thailand intermediate- acid rocks with zircon U-Pb ages of ~240-242 Ma (M Triassic). Sequence dominated by calc-alkaline andesites, dacites and rhyolites. Formed in...
response to slab roll-back during transition from subduction to continental collision between Sibumasu and Indochina blocks. Constitute part of Chiang Khong- Lampang- Tak igneous zone, extending N to Lancangjiang igneous zone and S to Chanthaburi, Malaysia and Singapore areas)

(Common Permian- Triassic volcanic rocks in Chiang Khong area of N Thailand. Zircon ages of basaltic andesite samples from Doi Yao zone 241 ±6 Ma. Rhyolite from Doi Khun Ta Khuan zone 238±9Ma. M Triassic ages comparable to arc-volcanic rocks in Lampang area, N Thailand (Chiang Rai Arc) and Jinhong area, SW Yunnan (Lancangjiang arc). Also zircons of 1885-1323 Ma, indicating Proterozoic-Mesoproterozoic basement)

(online at: http://library.dmr.go.th/library/Proceedings-Yearbooks/M_1/1997/7641.pdf)
(AFT analyses on Early Cretaceous fluvial sandstones from NE Thailand and SW Laos (incl. Khorat Plateau). Max. paleo-T before cooling >120° during burial. Cooling started at ~55 Ma for most samples, with possible final cooling to present outcrop between 35-25 Ma (Oligocene))

(Age of much of Khorat Gp (Late Jurassic?- Early Cretaceous, not Jurassic). Lowermost formation of Khorat Gp (Nam Phong Fm) dated as latest Norian-Rhaetian (Ovalipoliis ovalis))

(Khorat Gp of NE Thailand commonly assumed to be of Late Triassic- E Cretaceous age, but here argued to include only Late Triassic and E Cretaceous sediments. Possibly reflects Late Jurassic collisional event (Sibumasu-Indochina collision)

(online at: http://library.dmr.go.th/library/Proceedings-Yearbooks/M_1/2002/6373.pdf)
(Brief review of Carboniferous-Permian stratigraphy of Thailand)

(Lacustrine oil shales in multiple Tertiary rift basins of NW Thailand dominated by Alginite B with disseminated Alginite A (Botryococcus brownii, Pila, Reinschia alga). Also Pediastrum)

(NE Thailand Tertiary rift basins with coals and oil shales. In lower part E Tertiary (especially in Fang oilfield), mainly alginite A (Botryococcus sp.) only type of algae, changing upward into association of Botryococcus braunii, Pila, thick-walled alginite B, and temperate palynomorphs (Late Oligocene?-E Miocene). In upper section alginite B dominant with Botryococcus-related taxa Pila, Reinschia and fresh-water-dwelling ferns)


Ratanasthien, B., W. Kandharosa, S. Chompusri & S. Chartprasert (1999)- Liptinite in coal and oil source rocks in northern Thailand J. Asian Earth Sci. 17, 1-2, p. 301-306. (N Thailand coal and oil shale deposits similar palynological associations to Borneo region. Oldest coal and oil shales (Late Oligocene- E Miocene age) dominated by Botryococcus sp. or related algae. Thick-walled lamaginites and spores and pollen of temperate affinity in some areas. Thin-walled lamaginites dominant in late M Miocene. Resinite, suberinite, and cutinite dominant in forest swamp coal deposits whereas alginite, cutinite and lycopodium spores dominant in lacustrine environments)


Saegusa, H., B. Ratanasthien & H. Nakaya (2000)- A new Miocene mammalian locality, Mae Soi and the occurrence of partial skeletons of rhinocerotids and gomphotheres from northern Thailand. Asian Paleoprimatology 1, p. 137-147 (online at: https://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/199736/1/aspp_01_137.pdf) (New E or M Miocene vertebrate fossil locality in Mae Soi, Chiang Mai Province, with nearly complete gomphothere (Archaeobelodon or Gomphotherium) (elephant-like proboscideans))


(Triassic volcanic sandstone with Carboniferous chert fragments, possibly sourced from Sukhothai volcanic belt)


Saminpanya, S. & F.L. Sutherland (2014)- Different origins of Thai area sapphire and ruby, derived from mineral inclusions and co-existing minerals. European J. Mineralogy 23, 4, p. 683-694. (Gem corundum from Thailand divided into sapphire and ruby suites. Rubies may have crystallized in high-P metamorphic rock of ultramafic/mafic composition. Sapphires may have crystallized in high-grade metamorphic rock or from highly alkaline magmas, at shallower depths than those hosting Thai rubies)

Sasada, M., B. Ratanasthien & R. Soponpongpipat (1987)- New K-Ar ages from the Lampang basalt, Northern Thailand. Bull. Geol. Survey Japan 38, 1, p. 13-20. (online at: https://www.gsj.jp/data/bull-gsj/38-01_04.pdf) (Two samples of aphyric Lampang basalts from SW part of Mae Moh basin, NW Thailand. Chemically of basanite composition. Whole rock ages 0.8 ± 0.3 Ma and 0.6 ± 0.2 Ma. K-Ar ages may give lower limit of formation age because of argon loss due to hydration. Most flows of Lampang basalt normal polarity, except lower flow. Some flows overlie gravel with early Paleolithic pebble tools)


trigoniodid bivalves, in NE and Peninsular Thailand and in Savannakhet (Donghen) Basin of S Laos: T kobayashi- Plicatounio suzukii assemblage, and T. diversicostatus-Pseudohyria subovalis assemblage

(Late Permian- E Triassic continent margin arc volcanics on E side of oceanic basalts in Chiang Mai belt indicative of E-ward subduction of oceanic crust in Chiang Mai belt)

(Oceanic island arc rocks in Chiang Mai zone, N Thailand, are usually covered by Lower Carboniferous-Permian shallow marine carbonates. Geochemistry typical of oceanic island basalts and alkali basalts, similar to equivalents in Deqin and Gengma (Changning-Menglian zone) of Yunnan Province, China)

(~850m thick Tarutao Fm of Tarutao Island off SW Peninsular Thailand shallow marine clastics with U Cambrian and basal Ordovician trilobites. Terminal Cambrian assemblage with Micragnostus, Prosaukia, Hoytaspis, Lophosaukia, etc. Fauna resembles assemblage known from Vietnam)


(online at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0145904)
(New basal hadrosauroid dinosaur from Lower Cretaceous (Aptian) Khok Kruat Fm of Thailand: Sirindhorna khoratensis gen. et sp. nov.)

(Metamorphic formations at E side of Upper Peninsula of Thailand near Khao Tao. Pranburi Fm paragneiss and schist, marble and quartzite originally shallow marine island arc sediments. Khao Tao Fm orthogneiss originally granite. Since peak metamorphism in Late Triassic uplifted by ~10km. Several deformation episodes. N-S to NNE-SSW trending folds and schistosity. Tied to Sibumasu-Indochina collision)

(online at: www.ccop.or.th/download/as/52as2.pdf)
(Geochemistry of M-L Triassic mildly calc-alkalic andesite porphyry from Chiang Kong- Lampang- Tak volcanic belt of NW Thailand. Erupted in volcanic arc setting)

(Thailand three metallogenic provinces, NE, Central (A, Cu, etc.) and West (Sn, Pb, Zn, etc.) representing continental and subduction system settings)


(Quarries N of Noen Sa-nga, Khorat Basin, NE Thailand, with lower fluvial gravel unit (with thin ferricrete layer at top) and upper bright reddish brown structureless sand unit with fining-upward basal portion (Yasothon soil series). Black glassy tektite (4x2 cm) found at contact between two units. Tektite deposition followed by larger-sized sediments and angular quartz fragments forming fining-upward sedimentary series. Finer sediments gradually settled down, forming Yasothon structureless sand deposit. Meteoritic impact event occurred at ~0.77 Ma)


(Two new algal species of algae Actinastrum bansaense n. sp. and Closterium thailandicum from late M Miocene (~13.5 -10 Ma) lacustrine deposits associated with coals of Chiang Muan basin. Palynofloras from tropical monsoon forests (incl. Crassoretiritles vanraadshoovenii fern spores, also Dipterocarpaceae, Lagerstroemia, Illexpollenites, Myrtaeides and Combretaceae with rare Florschuetzia-type, Homonoia, Calophyllum, Striatriletes susannae, Botryococcus and Mimosaee. Laeivagatosporites haardtii fern spores in some horizons. Three acme zones; upper zone mainly with freshwater alga Actinastrum bansaense)

Songtham, W., B. Ratanasthien & D.C. Mildenhall (2001)- Tropical palynofloras from Middle Miocene Chiang Muan basin, Phayao, Thailand. .

(Sporomorphs from M Miocene sediments of Chiang Muan basin include abundant Crassoretiritles vanraadshoovenii, Dipterocarpaceae, Illexpollenites, Botryococcus and rare Florschuetzia, , representing tropical palynofloras derived from tropical monsoon forests, accumulated mainly in lacustrine environments)


(Palynology of Oligocene- E Miocene Li Basin sediments, N Thailand. Climate became warmer and wetter with time)


(Fresh-water molluscs in M Miocene Mae Moh Gp of N Thailand (?Paludina, Melanoides, Bellamya, Margarya, Planorbidae, etc.))


(online at: http://igcp589.cags.ac.cn/4th%20Symposium/Abstract%20volume.pdf)
(U-Pb-Th zircon ages of igneous and sedimentary rocks in Chiang Khong-Lampang-Tak volcanic belt in middle part of Sukhothai Fold Belt. Most volcanic belt igneous rocks crystallized in late M- early Late Triassic (216-237 Ma) and show zircon age groups of ~ 220 Ma and ~230 Ma. Permian zircons (261-280 Ma) possibly inherited from Permian granites. Detrital zircons in sedimentary rocks in belt indicate Devonian-Carboniferous, Permian and Late Triassic rocks in provenance areas)


(online at: https://air.repo.nii.ac.jp/?action=repository_uri&item_id=2547&file_id...2)


(Eight genera of Proboscidea fossils in sand pits in Nakhon Ratchasima province, NE Thailand, of families Dienotheriidae (Proteinotherium, Gomphotherium, Tetralophodon, Sinomastodon, Protanancus), Stegodontidae (Stegolophodon, Stegodon) and Elephantiidae (Elephas). Ages M Miocene- Pleistocene)


(>42 species of U Devonian (Frasnian-Famennian) radiolaria in cherts-siliceous shales in NE Thailand sector of Loei fold belt (Indochina terrane). Geochemistry suggests continental margin environment near volcanic arc, different from U Devonian cherts from N Thailand, Truong Son foldbelt (Laos) and S China. U Devonian deepmarine sequences in Loei fold belt deposited in rifted continental margin basin, possibly back-arc basin, not in large oceanic basin)


(>30 species of Late Ladinian radiolaria from red chert- siliceous shales in E of Sukhothai fold belt, incl. Muelleritortis cochlata, M. expansa, Triassoscampe deweveri, T. coronata, T. scalaris, Anulotrissocampe companilis, A. multisegmantatus, A. sulovensis, Pseudostylosphaera spp., Canoptum inornatus, C. l.


(Vertebrate fossils from Late Eocene lignite beds of Krabi coal mine in S Thailand 6 genera of reptiles and 28 genera of mammals, incl. two primates (Wailekia, Siamopithecus). Krabi fauna dominated by artiodactyl mammals, particularly anthracothers (Anthracotherium, etc.). Paleoenvironment tropical forests with swamps)


(Limestone-chert sections from Loei foldbelt, NE Thailand, yielded M-L Devonian (Givetian- Famennian) conodonts and Late Devonian radiolarian faunas. M Devonian siliciclastics interbedded with volcanoclastics and locally replaced by pillow basalts. Conformably overlain by argillaceous limestones and U Givetian reefalstromatoporoid-coral limestone. Drowning of bioherms and deposition of condensed continental margin oozes with radiolarians Triloneche spp and Famennian conodonts Palmatolepis spp.. Transgressive M-U Devonian series broadly similar to sections in S China and in Germany. Continental margin series)


(E Permian Kaeng Krachan Gp on Phi Phi Island off Krabi, S Peninsular Thailand, part of Sibumasu Block. Cyclic, ~350m thick quartz-rich marine clastics, including sparse dropstones, overlain by temperate-subtropical Rathuri Limestone. Formed in glaciation-influenced basin. No figures)


(online at: www.palaeo-soc-japan.jp/download/TPPSJ/TPPSJ_NS171.pdf)

(Limestone outcrops at Ban Na Din Dam, E of Loei, NE Thailand. Previously assigned to Lower Permian Nam Mahoran Fm, but with fusulinids Triticites samarcicus and Jigulites grandis n.sp., indicating Gzhelian (latest Carboniferous) age. Also descriptions of smaller foraminifera)


(Pterosaur humerus (PRC 64) from U Jurassic of Thailand reassigned to Rhamphorhynchidae)


(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1999/6605.pdf)

(>40 Tertiary intra-cratonic basins in N Thailand, mainly N-S trending, and with 500-3000m of sediment fill)


(Area of Chatree gold deposit, W side of Khorat Plateau, N-C Thailand with subduction-related Loei-Phetchabun- Ko Chang volcanic arc sequence from basalt porphyry, basaltic tuff to rhyolite/rhyodacite tuff. Andesite dated as 250 ± 6 Ma, younger basaltic andesite dykes 244 ± 7Ma)


Wang, Y., H. He, P.A. Cawood, B. Srithai, Q. Feng, W. Fan, Y. Zhang & X. Qian (2016)- Geochronological, elemental and Sr-Nd-Hf-O isotopic constraints on the petrogenesis of the Triassic post-collisional granitic rocks in NW Thailand and its Paleotethyan implications. Lithos 266-267, p. 264-286. (Inthanon zone main suture zone of E Paleotethys Ocean in NW Thailand and links with Changning-Menglian suture zone in SW Yunnan. In NW Thailand switch from E-ward subduction of Paleotethys ocean plate to collision of Sibumasu with Indochina at ~ 237 Ma, with syn-collision at ~237-230 Ma and post-collision time at ~200-230 Ma. Late Triassic granites in Inthanon and Sukhothai zones of NW Thailand post-collisional magmatic products)

Wang, Y., H. He, Y. Zhang, B. Srithai, Q. Feng, P.A. Cawood & W. Fan (2017)- Origin of Permian OIB-like basalts in NW Thailand and implication on the Paleotethyan Ocean. Lithos 274-275, p. 93-105. (manuscript online at: https://research-repository.st-andrews.ac.uk/handle/10023/12399) (Basaltic rocks in NW Thailand part of SE Asian igneous zone that delineates extension of Paleotethys Ocean from SW China into NW Thailand. Chiang Mai basalts two groups of high-iron basalts, resembling OIB-like rocks. Origin intra-oceanic seamount setting in Paleotethyan Ocean, continued at least till 283 Ma (E Permian). Inthanon/ Changning-Menglian zones define main Paleotethyan suture zone)

Wasson, J.T., K. Pitakpaivan, P. Putthapiban, S. Salyapongse, B. Thaphimthong & J.F. McHone (1995)- Field recovery of layered tektites in northeast Thailand: evidence of a large scale melted sheet. J. Geophysical Research 100, E7, p. 14385-14389. (Australasian tektites from 40×130 km region in NE Thailand all layered (Muong-Nong-type) tektites, with two exceptions near W edge of region, implying impact melt hot enough to flow if deposited on sloping surface. Absence of splash-form tektites indicates that layer still molten when reached ground. This requires that atmosphere remained hot (>2300°K) for few minutes. In-place tektites almost always associated with 10cm -1m thick layer of loess-like sandy layer. Part of 1100-km-long area with layered tektites)


Yan, Y., B. Huang, J. Zhao, D. Zhang, X. Liu & P. Charusiri & A. Veeravinantanakul (2017)- Large southward motion and clockwise rotation of Indochina throughout the Mesozoic: paleomagnetic and detrital zircon U-Pb geochronological constraints. Earth Planetary Sci. Letters 459, p. 264-278. (Paleomagnetic and U-Pb geochronologic study of Late Triassic-Cretaceous Huai Hin Lat and Nam Phong Fms in NE Thailand (W Khorat Plateau; part of Indochina Block). Paleolatitudes in Norian (<227 Ma) 33.4 ± 7.2°N to Late Cretaceous 24.5 ± 4.9°N. Data indicate S-ward displacement with CW rotation)


Yanagida, J. (1976)- Palaeobiogeographical consideration on the Late Carboniferous and Early Permian brachiopods of Central North Thailand. In: T. Kobayshi & R. Toriyama (eds.) Geology and Palaeontology of Southeast Asia, University of Tokyo Press, 14, p. 173-189. (Brachiopod faunas from Thum Nam Maholan Lst of N-C Thailand strong similarities to Lower Permian of Eurasian continent, but not to Australia- New Zealand. Etc.)

(U Carboniferous and Lower Permian Brachiopod localities near Loei, N Thailand with similarities to N China, Europe, N America, etc.; few similarities with Australia)

(Delineation of potash (carnallite) layer in Cretaceous evaporites of Khorat Basin, NE Thailand. Thickness 4.3-40m)

(Phu Thap Fah gold skarn deposit in Loei Province, NE Thailand, in Permian crystalline limestone and siltstone intruded by E Triassic granodiorite (~245 Ma) and Late Triassic andesitic dykes (~221 Ma). Gold occurs as electrum and gold-bismuth-telluride association. Most gold confined to massive pyrrhotite and pyrite)

(online at: http://en.earth-science.net/PDF/20160612015946.pdf)
(E Permian very high-iron basalts from Chiang Dao, NW Thailand, have geochemical affinity to Oceanic Intraplate Basalts (OIB). Probable evidence for Paleotethys seamount, and suggest Paleotethys Ocean was located between Shan-Thai terrane of Sibumasu and Sukhothai arc along Inthanon zone of Chiang Mai-Chiang Rai rather than Nan-Uttaradit zones)

(Late E Permian (Kungurian) verbeekinaceans associated with Perrinites ammonoid fauna from Saraburi Group in S C Thailand. They represent mixed association of faunas with different ecological attributions)
IX.4. Myanmar (Burma), NE India, SW Yunnan (Sibumasu-West Burma plates) (251)

(online at: http://igcp589.caggs.ac.cn/5th%20Symposium/Abstract%20Volume.pdf)
(Naga Hills in Indo-Myanmar Ranges dominated by Cenozoic sediments structurally overlying Indian passive-margin sequence. Near India-Myanmar border imbricate thrust stack also contains sheets of ophiolitic melange. Ophiolite disrupted and overlain by Eocene shallow marine sediments of Phokphur Fm. Further E high-grade metamorphic units thrust W-wards over ophiolite. Well-preserved Jurassic, Cretaceous and Paleo-Eocene radiolarians together with U/Pb data from ophiolitic and metamorphic units. New detrital zircon ages suggest derivation of some units from Sibumasu rather than Lhasa or Qiangtang terranes)

(M Permian (~262 Ma) Emeishan Basalts of SW China commonly cited example of large igneous province that formed as result of mantle plume generating large regional-scale up-doming prior to volcanism. Support idea that ELIP was generated by plume that originated in mantle, but amount and lateral extent of uplift significantly less than predicted by conventional deep-mantle plume models. Large-scale doming may not be diagnostic feature of mantle plumes)

(online at: http://ia600708.us.archive.org/4/items/bulletinofbritis18brit/bulletinofbritis18brit.pdf)
(M Devonian articulate brachiopods from weathered 'Lower Plateau Limestone' in Padaukpin area, NE of Maymyo area, E of Mandalay, associated with colonies of tabulate corals and stromatoporoids. Brachiopod fauna 32 species, similar to West Yunnan faunas and with marked affinity with Eifelian of W Europe (stronger affinity with Europe than USSR))

(Underexplored Lower Miocene carbonate play in Pyay sub-basin of C Myanmar, with Htantabin oil field (1979-1987))

(Review of late Middle Eocene molasse-type sediments of Central Burma Tertiary Belt (Inner Burman Tertiary Basin), at E side of the Indo-Burman Ranges)

(online at: ttps://gsmpubl.files.wordpress.com/2014/09/warta-36_4.pdf)
(E-M Devonian limestone with tentaculites from Taunggyi area, SE of Mandalay, in S Shan State. ~10m thick, between Silurian Linwe Fm and Permian-Triassic Plateau Lst. Resemble Mahang Fm and Lalang Mb of NW Peninsular Malaysia. Also correlatable with E Devonian Zebingyi Fm of Pyin Oo Lwin)

(Rel. complete and mainly shallow marine Devonian section E of Mandalay, C Myanmar)

Aung, A.K. & L.R.M. Cocks (2017)- Cambrian-Devonian stratigraphy of the Shan Plateau, Myanmar (Burma). In: A.J. Barber et al. (eds.) Myanmar: geology, resources and tectonics, Geol. Soc., London, Memoir 48, Chapter 14, p. 317-342. (Sibumasu (Shan-Thai) Terrane of Shan Plateau with common limestone-dominated Cambrian - Devonian rocks, which, before Permian were part of N Gondwana margin. By M Cambrian (~510 Ma) Myanmar part of Sibumasu sector of Gondwana straddled equator and was close to NW Australian sector. Some acidic Cambrian volcanics, but passive margin setting from E Ordovician- end Carboniferous)


Aung, N.S., O. Chavasseau, Y. Chaimanee, C. Sein, J.J. Jaeger, X. Valentín & S. Ducrocq (2017)- New remains of Siamotherium pondaungensis (Cetartiodactyla, Hippopotamoidea) from the Eocene of Pondaung, Myanmar: paleoecologic and phylogenetic implications. J. Vertebrate Paleontology 37, 1, p. (Well preserved skull of small anthracotherium from late M Eocene of Pondaung Fm, attributed to Siamotherium pondaungensis. New material confirms it is anthracotherium and not helohyid. Most likely terrestrial, open-forest animal with omnivorous diet. Both species of Siamotherium confirms basal position in Hippopotamoidea)


Aung Zaw Myint, Khin Zaw, Ye Myint Swe, K. Yonezu, Yue Cai, T. Manaka & K. Watanabe (2017)- Geochemistry and geochronology of granites hosting the Mawchi Sn-W deposit, Myanmar: implications for tectonic setting and emplacement. In: A.J. Barber et al. (eds.) Myanmar: geology, resources and tectonics, Geol. Soc., London, Memoir 48, Chapter 17, p. 385-400. (Mawchi Mine in Myanmar is historic world-class Sn-W deposit in SE Asia tin province (world’s largest tin-tungsten quartz vein system exploited before WW II). M Eocene (~43 Ma) Mawchi granite small pluton at W side of Shan Plateau with biotite granite and tourmaline granite, derived from melting of crustal rocks. Part of Paleogene Western granite province (with nearby granites generally older: ~48-60 Ma)

Aung Zaw Myint, K. Yonezu, A.J. Boyce, D. Selby, A. Schersten, T. Tindell, K. Watanabe & Ye Myint Swe (2018)- Stable isotope and geochronological study of the Mawchi Sn-W deposit, Myanmar: implications for timing of mineralization and ore genesis. Ore Geology Reviews 95, p. 663-679. (World-class Mawchi Sn-W mineralization in N-S trending steeply dipping quartz veins, hosted by Eocene granite and Carboniferous- E Permian metasediments. Three stages of ore formation; (1) tourmaline-cassiterite stage (2) main ore stage and (3) sulfide stage (with 40Ar/39Ar magmatic biotite age of ~41.5 Ma and zicon U-Pb age of 42.7Ma. Sn-W mineralization synchronous with late Eocene granitic magmatism)


Barber, A.J., K. Zaw & M.J. Crow (2017)- The pre-Cenozoic tectonic evolution of Myanmar. In: A.J. Barber et al. (eds.) Myanmar: geology, resources and tectonics, Geol. Soc., London, Memoir 48, Chapter 31, p. 687-712. (Myanmar 7 N-S tectonic units, from W to E: (1) Indo-Myanmar Ranges (accretionary prism); (2) W Myanmar (Burma) Block (metamorphic basement overlain by Cenozoic C Myanmar Basins); (3) Mogok Metamorphic Belt (high-grade metamorphic core complex with Late Oligocene- E Miocene exhumation age, and granitoids); (4) Slate Belt (Mergui Gp with Late Carboniferous- Permian diamictites and intruded by Late Jurassic- E Cretaceous granodiorites); (5) Paunglaung Mawchi zone (isoclinally folded Shan Plateau margin rocks), (3,4,5 = Shan Scarps area) and (7) Shan Plateau (Paleozoic- Triassic stratigraphy, part of Sibumasu Terrane). Indochina Block does not extend into Myanmar. Mt Victoria/ West Burma Block identified in literature, but E margin of this block against Sibumasu, conventionally identified as Sagaing Fault, not clearly defined. Cenozoic development of Myanmar profoundly affected by N-ward movement of India and collision with Eurasia at ~50 Ma, resulting in ~70° rotation of whole country)


Baxter, A.T., J.C. Aitchison, S.V. Zyabrev & J.R. Ali (2011)- Upper Jurassic radiolarians from the Naga Ophiolite, Nagaland, northeast India. Gondwana Research 20, p. 638-644. (Cherts from ophiolitic melange near Salumi, Nagaland, NE India, part of Naga- Andaman suture (Neotethys/Mesotethys oceanic material?) with U Jurassic (Kimmeridgian- lower Tithonian) radiolaria. Significantly older than fossils previously reported from this melange, but similar to radiometric ages from associated igneous units)


(C Burma Depression with up to 15km Albian- Recent sediments. Oils from Salin Basin from predominantly terrestrial source. Thermal maturity increasing from N to S across Salin Basin)


(Menghai batholith in W Yunnan is S extension of ~370km long Lincang granite body that syntectonically intruded Paleotethys collision zone between Gondwanan Baoshan block and Laurasian Simao block. Crustal anatexis of Menghai granodiorites related to post-collisional lithosphere delamination and upwelling of hot asthenosphere, forming large-volume melts. Zircon ages from ~3234 to 172 Ma. Inherited zircons Carboniferous (~318 Ma) and older. Crystallization ages Permian- E Jurassic, with ages decreasing from centre of batholith to E perimeter from ~227- 211 Ma to 212- 171 Ma respectively. Collision and closure of branch of Paleotethys here over ~100 Myr period (Permian (281 Ma)- Jurassic (172 Ma))

(online at: www.pnas.org/content/109/26/10293.full.pdf)
(Earlier hypotheses supported African origin for anthropoids, but recent discoveries of older and phylogenetically more basal fossils in China and Myanmar indicate group originated in Asia. New fossil primate from late M Eocene Pondaung Fm of Myanmar (Afrosia dijjidae) remarkably similar to, but dentally more primitive than roughly contemporaneous N African anthropoid Afrotaurus. Members of this clade may have dispersed from Asia to Africa in M Eocene, shortly before first appearance in African fossil record)

(Tectonic slices of eclogite and blueschist in E Cretaceous-Eocene Naga Hills ophiolite belt. Part of accretional wedge, reflecting E-ward subduction of Indian plate under Burma microplate prior to India-Eurasia collision. Glaucophane and epidote represent post-peak assemblage)


(online at: https://www.sciencedirect.com/science/article/pii/S0169136817302007)
(Tengchong-Lianghe tin belt in W Yunnan, SW China, important tin mineralization belt with two large tin deposits: Paleogene Lailishan and Late Cretaceous Xiaolonghe, associated with A-type granitoids)

(Three commercial biogenic methane gas discoveries in Late Pliocene deepwater turbidite sandstones reservoirs of Bengal Fan off NW Myamna, 2900-3300m subsea. Modeling indicates M Miocene- Pliocene section thermally immature. Most biogenic gas generated from M Miocene and E Pliocene shale. Accumulation
of commercial quantities of biogenic gas requires early formation of traps and seals. Miocene- Pliocene paleo-
hydrates formed have played important role in gas accumulation, acting as seals in initial gas generation stage.

Ciochon, R.L., P.D. Gingerich, G.F. Gunnell & E.L. Simons (2001)- Primate postcrania from the late middle
(online at: www.pnas.org/content/98/14/7672.full.pdf)
(First postcrania fossils of Pondaungia from M Eocene of C Myanmar. Overall, humeral and calcaneal
morphology most consistent with that of other adapiforms and does not support inclusion in Anthropoidea)

Ciochon, R. L. & G.F. Gunnell (2002)- Eocene primates from Myanmar: historical perspectives on the origin of
Anthropoidea. Evolutionary Anthropology 11, 4, p. 156-168.

Ciochon, R. L. & G.F. Gunnell (2002)- Chronology of primate discoveries in Myanmar: influences on the
(First Eocene mammals from Asia described from Myanmar in 1916. First primates (Pondaungia,
Amphipithecus) described in 1927 and 1937. all from M Eocene Pondaung Fm in Myanmar, and commonly
compared with anthropoids. In late 1990s new primates discovered in Myanmar (Bahinia, Myanmarpithecus).
None of known Asian primate taxa appear closely related to African anthropoids, making Asian origin for
Anthroipoidea unlikely)

considerations and phylogenetic affinities. In: C.F. Ross & R.F. Kay (eds.) Anthropoid origins: new visions,


Clegg, E.L.G. (1938)- The geology of part of the Minbu and Thayetmyo Districts, Burma. Mem. Geol. Survey
India, Memoir 72, 2, p. 132-307.

Cliff, D. & P. Carter (2016)- Exploration of the Rakhine Basin, pushing out the barriers with new 3D. 2nd
AAPG/EAGE/MGS Conf. Unlocking the complex geology of Myanmar, Yangon 2015, Search and Discovery
Art. 10848, 25p. (Abstract + Presentation)
(online at: www.searchanddiscovery.com/documents/2016/10848cliff/ndx_cliff.pdf)

Museum Novitates 951, p. 11-18.
(online at: http://digitallibrary.amnh.org/handle/2246/2188)
(First? primate fossil (mandibule with few teeth) from upper Eocene Pondaung fauna, NW of Mogauing,
Myanmar, named Amphipithecus mogaungensis, new genus and species)

Museum Natural History 74, 6, p. 395-436.
(online at: http://digitallibrary.amnh.org/handle/2246/372)
(Diverse collection of mammal fossils from (1) M-U Pleistocene terraces along Irrawaddy River in N Myanmar
(most common in Terrace 3); (2) in underlying E Pleistocene Upper Irrawaddy Beds (U Irrawaddy fauna
probably related to Upper Siwalik fauna of India and E Pleistocene faunas of Java (Tji Djoelang, Kali Glagah
and Djetis); and (3) Mogok cave fauna (likely equivalent to M Pleistocene Trinil fauna of C Java))

(Moattama Basin offshore Myanmar between Yadana-M8 High in W and Tanintharyi- Mergui Shelf to E,
continuing S as oceanic (or highly extended continental crust) E Andaman Basin. Basement of Yadana-M8
highs in N and Alcock and Sewell rises with E Miocene volcanic units (K-Ar age date of ~20 Ma), possibly continental crust intruded during arc magmatism (W Burma Terrane possible analogue.)


De la Rue, W. & H. Muller (1857)- Chemical examination of Burmese naphtha, or Rangoon tar. Proc. Royal Soc. London 1857, 8, p. 221-228. (online at: http://rspl.royalsocietypublishing.org/content/8/221.full.pdf+html) (At several localities in Burmah tar is mined from 60' deep wells. Mostly composed of volatiles. Etc.))


Diener, C. (1911)- Anthracolithic fossils of the Shan States. Mem. Geol. Survey India (Palaeontologica Indica), N.S., 3, 4, p. 1-74. ('Carboniferous fossils from Myanmar'. Mainly on (Permian) brachiopods from Fusulina elongata Limestone of Ke-Hsi Mansam in E Myanmar (incl. Spirifer, Spiriferella, Productus spp., Camarophoria purdoni, Oldhamina, Streptorhynchus, Dielasma, etc.). Also bryozoa (Fenestella, Polypora), corals (Amplexus, Zaphrentis, Lonsdaleia), etc.))


(Extensive review of geologic setting and mineral occurrences of Myanmar)


(Ultramafic pillow lavas from Late Palaeozoic marine sequences in Yunnan have >26% MgO, olivine phenocrysts, clinopyroxenes with or without plagioclase in devitrified glassy matrix. Termed high-Mg picrites. Chemistry consistent with mantle plume origin. Chert interbes with Carboniferous radiolaria)


(Contrasting paleolatitudes for Devonian sediments in E Yunnan (equatorial; part of Yangtze/S China Block), and W Yunnan (paleolatitude of ~42°; part of Gondwanan Shan-Thai Block). Majority of samples overprinted by present-day field magnetization. Blocks separated by Red River and Lancang (Mekong) River fault zones, one of which inferred to be ancient suture)


(Ordovician formations of Yangtze Paraplatform (South China Block) show paleolatitude of 48°S, supporting Ordovician position of South China adjacent to Gondwana)
Bibliography of Indonesia Geology, New for Ed. 7. 279  www.vangorselslist.com  8/6/18

(Ordovician- Silurian of Baoshan and Manpshi regions in W Yunnan regarded as parts of Sibumasu terrane. Significant disconformity in U Ordovician, possibly related to sea-level drop during Late Ordovician glaciations or, less likely regional tectonic uplift in N Sibumasu)

(Restudy of four poorly known Ordovician bivalve genera from Lw Ordovician Hongshiya Fm of E Yunnan. Similarities between cycloconchids suggest proximity of E Yunnan and Australia, although no species in common. Eastern W Yunnan fauna lay at much higher paleolatitude than E Yunnan fauna)

(Latest Permian Wujiaoping Fm limestones of Paleozoic- M Triassic Yangtze carbonate platform at Laren with rare fusulinids (Nankinella cf. inflata, Reichelia simplex) and low diversity calcisponges)

(Bawdwin Mine Ph-Zn-(Cu-Ag-Ni) world-class mineral deposit in N Shan State, NE Myanmar, with near-continuous mining since 1412. E Paleozoic (Late Cambrian- E Ordovician) exhalative marine siliciclastic-felsic volcanogenic massive sulphide (VMS) deposit. Originally exploited as silver deposit, redeveloped in early1900's as mainly lead-zinc producer (largest lead mine before WWII). Thermal overprint in Late Triassic, linked to Indosinian orogeny)

(Myanmar at least 4 major magmatic belts. Eastern and Main Range Provinces associated with Late Permian- E Triassic closure of Paleo-Tethys; Mogok- Mandalay- Mergui Belt and Wuntho- Popa Arc response to Eocene closure of Neo-Tethys. Mogok-Mandalay-Mergui Belt divided into Tin Province (~77-50 Ma magmatism) and Mogok Metamorphic Belt (complex magmatic- metamorphic history). Tagaung-Myiikyina Belt magmatic age of 172 Ma. New tectonic model for Myanmar: Baoshan and Greater Sibumasu likely assembled on or before Triassic, then subducted onto Indochina margin in Late Triassic. Tengchong Block within Myanmar southerly termination of Meso-Tethys suture immediately N of Mogok area. Tengchong Block subducted onto Greater Sibumasu before Late Cretaceous, after which Neo-Tethys subduction drove magmatism of Wuntho-Popa Arc)


(Comprehensive review of metallic mineral occurrences in Myanmar. Geology still poorly known)
(online at: http://digitallibrary.amnh.org/handle/2246/2914)
(Amber from thin lignite seams in Kachin, N Myanmar, ('burmite') used in China for at least a millennium for carving decorative objects. Metasequoia (Coniferae) possible source of amber. Age probably Turonian-Cenomanian (90-100 Ma; see also Shi et al. 2012) . Very rich in tropical plant and animal fossils. Newly excavated material in AMNH with 3100 organisms, incl. angiosperm flower and other plant material, mites, insects, flies, snails, etc., etc.)


(online at: www.terrapub.co.jp/journals/GJ/pdf/4803/48030259.pdf)
(Extensive Late Eocene coals- coaly shales at W margin C Myanmar Basin. Organic matter mainly terrestrial herbaceous vegetation and aquatic plants, deposited in oxic to oxygen-poor peat swamps in estuarine/ fluvial-deltaic setting. Phase-I rich in gymnosperm biomarkers such as retene and 1,7-dimethylphenanthrene (type II-III kerogen); Phase-II increase in angiosperm proxies like oleane (type III kerogen))

(Mogok metamorphic belt of Myanmar famous for classic ruby (corundum: Al2O3) specimens. Model for formation of rubies hosted in marble from Himalayan arc is metamorphosis of clays from evaporitic/organic-rich shale units. Mogok may involve igneous intrusions and formation of skarn)

(Compositional variations in Emeishan basalts generated by melting of heterogeneous mantle sources and interaction between Emeishan plume and lithosphere. High-Ti basalts products of deep melting plume head material, similar to oceanic island basalts, with little lithospheric overprint. Low-Ti basalts from shallower melting of plume head with either crustal contamination or by inherited subduction components in lithosphere)

(Published version of 2004 thesis. Late Paleozoic- E Mesozoic geodynamic evolution of Lancang River Zone (Yangtze Platform, SW Yunnan))


(Teeth of earliest rhinocerotid, M Eocene Teletaceras from C Myanmar)

(Ophiolitic rock in three parallel N-S belts: (1) Western Ophiolitic Belt (Naga Hill Line; eastern hills of the Naga, Chin and Rakhine ranges; pre-Triassic ocean floor? (likely E Cretaceous oceanic crust and plagiogranites?); (2) Central Ophiolitic Belt; and (3) Eastern Ophiolitic Belt (Tagaung-Mytikain Belt M Jurassic ophiolite with Late Jurassic chert). Mandalay Line is combination of (2) and (3). All dismembered
incomplete ophiolite bodies in fore-arc accretionary prism, emplaced in Late Cretaceous-Eocene. EOB associated with Cretaceous clastics, radiolarian chert and Orbitolina limestone, which probably overlaps Mesotethys suture)


Htut, Than (2017)- Myanmar petroleum systems, including the offshore area. In: A.J. Barber et al. (eds.) Myanmar: geology, resources and tectonics, Geol. Soc., London, Memoir 48, Chapter 11, p. 219-260. (Oil exploration and production in Myanmar date back to 13th century, a time of manual excavation from hand-dug wells in Yenangyaung District. Export of crude oil began in 1853. After British annexation of U Burma Burmah Oil Company (BOC) established and started drilling at Yenangyaung in 1887, followed Yenangyat in 1893 and Chauk (Singu) in 1902. In 1918 oil production of Yenangyaung Field was >5.8 MMbbl/ year and, in 1941, Chauk's production peaked at >4 MMbbl. U Triassic- Miocene stratigraphy of Salin sub-basin of C Myanmar Basin includes Paleocene with Distichoplax, U Eocene with Biplanispira, Asterocyclina, etc.)


Huang, H. & X. Jin (2016)- Permian oolitic carbonates from the Baoshan Block, China: ooid features, stratigraphic distribution and paleogeographic indications. In: Development of the Asian Tethyan Realm: genesis, process and outcomes, 5th Int. Symposium Int. Geoscience Program (IGCP) Project 589, Yangon, p. 15-16. (Abstract only) (online at: http://igcp589.cags.ac.cn/5th%20Symposium/Abstract%20Volume.pdf) (In Baoshan (W Yunnan) and Peninsular Thailand(Sibumasu) block onset of (mid-latitude) oolitic carbonates in late M Permian (Wordian- Capitanian) (see also Huang et al. 2017))

Huang, H., X. Jin, F. Li & Y. Shen (2017)- Permian oolitic carbonates from the Baoshan Block in western Yunnan, China, and their paleoclimatic and paleogeographic significance. Int. J. Earth Sciences 106, 4, p. 1341-1358. (M-L Permian ooids in Hewanjie Fm (N Baoshan) and Shazipo Fm (S Baoshan Block). Diachronous onset of Permian ooids among Gondwana-derived Cimmerian blocks: (1) mostly Sakmarian in Cl Taurides- C Pamir-Karakorum Block versus (2) Wordian-Capitanian in Baoshan Block, Peninsular Thailand and S Qiangtang (these also with Asselian- Sakmarian glaciomarine diamictite). Baoshan Block at higher paleolatitude during Asselian- Sakmarian than blocks with Sakmarian ooids. Marine ooids virtually absent near equator, so Baoshan Block interpreted to drift to warm-water southern mid-latitudes during Wordian- Capitanian)

Huang, H., X. Jin & Y. Shi (2015)- Mid-Permian fusulinids of the Bawei Section in southern Baoshan Block of western Yunnan, China with a discussion on paleogeographic implications. In: Proc. 4th Int. Symposium Int. Geosciences Program (IGCP) Project 589, Bangkok 2015, p. 28-30. (Extended Abstract) (online at: http://igcp589.cags.ac.cn/4th%20Symposium/Abstract%20Volume.pdf) (Permian fusulinids and carbonates of Baoshan Block in W Yunnan show dramatic switch from cool, Gondwana-affinity to warm, Tethyan affinity. M Permian carbonates in some areas have diverse verbeekinids and neoschwagerinids and rare staffellids (and ooid grainstones), others no verbeekinids/ neoschwagerinids
but abundant staffellids (and dolomitic peloidal/skeletal wackestone-packstones). This reflects local sedimentary factors (open vs. restricted platform), not large-scale paleolatitude changes.

(online at: https://ac.els-cdn.com/S187174X16300026/1-s2....)
(Bawei Section in Shazipo Fm of S Baoshan Block (part of Siibumasu) in W Yunnan, with 31 species of M Permian fusulinids, in two late Murgabian-Midian assemblages: (1) Yangchienia-Nankinella and (2)overlying Chusenella-Rugosofusulina. Overlain by Shanita-bearing limestone. Dominance of staffellids and paucity of neoschwagerinids and verbeekinids differs from coeval fusulinids in Nansan-Hewai area in S Baoshan Block with common neoschwagerinids and verbeekinids. Interpreted as due to different depositional environments. (Nansan-Hewai area high-energy open platform))

(N Myanmar remains primary source of top-grade jadeite. Primary jadeite in dikes, secondary jadeite in serpentinite boulder conglomerates)

Hurukawa, N., Pa Pa Tun & B. Shibazaki (2012)- Detailed geometry of the subducting Indian Plate beneath the Burma Plate and subcrustal seismicity in the Burma Plate derived from joint hypocenter relocation. Earth Planets Space 64, p. 333-343, 2012
(online at: https://www.terrapub.co.jp/journals/EPS/pdf/2012/6404/64040333.pdf)
(Geometry of subducting Indian plate under Burma plate from relocated subduction earthquakes at depths of 30-140 km. Strikes of contours oriented ~N-S, and show 'S' shape in map view)

(online at: http://en.earth-science.net/PDF/20160612014127.pdf)
(Triassic siliceous rocks of Muyinhe Fm in Changning-Menglian belt (Paleotethys suture). Triassic radiolaria Triassoscampe, Pseudostylosphaera, Eptingium and Paroertlispongus observed on etched surfaces. Geochemistry suggests unlikely to be oceanic pelagic deposits; possibly represent closure stage of Paleotethys)

(New lower jaw fragments of primates Amphipithecus and Pondaungia in Eocene Pondaung Fm in C Myanmar Together with Siampithecus from Late Eocene of Peninsular Thailand resemblance some African relatives)

(online at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0017065)
(First hominoid found in Myanmar (Khoratpithecus ayeyerwadyensis sp. nov.), together with Hipparion and other mammal fauna from Irrawaddy Fm, dated between 10.4- 8.8 Ma. Fauna and stable isotope data indicate evergreen forest environment)

(New anthropoid primate, Bahinia pondaungensis from late M Eocene Pondaung Fm. Part of Eosiimiiidae now known from three M Eocene localities in Asia, supporting hypothesis of Asian origin of anthropoids)

interaction during the Capitanian, Middle Permian ("end Guadalupian") extinction event. Palaeogeogr. Palaeoclim. Palaeoecology 441, 1, p. 65-73.

(M Permian platform carbonate deposition terminated by rapid subsidence, with onset of late M Permian Emeishan volcanism during deepening (with widespread losses amongst fusulinacean foraminifera and calcareous algae). Lower two thirds of 4-5 km thick lava pile erupted at or below sea level, with terrestrial lava flows only in later stages. Late Permian of SW China at time of Emeishan was extended area of thinned lithosphere with epeiric seas, sustained through onset of LIP emplacement. Geochemical support of plume origin for Emeishan volcanism, but LIP emplacement not associated with regional pre-eruption uplift)

(online at: https://watermark.silverchair.com/egs045.pdf.)
(Late Permian Emeishan flood picrite lavas represent low- and high-Ti end-members of continental flood basalt magmatism. Diverse spectrum of basaltic magma. Peridotite and garnet pyroxenite mantle source for low- and high-Ti end-members, and more likely from subcontinental lithospheric mantle than from deep mantle ‘plume’)

(Review of geology and hydrocarbons in offshore Myanmar M8 Block, S of Yadana field)


(A Almost all producing oil - gas fields in Myanmar in Salin, Irrawaddy and Martaban basins, in Mio-Pliocene reservoirs)

(online at: www.searchanddiscovery.com/documents/2012/50771khin/ndx_khin.pdf)
(On Late Cenozoic clastics Arakan Basin, W Myanmar, in frontal part of Himalayan orogenic belt)

(Mainly analysis of ~2000m thick Miocene clastics of W Arakan Basin. Overall shallowing-upward series. E Miocene sandstones quartz-rich. Overall upward increase in feldspar and high-metamorphic lithics, reflecting Himalayan uplift and orogenic unroofing)

(Indo-Myanmar Ranges (= Indo-Burman Ranges or Western Ranges) along W margin of Myanmar microplate extend from E Himalayas S-wards along E side of Bay of Bengal to Andaman Sea. Comprise Naga Hills in N, Chin Hills in middle and Rakhine (Arakan) Yoma in S. Considered to have formed as accretionary wedge due to E-ward subduction under Myanmar from ?E Cretaceous- Recent. Rocks Late Triassic-Eocene flysch-type
metasediments, three belts of Triassic-Jurassic ophiolitic rocks in E (W-ward obduction in Late Oligocene?). Ophiolitic sequence overlain by Eocene-Miocene flysch. Cretaceous and Paleogene limestone olistoliths


Kingson, O., R. Bhutani, J.K. Dash, S. Sebastian & S. Balakrishnan (2017)- Resolving the conundrum in origin of the Manipur Ophiolite Complex, Indo-Myanmar range: constraints from Nd isotopic ratios and elemental concentrations in serpentinitized peridotite. Chemical Geology 460, p. 117-129. (REE abundances and Nd isotopic ratios in serpentinitized peridotite from Manipur Ophiolite Complex (MOC), Indo-Myanmar Range. Variation of La/Yb consistent with progressive addition of subduction-derived fluid to depleted mantle source. MOC buoyant fore-arc-mantle-wedge system along with subducted slab that was obducted during terminal stage of subduction of Neotethys below Burmese plate)


Li, D., Z. Luo, Y. Chen, J. Liu & Y. Jin (2014)- Deciphering the origin of the Tengchong block, west Yunnan: evidence from detrital zircon U-Pb ages and Hf isotopes of Carboniferous strata. Tectonophysics 614, p. 66-77. (U-Pb and Hf isotope analyses on detrital zircons from Carboniferous in Tengchong block yield Neoarchean (~2.5 Ga), Mesoproterozoic (1.7-1.4 Ga), Grenvillian (~0.95 Ga) and Pan-African (0.65-0.5 Ga) age groups. Oldest Hf model ages indicate source magma included reworked Eoarchean (3.8-3.7 Ga) crustal material. Resemblance with Tethyan Himalayan, W Qiangtang and Indochina suggests Tengchong block was located along Indian margin of Gondwana in E Paleozoic)


(late M Eocene Pondaung Fm, Myanmar, with diverse silicified wood assemblage, incl. early Dipterocarpaceae. (Licht et al. 2014). Also Menispermoxylon, Glutoxylon and Heritieroxylon, related to modern taxa of mangrove and coastal forests in Bengal Bay. Assemblages suggest (1) monsoonal climate (with significant rainfall and marked dry season), confirming studies showing Bengal Bay experienced monsoonal regime as early as 40 Ma and (2) warmer annual temperatures, supporting hypothesis that monsoonal rainfall at that time favored by Eocene greenhouse conditions)


(Data from Eocene of Myanmar suggestive of monsoon-like climate patterns during Late Eocene greenhouse conditions (55-34 Ma))


Lwin, S.M., M.M. Aung & N.P. Oo (2017)- Paleo-environmental analysis of benthic foraminifera and radiolarians in Middle Eocene Tabyin Formation, Mindon-Taing Da Area, Magway Region, Myanmar. AAPG/EAGE/MGS 3rd Oil & Gas Conf., Yangon 2017, Search and Discovery Art. 51427, 45p. (Abstract + Presentation)
(Deep marine M Eocene benthic and planktonic foraminifera and radiolaria from folded sediments near eastern foothills of Rakhine Yoma, C Myanmar Basin)

(Bottom Simulating Reflector (BSR) in deepwater Rakhine Basin off Myanmar indicates Gas Hydrate Stability Zone (HSZ) and potential extensive gas hydrate system, likely indicative of extensive microbial gas system)


(onlone at: www.pnas.org/content/100/23/13173.full.pdf)
(Primate talus from Segyauk, Myanmar, more similar to anthropoids than to adapiforms. Foot bone may belong to Amphipithecus)


(‘Upper Member’ of ~500m thick fluvo-deltaic, late M Eocene (Bartonian) Pondaung Fm at Paukkaung area in C Myanmar known for vertebrate fossils (incl. primates) since 1920's. Formation underlain by M Eocene Tabyin Fm with Nummulites and overlain by Late Eocene Yaw Fm with Nummulites and Discocyclina. Primate fossil localities Pk1, Pk2, Pk3, and Pk5 all nearly at same stratigraphic level, with age of ~37.2 Ma)


Metais, G., Aung Naing Soe & S. Ducrocq (2006)- A new basal tapiromorph (Perissodactyla, Mammalia) from the middle Eocene of Myanmar. Geobios 39, p. 513-519. (New tapiromorph, Skopaiolophus burmese, from M Eocene Pondaung Fm suggests primitive tapiromorphs may have persisted in SE Asia until late M Eocene while they became extinct in both Eurasia and N America)

Metais, G., Aung Naing Soe, L. Marivaux, & K.C. Beard (2007)- Artiodactyls from the Pondaung Formation (Myanmar): new data and reevaluation of the South Asian faunal province during the Middle Eocene. Naturwissenschaften 94, 9, p. 759-768. (New dichobunid Cadutherium kyaukmyii and basal ruminant Irrawadymeryx pondaungi, from late M Eocene Pondaung Fm, Central Myanmar (small rabbit-like ungulates).)


(Zircon dating shows basement of Myanmar contains Proterozoic and E Paleozoic zircons. Igneous event of ~490 Ma ties basement to Gondwana. Shan Plateau of E Myanmar lacks Cenozoic-Cretaceous magmatism; Triassic event links it to Qiangtang block of C Tibet. Jurassic- E Cretaceous magmatism ties Mogok metamorphic belt to Gangdese belt of Tibet (Lhasa block) and Neotethys subduction. Both belts also share Late Cretaceous- Paleocene magmatism. Late Eocene- Oligocene high-grade metamorphism dominates Mogok belt; rapid cooling started at ~17 Ma and terminated before 10 Ma)

(Comprehensive overview of geology, mineral potential and plate tectonics of Myanmar. Several of the structural belts of Myanmar continue into SW China and NW Thailand. With chapters on petroleum occurrences in C Burma Depression by M.F. Ridd and offshore petroleum geology by A. Racey)


(online at: www.searchanddiscovery.com/documents/2017/30516myint/ndx_myint.pdf)

(Oil and gas in Myanmar currently limited to Tertiary petroleum systems, with bionic gas in Plio-Pleistocene reservoirs, thermogenic oil and gas in Eocene- Miocene reservoirs. Potential pre-Tertiary hydrocarbon plays in sizable Pre-Tertiary basins of Eastern Highlands)


(online at: www.gsm.org.my/products/702001-101349-PDF.pdf)

(Cambrian- Silurian stratigraphy of area SE of Mandalay, S Shan State, E Myanmar. Incl. basal Silurian Orthoceras Beds, Silurian graptolite shales (Monograptus, Climacograptus) and Tentaculites beds))


(Barber et al. 2017:) Permian limestone slivers in Sagaing fault zone and associated with ophiolites of C Ophiolite belt interpreted as displaced from W margin of Shan Plateau (but with 'Cathaysian' fusulinids??))


(Young alluvial fans and fanglomerates along Sagaing fault zone commonly displaced laterally relative to source areas. Sediments on E side of fault mainly (tilted) Upper Irrawaddy series fluvial-alluvial sediments, locally with rich Lower Pleistocene vertebrate faunas equivalent of Djetis fauna of C Java. Younger fans mainly on W side of fault))


(On eastern part of Central Myanmar Basin on W Myanmar Block. Lower Eocene- Pliocene sediments unconformably over U Paleozoic carbonates/ Mesozoic ophiolitic sediments in E, and igneous rocks of Wuntho Salingyi Mesozoic arc in W. Sediment source from N)


(Review of stratigraphy of Cretaceous sediments in different tectonic belts of Myanmar. Thick Lower Cretaceous- Cenozoic succession in Myanmar Central Basin)


(Indo-Burman Ranges accretionary wedge, resulting from subduction of Indian plate beneath Asian plate. Rakhine Coastal Belt thick stack of Cretaceous to Neogene turbiditic sediments and local thrust sheets of oceanic mafics and pelagic sediments. Eocene–Miocene sandstones provenance mainly from: (1) Late Cretaceous- Oligocene igneous rocks and (2) recycled orogenic terrane sources comprising ophiolitic rocks, from Burman margin and arc)


(‘Two late M Ordovician nautiloids from Wunbye Fm in Shan Plateau of Myanmar (= Sibumasu Block): orthocerid Sibumasuoceras langkawiense (Kobayashi) and discorisorid Tasmanoceras sp. Sibumasuoceras known only from Malaysia and Myanmar of Sibumasu Block. Tasmanoceras previously known only in Tasmania, implying Ordovician marine biotic linkage between Sibumasu and Tasmania’)


(Brief report of first visit of western geologist to jade mines in NE Myanmar)


(online at: https://babel.hathitrust.org/cgi/pt?id=mdp.39015068271041;view=1up;seq=45)

(‘On the occurrence of jadeite in Upper Burma’)


(online at: https://books.googleusercontent.com/books/...)

(Oilfields, mud volcanoes, etc. See also Pascoe 1912)


(online at: https://books.googleusercontent.com/books/...)


(‘World’s largest jadeite (NaAlSi2O6) deposit, with highest-quality jade, in Pharkant-Tawmaw Jade Mines Belt in N part of C Myanmar basin. N-S trending belt. Jadeitite in serpentinite melange, probably formed in subduction zone environment. Associated with albittites, chloride schists, garnet-mica schists, graphite schists, glauconephane and epidote schists and amphibolite. Timing of jadeite formation still controversial: original oceanic crust may have formed in M Jurassic (163 Ma zircon age), ~146 ma (Late Jurassic) zircons may reflect age of subduction and high-P metamorphism. Rapid exhumation required for jadeite preservation’)


(online at: www.currentscience.ac.in/Volumes/112/10/2122.pdf)

(In Indo-Myanmar Ranges ophiolitic rocks in two parallel belts along E margin of Indian plate: (1) E belt through C Myanmar, Sumatra and Java; (2) W belt through Nagaland, Manipur, W Myanmar and Andaman islands. Wide compositional gap in Cr and Mg content of spinel in mantle peridotites of W Belt Manipur)
Ophiolite Belt implies upper mantle melting in different tectonic settings: (1) mid-oceanic ridge (MOR) origin for high-Al spinel peridotites and (2) supra-subduction zone origin for high-Cr spinel peridotites


Paumard, V., E. Zuckmeyer, R. Boichard, S.J. Jorry, J. Bourget, J. Borgomano, T. Maurin & J.N. Ferry (2017)- Evolution of Late Oligocene - Early Miocene attached and isolated carbonate platforms in a volcanic ridge context (Maldives type), Yada field, offshore Myanmar. Marine Petroleum Geol. 81, p. 361-387. (Stratigraphic evolution of Late Oligocene-E Miocene (Aquitanian) carbonate platforms of Yadana High, offshore Myanmar (N of Andaman spreading zone). Seven seismic sequences in three stages: (1) Chattian development of aggrading attached and isolated platforms; (2) platform emersion at Oligo-Miocene transition; (3) Aquitanian drowning of small buildup and km-scale backstepping on large platforms (3DF and Yadana). Aquitanian onset of renewed volcanic activity, followed by development of ~300-850m thick Burdigalian fringing carbonate reefs in ~6 My. Platforms developed on volcanic ridge of hotspot origin in Indian Ocean, not part of volcanic arc)


Qi, M. H. Xiang, Z.Q. Zhong, H.N. Qiu, H. Wang, X.L. Sun & B. Xu (2013)- 40Ar/39Ar geochronology constraints on the formation age of Myanmar jadeite. Lithos 162-163, p. 107-114. (First direct 40Ar/39Ar dating of Myanmar jadeite from yielded plateau age of 123.9 ± 3.4 Ma, sodic-calcic amphibole associated with jadeite plateau age of 134.8 ± 1.4 Ma, and sodic amphibole of late amphibole rock plateau age of 92.7 ± 1.2 Ma. Indicate jadeitite formed during E Cretaceous from (135 Ma) high- P metasomatism, then experienced late Cretaceous (93 Ma) HP metasomatism)


structured deepwater area by dextral trench-parallel shear fault system which represents boundary between India Plate in W and Burma Platelet in E)

(Burma Platelet covers W part of Myanmar, between Indian Plate/ Bengal Basin in W and Sunda Plate in E. Boundaries are active Sagaing dextral strike-slip fault in E, and debatable Bengal Basin subduction zone in W. Non-rigid sliver plate with several right-lateral shear zones accommodated N-ward India/Sunda dextral wrench movement, with hyper-oblique convergence since E Cenozoic)

(Early description of Carboniferous- Permian Mergui series of S Myanmar, with probable diamictites, overlain by Permian Moulmein Limestone with Schwagerina, Lonsdaleia salinaria, Productus sumatrensis, etc.)

(Synopsis of Ridd & Racey (2015) papers. All Myanmar onshore oil-gas fields are in 1200km long Central Burma Depression. Possibly oldest oil production/mining in world. N-S trending basin with up to 15,000m of U Cretaceous- Pleistocene sediments. Most productive fields Yenangyaung, Chauk and Yenangyat)

(Fault-bounded, N-S trending Karen-Tenasserim Unit of Bender (1983) W of Shan Plateau in southern Central Myanmar is direct continuation of 'Phuket -Slate Belt Terrane' of Ridd (2009) in Peninsular Thailand (and Tengchong Block to N?). With metamorphic rocks (incorrectly called Mogok Metamorphics), overlain by thick U Paleozoic Mergui Gp with intervals of ?Carboniferous- E Permian glacial diamictites and Permian 'Moulmein Limestone' (= Ratburi Lst of Peninsular Thailand; at Myeik/Mergui archipelago of S Myanmar with Lonsdaleia, Schwagerina, Productus sumatrensis, etc.). Also with common granitoid intrusions. Often viewed as W part of Sibumasu Block, but interpreted as separate 'Phuket Terrane' or 'Irrawaddy block' (Mitchell 2012, 2015, Ridd 2016) (but no ophiolites found yet between them)

(Fischertes burmensis n.s. from M Ordovician Wunbye Fm in W part of S Shan State (first receptaculid described from SE Asia) (second is from W Thailand?; Kruse 1989))

(online at: https://ses.library.usyd.edu.au/handle/2123/35335)
(Naga Hills with dismembered Neotethyan ophiolite suite, assigned Late Jurassic age based on radiolaria from red cherts above ophiolite (Baxter et al., 2011). Naga Hills Ophiolite unconformably overlain by India-derived Phokphur Fm polymict conglomerates (incl. ophiolite debris), with detrital zircon peak ages Jurassic (190-200), Permo-Triassic (200-300 Ma), Cambrian, Mesoproterozoic (~1000-1200 Ma) and Archean (~2700-2750 Ma), suggestive of SW Australian provenance. Youngest zircon ages 90 Ma (=maximum age of Naga ophiolite emplacement)

(Mogok High-T Metamorphic terrane along W margin of Sibumasu/ Shan Plateau in Myanmar (Burma) thought to be S-ward continuation of Lhasa block of S Tibet. S of Burma MMB may extend into tin granite province of Mergui coast and S to Phuket. MMB has little in common with Western granite belt of peninsula Malaysia,
dominated by Triassic tin-bearing biotite granites. Includes Jade Mines Belt (ophiolitic mantle rocks subjected to high-P metamorphism). Peak metamorphism time ~M-L Eocene (~43-33 Ma), rapid exhumation in late E Miocene (~16-22 Ma)


(Highly disrupted and deformed slices of ophiolitic rocks occur in linear belt in Nagaland and Manipur, known as the Naga Hills Ophiolites. Principal rock types dunite, harzburgite, lherzolite, wehrlite, pyroxenite and mafic volcanics. Volcanics low-Ti and high-Ti groups, probably not cogenetic. Low-Ti group overlapping Mid-Ocean Ridge Basalt and island arc-like characteristics, and possibly suggest back-arc basin setting. High-Ti group similarities with within-plate basalts erupted at off-axis seamounts)


(online at: www.sciencedirect.com/science/article/pii/S1674987113001072)

(Late Permian Emeishan large igneous province in SW China covers W margin of Yangtze Block (S China Block) and E Tibetan Plateau, with displaced units in N Vietnam (Song Da zone). Contains base metal deposits and is contemporaneous with late Capitanian (~260 Ma) mass extinction. Mainly flood basalts, but also ultramafic and silicic volcanic rocks. Three nearly concentric zones with thicker crust from inner to outer zone. Age of the ELIP constrained to interval of 3 Myrs or less. Uncertainty whether magmas derived from subcontinental lithospheric mantle or asthenosphere/ mantle plume sources or both. ELIP likely derived from short-lived, plume-like upwellling of mantle-derived magmas)


(online at: https://journals.lib.unb.ca/index.php/GC/article/download/21548/26356)

(Review of Late Permian Emeishan large igneous province (ELIP) covers W margin of Yangtze Block and Tibetan plateau of SW China, with displaced correlative units in N Vietnam (Song Da zone). Contemporaneous with Late Capitanian mass extinction (260 Ma) erupted in <3 Myrs. Mainly flood basalts, but also also picritic and silicic volcanic rocks. Considered to be mantle plume-derived, albeit with some crustal contamination)


(New zircon CA-TIMS U-Pb from intrusive rocks of Panxi region (Inner Zone) of M-L Permian ELIP yielded ages between >257 Ma and ~260 Ma, consistent with estimates from magneto-biostratigraphic data)


(Neoproterozoic (i.e. ~750-850 Ma) zircons in Late Permian Emeishan basalts indicates either assimilation of older material during emplacement or rocks could be derived from mafic Neoproterozoic precursor, like Neoproterozoic Kangdian basalts)


(Kelang gabbro (256±3 Ma) in contact with syenite of Late Permian (~260 Ma) Baima igneous complex of Emeishan Large Igneous Province. Gabbro may be uppermost portion of large mafic-ultramafic intrusion unrelated to Baima igneous complex)

(Geochemoical characteristics of U Permian continental marginal arc volcanics from Xiaodingxi and Zangli on the E side of Yunxian-Lincang granite. Dominated by basalt-andesite-dacite. Lancangjiang Belt, together with ocean-ridge and ocean-island volcanic rocks and ophiolites in Changning-Menglian Belt, indicate Lancangjiang oceanic crust (Paleotethys) subducted E-wards)

Shen, S., Q. Feng, Q. Wei & Z. Zhang (2007)- Newly developed evidence for the original Tethysan island-arc volcanic rocks in the southern segment of the South Lancangjiang Belt. Chinese J. Geochemistry 26, 1, p. 91-97.

(Pre-Ordovician metamorphic volcanic rocks in Huimin-Manlai region of Yunnan Province represent Tethysan island-arc volcanic rocks)


(online at: https://riviste.unimi.it/index.php/RIPS/article/download/6146/6108)

(28 species and 3 assemblages of E Permian brachiopods in Dingjiazhai Fm of Baoshan block. In ascending order: (A) Bandoproductus qingshwigouensis- Marginifera semigoriaosa (lower member with dropstones; Asselian), (B) Punctocyrtella australis- Punctospirifer afghanus (latest Asselian- E Sakmarian) and (C) Callytbarrella dongsbanpoensis (Late Sakmarian-Artinskian). Strong Gondwanan affinities)


(Jadeitite composed almost entirely of jadeite and related pyroxene. It is found in subduction channel serpentinite melange associated with High P/ low T metamorphosed rocks, but generally rarer than eclogite or blueschist. Late Jurassic jadeitite from Myanmar Jade Mine Tract at W side of Sagaing Fault highly diverse mineralogy, with >30 minerals: jadeite, omphacite, kosmochlor, etc. Primary jadeitite veins occur in serpentinite with albite and/or amphibolite boundaries. At least two stages of jadeitization identified. Late-stage zeolites, pectolite, hyalophane, etc. formed at lower P and T. Jadeite-forming fluids rich in Na, Al, Ba, Sr and Ca. Most rocks in serpentinite melanges subject to infiltration and potential replacement by jadeitite or reaction with jadeitite)


(Fluid inclusions in high-pressure jadeitites from famous jadeite tract of N Myanmar mostly H2O (87-94%) and methane (CH4). Stable isotope ratios of CH4 indicative of abioticogenic thermal maturation, probably from subducted organic carbon in paleosubduction zone. CH4 may be stable to at least upper 20 km of subduction zone where jadeitite veins formed under low T / high-P conditions)


(E Paleozoic magmatism in Baoshan block (granitoids with zircon Pb/U ages of ~481, 493 Ma and indications of crustal melting/reefacing. Tengchong block Late Triassic S-type granites with zircons of 216-226 Ma, probably in post-collisional tectonic setting. Late Early Cretaceous (118 Ma) S-type granite; emplacement may be related to closure of Neotethys ocean)


(online at: www.cambridge.org/core/journals/journal-of-paleontology/article/depauperate-fusul...)

(M Permian fusulinids from Tengchong Block, W Yunnan, China (= part of Sibumasu) dominated by Chusenella, Nankinella and Schwagerina. Low diversity through E-M Permian and paucity of M Permian
neoschwagerinids and verbeekinids in block confirm Gondwana-affinity and possibly relatively low temperature of seawater. Depauperate assemblages of limited number of species with abundant individuals.

Shi, Y., H. Huang, X. Jin & X. Yang (2011)- Early Permian fusulinids from the Baoshan Block, Western Yunnan, China and their paleobiogeographic significance. J. Paleontology 85, 3, p. 489-501. (Sakmarian-Artinskian fusulinids from N and S Baoshan and W Yunnan, dominated by Pseudofusulina and Eoparafusulina spp. and similar to those from C Pamir, S Afghanistan, E-C Iran, C Oman, E Hindu Kush and N Karakorum)


Singh, A.K., R. Nayak, S. Khogenkumar, K.S.V. Subramanyam, S.S. Thakur, R.K.B. Singh & M. Satyanarayanan (2016)- Genesis and tectonic implications of cumulate pyroxenites and tectonite peridotites from the Nagaland-Manipur ophiolites, Northeast India: constraints from mineralogical and geochemical characteristics. Geological J. 52, 3, p. 415-436. (Ultramafic sequence of Nagaland- Manipur Ophiolite generated at mid-oceanic ridge tectonic setting, close to E boundary of Indian passive margin, then thrust over continental margin of Indian Plate to W during collision with Myanmar Plate)


Singh, A.K., V.C. Tewari, A.N. Sial, P.P. Khanna & N.I. Singh (2016)- Rare earth elements and stable isotope geochemistry of carbonates from the melange zone of Manipur ophiolitic Complex, Indo-Myanmar orogenic belt, Northeast India. Carbonates and Evaporites 31, 2, p. 139-151. (Carbonates in Neotethyan melange zone of Manipur Ophiolitic complex (= NE India-Myanmar plates collision zone/ accretionary prism). Melange with Late Cretaceous (Santonian- Maastrichtian) pelagic limestones that originally formed cover of ophiolitic oceanic crust, also Eocene flysch and younger molasse)

Sloan, R.A., J.R. Elliott, M.P. Searle & C.K. Morley (2017)- Active tectonics of Myanmar and the Andaman Sea. In: A.J. Barber et al. (eds.) Myanmar: geology, resources and tectonics, Geol. Soc., London, Memoir 48, p. 19-52. (online at: http://mem.lyellcollection.org/content/memoirs/48/1/19.full.pdf) (Active tectonics of Myanmar controlled by combination of: (1) continuing N-wards penetration of India into Asia; (2) active shear along right-lateral Sagaing strike-slip fault, and region to W; (3) active E-dipping Burma Seismic Zone indicating subduction of downgoing plate to >150 km; (4) CW rotation around E Himalayan Syntaxis and series of arculate strike-slip faults in N Shan Plateau; and (5) active extensional and strike-slip tectonics in back-arc Andaman Sea)

(Primate-bearing Pondaung Fm in NW part of C Myanmar mainly composed of cyclic sequences of sandstones and variegated clays, deposited in fluvo-deltaic environment. Anthropoid primate remains in swale-fill sediments, sometimes in carbonate nodules of pedogenetic origin and in small crevasse channel deposits of U Pondaung Fm)


(Kyaukkyan Fault active N-S dextral strike-slip structure across W Shan Plateau, parallel to and ~100-150 km E of central Sagaing Fault. Probable Late Oligocene- M Miocene onset of dextral shear)


(Manipur Ophiolite Complex disrupted belt of ophiolitic melange along border ranges between Myanmar and NE Indian states Manipur and Nagaland. Ranges formed through collision of Indian plate and displaced elements of Sibumasu terrane that have been sinistrally displaced >450 km along Asian margin by Sagaing fault (Neotethys suture). Well-preserved Lower Cretaceous radiolarian assemblages in green ribbon chert blocks (= minimum age of underlying ophiolitic ocean floor))


(online at: https://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/199770/1/aspp_04_067.pdf)
(Detailed survey of ~275m thick Upper Member of Eocene Pondaung Fm W of Paukkaung, to clarify stratigraphic relationship among the localities of fossil vertebrates. Most localities (Pk1, Pk2, Pk3, Pk4, Pk5 and Pk8) in single claystone (Ayoedawpon Taung Claystone), which overlies widely traceable Ayoedawpon Taung Sst. Localities Pk9 and Pk12 below and above this claystone)


(online at: https://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/199769/1/aspp_04_075.pdf)
(Pondaung Fm along Tabyin-Kyauktakha route composed of sandstone, siltstone and claystone with minor coal, acidic tuff and pebbly sandstone. Thickness~1170m. Upper Member mainly sandstone that, unlike in areas of Pale and Myaing, did not preserve fossil vertebrates)


(>300 gold occurrences in Myanmar, in 6 main associations: porphyry and epithermal deposits in Late Cretaceous- Paleogene Central Magmatic Arc; orogenic gold; skarn, sediment-hosted, Slate Belt-hosted and quartz veins in ophiolite-greenschist units)


(online at: https://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/199765/1/aspp_04_143.pdf)
(Review of Neogene mammalian fossils from E-M Miocene Pegu beds (12 mammal genera) and Late Miocene- Pliocene Irrawaddy beds (14 mammal families) along Irrawaddy River, Myanmar. Although fossils scarce, Myanmar faunas greater similarity to S Asian(India) fauna than to E Asian (China) fauna until Pliocene)


Takai, M. & N. Shigehara (2004)- The Pondaung Primates, enigmatic possible anthropoids from the Latest Middle Eocene, Central Myanmar. In: C.F. Ross & R.F. Kay (eds.) Anthropoid origins: new visions, Kluwer/ Plenum, New York, p 283-321. (Recent discoveries of 'possible anthropoids' from M Eocene from China, Myanmar and Thailand suggest 'protoanthropoids' may have originated in E Asia, not Africa)


Thein, Z.M.M., T. Htihe, A.N. Soe, C. Sein, M. Maung & M. Takai (2017)- A review of the investigation of primate fossils in Myanmar. In: A.J. Barber et al. (eds.) Myanmar: geology, resources and tectonics, Geol. Soc., London, Memoir 48, Chapter 9, p. 185-206. (Fossil primates in latest Middle Eocene Pondaung Fm in C Myanmar. Two large-bodied primates, Pondaungia cotteri and Amphipithecus mogaungensis. Some authorities believed they are primitive anthropoids, others regarded them as adapiforms or non-primate. Also rare primate fossils from Late Neogene Upper Irrawaddy Beds, dominated by proboscideans and bovids)


(M Eocene (37.2 ± 1.3 Ma) Pondaung fauna from C Myanmar with six orders of mammals: Primates 4 genera), Creodonta (2 genera), Rodentia (1 genus), Artiodactyla (4 genera), Perissodactyla (9 genera), and Ungulata (1 genus). All primates considered to be primitive anthropoids. Anthracotheres all one genus (Anthracotherium), with 4 species (A. pangan, A. rubricum, A. birmanicus, A. tenuis))


(Two new ungulate taxa from M Eocene Pondaung Fm. Pondaung ungulate fauna now 29 species, mainly artiodactyls and perissodactyls. Paleoenvironment of fauna was humid forested/woodland vegetation with large rivers, located not far from E Tethyan Sea. Relatively high endemism at generic level)


Mandible and molars of new anthracotherid from M Eocene Upper Pondaung Fm (~38 Ma), C Myanmar, Myaingtherium kenapotamoides. Some similarities of M3 molar with 'Anthracothema' verhoeveni Von Koenigswald from Timor

Tsubamoto, T., M. Takai, N. Shigehara, N. Egi, S.T. Tun, A.K. Aung, M. Maung, T. Danhara & H. Suzuki (2002) - Fission-track zircon age of the Eocene Pondaung Formation, Myanmar. J. Human Evolution 42, p. 361-369. (Pondaung Fm in C Myanmar with >20 mammal genera, ~2000m thick freshwater deposits, overlying and partially interfinger with Tabyin Fm (with M Eocene Nummulites acutus). Overlain by marine Yaw Fm )with Late Eocene Nummulites yawensis, etc.). One tuff from upper Pondaung Fm with fission track age from 75 zircons of 37.2 ± 1.3 Ma (M-L Eocene boundary)


Tun, Soe Thura & I.M. Watkinson (2017)- The Sagaing Fault, Myanmar. In: A.J. Barber et al. (eds.) Myanmar: geology, resources and tectonics, Geol. Soc., London, Memoir 48, Chapter 19, p. 413-441. (N-S trending and relatively straight Sagaing Fault across Myanmar 1500 km long active strike-slip fault that accommodates more than half of right-lateral motion between Sundaland and India, within diffuse plate
boundary along E margin of India, which occupies much of Myanmar. Ridge-subduction transform linking major thrust systems in N (E Himalaya) to Andaman Sea spreading centre S. N-ward younging strike-slip segments. Little evidence for pre-M Miocene movement, but more diffuse dextral slip possibly accommodated 300-700km of offset since Eo-Oligocene)

(Lower Palaeozoic rocks mapped in Kayin State (Sibuma Block). Three new formations with thickness >900 m, Lower siliciclastics overlain by predominantly carbonate with M Ordovician conodonts. Older formations probable correlate to S Shan State of Myanmar and Lower Ordovician siliciclastics of W Thailand. Folds in Lower Palaeozoic rocks overturned to NE; deformation in one major phase between Tournaisian- E Permian)

(Orogenic sedimentation had begun in Bengal basin by E Miocene. Laser 40Ar/39Ar age determinations of detrital muscovite grains from E-M Miocene Bhobhan Fm show ages from ~12 Ma- 316 Ma, suggesting derivation from a combination of sources. Modes of ~16, 18, 26 and 40 Ma most consistent with unroofing of Higher Himalayas since E Miocene. Detrital ages of ~16 and 22 Ma most prominent in highest levels, consistent with M Miocene unroofing of crystalline rocks of E Himalayas)

(U Eocene- Neogene fill of Bengal basin provides unroofing history of E Himalaya and Indo-Burman ranges. Quartzose sandstones of Eocene-Oligocene Fms only 0.2% heavy minerals, most likely sourced from Indian craton immediately to W. E Miocene sandstones of Surma Gp contain more heavy-minerals, indicating mostly metamorphic source rocks. U Miocene U Surma Gp also abundant blue-green amphibole, orthopyroxene, and sparse chromite, suggesting deeper exhumation, of high P metamorphic and ophiolitic rocks)


(Fault-bounded blocks of Permian limestones in Sagaing Fault Zone at Minwun Range with fusulind faunas containing abundant Chalaroschwagerina, together with Pseudofusulina kraftii, Levenella, Pamirina, Schubertella, Toriyamaia, Minojapanella, and Pseudoreichelina. Age late Yakhtashian (late E Permian) age and Tethyan paleobiogeographic affinity)

(Major Pleistocene strike-slip deformation over 200- 300 km wide belt of Myanmar sedimentary basins between Sagaing fault and escarpment between shallow and deep waters of Rakhine Yoma foldbelt. Tied toN-ward translational subduction of India below SE Asia plates)

(Mantle plumes should generate broad domal uplift (~1000 km wide, 500-1000m high) preceding volcanism in large igneous provinces. Most of Emeishan large igneous province in SW China emplaced at sea level, with no
evidence for dynamic pre-volcanic uplift. Any positive relief that developed more likely result of formation of volcanic edifice and rapid accumulation of volcanic pile.


Wang, M. & D. Cheong (2016)- Reconstruction of burial history and analysis of the hydrocarbon potential using sedimentary modeling the middle Bengal Fan, Myanmar. Geosciences J. 20, 6, p. 813-825. (Bengal Fan 3 stages of evolution: I (4.5-1.81 Ma; low sedimentation and subsidence), II (1.81-0.79 Ma; highest sedimentation and rapid subsidence), and III (0.79-0 Ma; high sedimentation, slowest subsidence). Biogenic gas typical hydrocarbon in area; generation and migration probably immediately after deposition of Unit 2. Thermogenic hydrocarbon potential low due to relatively low T and short burial)

Wang, Y. & Y. Zhang (2010)- Llandovery sporomorphs and graptolites from the Manbo Formation, the Mojiang County, Yunnan, China. Proc. Royal Society (London), B, 277, p. 267-275. (online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2842664/) (E Silurian (Llandovery) sporomorphs and graptolites from Manbo Fm, Mojiang area, W Yunnan (part of Indo-China plate in Palaeozoic). Sporomorphs suggest South China and Indo-China paleo-plates may have been in close proximity in Llandovery; both closely related to Gondwanaland)


Xu, Y.G. & B. He (2007)- Thick, high-velocity crust in the Emeishan large igneous province, SW China: evidence for crustal growth by magmatic underplating or intraplating. Geol. Soc. America (GSA), Special Paper 430, p. 841-858.

(Petrography, detrital zircon ages and Hf isotopic data from Late Triassic Pane Chaung Fm exposed in Indo-Burman Ranges (W Burma Block). With Carnian-Norian Halobia molluscs; maximum depositional ages ~233-206 Ma. Detrital zircon age populations and Hf values interpreted to be derived from W Papua region. Triassic zircons (mainly ~210-250 Ma) probably from contemporaneous volcanic source. Older populations (~600-450 Ma, 1250-900 Ma and Archean from orogenic belts and cratons in Australia. Zircon ages different from similar-aged strata in Indochina and Sibumasu, but comparable to NW Australia and Greater India. Probably deposited in Late Triassic submarine fan along N margin of Australia)

(Brief review of oil occurrences in C Myanmar onshore, where oil has been extracted perhaps as early as 13th century. Future oil-gas discoveries expected to be small)

(Three Daewoo gas field discoveries in Rakhine basin, NE offshore Myanmar from 2004-2006: Shwe, Shwe Phyu and Mya. Three fields with 2P reserves of 4 TCF. Biogenic gas in deepwater Late Pliocene Bengal Fan turbidite sand reservoirs (interbedded lobes, channels and slumps, sourced from NW and NE). (see also Yang & Kim 2014))

(Shihtien Beds lower Ordovician shales rich in brachiopods, trilobites, graptolites, overlain by 90m Hengshuitiang Lst, equivalent of Nyaungbaw Lst of Myanmar (N Shan), overlain by Silurian graptolite shale)

(Tree types of zircons in two Myanmar jadeitite samples: Type I-inherited zircons with igneous protolith age of 160 ± 1 Ma; Type II- metamosaic/hydrothermal zircons, giving minimum jadeitite formation age of ~77 Ma (Late Cretaceous subduction before India collision); Type III- incompletely recrystallized zircons with geologically meaningless ages of 153-105 Ma. Jadeitites formed through metasomatic replacement processes)

(Magnetite-hematite mineralization in northern continuation of Permian-Triassic Sukhothai island arc system along margin of Indochina terrane, in E Shan State, easternmost Myanmar. Hosted in Paleozoic siltstone-mudstone)

(Review of many different styles of mineralization of metallic and non-metallic mineral deposits in Myanmar (tin-tungsten, lead-zinc-silver, copper ± gold, Ni-Cr ± platinum (in Jurassic ophiolites), etc.)

(Theingon Pb-Zn deposit near Bawsaing, S Shan State comparable to Mississippi-Valley-type deposits. Pb-Zn mineralization within Lower- M Ordovician Wunbye Fm carbonates (Sibumasu Plate). Epigenetic in origin)


Zaw Win (2009)- Fossil brachiopods from the Zwekabin Range. Hpa-an University Research J. 2009, 1, p. 145-149. (Spinomartinia prolifica brachiopod assemblage found for first time from U Taungnyo Gp exposed along NW flank of Zwekabin Range, S Myanmar. Associated with Retimarginifera cf. alata, Torynifer, etc. Correlated with Spinomartinia prolifica fauna of E Permian Ko Yao Noi Fm of S Thailand and Kinta Valley of Wt Malay Peninsula, where age determined as Late Sakmarian (E Permian). Spinomartinia fauna viewed as 'transitional' biotic province with both Gondwanan and Tethyan affinities and endemic taxa of Shan-Thai Terrane)


accretionary complex. Amphibolites zircon ages of $119 \pm 3$ Ma and $115$ Ma, close to ages of nearby calc-alkaline granite and diorite, which belong to active continental margin arc along W side of Shan-Thai block. IBR accretionary complex generated during E Cretaceous (115-128 Ma) subduction of Neotethys Ocean.


(Arc-basin system along W Myanmar continental margin, with at least three igneous events in W Myanmar Arc: mid-Cretaceous (110-90 Ma), latest Cretaceous- E Paleocene (69-64 Ma) and Eocene (53-38 Ma), and associated uplift in Late Cretaceous, Eocene and Late Oligocene. Magmas significant juvenile mantle source component involving subducted sediments and juvenile crustal materials. Magmatism can be correlated with Gangdese arc in Lhasa terrane of S Tibetan Plateau. Model of E-ward subduction of Neo-Tethyan/Indian plate oceanic crust under Sibumasu starting in mid-Cretaceous, with long-lived back-arc extension in W Myanmar)


(Song Ma belt in N Vietnam with ophiolite, metabasite, metasediments and eclogite, and thought to be suture zone between Indochina and South China blocks. Eclogite high-P metamorphism in subduction zone with low T gradient (~8 °C/km). Song Ma ophiolite experienced ocean-floor metamorphism. Metabasalt and gabbro with MORB-type geochemical affinities. Eclogite U-Pb zircons mean age 230.5 ± 8.2 Ma, interpreted as closure age of Paleotethys and subsequent collision of two blocks in M Triassic (main Indosinian Orogeny))


(Song Ma ophiolites mainly peridotite, basalt and gabbro with greenschist- lower amphibolite-facies metamorphism. U-Pb zircon ages 340± 29 Ma (E Carboniferous), interpreted as protolith age. Metamorphic rims age of ~280 Ma (E Permian). Metabasalt protolith age ~315 Ma. Eclogite and garnet hornblende metamorphic ages ~ 230 Ma. Three-stage evolution: (1) Paleotethys oceanic crust formation at 340-315 Ma and ocean-floor metamorphism at 283-280 Ma, (2) <280-230 Ma: Paleotethys lithosphere subduction and HP metamorphism at ~230 Ma; closure of Paleotethys in M Triassic; and (3) <230 Ma: breakoff of Paleotethys oceanic lithosphere and exhumation of subducted slabs. Subduction polarity still problematic)


(online at: www.tandfonline.com/doi/pdf/10.1080/03115510903043762?needAccess=true)

(W Yunnan in SW China part of Sibumasu Terrane. Ordovician rocks affected by several phases of tectonics. M-L Darriwilian graptolite fauna from Shihtien Fm at Baoshan and Shidian with 15 species, incl. Didymograptus artus, D. murchisoni, D. spinulosus, Pterograptus sp., Hustedograptus spp, Archiclimacograptus spp, etc. Two biozones:Didymograptus artus and D. murchisoni. Graptolite fauna similar to Baltica and S China)


(Latest Permian Brachiopod fauna from section at Zhongzhai, Guizhou Province (S China). 15 species of Productida. Etc.)


(Yunnan province of SW China comprises three terrains: South China (E Yunnan), Indochina (Simao; C and S Yunnan) and Sibumasu (Baoshan- Tengchong; W Yunnan- E Myanmar, etc.). All were part of NE Peri-Gondwana Region in Early Paleozoic, possibly off the NW Australia sector)


(Paleomagnetic study of Late Triassic basalts from S part of Baoshan Terrane (= N-most Sibumasu Block) in W Yunnan indicates 15°N paleolatitude in Late Triassic time. Wider paleomagnetic comparison supports view that E Paleotethys Ocean separated Sibumasu and Indochina blocks and closed no later than Late Triassic. N-S directed Changning-Menglian suture zone likely E-W at time of Sibumasu-Indochina collision)


(online at: https://ia800304.us.archive.org/24/items/bulletinofnatura561natu/bulletinofnatura561natu.pdf)

(Burmese amber has been known since 1st century AD. Recorded from five regions in Myanmar, but only mined commercially in Hukawng Valley in N Myanmar. Amber in clastic deposits with Nummulites of M Eocene age, but amber as reworked pebbles and probably of Cretaceous age (also associated with reworked Cenomanian limestone clasts with Orbitolina birmanica). With 10 additional papers on insects from Burmese amber)


(M-L Permian Emeishan LIP considered example of crustal domal uplift caused by mantle plume upwelling before onset of volcanism, but emplacement began in deeper water setting. Lower Succession volcanism had grown into shallower water; Upper Succession subaerial lavas and tuffs. Inconsistent with domal uplift model)


(In Yunnan Province, SW China, regional extension associated with India-Asia collision formed series of N-S trending basins. Near Tengchong close to Myanmar border, basin is characterized by K-rich basalt-dacite volcanism which began in Pliocene (~ 7 Ma) and continued to historic times. Five chemical groups recognized)
IX.5. Cambodia, Vietnam, Laos, SE China (Indochina - South China Plates) (105)


(Dinosaur tracks in the Lower Cretaceous of Muong Phalane, Savannakhet Province, Laos'. Three levels with dinosaur footprints along Sang Soy River, in flood plain sandstone at top of late Lower Cretaceous 'Gres superieurs', dated by fresh water pelecypods (Trigoniodiaceae). Theropod, ornithopod and sauropod footprints)


(Partly-articulated postcranial remains of two sauropod skeletons in Tang Vay (Savannakhet) assigned to Tunguyosaurus hoffeti n.gen. n.sp. Considered as primitive titanosaur)


(First discovery of new spinosaurid theropod from Asia in late E Cretaceous Savannakhet Basin in Laos. Named Ichthyovenator laosensis n.gen. n.sp. Includes partially articulated postcranial remains with dorsosacral sail)


(Pleistocene tektites from Vietnam either of splash form (SiO2 70-77%), or larger, blocky Muong Nong-type (SiO2 74-81%). Geochemistry similar to Muong Nong-type indochinites, indicating same source and compositional similar to average upper continental crust, without obvious extraterrestrial components)


(online at: www.pnas.org/content/48/6/947)
(Chemical analyses of Muong Nong-type and 'normal' splashform indochinite flasgy tektites from Laos and Thailand)


(online at: www.wahre-staerk.de/~madelaine/2014_Bohme_NaDuong.pdf)
(Na Duong Basin in N Vietnam with high diversity Paleogene vertebrate, invertebrate and plant fossils in 220 m thick coal-bearing Na Duong section, ~20km SE of Lang Son. Affinities of new mammal species suggest M-L Eocene age (late Bartonian-Priabonian). High biodiversity unionid mussel (Nodularia, Cristaria), freshwater gastropods, fishes, turtles and crocodiles. Dipterocarp trees and tree ferns identified. In-situ tree-stump horizons suggest maximum canopy height (35m). Environment changed abruptly from swamp forest to tropical-warm subtropical lake. Strong biogeographic link with Eocene mammal faunas from Europe)


(New fossil wood from E Cretaceous continental red beds ('Gres superieurs') of islands in NE Gulf of Thailand off S Vietnam. Fossil wood samples belong to Agathoxylon saravanensis, Protophyllocladoxylon, Cycadeanoxylon. Brachyoxylon orientale and Prototaxoxylon asiaticum already known from this area. Associated with rel. common Classopollis pollen, Signify rel. aridclimate with some seasonality (growth rings))


(Dinosaur fauna discovered by Hoffet in 1930 in S Laos considered by him as Senonian in age, but sauropod and hadrosaurid material non-diagnostic. Dinosaur-bearing beds of Muong Phalane equivalent of Khok Kruat Fm of nearby Khorat Plateau in NE Thailand, dated as late E Cretaceous (Barremian; Buffetaut et al. 2005)


(Three new species of anthracothes from Late Eocene Na Duong coal deposits in NE Vietnam. Morphologically close to species known in China, Thailand, Myanmar and Egypt)

(Brief review of mineral occurrences of Laos)


('Geochronology of South Vietnam'. see also Lasserre et al. 1974)


(Pleistocene layered tektites particularly big and abundant near Muong Nong (Laos). Layered tektites also common in C Vietnam and NE Thailand. Part of large layered tektites subfield of Australasian strewn field)


('Fossiliferous beds from the coal basin of Quang-Nam', Vietnam)


('Tektites of southern Vietnam: geographic distribution and richness of the deposits')


('The ruby-bearing beds associated with marbles on Central and SE Asia: genesis and isotopic characterization')

(Late Silurian- Devonian of Ngoc Vung Series of N Vietnam with plant remains. Late Silurian localities earliest known flora of S China block. Flora supports hypothesis that more derived plants were present on E Gondwana earlier than elsewhere. Devonian localities with thick fibrous stem fragment, of Eifelian-Emsian age)

(online at: http://adsabs.harvard.edu/full/1994Metic..29..411H) 
(Tonle Sap lake in S-C Cambodia may be remnant source crater of Australasian tektites strewn field))

(A 10x6km ring of hills in NE Cambodia is possible impact crater of Australasian tektite strewn field)

(Abstract and Poster) 
(online at: https://agu.confex.com/agu/fm17/meetingapp.cgi/Paper/223717) 
(Onshore SE Vietnam Da Lat zone with Cretaceous intrusions with zircons aged ~122-76 Ma. Jurassic metasediments of Ban Don Gp contain dominant Jurassic, Permo-Triassic and Paleoproterozoic (c. 1.8 Ga) age populations. Oligocene samples from offshore Cuu Long Basin strong Cretaceous age peak (mainly 90-110
Ma, and not much else. M Miocene sandstones mainly Triassic peak (220-240 Ma) and subordinate peaks of Cretaceous and many older ages, mainly 1.8 Ga (from proto-Mekong Delta more distant sources?)


(Oligo-Miocene Di Linh Fm with abundant Cretaceous zircons and subordinate Paleoproterozoic (c. 1.8-1.9 Ga), sourced mainly from Cretaceous plutons. Pliocene- Pleistocene Song Luy Fm with additional Permian-Triassic and Orдовician-Silurian age populations, interpreted to be from basement in C and N Vietnam and reflecting intra-Miocene unconformity)


(Song Ma zone in NW Vietnam subduction corridor between Indochina and S China blocks. Two-stage magmatic evolution: ocean subduction at ~290-260 Ma and post-collisional magmatism at ~245-230 Ma)


(Permo-Triassic intermediate-felsic magmatism along Truong Son fold belt in N Vietnam, along E margin of Indochina Block: calc-alkaline volcano-plutonic associations (272-248 Ma), peraluminous granites (259-245 Ma), and subalkaline felsic volcano-plutonic associations (<245 Ma). Products of Paleotethys subduction during Indochina/ N Vietnam- S China amalgamation. Event ended in E-M Triassic (246-240 Ma))


(Hydrocarbon exploration in Champasak and Saravan provinces, geologically SE part of Khorat Plateau. No significant hydrocarbon flows obtained yet)


(online at: https://www.sciencedirect.com/science/article/pii/S002449371730405X)

(Geochmical composition of Late Cenozoic intraplate basaltic rocks from C and S Vietnam indicates basalts sourced from mantle dominated by garnet peridotite, and recycled oceanic crustal material (sediment, basalt, and gabbro). Possibly result of entrainment of accumulated Paleo-Pacific slab into rising Hainan plume)


('Note on the geology of lower Laos')


('Description of some titanosaurian bones from the Senonian of Lower Laos'. See also Buffetaut 1991)


(Bach Long Vi Island is crest of inverted Oligocene Bach Long Vi Graben in Gulf of Tonkin area, at intersection of Song Hong and Beihuan basins, N Vietnam. 500m-thick Paleogene lacustrine oil-prone source rock succession in Enreca-3 core-hole)

(N.E-trending Yong’an Basin, SE S China craton, preserves Permian-Jurassic marine-continental, clastic-dominated retroarc foreland basin succession. Sources for M Paleozoic- E Mesozoic detrital zircons include input from beyond currently exposed China mainland, possibly from active convergent plate margin along SE rim of craton that incorporated part of SW Japan and is related to subduction of Paleo-Pacific Ocean. Termination of Paleo-Tethys subduction beneath SW margin in Permo-Triassic)


(online at: https://www.jstage.jst.go.jp/article/bullgsj/65/1-2/65_17/_pdf)

(Zircons from granitoids at Nui Phao in N Vietnam dated as earliest Triassic (~250 Ma). Possibly associated with Sn-W and REE ore deposits hosted in granitoids)


('Geochronology of South Vietnam')
(online at: https://www.sciencedirect.com/science/article/pii/S0375674217303035)
(Evaporite deposits in Sakhon Nakhon Basin, SE Laos, is northern continuation of M-L Cretaceous salt basin of Khorat Plateau (Thailand; Indochina Plate). Isotopes and trace metals in 600m halite-dominated core suggest continental and hydrothermal origins, with trace marine remnants (probably formed originally by evaporation of seawater, being dissolved in meteoric water and hydrothermal fluid, and subsequently precipitated))

(SE China widespread Jurassic- Cretaceous magmatism, but episode of 'magmatic quiescence' at ~130-110 Ma. E Cretaceous (~140-130 Ma) magmatism in coastal SE China attributed to Paleo-Pacific plate subduction beneath SE China. Collision between W Philippines and SE China blocks at ~130-120 Ma resulted in magmatic quiescence and formation of Changle-Nan'ao metamorphic belt. Post-collisional extension triggered initiation of magmatism associated with amphibolite-facies metamorphism at ~110 Ma)

(Daoxian mafic granulite xenoliths in basalts from S Hunan Province and structural features of Xiefengshan belt suggest Late Triassic orogenic collapse under central S China Block, accompanied by lithospheric extension and asthenospheric upwelling. Could have contributed to mantle disturbance to enhance rollback of Paleo-Pacific slab)

(online at: http://or.nsfc.gov.cn/bitstream/00001903-5/252870/1/1000014253494.pdf)
(NW-SE trending Ailaoshan suture part of ~2900 km long Jinshajiang- Ailaoshan- Song Ma- Hainan suture, and separates Yangtze (S China Craton) block in N from Simao (Indochina) block in S. Granitic plutons in Ailaoshan zone yield zircon ages of 247-252 Ma. Indosinian magmatism confirmed along Ailaoshan zone. Latest Permian convergent margin magmatism represented by Xin'anzhai granitoid (~252 Ma) terminated through accretion of Simao-Indochina to S China block, marking start of Triassic Indosinian Orogeny, resulting in generation of the ~247 Ma (earliest Triassic) Tongtiange S-type leucogranite)

(Late Triassic gabbroic intrusion in Mengdong village in S China- Indochina collision zone, Yunnan, SW China, metamorphosed to amphibolite. Late Triassic magmatic flare-up at ~222± 5 Ma in Ailaoshan suture zone post-collisional setting, with heat source from slab break-off and OIB-type asthenospheric mantle upwelling)

(Brief review of Cambodia porphyry gold-copper deposits, associated with Permian- Triassic (260-230 Ma magmatic system, Cu in Jurassic and gold in Cretaceous magmatic sytems (SW continuation of Yanshanian Orogenic Belt of S China)

(Cuu Long basin off S Vietnam with 12 or more oil discoveries, 80% of oil in fractured-weathered granite basement, with additional production from onlapping and draping clastics)

(First Triassic foraminifera reported from shallow marine limestones in U Nam Sam Suite, Sam Neua area, N Laos (N part of Indochina Block). 17 taxa, incl. Pilammina densa, Pilamminella grandis, Citaella dinarica, etc. Age M Anisian (M Triassic). Fauna shares several important species with Sibumasu Block, Sukhothai Zone and S China Block, suggesting these domains formed single paleobiogeographic province in Anisian time)


(online at: https://www.jstage.jst.go.jp/article/jmps/advpub/0/advpub_151019b/_pdf/-char/en)

(Da Lat basin in SE Vietnam initiated during marine transgression in E Jurassic (Hettangian, ~198 Ma) and ended by regression in M Jurassic (Bathonian, ~165 Ma). Aalenian- Bajocian with common molluscs (?Myophorella) and mid-out shelf ichnofossils (Skolithis, Paleophycus, Thalassinoides))

(online at: http://en.earth-science.net/PDF/20160612013151.pdf)
(Volcanic rocks from Sayabouli area in NW Laos traditionally mapped as Permian- E Triassic sequences on geologic map, but basaltic-andesite with zircon U-Pb age of 238±2 Ma, suggests M Triassic age. Rocks similar to continental arc volcanic rocks from Phetchabun belt in NE Thailand, through W Loei sub-belt (E-dipping subduction linked closing of Nan backarc basin between Sukhothai terrane and W margin of Indochina Block))

(online at: http://sciencepress.mnhn.fr/sites/default/files/articles/pdf/g2006n1a1.pdf)
(New vertebrate remains from Devonian of C Vietnam (Indochina Block) provide further information about various fish fossils (similar to Yangtse Platform, S China block, brachiopods (Corbicularia, etc.) and charophytes (Sycidium))
(Indo-Burma Fold Belt) 

(Large negative Qui Nhon Slope Anomaly is sea surface depression of ~1.5 m over 100km diameter. Corresponds to gravity anomaly of ~ -50 mgal. May be impact structure that produced Australasian strewn field) 

(online at: https://www.gsj.jp/data/bulletin/60_11_02.pdf) 

(On some deposits of tektites of Southern Indochina) 

(Song Chay Range with high-grade granitic and metamorphic dome near Cenozoic Ailao Shan-Red River fault zone. Previously considered to be Proterozoic S China basement. Granite with zircon age of 428±5 Ma. Rb/Sr on ands 39Ar/40Ar ages suggest Late Triassic episode of rapid cooling interpreted as due to doming. AFT age of 33.6±3.6 Ma confirms rapid Eocene-Oligocene cooling event, final exhumation of Song Chay dome) 

(New Triassic stratigraphic framework for Song Da and Sam Nua basins, N Vietnam. Song Da Basin at S margin of S China Block in foreland setting during late E-M Triassic, not rift. Sam Nua basin on N margin of Indochina Block records activity of proximal magmatic arc from late Permian-Anisian, resulting from subduction of S-dipping oceanic slab that separated S China and Indochina blocks. Both basins M-L Triassic erosion, creating major unconformity from erosion of M Triassic Indosinian S China -Indochina collisional basin. Late Triassic terrestrial syn- to post-orogenic foreland basins with coarse detrital material) 

(The Permiano-Triassic sedimentary basins of North Vietnam: archives of the Indochina- South China collision (Indosinian orogeny)" Indosinian unconformity in N Vietnam postdates Middle Triassic. E Triassic arc S of Song Ma suture suggests S-dipping subduction of oceanic crust under Indochina Block) 

Bibliography of Indonesia Geology, New for Ed. 7. 310 www.vangorselslist.com 8/6/18

(Presence of Brachoxylon rotnaensis Mathiesen in the Mesozoic flora of lower Laos)


(Two underexplored basins off Vietnam, both with initial extension tectonics but have contrasting post syn-rift evolution. Phu Khan Basin no evidence for wrench fault system; mild M Miocene compressional event caused reactivation of pre-existing extensional faults. Compression event appears to have ceased by end M Miocene. Post M Miocene transformation of basin into passive margin with progradational-aggradational mega-sequences. Hai Phong sub-basin in N with major M Miocene and Late Pliocene inversion events)


(E Cretaceous Lingxi pluton in interior of Cathaysia Block (zircon U-Pb age 100±1 Ma). Granodiorite with geochemical features of adakitic rocks, derived from partial melting of thickened Proterozoic lower continental crust at P ≥12 kbar (= crust thickness ≥40 km), leaving garnet-bearing amphibolite residue. Crust thickened by late E Cretaceous compressive event (angular unconformity between Upper Cretaceous rift deposits and folded early Lower Cretaceous or Jurassic). During subsequent lithospheric extension (driven by Paleo-Pacific subduction?) lower crust heated by upwelling asthenospheric materials, resulting in Lingxi and other coeval granitoids in Cathaysia Block)


(Bo Xinh ultramafics, N of Song Ma fault zone isolated bodies long considered as remnants of Paleotethys Ocean lithosphere between Indochina and S China blocks. Cr-spinel compositions suggest parental magma was lherzolite-harzburgite in composition, indicating forearc tectonic environment. Combined with information on magmatism, metamorphism and sedimentary environment, suggest presence of S-ward subduction zone since Cambrian and collision of Indochina and S China in Late-Silurian- E Devonian. Permian-Triassic magmatic-metamorphic events in Indochina block linked to N-ward subduction of Paleo-oceanic plate beneath Indochina block, followed by M-L Triassic Sibumasu collision)


(Yunnanolepiform antiarch (placoderm fish) from the Givetian Dong Tho Fm of C Vietnam, well S of Song Ma suture, in marginal marine facies. Hitherto known exclusively from Lower Devonian of S China block, suggesting close links between Indochina and South China blocks in M Devonian time)


(Late Silurian radiolarian fauna of 18 species from cherts in Sepon Mine area, C Laos. With Futobari morishitai, F. solidus, Zadrappolus yoshikienisis and Z. tenius. Evidence from Silurian-Devonian of S Truong Son Terrane indicates deepening to S (radiolarian cherts; terrestrial red sandstone facies to NE). In contact with E Silurian limestone and U Ordovician- E Silurian graptolitic shale, overlain by turbiditic volcanioclastics from nearby Long Dai Volcanic Arc. Arc probably maintained by N-ward subduction along Thakhek-Danang Shear Zone)
('Silurian vertebrates from Central Vietnam'. New placoderm fish Myducosteus anmaensis from Indochina Plate, associated with brachiopods)

(Review of Silurian and Devonian sediments in Vietnam. Most Devonian units in N and C Vietnam consist of shelfal shallow water sediments, apparently deposited in passive margin marine setting)


(Vietnam five structural blocks, from N to S: NE, NW, Truongsong, Kontum, Nambo)

(Coal-forming episodes in Indochina region: M-L Devonian, E Carboniferous, Late Permian, Late Triassic, E Jurassic, Tertiary and Quaternary. Only E Carboniferous, Late Triassic and Tertiary coals economically important)

(Paleomag of Late Jurassic- E Cretaceous red beds in Phuquoc-Kampot Som Basin (part of Indochina Block) suggests S-ward displacement of 6.0 ± 3.5° and CW rotation of 33 ± 4°. CW rotation ~15° larger than Khorat Basin, attributed to dextral motion along Wang Chao Fault since M Oligocene. Comparison with CCW rotation reported from Da Lat area in Vietnam suggests differential tectonic rotation in S tip of Indochina Block)

(E-W melange-ophiolite belt, 3 km wide-20 km long, separating northern block of amphibolitic Pailin Crystalline Complex from southern area of Triassic submarine fan siliciclastic rocks. Cherts with Asselian-Sakmarian radiolarian fauna of Pseudoalbaillella spp. etc.. Sa Kao Suture appears to extends E into Cambodia and possibly then turns S-wards along strike of Pursat-Kampot Foldbelt)


(N Laos Carboniferous and Permian limestones NW of Luang Prabang and S of Sayabouli. Carboniferous limestone with Profitusulina, Fusulinella, Beedeina, and Fusulina. E-M Permian platform carbonates with Yangchienia, Parafusulinina, Neoschwagerina, Afghanella, Presumatrina, Verbeekina, etc. Similar to W margin
of Indochina Block in Loei area of M Thailand, suggesting link between NE Thailand and NW Laos. Nan-Uttaradit Suture between Sukhothai zone and Indochina Block runs NNE-ward into NW Laos and continues to Lancangjiang suture in W Yunnan)


(Large Carboniferous-Permian Yangtze carbonate platform of S China (Yangtze) Block, with 26 Late Carboniferous- E Permian cyclothsems identified. Probably rel. arid climate)


(Sukhothai Zone Permian-Triassic Paleo-Tethyan island-arc system along W margin of Indochina Block considered to extend from N Thailand to SW Yunnan (China), but no evidence from N Laos in between. Foraminifers from shallow marine limestone in Long area of NW Laos of Triassic (Carnian) age (Aulotortus sinusus, A. tumidus, Ophthalmidium, Endotriada, Endoteba, Palaeolituonella, etc.). In Thailand similar Carnian limestone only in Doi Long Fm in Sukhothai Zone)


(Extended Abstract)

(Permian limestones in N Laos dominated by sponge- Tubiphytes-microbial reeval boundstone with Coloniella cylindrica, Agathammina, Pachyphloia, Neoendothyra, Reichelina, Palaeofusulina?, etc., referable to Changhsingian (latest Permian). Also M Triassic (Anisian) carbonates with ooid grainstones and Late Triassic (Carnian) sponge-microbial boundstones. In Thailand similar carbonate succession only in Lampang-Phrae-Nan area of Sukhothai Zone, suggesting Sukhothai Zone extends to W part of N Laos)


(The phytostratigraphic significance of the Mesozoic Nong-Son-Vinh Phuoc coal basin, Central Vietnam, and phylogeny of species')


(online at: http://library.dmr.go.th/library/Proceedings-Yearbooks/M_1/1997/7641.pdf)

(Discovery of new M Jurassic (E Bajocian) marine fauna in Langa Fm of Datat Basin, S Vietnam, incl. ammonite Fontannesia and bivalves Bositra ornata and B. buchii)


(Six possibly oil-gas-bearing basins identified in Cambodia: Siam (N Gulf of Thailand), Tonle Sap, Khorat (S portion), Preah, Chung and Svarrieng Basins)


(online at: www.sciencedirect.com/science/article/pii/S1674987111001095)

(M Jurassic- Late Cretaceous extensional basin and range tectonics and associated magmatism widespread in SE China, tied to W Pacific Plate subduction. Basin types: (1) post-orogenic Late Triassic- E Jurassic with
coarse clastics, and (2) intra-continental extensional basins, formed during crustal thinning and characterized by development of grabens/ half-grabens. Grabens mainly E-M Jurassic, with bimodal volcanism; half-grabens E Cretaceous, with rhyolitic tuff- lavas and mainly Late Cretaceous-Paleogene redbeds. Ranges composed of granitoids, volcanic rocks and dome-type metamorphic core complexes. Basin and range terrane developed on pre-Mesozoic folded belt, derived from polyphase tectonic evolution, mainly due to subduction of W Pacific Plate since Late Mesozoic)


(Se coastal area of S China Block generally interpreted as Cretaceous active continental margin due to subduction of Paleo-Pacific plate beneath Eurasian plate. NW-directed ductile thrusting at ~130-105 Ma, before deposition of undeformed (~104 Ma) volcanic rocks and intrusion of ~90 Ma plutons. Interpreted as back-thrust resulting W Philippines microcontinent collision with SCB rather than effect of oceanic subduction.


(Seismotectonic structures of Song Ma fault zone indicate a complex fault system at different segments)


(Late Triassic foreland basin in W Guizhou and E Yunnan provinces)


(online at: http://en.earth-science.net/PDF/20160613095735.pdf)

(Wuliangshan Gp low-grade metasediments E of Lancang giant igneous zone, SW Yunnan, syn-orogenic product of collision between Baoshan with Simao-Indochina blocks. Detrital zircons major age-peak at ~259 Ma, four subordinate-peaks at ~1859, 941, 788 and 447 Ma. Youngest zircon age of 230±5 Ma suggests deposition after M Triassic. Provenance mainly from Simao/ Yangtze blocks to E rather than Baoshan Block to W)


(online at: https://www.jstage.jst.go.jp/article/jmps/108/2/108_120813/_pdf)

(NW-SE trending Trans-Vietnam Orogenic Belt thought to have formed by continent-continent collision between S China and Indochina blocks in Permian- Triassic. Amphibolite-facies metamorphosed mafic rocks widespread in Song Ma suture zone, Kontum Massif, etc., derived from arc and oceanic crust between these plates)


(SE China coast granites two groups: (1) in N, I-type alkali-feldspar granites generated by mixing of mantle-derived material with crustal-derived magmas (98-96 Ma); and (2) in S, A-type plutons (89-86 Ma). All granites highly siliceous, K-rich. Both granite types emplaced during post-collisional extensional tectonism associated with rollback of steeply subducting Paleo-Pacific Plate (increase of dip angle of subducted Paleo-Pacific plate between Early- Late Cretaceous)


(Late Cretaceous Yongchun pluton adakitic intrusion in S Fujian, SE China. Zircon U-Pb ages of ~98-100 Ma, similar to those of nearby plutons. Magmas generated by partial melting of Mesoproterozoic continental crust mixed with mantle-derived magmas. Magmatism associated with thickening of lower crust during change in subduction angle and convergence rate of Paleo-Pacific Plate at 100 Ma)


(New work in NW Laos shows Permian-Triassic (incl. U Permian clastics with coal) between Luangprabang and Chiang Rai belts are comparable to Simao basin between Ailaoshan and Lancangjiang belts. Nan River belt in N Thailand can therefore not be linked with Lancangjiang belt by crossing NW Laos)


(online at: research-repository.uwa.edu.au/files/3214568/Zi_Jianwei_2012.pdf)


(Jinshajiang orogenic belt, SW China, records closure of Paleo-Tethys seaway and ensuing collision. Following consumption of the ocean, M Triassic (247-237 Ma) collision zone magmatism. From 234-214 Ma emplacement of high-K, calc-alkaline granodiorites-monzogranites prior to isostatic uplift and extension, probably caused by breakoff of subducted slab. Melange and collision-related magmatic suites unconformably overlain by Late Triassic (229-217 Ma) conglomerate-rich sequence that represents overlap assemblage, across Qamdo-Simao terrane (Indochina) and Yangtze Block of S China)


(Collision-related Triassic volcanic rocks in Jinshajiang-Ailaoshan orogenic belt in SW China suggest initial collision and amalgamation of Qamdo-Simao (Indochina) terrane with Yangtze Block (S China) along Jinshajiang- Ailaoshan and Song Ma sutures probably in E Triassic, following consumption of Paleo-Tethys Ocean. 247-246 Ma Pantiange high-Si rhyolites represent early magmatic products. 245-237 Ma bimodal volcanism interpreted as extension within evolving collisional orogen, probably related to oblique convergence)


(Velocity model shows evidence for presence of slab segments in Mantle Transition Zone beneath C and slab window beneath W Indo-China plate. Also broad mantle upwelling adjacent to E edge of slab segments, which may responsible for widespread Cenozoic volcanism and pervasive low upper mantle velocities in area)
(Numerical modeling of transition from Mesozoic compression to extension in Cathaysia Block, SE China (upper plate of Paleo-Pacific subduction zone). Initiation of Late Cretaceous- Paleogene extensional regime probably triggered by roll-back of slowly subducting slab)
IX.6. Malay Basin, Gulf of Thailand (19)


(High-resolution 3D seismic data from Malay Basin Pleistocene-Recent shows six fluvial channel types in eight 18-145m-thick depositional units, with (1) relatively large (300-3000m wide, 15-45m deep) and straight channels at bases, and (2) smaller (75-250m wide, 8-23m deep), highly sinuous channels at tops. Cyclical architecture interpreted as mainly climatically driven changes in fluvial sediment supply. Two large incised valleys interpreted to be formed due relative sea-level fall during Last Glacial Maximum)


(online at: www.searchanddiscovery.com/documents/2015/20333centhonglangndx_centhonglang.pdf)

(Arthit gas field in NW North Malay Basin, offshore Thailand, mostly in Miocene- Oligocene reservoir. Most of the gas production from stacked channel reservoir in structural traps. 2012 appraisal well confirmed gas in 'nose structure' combination trap)


(Jasmine Field (Jasmine and Ban Yen) in NW Pattani Basin, Gulf of Thailand. Discovered in 1974, cumulative production 65 MMSTB Oil from >160 pools in 30 fault blocks and 27 M-L Miocene reservoirs. Oils appear to be expelled from similar organofacies at similar maturities, from kitchen S of Ban Yen area)


(online at: http://maxwellsci.com/msproof.php?doi=rjaset.11.1792)

(Malay Basin with up to 14 km of sediments. Sedimentation rate analysis and 2D modeling suggest sediment accumulation started at 33.9 Ma towards the basinal side, possibly associated to activation of Tenggol fault. Prior to unit K (25.2 Ma) sediments absent on Tenggol arch. During Late Miocene basin wide inversion sediments still accumulated in SW part)


(online at: http://iopscience.iop.org/article/10.1088/1755-1315/30/1/012002/pdf)

(Features of gas seepage on Malay Basin seismic data (amplitude anomalies, wipe out zones, sag or push down, pockmarks/ craters, etc.)


(same as Jardine 1997)


(Unocal Erawan gas field in Gulf of Thailand with series of E- and W-dipping normal faults that displace E-M Miocene clastic reservoirs. Most faults adequate seal capacity)

(Gulf of Thailand part of suite of Cenozoic basins within Sundaland, with multiple phases of extension and inversion, rapid post-rift subsidence, low-angle normal faults and Basin and Range-style. Songkhla Basin in SW Gulf asymmetric half-graben, bounded by NNW-SSE faults along W edge, ~75 km long, 30 km wide. Two oil fields in basin. Pre-Cenozoic basement fabrics broadly N-S. Sediments thicken to W along growth fault surfaces; most faults E-dipping. Three main tectonostratigraphic packages in basin: 1) Eocene E Miocene synrift, with three sub-extensional packages; 2) early M Miocene inversion and deposition of post-rift package, terminated by M-Miocene Unconformity; 3) Late Miocene-Recent post-rift)


(online at: www.geo.sc.chula.ac.th/BEST/volume5/number2/4_Heliosita_BEST_4_2_p%202025-31.pdf)

(Songkhla Basin in Western Graben of Gulf of Thailand asymmetric half-graben, bounded by NNW-SSE-trending major extensional faults. Basin fill thicker in W due to growth faulting. Maximum displacement along main boundary fault in W ~1.2 km in E Oligocene. Most faults E-dipping. Three tectonic phases: Eocene or E Oligocene initial rifting, E Miocene inversion, M Miocene resumption of extensional tectonics)


(online at: www.searchanddiscovery.com/documents/2017/51366lambiase/ndx_lambiase.pdf)

(E-M Miocene late rift- early post-rift sediments in Gulf of Thailand traditionally viewed as fluvial, but also widely distributed marginal marine mudstones and coaly mudstones and tide-dominated sandy facies)


(online at: https://www.jstage.jst.go.jp/article/japt1933/67/1/67_16/_pdf/char/en)

(In Japanese with English abstract. Gases in Pattani Trough derived from thermal cracking of Type III kerogens and cracking of pre-existing oils. Oils waxy and heavy, probably of lacustrine algal origin. Two different source facies, Oligocene lacustrine-algal and Miocene fluvial-coaly. Oil generation from Oligocene source rocks initiated in E Miocene, and gas generation mainly M-L Miocene in central trough. CO2 contents increase with depth from few to ~25% in trough. Some wells CO2 as high as 91%. (Platong gas field), probably of inorganic origin (magmatic decomposition of carbonate basement)


(online at: www.geo.sc.chula.ac.th/BEST/volume5/number2/Dini_02.pdf)

(Songkhla Basin in Gulf of Thailand N-S trending, Eocene rift basin. Early Oligocene and Late Oligocene- E Miocene local inversion structures at E and W sides of basin in overall extensional regime)


(Acoustic and coring record of Last Glacial Maximum and postglacial sea-level rise in central Gulf of Thailand. Valley incision (Kelantan River), followed by estuarine marine transgression, interrupted by deltaic progradation. Transgressive ravinement followed by thin, condensed cover of modern marine muds)

(On estimates of GRV from seismic data in Sepat Field in Malay Basin (1983 discovery, structure 30km x 10 km E-W trending structure dissected by normal faults)


(online at: www.searchanddiscovery.com/documents/2017/10922rivas/ndx_rivas.pdf)

(Songkhla basin in W Gulf of Thailand, with several producing oil fields. Asymmetric Tertiary rift basin formed between 40-20 Ma, controlled by NNW-SSE faults mainly at W side, filled by Eocene-Miocene continental sequence. Reservoir intervals fluvial- alluvial sandstones of Eocene, Lower Oligocene and Lower Miocene age. Lower Oligocene lacustrine shales are supposed source rocks of basin)


(online at: www.geo.sc.chula.ac.th/BEST/volume4/number2/5_Jana_BEST_4_2_p%2032-35.pdf)


(online at: https://www.jstage.jst.go.jp/article/japt/73/1/73_1_74/-/pdf/-char/en)

(in Japanese, with English abstract)


(online at: http://english.hyxb.org.cn/EN/abstract/abstract4519.shtml)

(Chinese with English summary. NE Gulf of Thailand stronger inversion structures than elsewhere, enabling petroleum play with Eocene lacustrine source, Eocene- Oligocene deltaic sandstone reservoirs and Miocene delta front and marine shale seals)
IX.7. South China Sea (82)


(Restoration of conjugate margins of S China Sea to original Late Cretaceous unstretched geometries. Model suggests more extension of continental basement on W part of conjugate margins relative to E margin prior to initiation of seafloor spreading. Mid ocean ridge initially formed in E and propagated W-ward)


(Huizhou sag on N continental margin of S China Sea with en echelon fault distribution at margins of basin, suggesting oblique extension and caused by subduction of Proto-South China Sea towards NW Borneo. Tectonic evolution of basin: rifting (49–32 Ma), post-rift (32–15.5 Ma) and rapid subsidence (15.5-0 Ma))


(High-resolution oxygen and carbon stable isotope stratigraphy of 518m-long cored Quaternary section of ODP Site 1144 in northern S China Sea. One 5 cm thick layer with Australasian microtektites (386.18- 386.23 mcd) near Brunhes/Matuyama boundary and within transition of lower MIS 19- MIS 20 oxygen isotope stages. Proposed age model layer suggests age of microtektites layer 787 ka. Microtektite layer also in SONNE-95 core 17957 from southern SCS, within MIS 19–20 transition, 10 cm (~11.6 ky) below Brunhes/Matuyama reversal)


(Late Pleistocene-Holocene sequence of SE Vietnam Shelf with basal sequence boundary formed by subaerial exposure during Late Pleistocene sea-level fall and subsequent marine reworking during transgression. Northern incised-valley system narrow and deep V-shape in cross-section (<5 km wide, 10s of m deep) likely result of high-gradient of paleo-shelf. Off Mekong Delta and Ca Mau Peninsula low-gradient paleo-shelf created shallow incised-valleys (5-15 km wide, <15m deep. Lowstand ST prograding outer shelf delta-wedge formed during Last Glacial Maximum. Transgressive ST preserved in incised-valleys, with thickness 15-25m)


(Two sequences in Late Pleistocene-Holocene on steep and narrow shelf off Nha Trang. Relict beach ridge deposits ~130m below present water depth indicate Last Glacial Lowstand sea level in this area lower than in neighboring areas, probably resulting from subsidence due to high sedimentation rate and/or neotectonic movements of E Vietnam Fault System)


(Differences in sedimentation rate changes and calculated subsidence between East and SW subbasins of S China Sea. Abrupt increase in sedimentation rates since Pliocene suggestst glacial-interglacial climate variability impacted erosion rates)


(Taiping Island in Spratly (Nansha) Islands in northern part of S margin of SW Sub-basin of S China Sea. Basement highs dominated by fault blocks and volcanic basement structures)


(online at: https://link.springer.com/article/10.1186/s40562-015-0029-9)

(Several basins around S China Sea with accelerated phases of basement subsidence associated with phases of fast erosion onshore and deposition of thick sediments offshore, causing flow of ductile crust from offshore towards continental interior after end of active extension, partly reversing flow during continental breakup)


(online at: https://www.nature.com/articles/ncomms15698.pdf)

(Evaluation of processes controlling productivity and preservation of mangrove-bearing successions in Oligo-Miocene of basins of S China Sea (Vietnam, Gulf of Thailand, N Borneo). High tidal ranges optimize mangrove development along tide-influenced tropical coastlines. Preservation of mangrove organic carbon promoted by high tectonic subsidence and fluvial sediment supply)


(online at: https://www.sciencedirect.com/science/article/pii/S0012821X18300736)

(On bright reflectors within Oligocene- M Miocene oceanic crust of S China Sea. Dipping reflectors generally confined to lower crust above Moho reflection)


(Tectonic subsidence history from seismic profiles across Dangerous Grounds and Reed Bank area in S China Sea. Delay of tectonic subsidence after break-up, likely related to major mantle convection during seafloor spreading. Stage with delayed subsidence rate in Reed Bank area 32-23.8 Ma, in the Dangerous Grounds 19-15.5 Ma, tied to rift propagation)


(Cenozoic magmatism on N Hainan Island post-dates opening of S China Sea Basin. Tholeiite lava flows from WSW-ENE-trending fissures and interlayered with M Miocene-Quaternary sediments, forming 200-1000m sequence. With time basalts change from thin intercalated quartz tholeiite and alkali olivine basalt flows to more massive olivine tholeiites. Hainan basalts resemble Dupal-type oceanic island basalt)

(Volcanic rifted margins evolve by extension accompanied by extensive extrusive magmatism during breakup. (up to 15km volcanic flows, seaward dipping reflectors). Magma-poor rifted margins with wide domains of extended crust (rotated faults blocks with detachment surfaces near base of continental crust), but limited magmatism. South China Sea intermediate between above end-members, with basin-and-range type rifting followed by formation of oceanic crust)


(Toba tephra layer identified in core MD972151 in southern S China Sea (SCS). Tied to 1° cooling for ~1 kyr following Toba eruption (71 ka) during marine isotope stage 5a-4 transition)


(S China Sea marginal basins with >70 Cenozoic magmatic activities identified. Geodynamic evolution: (1) early bimodal volcanism (>32 Ma) mainly in Paleogene basins at N margin, under dextral transtensional regime from India- Eurasia collision; (2) syn-spreading igneous rocks, with magmatic emplacement resulting from NNE-trending dextral strike-slip pull-apart tectonics; (3) Quaternary E-W-trending post-spreading basalts, under extrusion regime from collision between Luzon–Taiwan Arc and Eurasian Plate. In Indochina and Malay Peninsula, widespread Cenozoic extensional post-spreading plutons possibly derived from mantle plume or controlled by Ailaoshan Red River left-lateral strike-slip fault zone)


(Late Pliocene- M Pleistocene extinction of many elongate, cylindrical benthic foraminifera in deep South China Sea ODP Sites 1143 and 1146, as part of 'last global extinction' in deep sea. Pulsed decline in abundance and richness, mostly during glacial periods, particularly during M-Pleistocene Climate Transition (1.2-0.6 Ma). Result of the increased glacial cooling and increased ventilation of deep-sea water masses)


(Young volcanics from S China Sea shelf zone (Thu, Cu-Lao Re, Hong Jo islands, Katuik- Ile des Cendres) related to same type of rift volcanism in onshore Vietnam, basaltoids of S China Sea, Thailand and N Hainan island, despite different structural zones. Leading role of mantle diapirism in evolution of Indochina volcanism)


(Offshore E Vietnam Phu Khanh Basin last remaining true frontier basin in SE Asia. Seafloor coring identified Miocene-Pliocene stratigraphy and thermogenic hydrocarbons)

Bibliography of Indonesia Geology, New for Ed. 7.


Li, C.F., X. Xu, J. Lin, Z. Sun, J. Zhu, Y. Yao, X. Zhao, Q. Liu, D.K. Kulhanek, J. Wang et al. (2014)- Ages and magnetic structures of the South China Sea constrained by deep tow magnetic surveys and IODP Expedition 349. Geochem. Geophys. Geosystems 15, p. 4958-4983. (Magnetic anomalies and IODP 349 cores show seafloor spreading started at ~33 Ma in NE S China Sea, but varied slightly by 1-2 Myr along N continent-ocean boundary. S-ward ridge jump of 20 km occurred at ~23.6 Ma in E Subbasin; coeval with onset of seafloor spreading in SW Subbasin, which propagated for ~400 km SW-ward from 23.6-21.5 Ma. End of seafloor spreading 15 Ma in E Subbasin and 16 Ma in SW Subbasin)

Liu, C., P.D. Clift, R.W. Murray, J. Blusztajn, T. Ireland, S. Wan & W. Ding (2017)- Geochemical evidence for initiation of the modern Mekong delta in the southwestern South China Sea after 8 Ma. Chemical Geology 451, p. 38-54. (Clay minerals from IODP Site U1433 and seismic suggest onset of Mekong Delta in present location after 8 Ma, following avulsion from Gulf of Thailand)


(d18O oxygen stratigraphy across last two glacial-interglacial cycles in southern S China Sea off SE Vietnam. Tephra layer of Toba eruption at 71ka helps anchor transition of O-isotope stages 5/4)

Ma, Z.L., Q.Y. Li, X.Y. Liu, W. Luo, D.J. Zhang & Y.H. Zhu (2017)- Palaeoenvironmental significance of Miocene larger benthic foraminifera from the Xisha Islands, South China Sea. Palaeoworld 27, 1, p. 145-157. (online at: https://www.sciencedirect.com/science/article/pii/S1871174X1730029X) (Well XK-1 in Xisha (= Paracel) Islands, NW part of S China Sea, penetrated Miocene reef carbonate section with 66 species of larger foraminifera. Three assemblages: (1) 1256-1180m Spirolypeus higginsi- Borelis pygmaeus (Te5, E Miocene); (2) 1031-577m Nephrolepidina- Miogyspina Assemblage (Tf, M Miocene), and 468-380m Cycloclypeus- Heterostegina Assemblage (Tg, Late Miocene). Facies backreef lagoon-shelf in E Miocene, normal-frontal reef in early M Miocene, backreef lagoon-shelf in later M Miocene, normal- frontal reef in early Late Miocene, and proximal forereef shelf in later Late Miocene)

Mai, H.A., Y.L. Chan, M.W. Yeh & T.Y. Lee (2017)- Tectonic implications of Mesozoic magmatism to initiation of Cenozoic basin development within the passive South China Sea margin. Int. J. Earth Sciences 107, 3, p. 1153-1174. (S China Sea classic example of non-volcanic passive margin, situated within three tectonic plates. Reconstruction indicated SE margin of Asia had gone through two crustal thinning events (NW–SE extension in Late Cretaceous and Paleogene). Sites for rifting development controlled by localized thermal weakening of magmatism. Interaction of two continental stretching events by Pacific followed by Neotethys subduction with local magmatic thermal weakening is cause for non-volcanic nature of SCS)


(Previous discoveries in Song Hong Basin off N Vietnam, marginal-subcommercial, and mainly in Miocene inversion clastics or fractured/karstified Pretertiary carbonate basement plays. Recent discoveries: (1) Ham Rong Dong gas-condensate in Oligocene clastics overlying basement high; (2) Ky Lan gas in E-M Miocene sands in 4-way-dip closure. Recent E well on V Island with ~500m Oligocene lacustrine source rock with TOC up to 9% and mainly Type I and II kerogen)

Nguyen Quang Tuan & Tran Van Tri (2016)- Seismic interpretation of the Nam Con Son Basin and its implication for the tectonic evolution. Indonesian J. Geoscience 3, 2, p. 127-137

(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/312/210)

(Nam Con Son Basin off Vietnam two extensional phases: (1) N-S extension, terminated at ~30 Ma, forming E-W trending grabens/half grabens with up to 5km of Eocene?- E Oligocene sediments; (2) graben reactivation during M Miocene NW-SE extension. Most faults inactive by U Miocene except N-S fault system active until recent. U Miocene -Recent post rift sequence associated with onshore uplift, causing increase in sediment supply to basin)


(online at: https://www.ripublication.com/ijaer17/ijaerv12n22_148.pdf)

(Numerous paleokarst features seen on offshore 3D seismic in M Miocene carbonate platform on Tri Ton high, S Song Hong Basin, Vietnam. Paleokarst networks beneath unconformity shows erosional topography, sinkholes, rivers/canyons and hills, revealing mature surface drainage system)


(online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2015GC006113)

(Zircon U-Pb geochronology of syn-rift sequences in northern S China Sea suggests significant intrabasinal provenances in addition to terrigenous supply from China margin in N. Dongsha Uplift considered to account for dominance of E Cretaceous zircons in Eocene samples. Episodic nature of rifting and erosion processes in early S China Sea cause of complex patterns in Paleogene provenance history)


(Zircon U-Pb geochronology and heavy mineral analysis of Cretaceous and Eocene from northern S China Sea and Palawan continental terrane show similarities of Upper Cretaceous and Eocene, exclude possibility of latest Cretaceous drift of Palawan continental terrane in response to Proto-S China Sea opening. Zircon age signatures suggesting conjugate relationship between Palawan terrane and eastern Pearl River Mouth Basin and remained attached to S China margin until Oligocene oceanization of S China Sea)


(Littoral M-L Eocene sandstone sequence in IODP Hole U1435A mainly composed of subangular quartz (70-80%) and K feldspar (10-15%), indicating proximal provenance of felsic rocks. Detrital zircon ages mainly
Mesozoic (E Cretaceous peak at ~110 Ma, derived from China active continental margin arc). Some grains with ages between ~ 65-38 Ma, indicating M-L Eocene deposition before opening of S China Sea)

(online at: https://d-nb.info/972182144/34)
(Holocene deposits on Vietnamese shelf of S China Sea since last deglacial sea level rise. Sediments from 2 major rivers (Red River, Mekong; mainly deposited in deltas) and numerous small mountainous rivers)

(Shallow high-resolution seismic and sediment cores on Vietnam Shelf analyzed to unravel post-glacial evolution. Southern Shelf sedimentation with abundant incised valley fills, cut into late Pleistocene land surface by Paleo-Mekong River during sea level lowstands and filled with transgressive deposits. Central Shelf narrow and conformable strata. Northern Shelf with paleo-Red River channels incised valleys)

(1.4 Ma paleoceanography history of offshore north-central Spratly islands, southern S China Sea)

(Most igneous emplacements in S China Sea margins after end of seafloor spreading, rare during rifting and spreading phases, supporting magma-poor margins before breakup of continental lithosphere. Post-spreading magmatic activities widespread in continental slope areas and central SCS, likely triggered by extension in relation to cooling and subsidence of oceanic and attenuated continental lithosphere. Possible total thermal contractual displacement up to 24 km)

(online at: http://english.gyig.cas.cn/pu/papers_CJG/201608/P020160809552862768935.pdf)
(Multiple models proposed for origin of S China Sea. Preferred model involves two-stage backarc extension, induced by N-ward subduction of Neotethys Plate, with normal subduction followed by ridge subduction/ flat subduction. First backarc extension responsible for formation of proto-SCS, second extension responsible for the Shenhu event and ultimately formation of SCS)

(online at: http://users.clas.ufl.edu/krigbaum/6930/Sun_etal_MarineGeology_1999.pdf)
(Distribution of pollen in surface sediments of S China Sea in 28 samples from water depths of 329-4307m)

(online at: www.scichina.com:8080/kxtbe/fileup/PDF/03ky2155.pdf)
(Study of pollen distributions in deep sea sediments of S China Sea and E China Sea (mainly Quaternary). Spectral analyses show Milankovich cyclicities in vegetation of surrounding land areas. Changes of herbs and pine pollen percentages in phase with d18O record. Not much detail)

(High-resolution pollen record from northern S China Sea ODP Site 1144, covers last 1.03 My. High, varying proportions of Pinus and herb pollen, forming base of 29 pollen zones that are closely correlated to Oxygen Isotope Stages (MIS) 1-29. Pinus dominant pollen zones correspond to interglacial periods, herb peaks relate to heavier N18O stages assigned to glacials. Exposed N continental shelf covered by grassland during glacials.
Relatively high fern percentage with smaller amplitude in variations before 600 ka may suggest more stable humid conditions before intensification of winter monsoon. Microtektites at 386.44m, part of Australasian strewnfield, close to Brunhes/Matuyama boundary (780 ka). Milankovich cyclicity


Tran Tuan Dung, Bui Cong Que & Nguyen Hong Phuong (2013)- Cenozoic basement structure of the South China Sea and adjacent areas by modeling and interpreting gravity data. Russian J. Pacific Geology 7, 4, p. 227-236.


Wang, L., M. Sarnthein, H. Erlenkeuser, J. Grimalt, P. Grootes, S. Heilig, E. Ivanova, M. Kienast, C. Pelejero & U. Pflaumann (1999)- East Asian monsoon climate during the Late Pleistocene: high-resolution sediment records from the South China Sea. Marine Geol. 156, p. 245-284. (Sediment cores from S China Sea (SCS) with proxy records of past changes in East Asian monsoon climate on millennial to bidecadal time scales over last 220,000 years. Two different regimes of monsoon circulation in SCS over last two glacial cycles: (1) glacial stages with stable estuarine circulation and strong O2-minimum layer via closure of Borneo sea strait; cool surface water during winter; large river input from emerged Sunda shelf; (2) Interglacials with strong inflow of warm water via Borneo sea strait, intense upwelling SE of Vietnam and continental wetness in China during summer; low seasonality)

Wang, P.X., Q.Y. Li, J. Tian, Z.M. Jian, C.L. Liu, Li Li & W.T. Ma (2014)- Long-term cycles in the carbon reservoir of the Quaternary ocean: a perspective from the South China Sea. Natl. Science Review (China) 1, 1, p. 119-143. (In last million-year two major changes in climate regime: mid-Pleistocene transition, centered at 0.9 Ma and the mid-Brunhes event at ~0.4 Ma)


(Widespread and thick Cenozoic carbonate sequences along margins of S China Sea. Platforms developed during rifting and initiated on fault blocks of conjugate rift margins. Most carbonate platforms drowned after Miocene. Malampaya Carbonate >600m thick, developed on Oligocene rifted horst block. Subsidence, tectonic tilting, faulting, and foreland bulge controlled drowned carbonate platforms. The tectonic evolution and relative sea-level fluctuations controlled depositional cycles of carbonate platforms. Carbonate platforms flourished in M Miocene due to stable tectonic conditions and shrunk during Late Miocene due to rapid subsidence. Relative sea level exerted 2nd-order control on evolutionary trend of carbonate platforms and third-order control on evolutionary periods in each stage)


(Halimeda one of the major reef-building algae in M Miocene of Xisha, making good oil- gas reservoirs)


(Daimao Seamount (16.6 Ma) formed 10 My after cessation of 17°N spreading center. Basaltic breccia clasts in volcanioclastic suggest Daimao and other SCS seamounts typical ocean island basalt composition and ‘Dupal’ isotopic signature. Daimao Seamount formed through submarine explosive basaltic volcanism at 16.6 Ma. Seamount subsided rapidly, with deposition of shallow-water, coral-bearing carbonates around summit)


(K-Ar ages of basalts from S China Sea basin 3.8- 7.9 Ma, suggesting intra-plate volcanism after cessation of spreading of S China Sea, comparable regions around SCS. Belong to alkali basalt series, similar to OIB-type basalt. Also geochemical constraints on Hainan mantle plume)


(online at: www.hxxb.org.cn/aosen/ch/...)

(Geochemical study of Kon Tum plateau, Sanshui basin and Daimao seamount volcanic rocks. Basaltic lavas indicate not a deep-rooted plume origin, but shallow mantle domain)


(Offshore Tertiary basins along broad shelf from Taiwan to Hainan Island with similar characteristics. Paleogene basins mainly NE-SW trending half-grabens and fault blocks)


(online at: https://www.sciencedirect.com/science/article/pii/S1674987116000050)

(Model for Oligo-Miocene spreading in S China Sea basin. NW-SE expansion of SW subbasin later than N-S expansion of central basin; both expansions end at same time. Expansion of SW sub-basin similar to Japan Sea, likely caused by left-lateral strike slip on central fault zone in S China Sea)

(Two tectonic cycles of marginal sea basins in S China Sea: Palaeo-SCS and Neo-SCS. N part of SCS is rifted continental margin; Nansha Block is drifting rift basin. S part compound compressional basin on active margin; W part is shear-extensional basin on transform continental margin; E part is accretionary wedge at subduction continental margin. Deep-water basins mainly on continental slope and Nansha Block. Three sets of source rocks in N continental margin: Eocene terrestrial facies, E Oligocene transitional and late Oligocene marine facies. Main hydrocarbon reservoir types related to structural traps, deep water fans and reefs)

(ODP Site 1144 in northern S China Sea with >969 microtektites and 1543 fragments in 10 cm interval (386.17-386.27 md). All microtektites entirely glassy, mostly spherical and oval in shape and with many bubbles. Composition within the range of Australasian tektites. Source crater probably further to NE and more closer to South China than previously predicted. Size of the crater estimated 50-140 km)

(ODP Site 1144 in northern C China Sea with many microtektites at depths 386.17-386.27 md. Shapes mostly spherical and oval, but also teardrops, saddles, buns, dumbbells, disk shapes and fragments. Major elements geochem suggest Australasian microtektites. Parent material may include clastic sediments)


(South China Sea 3 tectonic stages: (1) development of Proto-SCS, (2) subduction of Proto-SCS and (3) development of Neo-SCS (rapid subsidence followed by shrinking). Southern and Northern Tertiary basins belts in southern continental margin (N Borneo). Main source rocks in S basin belt Miocene coal, nearshore marine (oil) and offshore (gas). In N basin belt, source rocks Eocene -Oligocene, gas-prone, highly mature, with reefs and faulted blocks as main traps)

(Gas hydrates usually buried in sediments, but found exposed on seafloor of S China Sea at water depth of 1130m. Likely cold seep of thermogenic hydrocarbons)

(Eustatic sea level curve since Pliocene (5.3 Ma) derived from high-res seismic data from N Sunda Shelf/ South China Sea (SCS). 36 fourth order sea level cycles recognized with periods ranging from 0.08- 0.29 My)


Oceanic plagiogranite dredged from Penglai Seamount on 17°N fossil spreading center of East Sub-basin of SCS near Manila Trench. 40Ar/39Ar ages of 32.3 ± 0.5 Ma and 28.9 ± 1.9 Ma. Trace elements and isotopic composition similar to mid-oceanic ridge basalts. New geochronology demonstrates that initial opening of South China Sea occurred before 32 Ma (E Oligocene))
IX.8. The Philippines (General, Palawan, Luzon) (84)


(Acoje massif (northernmost massif of Zambales Ophiolite Complex) relatively intact fragments of Mesozoic oceanic lithosphere)


(Isotopically anomalous CH4-rich gas escapes at low rate from seeps in serpentinized ultramafic rock in Zambales Ophiolite, W Luzon. Gas mainly methane/CH4 and H2 (55 and 42%). d13C-value of CH4 is -7.0 ‰, ~8 ‰ higher than highest published values for CH4 in other natural gases, but similar to values attributed to mantle carbon. Carbon and He isotopic data consistent with derivation directly from reduced mantle, but could also have been produced during low-T serpentinization of ophiolite)


(Methane-hydrogen gas seeps with mantle-like C and noble gas isotopes seep from partially serpentinized ultramafic rocks in Zambales ophiolite, Philippines. Gases products of periodotite hydration)


(Peridotite xenoliths from subarc mantle at Iraya volcano of Batan, Luzon arc mainly hartzburgites. F-type peridotite characteristic of upper mantle of island arc, especially incipient arc)


(online at: https://academic.oup.com/petrology/article/45/2/369/1522080/Petrology-of-Peridotite-Xenoliths-from-Iraya)

(Two types of peridotite xenoliths in calc-alkaline andesites from Iraya volcano, NE Batan: C-type (coarse) and F-type (fine; with transitional types). C-type hartzburgites similar to arc-type hartzburgite and may be from subarc lithospheric mantle, strained and deformed during oblique subduction of S China Sea Plate)


(Abstract only)

(online at: http://igcp589.cags.ac.cn/4th%20Symposium/Abstract%20volume.pdf)

(Samar Ophiolitic Complex, exposed in eastern C Philippines, and part of Jurassic- Cretaceous ophiolitic belt that serves as basement to most E Philippines islands. Paleomagnetic studies on upper crust of ophiolite suggests paleolatitude of -14°± 6°. This, and results from E Indonesia evidence that ophiolites preserved along W and S margins of Philippine Sea Plate are remnants of Mesozoic oceanic basin E of eastern Neo-Tethys and W of Panthalassa. Cretaceous and Cenozoic intra-oceanic arcs associated with this basin part of the Amami-Daito region, E Philippines, E Indonesia and N New Guinea, and were separated by Eocene opening of PSP)


(Basement complex of Bohol Island consists of SE Bohol Ophiolite Complex, Cansiwang Melange and Alicia Schist. SEBOC is complete, but dismembered ophiolite with outcrops generally trending NE-SW and dipping NW. SEBOC thrusted onto Cansiwang Melange, which is thrust over Alicia Schist. Orientation of Bouguer highs suggests thrusting direction of ophiolite units was to SW, not to SE)
(Philippines hosts world's largest deposits of tektites. Part of Indo-Malaysianite great shower in mid-Pleistocene time. Largest known tektites in SE Luzon (Bikol Peninsula) up to 1070g and >4 inches in diameter, but average weight for region only 15-20 g)

('Coal mining in The Philippines')

(online at: https://eprints.utas.edu.au/18070/1/Whole-Braxton-thesis.pdf)
(Recently discovered Boyongan and Bayugo porphyry copper-gold deposits part of emerging belt of M Pliocene intrusion-centered gold-rich deposits. Formed in association with composite diorite complex; U-Pb zircon ages from ~2.3-2.1 Ma)

(Late Pliocene-age Boyongan and Bayugo porphyry copper-gold deposits intrusion-centered gold-rich deposits in NE Mindanao. Exhumation and weathering led to porphyry oxidation profile of 600m at Boyongan and 30-70m at adjacent Bayugo. Etc.)

(Boyongan and Bayugo porphyry Cu-Au mineral deposits part of emerging belt of Au-rich Cu mineral deposits in NE Mindanao. Formation. Mineral deposits formed in E Pleistocene, in association with diorite complex containing at least 12 discrete intrusive stages. Repeated cycles transpired rapidly, between 2.3-2.1 Ma)

(Black Mountain porphyry Cu-Au deposit in Baguio district, N Luzon, associated with Late Miocene- Pliocene intrusive rocks. Amphibole in felsic rocks aged ~6.4-2.8 Ma suggest long-lived and hot felsic magma chamber. Large-scale mafic magma recharge (particularly at ~2.8 Ma), likely introduced ore-forming metals to felsic magma chamber, contributing to Cu-Au mineralization)

(Chromitite pods and lenses in Ulugan Bay area occur as concordant and discordant bodies with respect to metamorphic banding in peridotite)


Dancer, N. (2003)- Reservoir characterisation of the Malampaya Field, a carbonate reefal build-up in the Philippines. Proc. 2003 SE Asia Petrol. Expl. Soc.(SEAPEX) Exploration Conf., Singapore, p. 1-36. (Abstract+ Presentation) (Malampaya Field Oligo-Miocene carbonate reservoir with high porosity and large variation in permeability at depth of ~3000m TVDSS. Gas column 650m, oil rim 56m (API 29.4°). In-place reserves ~4.1 TCF gas and 300 MMBO. Porosity affected by diagenesis: (1) early cementation of flanks decreased porosity, meteoric leaching of lagoon increased porosity; (2) late stage burial decreased porosity with cementation along faults, porosity increased by late leaching by mixing of burial fluids and pore waters)


Dimalanta, C.B., D.V. Faustino-Eslava, J.T. Padrones, K.L. Queano, R.A.B. Concepcion & S. Suzuki (2018)- Cathaysian slivers in the Philippine island arc: geochronologic and geochemical evidence from sedimentary formations of the west Central Philippines. Australian J. Earth Sciences 65, 1, p. 93-108. (Clastic units from W Central Philippines (Mindoro, Panay and Palawan) likely from sources of Cathaysian origin. U-Pb dating peaks at 185-140 Ma, 140-120 Ma and 112-90 Ma, chronicling Yanshanian magmatic events. Same formations also older intercept at 1.9-1.85 Ga, likely corresponding to orogenic episode in late Paleoproterozoic Cathaysian block. Also rel. strong continental chemical signature)


Durkee, E.F. (2001)- With Malampaya producing, here are other Philippines exploration targets. Oil and Gas J. 99, 47, p. 46-50. (Shell-operated Malampaya producing gas since September 2001. Two important areas for gas exploration Reed Bank and S Tanon Strait. Other possible areas Crescent, Santa Monica, N Coron, Amity, Cherry and Hippo. Possibility of oil leg under gas accumulation at Malampaya)

(Tomography of high-velocity subducted slab of S China Sea beneath Manila Trench. Angle of slab varies along trench: at ~16° N slab dips at 24° ~ 32° for 20-250 km depth. A ~17.5° slabs near vertical from 70-700 km depth, at 20° N from horizontal abruptly to near vertical to 500 km depth. Steepening may indicate slab tear, coincident with axis of fossil ridge in SCS slab at ~17° N. Low-velocity zones above 300 km may represent the formation of slab window. Slab tear could explain volcanic gap and geochemical difference between Miocene and Quaternary volcanoes in Luzon Arc, and distribution of adakites and related porphyry Cu-Au deposits in Luzon area. Initial time of ridge subduction possibly started at ~8 Ma)


(Tomographic data show subducted S China Sea slab under S segment of Manila Trench steepens and tears, resulting in migration of active volcanism in Macolod Corridor, due to between Palawan block- Philippine Mobile Belt collision. Subduction of Philippine Sea Plate along Philippine Trench started at 10-12°N or S of 12°N from at least ~10 Ma. High-velocity anomaly near mantle transition zone interpreted as subducted Proto S China Sea slab, sinking deeper SE-ward, suggesting Palawan block collision younging from S to N)


(Cretaceous outcrops in Catanduanes Island, E Philippines with two distinct nanofossil assemblages: UC10-UC12 zones (Coniacian-Santonian) and Campanian-Maastrichtian. Previously unmapped black mudstone in N Catanduanes UC5c subzone (Cenomanian-Turonian boundary; possibly oceanic anoxic event 2 (OAE2))


(Shallow marine, mollusk-bearing clastics in Danao basin of C Bohol with Discoaster quinqueramus and D. berggrenii, suggestive of NN11, Late Miocene. Cooler oceanographic conditions suggested for LateMiocene in Visayan Basin)


(Pliocene calcareous nanofossils from Indahag Lst (NN15-NN17), N Mindanao)


(K-feldspar from Late Miocene Capoas Granite on NW Palawan with retentive diffusion domains that are closed to argon diffusion at near-solidus temperatures during cooling. High closure T from Capoas Granite K-feldspar consistent with coincidence of 40Ar/39Ar ages with U-Pb zircon ages at ~13.5 ± 0.2 Ma. Cooling rate then accelerated, but slowed by ~12 Ma, then once again accelerated at ~11 Ma)


Bibliography of Indonesia Geology, New for Ed. 7. 334


(On initiation of subduction zones at spreading centers. In W Philippines oceanic crust was less than ~1 My old when it was underthrust and metamorphosed at onset of young, short-lived subduction in Palawan. Differences between ages of upper plate (Palawan ophiolite; 35.2 Ma), subducting plate (protoliths of oceanic? sole.), and metamorphism (~34.2 Ma) of sole less than ~1 My. Young and positively buoyant, but weak, lithosphere was preferred site for subduction nucleation)


(Metamorphic complexes exposed in NE part of Palawan Continental Terrane considered to be rifted parts of Asian margin. Mindoro and Romblon Metamorphics with protoliths of variable age: Late Carboniferous-Late Permian in NE Mindoro; Eocene or younger in NW Mindoro; Miocene at S margin of Mindoro metamorphics (detrital zircon ages 22-56 Ma); and Cretaceous or later on Tablas (zircons as young as 112 Ma). Presence of non-metamorphic sediments of Late Eocene- E Oligocene age in Mindoro (Lasala Fm) suggests metamorphism of sediments of Mindoro result of Palawan terrane collision in Late Miocene (similarities in age spectra of zircons from Eocene-Miocene metamorphics with Eocene - E Miocene Lasala Fm))


(Philippine Sea Plate overrides Eurasian Plate along E-dipping Manila Trench between Taiwan and Luzon islands. From S to N plate convergence gradually evolves from normal subduction of S China Sea lithosphere to initial collision of Taiwan orogen. Accretionary prism dramatically wider toward Taiwan. Subducting crust in the N Manila Trench area three zones: normal fault zone (where crust starts to bend and induces gravity sliding of upper sedimentary layers), proto-thrust zone and thrust zone (with blind thrust faults along location of pre-existing normal faults)


(online at: https://d28rz98at9fks.cloudfront.net/14753/Rec1994_041.pdf)


(Bulawan Au-Ag-Te deposit in porphyry copper belt of SW Negros Island, hosted in Miocene dacitic hydrothermal breccia pipes


(Three Carlin type-like gold deposits on NE Mindanao in jasperoid lenses in marl of M Miocene Mabuhay Fm)


(online at: https://www.jstage.jst.go.jp/article/jgeography1889/116/5/116_5_643/_pdf)

Manalo, P., C. Dimalanta, N. Ramos, D. Faustino-Esla, K. Queano & G. Yumul (2016)- Magnetic signatures and Curie surface trend across an arc-continent collision zone: an example from Central Philippines. Surveys in Geophysics 37, 3. p. 557-578. (In C Philippines striking differences between magnetic signatures of islands with continental affinity (negative magnetic anomalies) and island arc terranes (positive anomalies over Philippine Mobile Belt). Linear features in magnetic anomaly map coincide with Philippine Fault and its splays. Deepest point of magnetic crust is under Mindoro at 32 km. Curie surface shallows to E and is 21 km deep between Sibuyan and Masbate, and 18 km deep at junction of Buruang Peninsula and Panay Island (boundary of the arc-continent collision, with obduction of mantle rocks over continental basement. Coincidence of magnetic boundary and density boundary supports compositional boundary that reflects the crust- mantle interface)


(Cenozoic sediments of S Samar Island in E Philippines record unroofing history of ancient arc terrane. Late Oligocene- E Miocene Daram Fm common chert and volcanic fragments, late M Miocene- E Pliocene Catbalogan Fm mainly composed of ultramafic components. Daram Fm eroded crustal portions of ophiolite, Catbalogan Fm represents later exhumation and erosion of ultramafic section. Oceanic island arc setting proposed for both formations)


(Two geochemically similar plutons investigated for potential for placer-type LREE deposits on Palawan Block in Philippines: M Miocene Kapoas pluton (13.2 Ma) and Late Cretaceous Daroctan Granite (= Late Yanshanian of SE China))


(Late Cretaceous Daroctan Granite intruded Mesozoic melange in N-most Palawan Island. Monazite U-Th-Pb dating yielded Late Cretaceous age, similar to some Mesozoic granites surrounding S China Sea. Maximum ages of sediments and semi-schist Jurassic-E Cretaceous, with Late Cretaceous maximum age of deposition for meta-sediments. Palawan block accreted units possibly located at margin of continent-ocean collision in Mesozoic and eventually broke off from SE Eurasian margin)


(online at: https://www.solid-earth.net/9/713/2018/se-9-713-2018.pdf)

(Boninites are high-magnesium andesites that are key component of subduction-initiation suites, and is predominant in W Pacific forearc terranes. New discovery of boninite in Acoje Block of M Eocene (~44 Ma) Zambales ophiolite of W Luzon. Paleolatitudes place juvenile arc of N Zambales ophiolite in W margin of Philippine Sea plate, possibly in doubly vergent subduction initiation setting)


(Dos Hermanos melange in NW Ilocos Norte, NW Luzon, with peridotites and metamorphic rocks blocks in sheared sandy matrix. Thrust onto the Eocene Bangui Fm turbidite succession and capped by U Miocene Pasuquin Limestone. With uppermost Jurassic- Lower Cretaceous radiolarian assemblages in deep marine bedded chert blocks (incl. many 'Tan Sin Hok species'. Tectonic melanges in C Philippines attributed E-M Miocene arc-continent collision involving Philippine Mobile Belt and Palawan Microcontinental Block)


(Adakites are unusual felsic igneous rocks commonly associated with asthenospheric slab window opening or fast subduction of young (<25 Ma) oceanic plate that may allow slab melting at shallow depths (in forearc settings). Incl. examples from Philippines)


(Sandstone compositions of Philippine Mobile Belt suggest it formed in Eocene as primitive basaltic volcanic arc and developed to basaltic-andesitic arc in Oligocene-Pliocene time. Sandstones from U Cretaceous in Palawan Continental Block rich in quartz and felsic volcanic rock fragments, suggesting PCB was part of continent and supports idea that PCB collided with PMB to form Philippine Archipelago)

(Co-O epithermal gold deposit located along Pliocene-Quaternary calc-alkaline magmatic zone at E Mindanao. Intermediate sulfidation epithermal Au quartz vein type, hosted in Eocene- Oligocene island arc basaltic-andesitic volcanics and volcaniclastic rocks. K/Ar ages of hydrothermal minerals ~28.6 Ma (Late Oligocene) and ~31.7 Ma (E Oligocene))

(Calcareous nanofossils from Balanga Fm calcareous sedimentary sequence in Mamburao, NW Mindoro (Palawan Block). Late Pliocene- E Pleistocene age (NN14- NN19: 1~1.7- 4.1 Ma), formed after E-M Miocene collision of Palawan-Mindoro Block with Philippine Mobile Belt)

(Cretaceous calcareous nanofossils from limestone units of Codon Fm in Codon Point, SW Catanduanes. Occurrence of M. prinsii suggests Late Maastrichtian age (in N Catanduanes also Yop Fm with mid-Cretaceous Orbitolina))

(Catbalogan Fm clastics in N Samar late E Miocene- early Late Miocene calcareous nanofossils (NN4- NN9))

(Intermediate-low sulfidation epithermal gold deposit in Masara, E Mindanao, associated with diorite porphyry of Late Miocene Lamingag Intrusive Complex. Five major alteration zones, at least two mineralizing events)


(Silicic volcanic deposits relatively abundant in Macolod Corridor, SW Luzon. Possibly from partial melting of mantle-derived, moderate to K-rich calc-alkaline magmas that ponded and crystalized in mid-crust)


(Palawan-Mindoro Block drifted from mainland Asia with spreading of S China Sea. U-Pb age and Hf isotopic data on detrital zircon grains from Eocene-Miocene sediments in Palawan-Mindoro Block show four major age groups (80-120, 160-180, 1600-2100 and 2200-2700 Ma). Eocene samples from Palawan-Mindoro similar to Taiwan, suggesting P-M Block still attached to South China margin in Eocene. Difference of zircons in Miocene samples reflects S-ward drifting of Palawan-Mindoro Block at or before that time)


(online at: http://www.kahaku.go.jp/research/publication/memoir/download/48/4811.pdf)

(Palawan microcontinental block in Philippines separated from SW coast of Asian continent during opening of S China Sea in Oligocene-Miocene times. Jurassic- E Cretaceous sandstones from Palawan block (Busuanga, Mindoro, Panay islands) with bimodal age distribution of detrital monazites: 140-260 Ma and 1800-2000 Ma. Pattern unlike SE China Sea or Indochina Peninsula, but similar to Korean Peninsula and in Zhejiang Province in E China. Jurassic- E Cretaceous sandstones of Palawan area deposited on E side of present-day Taiwan?)


(Philippines ophiolites range from complete oceanic crust-mantle sequences (Tethyan type) to incomplete dismembered ones (Cordilleran type). Majority subduction-related. With viable chromitite, volcanic/ultramafic-hosted massive nickel-copper sulfide and platinum-group mineral deposits. Subduction-related ophiolitic sequences better exploration targets for metallic mineral deposits than mid-ocean ridge ophiolites)

(San Antonio part of Zambales Ophiolite complex with arc-like geochemistry)

(online at: http://igcp589.cags.ac.cn/2nd%20Symposium/Abstract%20volume.pdf) 
(N Palawan Block 4 episodes: (1) Permian- Jurassic oceanic plate travel, with deposition of chert and clastics; (2) M-Jurassic- E Cretaceous accretion of chert-clastic sequences at E Asian continental margin during Paleo-Pacific subduction; (3) M Oligocene- E Miocene opening of S China Sea, resulting in S-ward movement of N Palawan Block; (4) M Miocene collision between N Palawan Block and Philippine Island Arc)


(Manila subduction system three segments: (1) N Luzon, (2) seamount chain segment and (3) Luzon segment)
IX.9. South Philippines (Celebes Sea, Sulu Sea, Sandakan) (5)


(Several methane seeps along flanks of two S Mindanao submarine ridges (Sangihe and Talaud East-Mindanao), at 2000-3000 meter depth. Isotopic ratio of added δ3He indicates input of hydrothermal fluids, both mantle and crustal/ sedimentary components. Methane anomalies partially associated with 3He excess, comparable to observed in spreading axis hydrothermal fields. Also major methane anomaly few 10's of km from Sangihe Ridge with no 3He enrichment, that could originate largely from shallow sedimentary layers)


(Sandakan sub-basin in Sulu Sea off NE Sabah relatively under-explored. Paleogeography of Sandakan sub-basin evolved from active fluvio-deltaic progradation setting in late E Miocene- early Late Miocene to shelfal marine deposition in Pliocene)


(Planktonic δ18O from sediment core MD97-2141 in Sulu Sea reveals that for past 400 kyr, δ18O variability on orbital timescales similar to that caused by changes in ice volume alone)


(Australiasian microtektite peak layers in Sulu Sea ODP Holes 767B (49.63 mbsf) and 769A (61.31 mbsf))


(Sandakan Basin off NE Sabah mainly in Philippine waters. Under-explored Tertiary sag basin with up to 6 km of Miocene -Pliocene deltaic and deepwater sediments. Previous exploration in basin focused on shallow water deltaic and carbonate plays; failure attributed to seal failure due to high sand content and cross fault leakage)
IX.10. SW Pacific (incl. New Caledonia, Solomon Islands) (63)

Adachi, Y., H. Inokuchi, Y. Ototuji, N. Isezaki & K. Yaskawa (1987)- Rotation of the Philippine Sea Plate inferred from paleomagnetism of the Palau and Yap islands. Rock magnetism and paleogeophysics 14, p. 72-74. (online at: http://peach.center.ous.ac.jp/rprep/Rock%20Magnetism%20and%20Paleogeophysics%20vol14%201987.pdf) (Paleomag work on 16 sites in Palau Islands on S end of Kyushu-Palau Ridge suggest ~60°CW rotation, similar to results from other parts of W Philippine Sea)


Cathelineau, M., B. Quesnel, P. Gautier, P. Boulvais, C. Couteau & M. Drouillet (2016)- Nickel dispersion and enrichment at the bottom of the regolith: formation of pimelite target-like ores in rock block joints (Koniambo Ni deposit, New Caledonia). Mineralium Deposita 51, 2, p. 271-282. (In New Caledonia richest Ni silicate ores occur in fractures within bedrock and saprolite, generally several 10’s- 100m below present-day surface)

Coleman, P.J. (1970)- Geology of the Solomon and New Hebrides Islands as parts of the Melanesian re-entrant, Southwest Pacific. Pacific Science 24, p. 284-314. (Solomon Islands and New Hebrides Archipelago examples of fractured island arcs. Both are crustal blocks, 20-30 km thick, and isolated from neighboring blocks. Their generalized stratigraphic columns remarkably similar and complete. Deep fracturing is dominant structural style, with differential uplifts of up to 6000m)

Coleman, R.G. (1971)- Plate tectonic emplacement of upper mantle peridotites along continental edges. J. Geophysical Research 76, 5, p. 1212-1222. (Large oceanic-mantle crustal slabs thrust over or into continental edges contemporaneously with blueschist metamorphism in New Caledonia and New Guinea. ‘Obduction’ zones lack volcanic activity, and may result from initial stage of compressional impact between oceanic and continental lithospheric plate. Serpentinites represent alteration developed during tectonic emplacement into wet sediments of continental plate, which produces less dense and plastic envelope that facilitates further tectonic movement)


Collot, J., M. Patriar, S. Etienne, P. Rouillard, F. Soetaert, C. Juan, B. Marcaillou et al. (2017)- Deepwater fold-and-thrust belt along New Caledonia's western margin: relation to post-obduction vertical motions. Tectonics 36, 10, p. 2108-2122. (W margin of New Caledonia with 200 km long deepwater fold-and-thrust belt interpreted as gravity-driven system, after oversteepening of margin slope by post-obduction isostatic rebound. the margin. Thrust faults deeply rooted along low-angle floor thrust and connected to New Caledonia Island along major detachment)

(Ontong Java Plateau formed around 120 Ma. Region of fast shear wave speeds (>4.75 km/s) down to >100 km beneath plateau. Wave speeds similar to cratonic environments and consistent with compositional anomaly that resulted from residuum of eclogite entrainment during plateau formation. Surfacing plume head entrained eclogite from deep mantle and accounts for anomalous buoyancy of plateau and fast wave speeds)


(The genesis and evolution of the nickel deposits of New Caledonia)


(online at: https://academic.oup.com/petrology/article/49/4/697/1467522/Boninites-and-Adakites-from-the-Northern)

(Adakitic rocks dredged from N termination of Tonga Trench. Zircon ages 2.5 Ma, contemporaneous with boninite magmatism in area. High-SiO2 adakites in area where transition from steep Pacific subduction to transform fault plate boundary created slab window/slab edge. Adakites result from direct melting of slab edge as result of juxtaposition of subducting slab against hot mantle derived from Samoan plume)


(online at: www-odp.tamu.edu/publications/192_SR/VOLUME/SYNTH/SYNTH.PDF)

(Mid-Cretaceous Ontong Java Plateau is most voluminous of world's large igneous provinces and represents by far largest known magmatic event on Earth (comparable in size to W Europe). Formed rapidly around 120 Ma (122- >112 Ma). Collision with old Solomon arc resulted in uplift of OJP S margin to create onland exposures of basaltic basement in Solomon Islands (Malaita, Santa Isabel, San Cristobal). Biostratigraphic dating of pelagic sediment intercalated with lava flows suggests magmatism on high plateau extended from ~122–112 Ma, but ReOs isotopic data on basalts from same sites single isochron age of 121.5 ± 1.7 Ma)


(online at: https://openresearch-repository.anu.edu.au/...)

(Collection of 1957-1958 survey reports)


(Assessment of Eocene-Oligocene to late Miocene-Pleistocene porphyry copper in Outer Melanesian magmatic arc in Solomon Islands, Vanuatu, and Fiji. Originally part of Eocene- E-M Miocene 'Vitiaz Arc, formed by subduction of Pacific Plate beneath Indo-Australian Plate along Vitiaz-Tonga Trench system until subduction reversal due to E-M Miocene collision of Ontong Java Plateau (incl. included New Ireland, Bougainville, Solomon Islands, Vanuatu, Fiji). Three known Miocene porphyry copper deposits: Mt Koloula (Guadalcanal in Solomon Islands), Namosi and Waivaki (Viti Levu, Fiji) (Outer Melanesian in PNG with Panguna deposit on Bougainville and Arie deposit on Manus. Many other prospects))


(Ar/Ar age and geochemical data show Hikurangi Plateau basement lavas (118-96 Ma) similar to Ontong Java Plateau (~120 and 90 Ma; primarily Kwaimbaita-type composition). Manihiki Plateau Site 317 lavas (117 Ma) similar to Singgalo lavas on Ontong Java Plateau. Alkalic seamount lavas (99-87 Ma and 67 Ma) on Hikurangi Plateau and adjacent Kire Seamount derived from different mantle source (see also Timm et al. 2011)


(Large plumes of methane-enriched water in Mariana Trough back-arc basin and also in summit crater of Laihi Seamount (present site of Hawaiian hotspot). Mariana vents enriched in methane without corresponding enrichment in 3He)


(In New Caledonia high-pressure schists pyrite, pyrrhotite, chalcopyrite, rutile and sphene are common)


(On creation and subsidence of mid-Cretaceous Ontong Java, Manihiki, and Shatsky oceanic plateaus)


(Australian plate underthrusts Pacific plate to the ENE under Solomon and New Hebrides islands and overthrusts Pacific to E along Tonga-Kermadec arc and New Zealand North Island. Also NNE-SSW convergence of Pacific and Australian plates in NW New Guinea. Plate motions near Bismarck Archipelago complex because of presence of at least three additional small plates. Solomon Sea plate moving ~NW with respect to Australian plate and underthrusting Pacific plate to NE along Solomon arc)


(New-Caledonia island with ultramafic nappe thrust over continental and arc-derived basement as result of the closure of back-arc basin in Late Cenozoic. W and E edges of island are delineated by N140 trending normal faults. Onland main boundary of ultramafic nappe, also trend N140, all reflecting faults that accommodated extension and tectonic thinning peridotite nappe and its basement)

(Between 120-80 Ma 50-75% increase in Earth's oceanic crust formation, with spreading rate increases (especially in Pacific Ocean). Pulse decreased from 100-80 Ma, dropped significantly at 80 Ma, and continued decrease from 80-30 Ma. Mid-Cretaceous pulse interpreted as response to superplume that originated at ~125 Ma and erupted beneath mid-Cretaceous Pacific basin)

(Initial pulse of volcanism on Ontong Java and Manihiki Plateaus before 123-124 Ma and largely ceased by ~122 Ma, while intervening Pacific-Phoenix spreading ridge probably disrupted between 120-115 Ma by formation of Nova-Canton Trough rift system)

(Well-preserved earliest Cretaceous radiolarians from tuffaceous claystone sample collected from seamount flank of Mariana Trench slope. Several new genera)

(Common U Tithonian- Berriasian Vallupinae radiolaria in tuffaceous claystone from Mariana Trench. 17 radiolarian species, including three new)

(Well-preserved earliest Cretaceous radiolarians from tuffaceous claystone from seamount flank of Mariana Trench. Families Centrocubidae and probably Entactiniidae identified)

(online at: https://academic.oup.com/petrology/article/54/6/1149/1409047)
(In Izu-Bonin-Mariana initial subduction-related boninitic magmatism between 48-44 Ma. High-Mg adakites and low-Ca boninites dredged from Bonin Ridge fore-arc seamount, with overlapping ages or adakite magmatism occurred slightly later than boninitic magmatism. Both magma types could be generated by partial melting of depleted mantle source fluxed by water-rich slab-derived melts in subduction environment)

(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5105175/pdf/ncomms13309.pdf)

(online at: www.mantleplumes.org/WebDocuments/Mahoney93_GeoMon77.pdf)
(Basement rocks of Ontong Java Plateau tholeiitic basalts that appear to record very high degree of partial melting, like thse found in Iceland. Mean Ar/Ar ages of ODP Site 807 lavas and basement from Malaita island 122.4 ± 0.8 Ma (Aptian). Pb-Nd-Sr isotopes indicate hotspot-like source)

(Dredge samples from Three Kings Ridge between New Caledonia and New Zealand show presence of old collisional orogen: 38 Ma high-P metamorphic rocks, mantle peridotite (from forearc of island arc) and continental-derived rocks with Cretaceous and older Gondwana zircons and Late Oligocene- E Miocene fossil leaves. Large island E of Three Kings Ridge between 38-21 Ma, subsided with opening of S Fiji basin)
(Several W Pacific islands of Mariana-Bonin arcs with olivine-bronzite andesites, known as boninites. Production of boninite may require high geothermal gradients in mantle overlying subduction zone, as in subduction under young, hot Philippine Sea plate)

(First dredge samples s from Hikurangi Plateau basement volcanics/volcaniclastics of pre-Late Cretaceous age. All samples extensive seafloor weathering to phyllosilicate- and zeolite-bearing assemblages. Petrology similar to other Cretaceous large igneous provinces in W Pacific (e.g., Manihiki, Ontong Java Plateaus)

(Seismic stratigraphy study of flank of large deep water carbonate Ontong Java Plateau. Sediment column >1000m thick at top of plateau, consisting of mainly pelagic sediments)


(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2607379/pdf/rstb20080119.pdf)
(Pacific Ocean evolved from Panthalassic Ocean that first formed at ~750 Ma with breakup of Rodinia. First ocean floor ascribed to current Pacific plate formed by 160 Ma, W of spreading centre in C Pacific. Islands of Pacific originated as: linear chains of volcanic islands (mantle plume or propagating fracture origin), atolls, uplifted coralline reefs, fragments of continental crust (New Zealand, Chatham Islands, New Caledon), obducted portions of adjoining lithospheric plates and islands resulting from subduction along convergent plate margins. 11 linear volcanic chains identified)

(Basement depths of Philippine Sea range from 3200-6000m, with ages from 0-60 Ma. Depth of Philippine Sea ~800m deeper than that of major ocean floors of same age. Young back-arc basins (~10 Ma) both shallower and deeper than major oceans, depending on dip angles of corresponding subducting slabs: shallower back-arc basins above gently dipping slabs, deeper basins over steeply dipping slabs. Back-arc basins older than 15 Ma, always deeper than major oceans and follow age-depth curve of Philippine Sea back-arc basins)

(On restoring pre-subduction configuration of Ryukyu and Shikoku slabs, NW Philippine Sea)

(online at: https://core.ac.uk/download/pdf/46807769.pdf)
('Supergene alteration, circulation of fluids and internal deformation of the Koniambo Massif, New Caledonia: implication for the nickeliferous lateritic deposits')

(Weathering of peridotite nappe in New Caledonia created common laterites and some of largest nickel deposits in world. Koniambo nickel ore deposit three kinds of geometry: (1) thick (20-40m) laterite over saprolite, mainly on topographic highs; (2) a thin laterite cover on areas with gentle slopes; (3) exposure of saprolite without laterite cover. Highest Ni on slopes where laterite cover thin or absent, lowest Ni in topographic highs under thickest laterite cover)


(Serpentine sole of New Caledonia peridotite nappe at Koniambo with many magnesite veins, emplaced during pervasive top-to-SW shear deformation. O and C isotopes of magnesite suggest origin from meteoric fluids)


(Koniambo peridotite nappe upper level at least two deformation events(1) with growth of antigorite (WNW- ESE extension), (2) with growth of polygonal serpentinite (NW-SE compression). Lower level coincides with the 'serpentine sole’ of nappe, consisting of massive tectonic breccias overlying layer of mylonitic serpentinites. Intermediate level with several m-thick conjugate shear zones accommodating NE-SW shortening)


(Sediments at ODP Site 1201 lower sequence of volcaniclastic turbidites sourced from Palau-Kyushu Ridge and upper succession of Late Oligocene- E Pliocene red deep-sea clays. Paleolatitudes derived from sediments support N-ward movement of plate since Eocene. Basaltic basement indicates paleoposition of ∼7.1° S in M Eocene)


(online at: http://archimer.ifremer.fr/doc/00245/35654/34163.pdf)

(In S Philippine Sea remnant arc precursors of modern Mariana arc and intervening back-arc basins progressively developed from W to E in Eocene- Recent time, to form Palau-Kyushu Ridge. Parece Vela Basin, W Mariana Ridge and modern Mariana Trough- Mariana arc. New data suggest initial periods of back-arc spreading coincident with minimal arc volcanism)


(Samples from three SW Pacific volcanic arcs (Kermadec, New Zealand and Papuan arcs) shows contrasting geochemical patterns that correlate with different tectonic settings. Magmas with primitive chemical characteristics comparatively rare, and appear to occur where extensional tectonic setting allowed paths of relatively rapid ascent. In typical arc settings, magma ponds above its source and is modified by fractionation, eruption, assimilation and recharge processes)


Offshore Taranaki Basin region two phases of rifting, recording Gondwana break-up of E Gondwana margin: (1) Zealandia rift phase, producing NW-WNW-trending half-grabens in M Cretaceous (~105-83 Ma), predating Tasman Sea spreading centres, followed by short period (~83-80 Ma) of uplift and erosion, possibly representing break-up unconformity; (2) West Coast-Taranaki rift phase, producing N-NE-trending half-grabens in shelfal Taranaki Basin in latest Cretaceous-Paleocene (~80-55 Ma). Rift narrow (<150 km wide), orthogonal to Zealandia phase rifting, affecting mainly W Zealandia and did not progress to full break-up

(online at: https://www.bgs.ac.uk/research/bufi/downloads/SI176SimonTapster2014Thesis.pdf)

(Convergence between Ontong Java Plateau (world’s largest and thickest oceanic plateau) and intra-oceanic Solomon Island Arc, represents youngest arc-plateau collision, and prime example of subduction zone polarity reversal. Collision implicated as cause of several Cenozoic plate motion changes. Guadalcanal Island magmas emplaced at ~23.7 Ma contain Eocene-Archean-aged zircons first evidence of continent-derived material in Solomon Island Arc. Microcontinental plateau-arc collision likely caused transfer of zircons to Guadalcanal’s crust and triggered Eocene-aged ophiolite obduction in arc. Changes to magma geochemistry at ~23 Ma coeval with resumption of typical plate motions, following slowing and deflection of Australian Plate at ~26-23 Ma and slab detachment at ~23 Ma, after Ontong Java Plateau collision. Arc magmatism rejuvenated before ~7.7 Ma. Slab detachment crucial for causing M Miocene reversal of subduction zone polarity)

(online at: http://petrology.oxfordjournals.org/content/43/3/449.full.pdf+html)

(Sections of basalt basement in C Malaita 0-5-3.5 km thick and resemble expanded version of Ontong Java Plateau at ODP Site 807. Ar-Ar ages of 121-125 Ma identical to Site 807, S Malaita, Ramos, Santa Isabel and DSDP Site 289. The ~90 Ma eruptive episode seen in Santa Isabel, San Cristobal, and Sites 803 and 288 not present. C Malaitan basalts two distinct ocean-island-like mantle sources, not from normal ocean-ridge-type mantle. Plume-head may account for geochemical characteristics, but observed stratigraphic succession requires special conditions for latter model. Other features of Ontong Java Plateau that do not fit plume-head model: at least two important, geochemically similar eruptive episodes ~30 Ma apart, lack of obvious plume-tail trace, and lack of evidence for emergence/uplift)

(online at: www.nature.com/articles/ncomms5923)

(Large igneous province subduction at oceanic Hikurangi Plateau beneath S Kermadec arc, off N New Zealand. Large portion of Hikurangi Plateau (missing Ontong Java Nui piece) already subducted)

(Basement samples from Manihiki Plateau mainly tholeiites with minor basaltic andesites and hawaiites, with mean age of 124.6 ± 1.6 Ma. Geochemistry of Manihiki Plateau best explained by plume with three components, including recycled oceanic crustal-type component. Similarity in age and geochemical composition of Manihiki, Hikurangi and Ontong Java basement lavas)

(Global Positioning System measurements in Solomon Islands show active deformation between Pacific Plate and Solomon Arc block. Convergence at San Cristobal Trench ~52±4 mm/yr, with no apparent local deformation. Guadalcanal and Makira islands mainly moving with Pacific Plate, but probably minor decoupling from Pacific Plate of 14-23 mm/yr in direction of 75-83°)


Wright, N.M., M. Seton, S.E. Williams & R.D. Muller (2016)- The Late Cretaceous to recent tectonic history of the Pacific Ocean basin. Earth-Science Reviews 154, p. 138-173.


Zonenshayn, L.P. & V.V. Khain (1990)- Eocene-Miocene plate tectonic history of Melanesia. Int. Geology Review 32, 6, p.565-577. (Late Cretaceous-Eocene Melanesian island arc with subduction zone dipping NE beneath Pacific Ocean been reconstructed from distribution of island-arc complexes in N New Guinea, New Caledonia and North Island of New Zealand. Marked change in movement of Pacific plate with respect to Australia and Eurasia at 43 Ma. E Miocene collision between Melanesian arc and passive margin of Australia. At same time, spreading axis was at rear of Melanesian arc, from which Caroline basin was formed)
**IX.11. Papua New Guinea (East New Guinea main island) (69)**


*(Waropen and Ramu basins along N margin of New Guinea formed in Neogene. Characterized by extremely high Plio-Pleistocene sedimentation rates, of mainly marine turbiditic deposits: up to 12km in Waropen basin, up to 7km of Pleistocene in Ramu Basin. Common organic (plant) material. Waropen basin with biogenic methane flows in wells and seeps)*


*(Reservoir models of latest Jurassic Imburu Fm (lagifu, Hedinia, Digimu members) and earliest Cretaceous Toro Sst, using data from 156 wells in PNG foldbelt, from P’nyang in NW to Iehi Field in SE. Deposited in two depositional settings: (1) prograding, shallow marine or nearshore, and (2) outer estuarine mouth bar environment. Key reservoir sandbodies composed of stacked sequences of uniform sandstones, with lateral and vertical continuity of nearshore and incised valley fill deposits for 10’s- 100’s km along foldbelt. In Juha Field elevated temperatures (probably burial related) significantly reduced rock quality)*


*(Same paper as Boyd et al. (2015, above))*


*(online at: http://www.publish.csiro.au/EX/ASEG2018abT5_1A)*

*(River drainage of New Guinea evolved rapidly since Pliocene time. Relief growth initiated in accreted oceanic terranes in N and migrated into Australian margin interior over time. Rise of Highlands and Papuan Peninsula spurred drainage reorganization, and affected composition of clastic sediments delivered to shelves)*


*(Full paper of Callot et al. 2015 Abstract)*


*(Late Quaternary sea level changes from 120ka- now derived from raised coral reef terraces at Huon Peninsula in PNG now good correspondence with trends derived from oxygen isotopes in deep sea cores)*


*(Thermochronological data for 29 wells in Papuan Foreland show present-day heat flow consistent with median values for Australian continental plate. Paleothermal data suggest Cecilia Trough and Morehead Graben presently at maximum temperatures, but wells in central Foreland much higher temperatures in past, suggesting either km-scale uplift and erosion or (less likely) elevated heat flows associated with Coral Sea Rifting in Late Cretaceous-Paleocene)*


*(Similar to Darnault et al. 2015, 2016)*


*(online at: https://d28rz98at9flks.cloudfront.net/12326/Rec1969_067.pdf)*

*(Presence of nickel sulphide and chromitite lenses. Lateritic nickel prospects in Ultramafic Belt deemed uneconomic)*


*(SE one-third of Peninsula shows extensional tectonics N of ~10°S, with outcrops of ophiolite and metamorphic rocks, and contractional tectonics S of that line. Extensional tectonics reflect W-ward propagation of Woodlark Rift, contractional structures due to convergence between Papuan Plateau and Papuan Peninsula)*


*(Youngest known UHP eclogite from eastern PNG (Mailolo Dome) shows crustal rocks subducted to P 27-31 kbar and T ∼715 °C. Zircons suggest ages of 6.0 ± 0.2 Ma to 5.2 ± 0.3 Ma for UHP metamorphism and 3.2-2.3 cm/yr exhumation rate. Subsequent retrogression of terrane near base of crust and final emplacement in upper crust in <~3 My)*


*(Kainantu area in composite Scrapland composed of Mesozoic greenschist - amphibolite facies Bena Bena and Goroka Fm metamorphics and intrusives, overlain by Late Cretaceous-Miocene marine sediments, volcanics and M-L Miocene intrusives. Four deformation events, oldest producing slaty cleavage and isoclinal E-W trending folds. Known mineralization gold-copper skarn, porphyry copper epithermal and gold placer deposits, many associated with 9-13 Ma old porphyry intrusives)*


(Bilimoia gold deposit in NE PNG is fault-hosted quartz-gold vein system hosted by 290-221 Ma years old basement that was regionally metamorphosed to greenschist facies at ~45 Ma. Mineralisation related to I-type, intermediate-felsic 9-7 Ma year-old porphyries)


(online at: https://repositories.lib.utexas.edu/handle/2152/14789) 
(D'Entrecasteaux Island gneiss domes fault-bounded domes with ~2.5 km of relief, exposing UHP and HP metamorphic gneisses and migmatites, exhumed in Oligocene-Miocene arc-continent collision-subduction zone, subject to Late Miocene- Recent continental extension. Subduction slowed at ~8 Ma as margin transitioned to extensional tectonic environment. Lack of upper crustal extension accompanying subsidence in Tobriand and Goodenough basins suggests lithospheric extension from 8-0 Ma accompanied uplift of DEI gneiss domes. Basin extension of 2.3-13.4 km in upper crust, while subsidence values indicate >21-24 km of lower crust extension since ~8 Ma. DEI domes formation involve vertical exhumation of buoyant lower crust, far-field extension from slab rollback, and inverted two-layer crustal density structure)


(lagaflu- Hedinia oil-gas field in Pauan Fold Belt with 31 MMBO recoverable reserves. Large thrust fault duplex structure, with detachment surfaces in Cretaceous Ieru Shale, causing discordance between structure at surface and basal Cretaceous Toro Sst reservoir level. Toro Sst main reservoir 100m thick, composed of four stacked parasequences of wave-dominated delta complex, separated by marine flooding surfaces)


(Review of 'accretionary orogens' of N and E Gondwana (convergent margin orogens without continental block collisions), including chapter on Papua New Guinea Orogen)


(Similar Tertiary I-type calcalkaline granitoids in 3 structural-tectonic zones of PNG: island arc, continental-orogenic and cratonic. Associated with volcanics and porphyry Cu-Au mineralization. Tied to partial melting at base of crust, possibly resulting from subduction, crustal thickening or crustal buckling)


(online at: http://pubs.usgs.gov/sir/2010/5090/d/sir2010-5090d_text.pdf) 
(Assessment of porphyry copper deposits in E part of late Miocene to Pliocene-Pleistocene Medial New Guinea magmatic belt)

(assessment of porphyry copper deposits in M Miocene (~18-12 Ma) Maramuni magmatic arc in central part of PNG (S of Melanesian Arc terrane and N of Medial New Guinea magmatic belt), resulting from SW-dipping subduction of Solomon Sea Plate beneath E New Guinea. Known porphyry copper deposits include Frieda River (12 Ma). Yandera and Wafi-Golpu nearby but probably part of younger trend)


(Assessment of porphyry copper deposits in Eocene-Oligocene- E Miocene accreted Inner Melanesian magmatic arc terranes along N margin of island of Papua New Guinea, (Bewani-Torricelli Mts, Finisterre-Adelbert Arc). May be related to S-ward subduction of Pacific Plate or Philippine Sea Plate, fragmented by strike-slip faulting since 25 Ma. Rocks age-equivalent to New Britain assemblage. No known deposits)


(Juha gas-condensate field in25 km long/ up to 8 km wide anticlinal structure in SW Papuan foldbelt. Lower Cretaceous quartz sandstone reservoir buried by 1.5 km Cretaceous shale (regional seal), 1.5 km Miocene limestone and >1.6 km Pliocene-Pleistocene 'flysch' and 'molasse', before late Pliocene-Pleistocene uplift-erosion. Seismic indicates inverted basement faults beneath Juha, with detachment in Cretaceous mudstones, so overlying Miocene Limestone deforms partly independently. Deepest burial and gas-generation in Pliocene, before compressional deformation in Pleistocene. Part of ExxonMobil gas development)


(Tasman Line of E Australia is continental suture, separating E margin of Precambrian basement from W limit of Phanerozoic Tasmanides. Extension into New Guinea in W Papua New Guinea indicated by Quaternary magmatism (more intense volcanism in E, inherited zircons of Paleoproterozoic age (~1850 Ma) in W: Permian-Triassic (~250, 270 Ma) age peaks in E), morphological changes in axial ranges of New Guinea, dramatic displacement of Papuan ophiolite belt, etc. Important implications for understanding the occurrence of mineral deposits in region)

(Since ~6 Ma crustal elements that comprise PNG and Solomon Islands began interacting with impending collision between Ontong Java Plateau and Australian continent, leading to regional microplate tectonics and escalation in tectonic complexity. Bismarck Sea initially formed as back-arc basin behind New Britain arc, but later modified during arc-continent collision. Ttc.)


(presentation at: https://digital.library.adelaide.edu.au/dspace/bitstream/2440/105356/1/02whole.pdf)
(In Papuan foldbelt hydrocarbon distribution likely influenced by hydrodynamic behavior in Toro and Imburu Fm reservoirs. E Cretaceous Toro Sst extensive hydrodynamic aquifer that likely flows NW to SE, from Lavani Valley Toro outcrop (recharge region) in Highlands, through to Kutubu Complex, potentially via Hides, (possibly Angore) and Mananda/SE Mananda Fields)


(Same as Keenan and Hill 2015, above)


(Structure interpretation of magnetic data in area of Hides and Karius gas fields, PNG foldbelt, consistent with structures mapped from seismic and well data)


(Same as Kivior et al. 2015))


(25 km long sinuous Gobe Anticline in SE Papuan Fold Belt three structural compartments, believed to be in part controlled by E Jurassic rift architecture in Permo-Triassic basement. Main oil gas reservoir U Jurassic Igifu Sst. Overlying 1 km thick Cretaceous mudstone detached reservoir sequence from overlying 1 km thick Miocene limestone that formed Pliocene- Recent thin-skinned structures at the surface. Nearby basement-cored Iehi Anticline. Gobe Anticline resulted from interplay of two conjugate contractional fault sets)


(Ok Tedi is Earth’s youngest giant porphyry-skarn deposit. Zircons with inherited older cores in all intrusions. Inherited zircon populations and Hf isotopes of Pleistocene zircons record Proterozoic basement assimilation. Crystalization ages extend over 212 ± 44 k.y.. Youngest zircons in each intrusion reflect emplacement age and suggest three pulses separated by ~160 k.y. Injection of more mafic magma into magma reservoir preceded emplacement of Fubilan porphyry at ~1.19 Ma and may be trigger for Au-Cu mineralization)


(Platinum-group element mineralisation in mafic-ultramafic rocks of E PNG)


(Greater Juha area in Eastern Muller Ranges of Papuan Fold Belt in PNG with evidence of major inversion, detachment and triangle zone faults. Exposed Cenozoic Darai Lst shows ~13-21% shortening, yet structures elevated up to 7 km above regional, suggesting inversion of pre-existing rift architecture. Pervasive arc-normal oriented structures related to weakened Paleozoic basement cross-structures that affected E Mesozoic rifting)


(On amphiboles and biotites from porphyry copper-generating and barren intrusions in W Highlands, PNG)


(Bwata gas-condensate field in E Papua Basin is 1960 discovery on structural high of fractured Miocene Puri Limestone, with 157 m of gas pay. Geologic model constrained with new airborne potential field data, new seismic and data from nearby Triceratops-1 well, increasing gas in place resource to 762 BCF)


(Rapid extension led to formation of metamorphic core complexes ahead of W-sector-propagating Woodlark basin spreading center. Stream profiles on D’Entrecasteaux Islands and E PNG show prominent knickpoints, likely formed from transient Quaternary stream erosion due to increase in uplift rate)


(Kutubu Field in mountains of PNG comprises Hedinia Anticline (mainly gas) and oil-bearing Iagifu Anticline. Produced >300MMBBL oil from basal Cretaceous Toro Sst reservoir, overlain by 1 km of Cretaceous shale and 1 km of karstic Miocene limestone)


(onlaneous at: https://www.jstage.jst.go.jp/article/jgeography1889/104/5/104_5_725/_pdf)


(Significant lateral velocity variation across >1km thick Late Oligocene-Miocene Darai Limestone, due to alteration, including dolomitisation. Most alteration associated with small-scale faulting)

(Laloki massice Au-Ag sulfide deposit in Astrolabe Field, 20km E of Port Moreshy, SE PNG. Stratigraphically hosted by Paleo-Eocene mudstone and grey cherts. Early massive sulfide stage and late stage remobilization and brecciation. Temperatures of early and late stage mineralization range 309-498°C and 266-338°C).


(also as BMR Record 1973/91 at: https://d28rz98at9flks.cloudfront.net/12915/Rec1973_091.pdf)

(Sr isotope data for Quaternary volcanic rocks from six areas in PNG suggest two broad groups: (1) island volcanoes with lower Sr37/Sr38 ratios (0.7034–0.7043), probably from relatively homogeneous upper mantle source regions; (2) PNG mainland volcanoes with higher and wider range of Sr37/Sr36 ratios, probably affected by sialic crustal contamination, or derived from heterogeneous sources in upper mantle)


(online at: https://openresearch-repository.anu.edu.au/handle/1885/12535)

(Porgera gold deposit in highlands of PNG associated with Porgera Intrusive Complex, hosted in Jurassic-Cretaceous shelf sediments. K-Ar dating of igneous biotite, and Ar/Ar dating of hornblende suggest age of emplacement of PIC 6.0 ± 0.3 Ma)


(online at: www.iaea.org/inis/collection/NCLCollectionStore/_Public/24/058/24058940.pdf)

(Mesothermal- epithermal Porgera gold deposit associated with shallow level (< 2 km emplacement depth) stocks and dykes of Porgera Intrusive Complex, emplaced at 6.0 ± 0.3 Ma near NE edge of Australian craton, during period of Late Tertiary terrane accretion. Magmatism may have been related to deep subduction beneath continental margin. Gold mineralization immediately followed emplacement of PIC at 5-6Ma. Porgera intrusive suite sodic alkali basalts/gabbros, hawaiites, and mugearites)


(online at: https://eprints.utas.edu.au/22758/1/whole_Rinne_thesis.pdf)

(Wafi-Golpu gold district in Mesozoic metasediments of Owen Stanley Range of New Guinea Orogen, Morobe Province of PNG, ~65km WSW of Lae, and NW of Morobe Goldfield. Cu-Au mineralization ant ~8.67 Ma tied to Golpu diorite, which post-dates Maramuni Arc magmatism (17-12 Ma; with Frieda, Nena porphyries). Golpu probably part of W-ward younging belt of porphyry generation that also includes Porgera, Star and Ok Tedi. Uplift and exhumation during life of porphyry driven by low-angle subduction of Solomon Sea Plate, resulting in shift from porphyry to epithermal activity over period of 0.25-0.40 Myrs)

(Sediment cores from Lake Kutubu, S Highlands, PNG, with two prominent tephra layers, correlated with Tibito and Olgaboli tephras described nearby. Tibito tephra possibly from Long Island; Olgaboli tephra possibly from Karkar Island source)


(Sediment cores from Lake Kutubu, S Highlands, PNG, with two prominent tephra layers, correlated with Tibito and Olgaboli tephras described nearby. Tibito tephra possibly from Long Island; Olgaboli tephra possibly from Karkar Island source)


(Mildly peralkaline rhyolites (comendites) most abundant lavas in Quaternary volcanic province centered around Dawson Strait in D'Entrecasteaux islands, E PNG, associated with minor basaltic rocks. Tied to crustal extension and rifting)


(Late Cenozoic volcanic arc in SE PNG developed in environment of complex tectonic processes including obduction, subduction, rifting and sea floor spreading. Volcanic arc extends from Papuan Peninsula SE-ward through D'Entrecasteaux Islands into Louisiade Archipelago. Mainly basaltic andesite and andesite, but also basalt, dacite and rhyolite. Unusual abundance of high-Mg lavas in SE Papua related to extensional tectonics which allowed deep sourced magmas to rise without significant modification)


(Uplifted Late Plio- E Pleisocen erosional surface(s) up to 185m asl on Miocene- Pliocene volcanic rocks along Milne Bay on SE tip of PNG main island. Nearby uplifted coral reefs at >500m above sea level)


(Extended Abstract)

(Stanley, Elevala, Ketu and Ubuntu gas-condensate fields in foreland of W Papuan Basin. Basement architecture and regional NW-trending 3KB fault system control trap and Late Jurassic- E Cretaceous reservoir development (inversion of pre-existing faults and compactional drape of reservoirs over Basement highs). Map of spatial distribution of reservoir sands and paleogeographic models)


(New basin name proposed for area offshore SE tip of PNG Eastern peninsula, N of Coral Sea oceanic basin. Part of Papuan Plateau that rifted from Queensland Plateau during Late Cretaceous- E Paleogene opening of Coral Sea)

Traveling down a winding road of geological history, we explore the Papuan Peninsula, where forces of tectonism play out in a landscape sculpted by the collision and convergent movement of tectonic plates. This region, during the Late Miocene-Pliocene period, was formed by these plate interactions, but the scene shifted to extensional tectonics in subsequent epochs. In the SE part of the peninsula, the tectonics were dominated by compression on the south side and extension in the center and north, with structures indicating a dynamic interplay of forces.

In their study, Tobin, S. Zahirovic, R. Hassan & P. Rey (2018) shed light on the tectonic and geodynamic evolution of the Northern Australian margin and New Guinea. This work was presented at the AEGC 2018 conference, with extended abstracts available online. Their findings suggest a complex interplay of tectonic forces, with modeling of Cenozoic evolution, collision of Sepik terrane, and dynamic subsidence linked to the downgoing Sepik slab now beneath Central Australia.

Wacaster, S. (2015) delved into the mineral industry of Papua New Guinea, providing a snapshot of mineral production in PNG, along with data on the production of 2013. This overview is complemented by additional information on the oil potential of the region.

Warburton, J., J. Iwanec, J. Lamb, D. Waples & K. Wulff (2017) examined the potential for future petroleum resources in PNG, with insights drawn from the Oil Search 2015 assessment. This study highlights the significant potential of petroleum resources, both discovered and still to be found, setting the stage for future exploration and development.

Weiler, P.D. (1999) conducted a paleomagnetic study of the Finisterre Arc Terrane in Papua New Guinea, offering insights into the tectonic processes of this region. His findings suggest a CW rotation of the terrane, indicating rigid-body rotation rather than sequential docking.

Zhang, J., J.P. Davidson, M.C.S. Humphreys, C.G. Macpherson & I. Neill (2015) examined magmatic enclaves and andesitic lavas from Mt. Lamington in Papua New Guinea, providing insights into the recycling of earlier-fractionated minerals. Their research underscores the importance of understanding these processes to better predict the distribution of resources and their potential for future exploitation.
IX.12. Papua New Guinea (Bismarck Sea, Solomon Sea, Woodlark Basin) (66)

(Inversions of large earthquakes in Woodlark-D’Entrecasteaux region of active continental extension show events consistent with normal dip slip on shallow-dipping faults. Largest earthquake near mapped Pliocene-Quaternary metamorphic core complex, with shallow-dipping plane between 10°-25°)

(Woodlark Rift system extension rates vary along strike, with shallowest-dipping faults in most rapidly rifting segment. Several earthquakes suggest nodal planes dipping 23-35°, subparallel to shear zones bounding nearby metamorphic core complexes. No documented large earthquake exhibits seismic slip on subhorizontal surfaces)

(Manus Basin is rapidly opening, magmatically active back-arc basin associated with N-ward subduction of Solomon Sea Plate. Samples from 40 km segment of SE Rift span compositional continuum from basalt to rhyolite (50-75 wt % SiO2). Data form a coherent array suggestive of closed-system fractional crystallization, and point to rapid evolution in relatively small magma lenses located near base of thick oceanic crust)

Belford, D.J. (1988)- Late Tertiary and Quaternary foraminifera and paleobathymetry of dredge and core samples from the New Ireland Basin (Cruise L7-84-SP). In: M.S. Marlow et al. (eds.) Geology and offshore resources of Pacific island arcs- New Ireland and Manus region, Papua New Guinea, Circum-Pacific Council Energy and Mineral Resources, Houston, Earth Sci. Ser. 9, p. 65-89. (Late Miocene (N17)- Recent foraminifera in seafloor samples N of New Ireland, New Hanover, Manus islands)


(Ladolam gold deposit largest alkalic epithermal gold deposit in world. Four ore zones. Minifie ore zone three stages: (1) Plio-Pleistocene volcanosedimentary strata (part of alkalic composite volcanic island), (2) porphyry-style breccia dike, and (3) epithermal-style breccias. Quaternary uplift)

Bolton, B.R. & N.F. Exon (1988)- Geochemistry of bathyhal ferromanganese deposits from the New Ireland region in the Southwest Pacific Ocean. In: M.S. Marlow et al. (eds.) Geology and offshore resources of Pacific island arcs- New Ireland and Manus region, Papua New Guinea, Circum-Pacific Council Energy and Mineral Resources, Houston, Earth Science Ser. 9, p. 131-136. (Six samples with ferromanganese crusts dredged from seafloor at depths of 800-1500m around New Britain. Rel. low Co values)


(Four fields of undulating sediment in Bismarck volcanic arc N of New Britain island associated with downslope scour features and other evidence of turbidity-current activity, probably formed by combination of extensional deformation and repeated turbidity currents)


(Melanesian Arc Baining Volcanics (43-37 Ma; M-L Eocene) and Kupluk Volcanics (32-27 Ma; E Oligocene) represent 'normal' island arc volcanism that forms New Britain Basement. Collision of Ontong Java Plateau with Solomon Islands at 26 Ma ended subduction and led to post-collision adakitic Simuku Porphyry Complex (24-20 Ma; E Miocene). Origin of adakites probably from melting of subducted slab)


Jakes, P. & A.J.R. White (1969)- Structure of the Melanesian arcs and correlation with distribution of magma types. Tectonophysics 8, 3, p. 223-236. (Chemical data on Cenozoic lavas from Melanesia indicate zonal arrangement in New Guinea-New Britain arc: (1) tholeiitic on ocean side of New Guinea (Manam, Karkar), and N of New Britain; (2) calc-alkaline on East Papuan coast (Mt. Lamington, Mt. Victory); (3) shoshonitic association of New Guinea highlands (Mt. Hagen, Mt. Giluwe) and East Papua. Zonation not distinct in Solomon Island Arc. Lavas of the New Georgia Group tholeiitic and calc-alkaline affinities; rocks from Bougainville and Guadalcanal calc-alkaline)

Johnson, R.W. & R.J. Arculus (1978)- Volcanic rocks of the Witu Islands, Papua New Guinea: the origin of magmas above the deepest part of the New Britain Benioff zone. Bull. Volcanologique 41, 4, p. 609-655. (Witu Islands are Quaternary volcanoes overlie deepest (~300-580 km) part of New Britain Benioff zone. Rocks are olivine- and quartz-normative tholeiitic basalts, low- and high-SiO2 andesites, dacites and rhyolites. Alkaline rocks that overlie deep (>300 km) parts of other Benioff zones not found in Witu Islands)


(online at: http://ufdc.ufl.edu/UFE0008250/00001/pdf)
(Model of ore formation and magmatism in Tabar-Lihir-Tanga-Feni island arc: injection of volatile-rich magma into evolving magma body near surface is triggering event that results in ore mineralization. Subducted oceanic slabs control composition of island-arc magmas. Once contribution from subducting slab decreases, incorporation of mantle component with Indian affinity in isotopic composition of lavas)

(TLTF islands with mainly high-K alkaline and silica-undersaturated alkaline rocks with geochemical features typical of subduction-related magmatism. Sedimentary, mafic and ultramafic xenoliths from Tubaf seamount show underlying crust composed of sediments and oceanic crust of Pacific affinity)

(SiO2-undersaturated lavas from Lihir island, like most arc lavas, enriched in Sr, Ba, K, Rb and Cs and depleted in Hf, Ta, Nb and Ti relative to oceanic basalts, but not product of present-day subduction. Alkaline lavas reflect generation, in tensional tectonic environment, from 'fossil' arc mantle region enriched in alkali and alkali earth elements during two earlier subduction episodes)

(Tephra fallout layers and volcanioclastics from volcanic sources around/ on Papuan Peninsula form substantial part of Plio-Pleistocene Woodlark Basin marine sediment. Mainly rhyolitic compositions, with subordinate basaltic anodesites, etc. Volcanogenic layers indicate much calc-alkaline rhyolitic volcanism in E Papua since 3.8 Ma, but at 135 ka peralkaline tephras appear, reflecting change from crustal subduction to spreading)

(Porphyry copper-gold and epithermal gold mineralization on Gazella Peninsula, E New Britain, associated with Late Oligocene- E Miocene igneous activity. Mt Sinivit veins with chalcopyrite, pyrite, bornite, etc.. K-Ar age of sericitic wallrock alteration indicate formation at 22-23 Ma)

(New Britain Trench SE of New Britain island often viewed as subduction trench, but here reinterpreted as extensional jog-like element of left-stepping sinistral strike-slip zone that extends from Solomon Islands through to W New Guinea)

(Ambitle Volcano part of Pliocene-Pleistocene Tabar-Lihir-Tanga-Feni (TLTF) alkalic volcanic province in New Ireland Basin. Volcano rises 2500m above surrounding sea floor, with elevation up to 479 m above sea level. Volcanic deposits rest unconformably on Oligocene basement rocks of New Ireland Basin)

(Woodlark Island (Muyuw) rifting started in Late Miocene (8.8-6 Ma), associated with W-ward-propagating Woodlark Basin seafloor spreading centre. Island underlain by M Miocene calc-alkaline to shoshonitic Okiduse Volcanic Gp., with two major M Miocene volcanic centres (14-12 Ma))


(Rabaul Caldera most active of four N-S aligned volcanic centres in NE New Britain. Oldest exposed basaltic lavas dated at 0.5 Ma. Dacitic lavas in caldera wall 0.19 Ma, overlain by dacitic and andesitic pyroclastic flow and fall deposits. Holocene ignimbrites of latest caldera-forming eruptions ~3500 or 7000 yr B.P.)

(Woodlark Island E of PNG mainland, composed of central part of Miocene volcanics, surrounded by Quaternary coral reefs. Deformed by two fault systems)

(also as BMR Record 1973/191; online at: https://d28rz98at9flks.cloudfront.net/13014/Rec1973_191.pdf)
(New Britain volcanic arc system with intermediate- basic intrusives complexes emplaced into Eocene-Oligocene volcanics, overlain by E-M Miocene limestones. K-Ar ages two groups of ages: 27-29 Ma (M Oligocene) and 22 Ma (E Miocene). Gazelle Peninsula tonalite body 14 Ma)

(also at: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2015GC005847)
(Discussion of exhumation of UHP rocks, whether involving rising of pieces of crust detached from subducted continental lithosphere, or entire subducted plate undergoing 'eduction' (reverse subduction), based on metamorphic core complexes of D'Entrecasteaux Islands, PNG. Eduction followed by seafloor spreading can occur in zone of convergence when subduction of buoyant crust causes subduction zone to 'lock up' and cause formation of new subduction zone. Model implies Goodenough Basin crust exhumed by eduction in last 5 Ma)

(Woodlark Rift E of papuan Peninsula W-ward propagating spreading centre into continental crust. ODP leg 180 wells document history of Paleogene ophiolite emplacement, Miocene arc-related sedimentation and Late Miocene uplift and emergence of forearc area. Submergence to form Woodlark Rift began in latest Miocene, marked by marine transgression and input of tuffs and volcaniclastic sediments. Pliocene deposition dominated by deep-water turbidites. Pleistocene strong extension along N-dipping, low-angle Moresby Detachment Fault, associated with uplift of Moresby Seamount and shedding of fault-derived talus of meta-ophiolitic origin. Switch to pelagic-hemipelagic deposition in basin in Pleistocene related to W-ward propagation of Woodlark oceanic spreading centre at ~2 Ma)

(Epithermal gold hosted by late M Miocene Okiduse Volcanics on Woodlark Island. Mineralisation contemporaneous with volcanism (12.2 - 12.5 Ma) and tied to subduction of Solomon Sea plate along Trobriand Trench. Pyrite, sphalerite, galena and minor chalcopyrite occur in steeply dipping fracture zones)


(Lihir (also known as Ladolam) Au deposit in PNG telescoped ore deposit, in which volcanic sector collapse led to superimposition of shallow-level Au-rich epithermal mineralization on genetically related, porphyry-style alteration. Au concentrated only along rims of pyrite grains, creating complications for ore processing)


(Lihir (Ladolam) is world’s largest alkalic Au deposit gold deposit with 56-Moz Au resource and. Deposit in amphitheatere, inferred to be remnant of original ~1.1-km-high volcanic cone with NE-directed sector collapse(s) and prolonged weathering. Late-stage Au-rich low-sulfidation epithermal mineralization superimposed on early-stage porphyry-style alteration)


(Tabar, Lihir, Tanga and Feni island groups form alkaline volcanic chain NE of Tertiary New Ireland island arc. Mainly Pliocene-Pleistocene lavas and volcanoclastics. Alkaline rocks mainly phonolitic tephrite and trachybasalt, but also more mafic types. Raised Pleistocene coral reef terraces fringe many islands. E-M Miocene reef limestone on Simberi Island in Tabar Island group)


(Mai‘iu fault in rapidly extending Woodlark Rift is one of few active continental low-angle normal faults globally. Such faults may slip at >10-20 mm/yr faster than high-angle normal faults. Cosmogenic nuclide exposure dating (10Be in quartz) of Mai‘iu fault scarp indicates slip at 11.7 ± 3.5 mm/yr over past ∼5.5 k.y.)


(Late Oligocene Uasilau-Yau Yau intrusive complex of C New Britain compositional continuum from gabbro to granodiorite, dated at ~28-29 Ma. Tonalite porphyry that led to porphyry copper mineralization is younger intrusive event at 24 Ma. Granites probably formed by partial melting of subducted oceanic crust or overlying mantle, and may be termed mantle or M-type granites)


(online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2004TC001744)

(Correction published 1/2007)

(K-Ar ages for three major intrusive episodes of Uasilau-Yau Yau intrusive complex: Group 1 (gabbro and quartz diorite) >30 Ma; Group 2 (quartz diorite, tonalite, and granodiorite; main volume of complex) ~28.4 Ma; Group 3 tonalite ~23.5 Ma, followed closely by hydrothermal alteration and copper mineralization. All porphyry copper mineralization in New Britain may be result of late Oligocene igneous event)


(online at: https://d28rz98at9flks.cloudfront.net/13479/Rec1976_059.pdf)

(Geophysical survey of Gulf of Papua and Bismarck Sea by CGG. Bismarck Sea marginal basin partly enclosed by New Guinea and New Britain, and W Melanesian Arc)


(SuSu Knolls three steep-sided conical porphyritic andesite-to-dacite domes on N-NW-trending ridge in E Manus basin, with crests 1150-1520 m below sea level. Intense hydrothermal plumes, with Cu-Au sulfide mineralization. Good example of modern, high sulfidation, Cu-Au submarine hydrothermal system)


(Huon Peninsula of NE PNG, is uplifting shoreline ringed by emergent coral terraces, formed during episodes of rapid sea-level rise, and constructing coral platforms that were subsequently uplifted. Last glacial (OIS 3) coral terraces coincide with timing of major N Atlantic climate reversals between 30- 60 ka.Growth of terraces tied to sea-level rises arising from ice-calving episodes from major N Atlantic and Antarctic ice-sheets that precipitated extremes of cold climate called Heinrich events. Sea-levels at this time 60-90m lower than present)
IX.13. Papua New Guinea (Gulf of Papua, Coral Sea) (9)

(see also Bailey et al. 2015)

(Same as Botsford et al. 2015)

(Three successive rifting events in Coral Sea region: (1) poorly documented Triassic event, along N-S Permian structural fabric; (2) Jurassic reactivation forming small) basins bounded by N-S, NE-SW, and E-W listric faults. Extension continued in E Cretaceous with seafloor spreading in Owen Stanley Oceanic Basin, now incorporated in Papuan fold and thrust belts; (3) Late Cretaceous extension, followed by Coral Sea seafloor spreading from Danian-Ypresian. Coral Sea propagator cuts through rifted margin and is controlled by subduction complex tied to Tasman Sea opening)


(Incl. Gulf of Papua examples, adjacent to carbonate platform)


(Peak depositional period in late Quaternary deepwater Pandora Trough during Marine Isotope Stage 2, when large deep-sea channel network linked Pandora and Moresby Troughs, allowing long-distance sediment transport by large turbidity currents from Papuan mainland to Coral Sea Basin)

(Provenance of Pleistocene- Holocene deepwater sediments in Gulf of Papua. Multiple terrestrial sediment sources along~500 km basin margin converged to form continuous deep-sea system in two basins before 30 ka. During sea level fall of Last Glacial Maximum (18-22 ka) distinct depocenters, due to incision of individual rivers across newly exposed coastal plain, followed by compositional similarity near end of LGM. Holocene, deepwater sand transport shut down, except one locality with narrow shelf-slope setting and additional volcanic supply)

IX.14. NE Indian Ocean (21)


('Biostratigraphy of Quaternary foraminifera in cores MD 982152 and 982155 from the Indian Ocean'. Two 32 and 43m long IMAGES Expedition piston cores from SW and S of Java with Quaternary Globorotalia truncatulinoides Zone, subdivided into three subzones, Globorotalia crassaformis hessi, Globigerinella calida calida and Beella digitata)


(C and O isotope records of foraminifera from ODP site 758 in NE Indian Ocean on Ninetyeast Ridge. Climatic events recorded: 1. M Miocene Climate Optimum (17-15 Ma), (2) Monterey Excursion (17-14 Ma), (3) Et Antarctica Ice sheet formation (13.8 Ma), (4) Initiation of Indian summer monsoon with waning of Antarctica Ice sheet (12.3-10.4 Ma), and (5) cooling event (10.2–9.6 Ma))


(Study of changing patterns of sediment accumulation in Indian Ocean through Cenozoic. Paleogene sedimentation rates generally low, suggesting weak ocean circulation and stable, well-stratified conditions. Vigorous thermohaline circulation of Neogene resulted in substantial widespread sedimentation)


(Earthquakes in N Wharton Basin demonstrate pervasive brittle deformation between Ninetyeast Ridge and Sunda subduction zone. Evidence of recent strike-slip deformation along N-S fossil fracture zones and Miocene conjugate Riedel shears in sediment section and oblique to N-S fracture zones)


(Ablated button-shaped tektite, 12mm in diameter from Central Indian Ocean seafloor at 5300m water depth. Compositionally similar to high-Mg australites and microtektites in deep-sea sediment from Indian Ocean, suggesting Australian tektite field also covers most of Indian Ocean)


(550km long seismic reflection and refraction transect across Ninetyeast Ridge, Indian Ocean, which was created between ~90- 38 Ma above Kerguelen mantle plume. Normal oceanic crust W and E of ridge/ edifice, with crustal thickness average 6.5– 7 km. Crust under ridge bent downward by loading, and hotspot volcanism underplated pre-existing crust, leading to crustal thickness up to ~24km. Underplating continued to E under Wharton Basin)


(NW Australian margin DSDP Site 263 E Cretaceous with 66 agglutinated and 31 calcareous taxa: Three assemblages: (1) high-diversity Valanginian-Barremian Bulbobaculites-Recurvicoel; (2) moderately diverse Aptian-Albian Rhizammina-Ammodiscus-Glomospira; (3) low diversity Albian-younger of sparse agglutinans, nodosariids and rotaliids. Shelf- lower slope assemblages, deepening after initial breakup of E Gondwana margin in Valanginian. Absence of many cosmopolitan forms suggests faunal differentiation in Austral realm.)


(Seafloor tectonic fabric in Indian Ocean from satellite gravity gradient data reveals extinct Pacific-style oceanic microplate (‘Mamerrick’s Microplate’) W of 90E Ridge. Formed at Indian- Antarctic ridge, during chron 21n(o) (~47.3Ma; around E-M Eocene boundary). With rotated abyssal hill fabric. Probably plate reorganization linked to India-Eurasia collision (initial ’soft’ collision))


(Plagioclase and zircon dating indicate that portion of theWallaby Plateau off W Australia formed at ~124 Ma (E Aptian), i.e. >6 My younger than oldest oceanic crust in adjacent abyssal plains. Eruption made possible at 124 Ma via opening of Indian Ocean during breakup of Greater India and Australia along Wallaby-Zenith FZ)


(Flanged button tektite on Indian Ocean floor, at shallower level than ~750 ka microtektite horizon at 60-125mm below ocean floor))


(Fifteen new Australasian microtektite sites in C Indian Ocean, now to 61 microtektite sites in oceans. Contours joining highest values of square of correlation coefficient of all known data sites define source area in NE Thailand- C Laos (18° N and 104° E. Calculated crater diameter 33-120 km)


(Box core samples in Indian Ocean yied minitektites (>1-3.75 mm long), occurring with microtektites belonging to 0.77 Ma Australasian tektite strewn field)
Qin, Y. & S.C. Singh (2015)- Seismic evidence of a two-layer lithospheric deformation in the Indian Ocean. Nature Communications 6, 8298, 12p. (online at: www.nature.com/articles/ncomms9298) (Wharton Basin in Indian Ocean with active intra-plate deformation, with earthquakes rupturing entire lithosphere. In Wharton Basin direction of maximum stress is NW-SE, and deformation is accommodated along N5°E-trending re-activated fracture zones with left-lateral strike-slip movements. Seismic reflection profiles show faults down to 45 km depth. Lithospheric mantle deformation divided into two layers: upper fractured fluid-filled serpentinized layer and lower pristine brittle lithospheric mantle where great earthquakes initiate)


Singh, S.C., H. Carton, A.S. Chauhan, S. Androvandi, A. Davaille, J. Dyment, M. Cannat & N.D. Hananto (2011)- Extremely thin crust in the Indian Ocean possibly resulting from plume-ridge interaction. Geophysical J. Int. 184, 1, 2942, p. 29-42. (Thickness of crust created at ocean spreading centres depends on spreading rate and melt production in mantle. It is ∼5-8 km for crust formed at slow and fast spreading centres and 2-4 km at ultra-slow spreading centres away from hotspots and mantle anomalies. Crust is generally thin at fracture zones and thick beneath hotspots and large igneous provinces. Crust generated at fast Wharton spreading centre at 55-58 Ma only 3.5-4.5 km thick over 200 km segment of Wharton Basin as suggested by interpreted Moho on seismic reflection and refraction data. This is thinnest crust ever observed in fast spreading environment, and likely formed by interaction between Kerguelen mantle plume and Wharton spreading centre at ∼55 Ma)


Trueman, N.A. (1965)- The phosphate, volcanic and carbonate rocks of Christmas Island (Indian Ocean). J. Geol. Soc. Australia 12, 2, p. 261-283. (Christmas Island consists of interbedded volcanic and carbonate rocks, mainly of Eocene and Miocene age. Volcanic rocks successively more basic, varying from andesite to limburgite. Phosphate deposits three main mineral groups: apatite, barrantide and crandallite-millisite)
IX.15. NW Australia margin (90)


(Sequence stratigraphic mapping of K10 supersequence (Berriasian-Valanginian; Brewster Mb). Deposition of K10 started at onset of rifting between Greater India and N Carnarvon Basin. Sediment sourced from uplifted areas resulted in deposition of Barrow Delta in Exmouth and Barrow sub-basins and smaller K10 sand-rich progradational sequence in Caswell subbasin. Gas reservoir in Ichthys-Prelude and Burnside fields)


(Rock physics data from 4 wells in offshore Styanarrow field oil reservoir, Exmouth Basin, 65 km offshore NW Australia. Reservoir composed of turbiditic sandstones interbedded with claystones of E Cretaceous (Valanginian-Berriasian) age)


(Pyrenees-Macedon fields in Exmouth subsbasin of N Carnarvon Basine currently underfilled relative to available closure despite being regional focal point for Cretaceous- Recent charge. Vertical leakage may have controlled column heights, possibly via dynamic failure along pre-existing faults and conductive fractures, and lateral leakage across reservoir against chief zone fault juxtapositions)


(In Browse Basin oldest carbonate build-ups interpreted as Oligocene giant bryozoan build-up complex (34- 27.8 Ma). In late Burdigalian start of tropical reef growth and reef-rimmed carbonate platforms progressively coalesced into extensive barrier reef. M Langhian- E Tortonian Browse Basin barrier-reef system >500 km long, possibly extending into N Carnarvon Basin. After E Tortonian reefs smaller and less connected, likely resulting from cooling following the M Miocene Climate Optimum. Final phase of reef decline at ~6 Ma)


(New deep regional seismic data (WestraliaSPAN survey) show NW Australian margin with long history of Phanerozoic extension. North Carnarvon and Bonaparte Basins (Petrel sub-basin) with up to 20 km and 24 km sediment. Models of hyper-extension and/or mantle exhumation required to isostatically provide accommodation space for such deep basins. Progressively higher grade metamorphism at base of sedimentary pile evidenced by reflections that appear sedimentary, but with have seismic velocities of 6 km/s and more)
North Scott Reef and Echuca Shoals. Structures fault-bounded, with gas in Lower to Middle Jurassic sandstones, sealed by U Jurassic and Lower Cretaceous claystones


(Nine dinoflagellate subzones within Tithonian U Dingodinium jurassicum- Pseudoceratium iehiense zones of Helby et al. (1987), in ~300m thick Angel Fm oil reservoir sandstones section. >150 dinoflagellate species. Zircons from ash beds in Wanaea 2 well indicate basal Cretaceous age for P. iehiense- K. wisemaniae zone boundary)

(Three populations of normal faults in Exmouth Subbasin of NW Shelf volcanic margin of Australia: (1) latest-Triassic-M Jurassic N-NNE-trending; (2) Late Jurassic- E Cretaceous NE-trending, and (3) latest-Triassic- E Cretaceous N-NNE faults. Fault displacement during two periods, 210-163 Ma and 145-138 Ma)

(On Quaternary mixed carbonate- siliciclastic sedimentation on 630km-wide Bonaparte Basin shelf, NW Australia)

(Bonaparte Basin unusually wide (~630km) continental shelf where carbonate and siliciclastic sediments accumulated during Late Pliocene- Quaternary (~3.5 Ma BP onwards). Early Australia-Banda Arc collision flexure-induced Neogene deformation shaped very low gradient (< 0.07°) basin in middle of shelf. Two main seismic sequences: (1) aggradate of carbonate platforms in late Pliocene- E Quaternary, followed by (2) phase of reduced carbonate production infill of intrashelf basin with clastic and mixed sediments. Change attributed to onset of 100 kyr-long, large amplitude glacio-eustatic cycles at E-L Quaternary transition)

(online at: www.sciencedirect.com/science/article/pii/S0278434316303375)
(Palaeoshorelines on stable continental shelves around Australia are relict features formed during periods of lower sea level. Well-dated Late Quaternary (0-128 ka) sea-level record indicates most persistent lower sea levels at 30-40m below present (97-116 ka and ~85-10 ka); secondary modal position at 70-90m (during fluctuating sea level between 30-60 ka and ~87 ka). Tectonically stable Australian continental shelf with range of shorelines, potentially useful for targeting sites of human occupation during periods of lower sea level)


(online at: https://digital.library.adelaide.edu.au/dspace/bitstream/2440/103148/4/02whole.pdf)
(Presence of 100-140m thick M Triassic (Ladinian) carbonates in Phoenix 1, 2 and Cossigny 1 wells. Cossigny Mb oolitic-peloid grainstones represent brief marine transgression)

(Creation of N Carnarvon Basin was by multi-stage ductile movement of lower crust, in general northerly direction, from Exmouth Plateau, towards assumed decompression zones S bounding fault of Canning Basin)


(Micropaleo of 5m core from 116m water depth in Bonaparte basin records sealevel trends from ~40-12 ka. Supports ~120m relative sea level drop at Last Glacial Maximum before ~19 ka, followed by rapid marine transgression)


(Angel Fm sand-dominated submarine fan sequence deposited through most of Dampier subbasin. U Jurassic (Tithonian) age and in Wanaea area structureless sandstones interbedded with argillaceous siltstones)


(online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/97JB03295)

(N Carnarvon basin 4 extension events:(1) broadly distributed late Permian event, (2) localized Rhaetian event responsible for inception of Barrow and Dampier subbasins, (3) localized Callovian fault reactivation in Barrow-Dampier subbasins and (4) Tithonian-Valanginian event that generated large post-Valanginian regional subsidence across N Carnarvon basin with only minor brittle deformation and erosional truncation. (4) requires significant lower crustal and mantle extension across N Carnarvon, implying existence of E-dipping, intracrustal detachment with ramp-flat-ramp geometry, effectively thinning lower crust and lithospheric mantle. Detachment breached surface close to continent-ocean boundary W of Exmouth Plateau. Flat component of detachment at mid-crustal depths(~15 km) across plateau and ramped beneath Australian continent. Lower crustal ductile extension viable mechanism to generate large regional subsidence with little upper crustal brittle deformation)


(Exmouth Plateau with >2000m thick nonmarine- marginally marine Triassic section, overlain by thin, marine latest Triassic (Rhaetian)- Jurassic section. Thin Jurassic section overlain by a >1500m thick Berriasian-Valanginian-age clastic wedge that progrades from SE to NW, overlain by thin Hauerivian-Aptian glauconitic sands on shelf. Overlying Aptian-Tertiary section consists of fine-grained deep marine marls)


(E Permian ammonoid fauna of W Australia (Perth, Carnarvon basins) strikingly provincial (tied to Boreal Realm with dominance of Metalegoceratidae and Paragastrioceratidae, and lacking Tethyan Perrinitidae) Late Permian ammonoids tend to be cosmopolitan)


(online at: https://repositories.lib.utexas.edu/handle/2152/22220)

(Interpretation of 3D seismic data over four Plio-Pleistocene flat-topped carbonate platforms on NW Shelf)

Bibliography of Indonesia Geology, New for Ed. 7. 374  www.vangorselslist.com  8/6/18

Haig, D.W. (2018)- Permian (Kungurian) foraminifera from Western Australia described by Walter Parr in 1942: reassessment and additions. Alcheringa, 30p. (in press) (Study of well-preserved late E Permian siliceous agglutinated Foraminifera originally recorded by Parr from Quinnanie Shale and lower Wandagee Fm in Merlinleigh sub-basin of S Carnarvon Basin)

Hill, K.C. & L. Mahoney (2018)- Compressional evolution of the PNG margin from an orogenic transect from Juha to the Sepik. In: Proc. Australian Exploration Geoscience Conf. (AEGC 2018), Sydney, ASEG Extended Abstracts 2018, 1, p. 1-3. (Extended Abstract) (online at: www.publish.csiro.au/ex/pdf/ASEG2018abT5_3A) (Regional restored cross-section across PNG orogenic belt shows Oligocene- Recent compressional deformation of margin. N end of section with Landslip Metamorphics, an accreted continental terrane, separated from main foldbelt by Jurassic April Ultramafics/ Om Metamorphics/ Eocene volcanics, together constituting accretionary prism. Suture overlain by Miocene sediments indicating Oligocene docking prior to E Miocene subsidence, consistent with E Miocene extension in PNG and emplacement of metamorphic core complexes in Sepik area. Neogene compression started at ~12 Ma with shortening of ~12mm/yr from 12-4 Ma, and 1.5mm/yr from 4-0 Ma, consistent with change in structural style in foldbelt from thrust to more ductile, fold-dominated deformation. Etc.)


Hillis, R.R., S.D. Mildren, C.J. Pigram & D.R. Willoughby (1996)- The North West Shelf stress map. PESA News 22, p. 42-47. (NW Shelf stress map, based on analysis of borehole breakouts, indicates direction of maximum contemporary horizontal compression in upper few km of crust. Regional stress direction is consistently oriented ~050° 060°N (SW-NE) from onshore Canning Basin, Bonaparte basin to New Guinea. Between Canning and Carnarvon Basins max orientation swings ~ 40° to 090°-100°N (WNW-ESE.)

Hocking, R.M. (1988)- Regional geology of the northern Carnarvon basin. In: P.G. & R.R. Purcell (eds.) The North West Shelf, Australia, Proc. North West Shelf Symposium, Petroleum Expl. Soc. Australia (PESA), p. 97-114. (Carnarvon Basin of W Australia two distinct parts: (1) southern, onshore, N-trending sub-basins with up to 7km of mainly Paleozoic sediments, and (2) northern, offshore, NE trending sub-basins, up to 15 km deep, with thick Mesozoic and Cenozoic sequences as well as Paleozoic sediments)


Oligocene a strongly prograding carbonate margin established, persisting to present day. Late Miocene-Recent section significant basinward thickening and onlap above N17-1 SB, implying renewed tectonic subsidence associated with collision of Australia and SE Asia in Late Miocene)


(online at: https://geoscienceletters.springeropen.com/articles/10.1186/s40562-016-0065-0

(Bonaparte Gulf of NW Australian continental margin among widest in world (up to 500km), with shallow carbonate terraces and platforms exposed during periods of lower sea level. Switch from siliciclastic to carbonate-dominated sedimentation during last glaciation at ~26 ka, associated with local sea-level fall of -90m)


(Sea-level minimum at Last Glacial Maximum occurred at 20.8 ka and LGM durations shorter than reported)


(Jansz-Is gas field large stratigraphic trap over 2000 km2, with both structural (faulted anticline) and stratigraphic (reservoir pinch-out) components. Stratigraphic component defined by reservoir extent, (depositional downlap to NW and erosional truncation by U Jurassic and Lw Cretaceous unconformities to SE). Original gas in place for Oxfordian sandstone reservoir 11-33 TCF)


(Marine ostracod fauna from limestone cuttings Pearce Mb (497-502 m) of Hyland Bay Fm in Barnett 1 well in SE Petrel basin. Contains Graphiactylyllis formosa and other species known from Late Permian (Kazanian) of Russian Platform. Associated with APP 43 (=Dulhuntyispora dulhuntyi) spore-pollen zone)


(Brief seismic-based review of W Timor Trough. Jurassic sediments missing in wells on Ashmore Platform, but new seismic data indicates thicker Jurassic strata in NE, particularly in Timor Graben)


(online at: http://file.scirp.org/pdf/IJG_2016062913404548.pdf)

(Sahul Platform in N Bonaparte Basin between Timor Trough to N and Malita Graben to S. With Sunset-Loxton Shoals and Chuditch gas fields in M Jurassic Plover Fm sandstone. Hydrocarbons migrated mainly from U Jurassic Frigate Shale source rock in Malita Graben to Sunset-Loxton Shoals field in Late Cretaceous (66 Ma). In Chuditch field hydrocarbon migration initiated in Late Miocene (7.5 Ma) from Plover Fm source rock)


(online at: http://search.ror.unisa.edu.au/media/researcharchive/open/9915960302001831/53112361830001831)

(On causes of apparent vitrinite reflectance suppression in Jurassic-Cretaceous of Barrow- Dampier subbasins)

(Jurassic-Cretaceous formations of predominantly marine origin yield vitrinite reflectance values that are often lower than expected. Two possible explanations: (1) recent increase in thermal gradients occurred; or (2) vitrinite reflectance is suppressed, related to the marine environment of deposition)

(Seismic stratigraphy of basal Cretaceous (Berriasian- E Valanginian) Barrow Delta, S of Barrow island. Large shelf-margin fluvial-deltaic system built out to NE. Eleven 2nd-order sequences, with lowstand, transgressive and highstand systems tracts. Within Sequence 1 higher-order sequences with numerous lowstand system wedges and associated channel features)


(Seismic expression of hydrocarbon leakage across faults from Jurassic reservoirs in Laminaria and Corallina fields)

(U-Pb zircon dating allows direct calibration of palynostratigraphy to numerical time-scale highlights significant inaccuracies in the previous indirect correlation. Top Dulhuntyispora granulata Zone (APP4.1) in Wordian, D. dulhuntyi Zone (APP4.3) exceptionally short, within Wuchiapingian, not E Capitanian; top D. parvithola Zone (APP5) near Permo-Triassic boundary, not in latest Wuchiapingian, etc.)

(Permian palynozone recalibration via zircon dating of volcanic beds. Similar to Laurie et al. 2016))


(Ungani field, discovered in Canning Basin in 2011, with 37°API oil from Tournasian Lower Laurel Fm dolomite reservoirs. Sealed by Laurel Shale(?). Heterogeneous reservoir quality)

(Thermal evolution model of continental lithosphere at paleo-transform margin at SW side of Exmouth Plateau, NW Australia. Up to 3.5 km of sediments eroded from continental rim, decreasing to almost no erosion at 60 km from continent-ocean transform boundary. Surface elevation result of competing (1) thermal uplift, (2) surface erosion and (3) local isostatic rebound in response to erosion. Most erosion ceases by 40 Myrs after ridge emplacement and ~1000 km3 sediments eroded for every 10 km of transform length)

(Prograding 'lava delta' complex interpreted from seismic within Triassic of Roebuck Basin (offshore Canning), under Huntsman 1 well. Steeply dipping clinoforms show NW to SE progradation. Volcanic package up to 10 km thick, with pronounced magnetic anomaly. Within bigger scale rift complex, probably E-M Triassic magma plume that initiated triple junction at NW end of Canning basin/ Argo abyssal plain. Lavas possible source of Triassic zircons in Mungaroo Fm?)


(Paleozoic fault system of N Carnarvon Basin complex interaction of N to NE trending faults This older rift architecture affected geometry of subsequent U Triassic - M Jurassic deformation (initiated in Rhaetian, but most significant in E Jurassic))

Muller, R.D., S. Dyksterhuis & P. Rey (2012)- Australian paleo-stress fields and tectonic reactivation over the past 100 Ma. Australian J. Earth Sci. 59, 1, p. 13-28. (Changes in stress regime of Australian continent through time can be modelled by changing geometry and forces acting along boundaries of Indo-Australia and Paleo-Australian plate since E Cretaceous. Intraplate structural events may be caused by interaction of far field stress field with heterogeneous geology of Australia. Some intraplate suture zones of Australian continent particularly weak, i.e. faulted portions of NW Shelf and Flinders Ranges, which reactivated when favourable stress regimes existed)

(Ungan and Yulleroo fields oils derived from Carboniferous source. Maximum burial and oil generation/ expulsion in basin immediately prior to Fitzroy Uplift around 200 Ma)


(Carboniferous- Recent biozonations and stratigraphic columns of Browse Basin (Ashmore Platform, Brecknock- Scott Reef trend, Caswell-Barcoo subbasin, Prudhoe Terrace and Yampi/ Leveque Shelf (also 2016 edition?))


(Four Mesozoic petroleum systems identified in Caswell sub-basin. Source rocks in subbasin sufficient maturities to have transformed most of kerogen into hydrocarbons, with most expulsion from Late Cretaceous- Present. In Barcoo Sub-basin only source rocks within the J10-J20 supersequences sufficient maturity for generation. Predominantly gas-prone kerogen in Jurassic-Cretaceous)


(Major Carboniferous-Permian intra-continental rift in approximate locations of Jurassic-Cretaceous rift margin that separated Australia from various Asian terranes and India. Intracontinental rift structurally modified by later M Permian extension. Shallow marine conditions persisted across conjugate margin through Triassic and into Jurassic. With S to N back-stepping Late Permian carbonate ramps. With 300Ma plate restoration)


(E Cretaceous Barrow Group of offshore N Carnarvon Basin was major deltaic system, formed during late stages of continental rifting. Three major depocenters: Exmouth and Barrow subbasins and S Exmouth Plateau. Overcompaction of pre-Cretaceous sediments in S Carnarvon Basin and pervasive reworking of Permian and Triassic palynomorphs in Barrow Group, suggests onshore S Carnarvon Basin originally contained thicker sedimentary succession that was uplifted and eroded prior to breakup. Anomalously rapid tectonic subsidence during Barrow Gp deposition, despite minimal contemporaneous upper crustal extension, suggests period of depth-dependent extension or dynamic topography preceding breakup)

(Exmouth Plateau commonly perceived to be gas-prone province (giant gas fields at Scarborough, Jansz, Gorgon, etc.). N Exmouth plateau still significant resource potential)


(Miocene of Browse Basin with one of largest Neogene tropical paleo-barrier reef systems. M-L Miocene carbonate slope with multiple channel and channel-levee complexes. Mature stage larger channel-systems 12-20km long, with 150-200m incision depth. Some channels with levee complexes up to 850m wide)


(online at: http://www.publish.csiro.au/EX/ASEG2018abM2_2B)

(Exmouth Plateau of N Carnarvon Basin, NW Australia, multi-phase extensional history. Initially formed as basin during Permo-Carboniferous rift event that thinned crust and led to large volumes of Triassic sediment accumulation. Fault activity of second rift phase began in latest Triassic, mainly on NNE-SSW and NE-SW trending faults. Rotation of Triassic fault blocks continued in Jurassic, with erosion of pre-rift sediments. Latest Jurassic infilled of large grabens and deposition onto highs limited in W as area was starved of sediment. E Cretaceous progradation of Barrow Delta resulted in infilling of previously starved large grabens)


(Browse Basin with large gas-condensate accumulations and small light oil accumulations mostly in Cretaceous. Large undeveloped gas resources (41 TCF), development of Ichthys and Prelude fields. Seven supersequences from late Tithonian-Maastrichtian (K10-K60))


(online at: www.publish.csiro.au/ex/pdf//ASEG2018abM1_3B)

(Review of sequence stratigraphy of J10-J20 (Plover Fm) and J30-J50+ K10 (Vulcan Fm) supersequences, and paleogeography of Browse Basin. Large gas-condensate fields along Scott Reef Trend (Calliance, Brecknock, Torosa), in C and NW Caswell subbasin (Ichthys, Prelude, Crown, Proteus, Lasseter), and in Crux field in Heywood Graben, sourced from multiple horizons in Jurassic- basal Cretaceous)


(Browse Basin hosts large gas accumulations. Drilling focused in C Caswell Sub-basin (Ichthys, Prelude), and Brecknock-Scott Reef Trend. New sequence stratigraphy of Cretaceous succession and structural framework. Complex charge history, with fluids from multiple Mesozoic source rocks (Lw- M Jurassic J10-J20, Plover Fm), U Jurassic- lowermost Cretaceous J30-K10, Vulcan Fm) and Lower Cretaceous K20-K30, Echuca Shoals Fm))

Smith, B.L. & R.B. Lawrence (1989)- Aspects of exploration, development of Vulcan sub-basin, Timor Sea. Oil and Gas J. 87, p. 44; 33-46


(T)Primary architecture of Browse Basin of Australian NW Shelf largely result of NE-SW ?Late Devonian- E Carboniferous intra-cratic upper crustal extension, and NW-N-oriented M Carboniferous- E Permian full-lithosphere extension. Up to 11 km of sediment fill. During extension, crust beneath Browse thinned from 35 km to 10km by removal and stretching of upper and lower crust, leaving mid-crust largely intact. Later deformation events: Late Permian- E Triassic (Bedout Movement), M-L Triassic, and Late Triassic- E Jurassic (Fitzroy Movement) inversion events, post-breakup (Callovian-Oxfordian) margin sag, and ?Late Miocene transpressional anteclines in some areas)


(E Carboniferous Tournaisian Dolomite reservoir in Ungani field on S flank of Fitzroy Trough. Fractured and bioclastic-rich with ‘reefal’ organisms, but with pervasive dolomitisation. Shallow-moderate burial and marine or evaporative reflux fluids likely responsible for pervasive dolomitisisation. Subsequent leaching of calcite)

(Major review of evolution of NW Shelf of Australia, a major Mesozoic gas province with minor oily sweet spots. Since exploration drilling started in 1953, 754 exploration wells drilled (Dec 2001), discovering 2.6 billion bbls of oil, 2.6 billion bbls of condensate and 152 TCF gas in 233 fields. Most of traps sands in rift-related horsts and tilted blocks, or sands in overlying drape structures. 97% of resources reservoired under dominantly Cretaceous regional seal. Same as Longley et al. 2002)

(Perseus Field giant gas accumulation, in structural/stratigraphic trap on Rankin Trend. Gas reservoired in Bathonian- Callovian deltaic sandstones of Legendre Formation, which subcrop U Jurassic-Lower Cretaceous Main Unconformity in graben between Goodwyn and North Rankin horsts. Six third-order sequences within W. digitata, W. indotata and C. halosa dinoflagellate zones)

(N Carnarvon Basin rift-dominated basin, with five phases of extension (Pre-Top Permian, Top Permian, Base Jurassic, Middle Jurassic, and Late Jurassic) and the Base Cretaceous inversion. Magnitude of rift phases increased during M and Late Jurassic extension)


Tovaglieri, F. & A.D. George (2014)- Stratigraphic architecture of an Early-Middle Jurassic tidally influenced deltaic system (Plover Formation), Browse Basin, Australian North West Shelf. Marine Petroleum Geol. 49, p. 59-83. (Stratigraphic architecture and evolution of major E-M Jurassic fluvio-deltaic system (Plover Fm). Five 3rd-order sequences record progradational (S1, S2 and S4) and retrogradational (S3 and S5) phases of delta evolution. Common S-directed sediment dispersal in S2 and S3 and increasingly complex with W-directions in S4 and S5. Two rift-related depositional phases separated by phase of uplift between S3- S4. See also corrigendum in Vol. 54, p. 139-140)

Tyler, I.M., R.M. Hocking & P.W. Haines (2012)- Geological evolution of the Kimberley region of Western Australia. Episodes 35, 1, p. 298-306.  (online at: www.episodes.org/index.php/epi/article/viewFile/59916/46873)  (History of Kimberley cratonic region in NW Australia began in Paleo(protero)zoic with rifting along N Australian Craton margin at 1910-1880 Ma, followed by plate collision as part of 1870-1790 Ma events that formed Diamantina Craton within supercontinent Nuna (Hooper Orogeny, Halls Creek Orogeny, etc.))


(Late Jurassic extensional structuring in Vulcan sub-basin (between Browse and Bonaparte) at or immediately after time of continental breakup to W. Deep salt layer (Silurian-Devonian?) may act as detachment surface. Salt-related detachment explains nature of deep grabens at Swan and Paqualin and also occurrence of salt diapirs in these grabens (627m in Paqualin 1 well, Swan diapir). Renewed normal faulting, tied to Timor collision, began in Late Miocene, peaking in Pliocene, not active today)


(U Jurassic syn-rift sediments in Barrow-Dampier Basin subdivided into nine depositional sequences. Sequence boundary development related to tectonically-induced changes in basin architecture, associated with continental break-up of E Gondwanaland. Callovian-Oxfordian deposition whilst Barrow and Dampier were two separate sub-basins separated by intra-basinal arch; Kimmeridgian-Tithonian deposits more widespread)


(Onshore Canning Basin (W Australia) history began in E Ordovician ands largely completed by E Cretaceous. Up to M Triassic sedimentation in NW-trending depocenters; Jurassic-Cretaceous sequence relates to break-up of Gondwanaland, and global E Cretaceous rise in sea level)


(Gorgon Platform on SE edge of Exmouth Plateau in N Carnarvon Basin. Four major sets of extensional faults, controlled by three different extensional events in E-M Jurassic, Late Jurassic and E Cretaceous, all creating unconformities)
IX.16. NE Australia margin ('Tasmanides') (20)

(Decollements and resultant structures likely developed in response to mild contraction of E- C Bowen Basin synclinal depositional system during last phase of Permian-Triassic Hunter-Bowen orogeny)

(Duaringa Basin in E Central Queensland is Late Cretaceous? - Paleogene basin (with M-L Eocene oil shales) that developed simultaneously with opening of Tasman and Coral Seas. Basin overlies Permian-Triassic fold-thrust belt. NNW-striking, NE-dipping Duaringa main boundary fault probably inversion of Triassic thrust)

(Extensive oil shale deposits in Cenozoic Duaringa Basin of C Queensland. NNW-trending, 180 x 20km half-graben, superimposed on deformed E margin of Permo-Triassic Bowen Basin. Up to 1300m of flat-lying fluvio-lacustrine sediments, with oil shale of M-L Eocene age in two near-surface seams (Rundle and Stuart oil shale deposits) (see also Pope 2000))

(online at: https://d28r98at9flks.cloudfront.net/61747/Rec2005_004.pdf)  
(In Late Cretaceous Kenn Plateau was part of Maryborough Basin to W and Capricorn Basin to N. It separated from Australia in earliest Paleocene- M Eocene by moving NE along Cato Fault Zone and rotating 45° CCW).

(Texas Orocline in S New England Orogen of E Australia nucleated during subduction of seamount chain, resulting in orogenic curvature of Carboniferous subduction complex. Subduction of seamount chain shown by abundant limestone associated with ocean island basalts amongst accreted turbidites in core of orocline)


(In E Central Queensland series of small E Paleogene rift basins with M-L Eocene lacustrine oil shale deposits. Petrography of oil shales in Lowmead and Duaringa Basins)

(Review of non-collisional, convergent margin orogens, commonly called accretionary orogens. Along margin of Australian Plate, Papua New Guinea accretionary orogen, SW Pacific Orogen, Tasmanides (Lachlan Orogen, outboard New England Orogen), etc. All non-collisional orogens involve continental growth, but only New England Orogen and to lesser extent New Guinea Orogen involve significant crustal growth)


(Capel and Faust basins at NE margin of Tasman oceanic basin, between E Australia and New Caledonia at water depths of 1300-2500m. New data acquired by Geoscience Australia)


(Mellish Rise, E of Queensland Plateau, buoyant block of continental crust in SW Pacific, in water depths ~1500-2900m. Paleocene-Quaternary sediments in dredge samples. Common manganese crusts and nodules. Late Eocene tropical larger foram Biplanispira in dredge sample first in Australasian waters (but not figured))


(Earliest deformation of Gympie Terrane of E Australia during final pulse of Permian-Triassic Hunter-Bowen orogenesis (235-230 Ma; ~ Carnian). No evidence for crustal suture, suggesting terrane accretion not main mechanism behind deformation. Gondwanide Orogeny more likely linked to plate-reorganization)


(online at: https://www.geo.umass.edu/faculty/leckie/John%202011%20EPSL%20Marion%20SL.pdf)

(Marion Plateau carbonate platform 8 sequences (18.0, 17.2, 16.5, 15.4, 14.7, 13.9, 13.0, 11.9 Ma), controlled by glacio-eustasy as demonstrated by increases in δ18O (= deep-sea Miocene isotope events Mi1b, Mi1-3, Mi2, Mi2a, Mi3a, Mi3, Mi4, and Mi5), reflecting increased ice volumes primarily on Antarctica. Backstripping estimates combined with δ18O estimates yields sea-level fall amplitudes of 27m at 16.5 and at 15.4 Ma, 33m at 14.7 Ma, 59+6 m at 13.9 Ma. Sea-level fell by 53-69 m between 16.5-13.9 Ma. Implies >90% of E Antarctic Ice sheet formed during M Miocene)


(online at: http://ro.uow.edu.au/theses/1110)

(Analyses of M-L Eocene lacustrine oil shales of upper and lower seams of Duaringa deposit, Queensland. Telalginite (torbanite) with common green algae Botryococcus, Tasmanites and Gloeocapsomorpha; lamalginite (lamosites) mainly with planktonic Pediastrum; lamalginite (lamosite) mainly with planktonic Pediastrum


(online at: https://web.anl.gov/PCS/acsfuel/preprint%20archive/Files/28_3_SEATTLE_03-83_0010.pdf)

(Duaringa Tertiary basin in NE Queensland E Tertiary rift basin, related to Tasman Sea-Coral Sea rifting. With algal-rich lacustrine oil shales (lamosites). Highest grade in Rundle deposits; 25-161m thick (see also Dixon 1987)


(online at: https://eprints.qut.edu.au/16145/1/Graham_Pope_Thesis.pdf)

(M-L Eocene lacustrine oil shales of Stuart deposit in Rundle Fm of Duaringa half-graben, C Queensland coast)


(At ~100 Ma E Gondwana cordillera started oceanward gravitational collapse, until opening of Tasman Sea from ~90 to 52 Ma. Collapse of cordilleran orogens, marginal basin opening and detachment of micro-
continents often considered consequence of slab rollback, but along E Gondwana margin Late Cretaceous change in plate motion probably caused switch from contractional to extensional tectonics)

Shaanan, U. & G. Rosenbaum (2018)- Detrital zircons as palaeodrainage indicators: insights into southeastern Gondwana from Permian basins in eastern Australia. Basin Research 30, Suppl. 1, p. 36-47. (U-Pb ages from detrital zircon grains from E Permian sediments (~290-297 Ma) in southern New England Orogen. Over 80% of ages Late Carboniferous, from adjacent forearc sediments. Pre-Devonian detritus from SE Gondwanan craton, with peaks of 2000-1500 Ma, 1200-900 Ma (Grenvillian) and. 620-480 Ma)


X. PALEONTOLOGY, BIOSTRATIGRAPHY (483)

X.1. Quaternary-Recent faunas-microfloras and distribution (115)


(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/205/195)

(‘Foraminifera from waters off Balikpapan, East Kalimantan: depositional environment and its effects’. 195 benthic and 34 planktonic foraminifera species in Makassar Straits seafloor samples off Balikpapan, between 18-562m depth. Asterorotalia trispinosa dominant around 20m, Heterolepa praecincta most abundant from ~50-300m, Karreriella brady and Uvigerina spp. common only >300m, etc. Cycloclypeus only at 71 and 83m. Abundant planktonic foraminifera Neogloboquadrina dutertrei below 100m, indicating rel. low salinity.)


(online at: https://journal.ugm.ac.id/index.php/jag/article/viewFile/7232/5672)

(‘Deposits of July 26 tsunami at Pangandaran Beach, W Java. Mainly f-m sand, ~10-12cm thick, separated from older beach sediment by erosional surface. Sedimentary structures parallel lamination and current ripples. No vertical fining trends. With transported shallow and deeper marine benthic foraminifera, incl. Ammonia, Elphidium, Amphistegina, Cibicides sp., Biginerina, Bolivina, Bathysiphon, Nodosaria and Quinqueloculina’)

Anderson, J.A.R. (1963)- The flora of the peat swamp forests of Sarawak and Brunei, including a catalogue of all recorded species of flowering plants, ferns and fern allies. Singapore Gardens Bull. 20, p. 131-228.

(All modern coastal and deltaic peat swamps of N Borneo raised bog type. 243 plant/tree species, in 6 communities: 1) Mixed swamp forest, 2) Alan forest, 3) Alan bunga forest, 4) High pole forest, 5) Low pole forest, 6) Padang kerumut)


(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/115/105)

(‘Seafloor sediment samples of 1-78m in Sepi-Blongas Bay, S Lombok, with 133 foraminiferal species, mainly Ammonia beccarii, Elphidium crispum, Patelina, Amphistegina lessonii, Calcarina, Pyrgo, Quinqueloculina, etc.. Genus Calcaria with 15 species (?)’)


(Eight species of soriitids, incl. Marginopora vertebralis)

(online at: http://popups.ulg.ac.be/0037-9395/index.php?id=5368&file=1&pid=5366)


(Dinoflagellate symbionts and an orbitoidal chamber arrangement in foraminifera linked to exposed reefs and hard substrate, whereas rhodophyte symbionts linked to sheltered reefs and sandy substrate. Etc.)


('Recent facies of the eastern platform of Kalimantan and the micropaleontological content (benthic foraminifera)'


(Larger foraminifera Baculogypsina sphaerulata, Marginopora and Amphistegina contribute 55% of calcareous sediment produced on Raine Island reef)


(Variable and often chaotic diatom assemblages can be attributed to tsunami waves incorporating and depositing diatoms from intertidal and offshore habitats during runup and subsequent backwash. Tsunami sand deposits have high % of broken diatom valves and dominance of centric (circular) species)


(online at: ejournal.mgi.esdm.go.id/index.php/bomg/article/download/60/61)

(43 species of ostracods from 3 short seafloor cores of Sunda Shelf, in water depth 11-27m. Highest abundance/diversity in upper 70 cm of cores. Main genera Actinocythereis, Hemicytheridea, Loxoconcha, Neocytheretta, Stigmatocythere, Neomonomeratina, Phycostenophora, Argillloecia, etc. (see also Mostafawi 1992))


(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/333/263)

('Ostracoda as indicators of marine environmental changes off the Tarahan power plant, Lampung Bay, Sumatera'. Ostracods from surface sediments in Lampung Bay quite diverse and abundant, with 27 genera, dominated by Keijella, Hemicytheridea and Cytherella. Also locally abundant Bairdopillata)


(online at: ejournal.mgi.esdm.go.id/index.php/bomg/article/download/1/1)

(Microfauna in seafloor samples in 14-43m deep water off Nunukan and Sebatik islands in NE Kalimantan with typical microfauna of shallow marine ostracoda (Hemicytheridea spp., Keijella spp., Cytherella) and foraminifera (Asterorotalia trispinosa, Operculina))


('Spatial distribution of foraminifera in relation to water depth and sediment types in Bone Bay, S Sulawesi'.
Foraminifera from 23-85m water depth in N Bone Bay mainly Operculina spp., Heterolepa, Pseudorotalia. Absence of 'Sunda species' Asterorotalia trispinosa)


(online at: www.ukm.my/jsm/pdf_files/SM-PDF-45-5-2016/02%20Noraswana%20.pdf)
('The distribution and diversity of benthic Foraminifera in surface sediment of Pahang River Delta, Pahang, Malaysia'. 82 species of Recent benthic foraminifera offshore Pahang River delta. Amphistegina lessonii and A. gibbosa most abundant, followed by Elphidium advenum, Operculina ammonoides and Asterorotalia pulchella. No specifics on water depth of samples or detailed distribution)

(online at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0145752
(380 species of shallow benthic foraminifera from around Moorea)

(online at: http://journal.unpad.ac.id/bsc/article/view/8292/3839)
(Vertical distribution of ostracods and relationship with environmental changes in Jakarta Bay waters'. Similar to Fauzielly et al. (2012), below)

(online at: http://repository.unpad.ac.id/21772/1/Distribusi-foraminifera-bentonik-sedimen...)
('The distribution of benthic foraminifera in sedimentary paleo-tsunami eruption of Krakatoa based on data from core U-6 in the Ujungkulon area, Banten'. Marine microfossils in onland sediments may indicate paleo- tsunami deposits. Sand with coral debris at 90-120cm in core from Ujung Kulon recognized as tsunami deposit. With 55 species of benthic foraminifera, dominated by Streblus beccarii, Planulina wuellerstorfi, Hyalinea balthica, Bulimina marginata, Bolivina spathulata, Elphidium, Uvigerina peregrina Cushman. Origin of tsunami sediments is (outer) shelf-bathyal and inner shelf lagoon)

(Recent foraminifera from seafloor samples across Andaman Sea, between 13-3778m depth. Number of forams increases with depth to 1800m; below this affected by dissolution of calcareous foraminifera. Planktonic number increases with depth and distance from shore. Planktonic assemblages from shelf sediments have globose chambers (Globigerina, Globigerinoides, Globigerinita); in bathyal deposits also common Globorotalia and Sphaeroidinella. Radiolarian number increases with depth; not significant above middle bathyal depths. Benthic foraminifera five faunal provinces. Etc.)

(Reef-flat foraminiferal assemblages characterized by dominant Calcarinidae, whereas fore-reef foraminiferal assemblages are characterized by various dominant species)


Gorog, A.J., M.H. Sinaga & M.D. Engstrom (2004)- Vicariance or dispersal? Historical biogeography of three Sunda shelf murine rodents (*Maxomys surifer*, *Leopoldamys sabanus* and *Maxomys whiteheadi*). Biological J. Linnean Society 81, p. 91-109. (online at: https://academic.oup.com/biolinnean/article/81/1/91/2639894) (DNA tests of three rain-forest-restricted murine rodents of Borneo, Sumatra, Java, Malay Peninsula and Indochina do not support hypothesis of migrations enabled by Late Pleistocene land bridges/ rainforest corridors, but suggest older history of divergent evolution since Pliocene fragmentation of Sunda block)

Grand Pre, C.A. (2011)- The application of macro- and microfossils to identify paleoearthquakes in Sumatra, Indonesia and to characterize geomorphic and ecological succession on a marsh platform after Hurricane Isabel in North Carolina, USA. Ph.D. Thesis University of Pennsylvania, p. 1-179. (Study of Early Holocene coseismic subsidence in Aceh. Buried mangrove soil horizons overlain with sharp contact by 5-20 cm thick sand that tapered landward, with intertidal and shallow marine foraminifera (*Ammonia, Asterorotalia, Pararotalia, Quinqueloculina, etc.*) and probably tsunami deposit. Sands overlain by 1-3 m of silty clay with at base common *Cerithidea cingulata*, an opportunistic intertidal gastropod)

Gremmen, W.H.E. (1987)- Palynological evidence from Quaternary sediments in southeast Asia, a review. Palaeohistoria 29, p. 77-84 (online at: http://nopr.niscair.res.in/bitstream/123456789/39098/1/IJMS%2010(3)%20293.pdf) (DNA tests of three rain-forest-restricted murine rodents of Borneo, Sumatra, Java, Malay Peninsula and Indochina do not support hypothesis of migrations enabled by Late Pleistocene land bridges/ rainforest corridors, but suggest older history of divergent evolution since Pliocene fragmentation of Sunda block)


(20%) of cosmopolitan deep-sea benthic foraminifera extinct during late Pliocene-M Pleistocene, with peak of extinctions during M Pleistocene Climate Transition (1.2-0.55 Ma). Family Stilostomellidae (30 species) wiped out, Pleurostomellidae (9 species) decimated. Pulsed declines in abundance, earlier in deep sea water sites. Tied to demise of microbial food source due to increased cold and oxygenation of S-sourced deep water masses during major late Pliocene and E Pleistocene glacials)


(online at: http://ejournal.mgi.esdm.go.id/index.php/bomg/article/view/313/277)

(4m thick Quaternary clay sediment core BS36 in S Andaman Sea (Mergui-N Sumatra Basin). With 11 genera of calcareous nannofossils, dominated by Gephyrocapsa, Emiliania, and Helicosphaera)


(Good review of depth distribution of modern larger foraminifera, mainly in W Pacific)


(online at: http://nopr.niscair.res.in/bitstream/123456789/68/1/IJMS%2036(4)%20(2007)%20369-377.pdf)


(online at: www.iisc.ernet.in/currsci/dec252006/1655.pdf)

(Diverse marine foraminifera and ostracods from likely tsunami deposits on Andaman Islands. Common Amphistegina, Operculina ammonoides, Calcarina, Textularia, Ammonia, etc. Also deeper marine elements)


(Presence of marine ostracods in 2004 coastal tsunami deposits)


(Unpublished)

('Biostratigraphy and palaeoecology based on nannoplankton and foraminifera in the Madura waters from Pliocene to Recent'. 10 biozones in waters S of Madura. Climate trends: warm conditions characterized by nannoplankton Discoaster quinqueramus and foramin Globorotalia tumida)

('Characteristics and microorganisms of seafloor sediments north of Madura'. Clay and silt seafloor samples in water depths 5-77m with 20 nannoplankton species (mainly Emiliania huxleyi, Gephyrocapsa oceanica), 30 planktonic forams species (mainly Globigerinoides ruber) and 16 benthic foraminifera species (common Ammonia, Quinqueloculina, Eponides, Triloculina, Asterorotalia, Cibicides, Cancris, Êlphidium, Textularia). Pseudorotalia, Cibicides and Anomalinella more abundant in N, away from coast. Abundance and diversity increase with depth. Gephyrocapsa mainly in samples closest to shoreline)


(Foram distribution in 18 samples from water depth 29-74m in N Gulf of Thailand >99% benthics (83% calcareous). Common Asterorotalia pulchella, Cellanthus craticulatus, Elphidium, Pseudorotalia spp., Quinqueloculina, Textularia, etc.)


(Brackish water foraminifera from five provinces along Gulf of Thailand 53 benthic species. Low salinity facies with Ammobaculites, Ammotium cassis, Arenoparella, Miliammina fusca and Trochammina. Higher salinity assemblages with more calcareous forms Elphidium, Pararotalia nipponica))


(92 species of brackish foraminifera in estuaries and coastal zones along Andaman Sea. Arenaceous taxa Arenoparella mexicana, Haplophragmoides, Miliammina fusca and Trochammina dominant in mangrove forests; calcareous taxa Ammonia beccarii, Elphidium and Pararotalia nipponica dominant in coastal areas)


(Late Pliocene- M Pleistocene decline and extinction of 63 species of elongate, bathyal-upper abyssal benthic foraminifera (Stilostomellidae, Pleurostomellidae, some Nodosariidae). Two Indian Ocean ODP sites show pulsed declines in Extinction Group abundance and richness, especially in glacial periods, with partial recoveries in interglacials. Glacial declines result of increased production of colder, well-ventilated Antarctic Bottom Water and Glacial Northern Atlantic Intermediate Water)


(late Pleistocene- Recent calcareous nannofossils from 13m thick core KL139 in ~2700m water depth of Sabah Trough. Emiliania huxleyi, Gephyrocapsa oceanica and 'small Gephyrocapsa' >50% of total assemblages. Four zones: deeper zone C (Late Pleistocene Last Glacial Maximum?) with peak 'small Gephyrocapsa' represents rel. cool period, youngest zone A with peak G. oceanica rel. warm)

Lei, Y. & T. Li (2016)- Atlas of benthic foraminifera from China Seas, the Bohai Sea and the Yellow Sea. IUP Science Press, Beijing, Springer, p. 1-399. (Descriptions of 183 species of mainly shallow marine foraminifera from northeen South China Sea)
(online at: http://digitallibrary.usc.edu/edm/ref/collection/p15799coll30/id/107855)
(Mainly on distribution of Baculogypsina and Tinopor us in western tropical Pacific)

(Cores from upper Mekong River delta in Cambodia record transgressive sequence from floodplain freshwater marsh to tidal flat (~9.4-6.3 ka), overlain by mangrove. At decelerated sea-level rise at ~8.3 ka pioneer (high-salinity tolerant) mangrove species Sonneratia alba and Sonneratia caseolaris appeared, then was replaced by regressive mangrove succession of increasing Rhizophora apiculata and Bruguiera spp.)

(online at: http://repository.naturalis.nl/document/565696)
(Quaternary Ulmus pollen present in Pua Bulok swamp in N Sumatra. Ulmus not necessarily indicator for seasonal dryness)

(Pollen analysis and 14C sequences from two Sumatra highland sites, Pea Bullok (Toba Plateau) and Danau di-Atas, spanning last glacial period. Strong indications of extensive forest clearance after ~2 ka)

(Taxonomy of 133 benthic foraminifera species from Heron Island, One Tree Island, Wistari and Sykes Reefs)

(Pyroclastic materials from 1991 eruption of Mt Pinatubo resulted in decimation of most benthic foraminifera in E South China Sea. Samples above eruption layers in deep water cores much lower abundances, lower diversity and relative common of Quinqueloculina spp., probably form part of recolonization fauna)

Martin, S.Q. (2016)- Distribution and taxonomy of modern benthic foraminifera of the western Sunda Shelf (South China Sea) off Peninsular Malaysia. Masters Thesis, East Carolina University, p. 1-
(Distribution and taxonomy of 125 modern benthic foraminifera species from 54 seafloor samples in southern S China Sea, between 8-60m. Main assemblages across Sunda Shelf: (1) nearshore areas (<40m) dominated by symbiont-bearing Amphistegina lessonii, A. radiata; (2) inner shelf (40-100m), sandy mud substrates and abundant Heterolepa. dutemplei; (3) outer shelf (100-200m), muddy substrates and Uvigerina schwageri)


(Modern subtidal benthic foraminifera on E coast of Johor 279 species, dominated by Asterorotalia pulchella (= A. tripinosa), Discorbinella bertheloti, Pseudorotalia indopacifica, Ammonia and Cavarotalia annectens. Agglutinated species Textularia pseudosolita, T. agglutinans, Bigenerina nodosaria and T. foliacea in middle-shelf (>20m), calcareous genera Elphidium, Pararotalia and Ammonia in inner-shelf (<20m))


*(Chagos Archipelago in C Indian Ocean close to the equator. Relatively high energy conditions in shallow waters around reefs. On oceanic side of atoll reefs Amphistegina lessonii dominant, with minor miliolids and up to 20% planktonics. Lagoon assemblages dominated by Calcarina calcar, with minor miliolids)*


*(28 species of tropical marginal- shallow marine benthic foraminifera around South Andaman Island)*

Muruganantham, M., P. Ragaven & P.M. Mohan (2017)- Diversity and distribution of living larger foraminifera from coral reef environments, South Andaman Islands, India. J. Foraminiferal Research 47, 3 p. 252-257. *(Larger foraminifera at six reef sites (4-30 m) around South Andaman Islands 16 species, incl. Amphistegina lessonii, A. radiata and Calcarina spengleri)*


*(Recent tsunami deposit from Pangandaran with Ammonia, Elphidium, Amphistegina, Cibicide, Biggerina. Bolivina, Bathysiphon, Nodosaria and Quinqueloculina, suggesting source from shallow to deep marine environments. Recent tsunami sediments at Parangendog Beach with Ammonia beccarii and Elphidium advenum, suggesting sediments came from lagoonal to shallow marine environment)*


*(Brief review of Quaternary (displaced) spores-pollen studies in marine environments in Indonesia)*


*(online at: http://jurnal.unpad.ac.id/bsc/article/view/8364/3885)*

*(‘Determination of small benthic foraminifera species dominant in the waters of Semarang, C Java Province’. Foraminifera in 20 samples from 38-54m in Java Sea N of Semarang dominated by Heterolepa (36%), Anomalina, Ammonia spp. (12%), Pseudorotalia, Quinqueloculina spp. (9%) and Asterorotalia trispinosa(6%)’)*


*(‘Distribution of benthic foraminifera in Aceh waters’. Shallow marine foraminifera distribution off NW tip of Sumatra, in water depths of 7-170m. 45 species of benthic foraminifera, dominated by Amphistegina papillosa. Ammonia tepida dominant in N part of Weh island)*

(online at: https://d-nb.info/1113875569/34)
(Collection of papers/ manuscripts of palynological studies in four shallow cores in Holocene deposits in Java Sea off NE Java (Solo River) and S Kalimantan (off Jelai and Pembuang rivers))

((A 134-cm-long sediment core from ~50 km off Pembuang River mouth, S Kalimantan. Mixed terrestrial and marine organic matter, with low pollen-spore concentrations. Dinoflagellate cysts mainly Operculodinium and Spiniferites with minor Impagidinium (mainly I. striatum). After ca. 2480 cal yr BP, bottom waters became increasingly ventilated. After 1530 cal yr BP, more pronounced influence of Pembuang River indicated by nutrient-sensitive Lingulodinium machaerophorum and Nematosphaeropsis labyrinthus)

(S Andaman Island three distinct environments: rocky shore with Elpidium, Amphistegina; (2) sandy shore with common Calcarina and (3) intertidal muddy region with Tromschammina inflata is common in intertidal clays)

(Throughout last glacial cycle, region between Australia and New Guinea (now Gulf of Carpentaria) oscillated from open shallow marine conditions to freshwater lake behind Arafura sill. Six ostracod biofacies in last 130 ka: (1) open shallow marine with bairdids, pectocytherinids, cytherettids; (2) shallow marine dominated by Cytherella and Hemikrithe; (3) marginal marine with Xestoleberis and Praemunita; (4) tidal channel dominated by Loxoconcha; (5) estuarine with Venericythere and Leptocythere; (6) non-marine facies: brackish lagoon/lake dominated by Cyprideis and Leptocythere and freshwater with Ilyocypris, Cyprinotus and Cypretta. Also morphological variations within species tied to paleoenvironments)


(online at: http://onlinelibrary.wiley.com/doi/10.1029/2012PA002299/epdf)
(Late Pleistocene diatoms in core GeoB10038-4 off S Sumatra show highest paleoproductivity during interglacials, due to nutrient input after rise in sea level. In Marine Isotope Stage 5 response of diatom productivity and upwelling intensity to boreal summer insolation. Resting spores of Chaetoceros, typical of nutrient-rich waters, dominant during periods of highest diatom paleoproductivity)

(online at: http://scienceasia.org/2008.34.n2/scias34_137.pdf)

(On many ‘varieties’ of Lagena vulgaris (incl. Oolina) from seafloor samples at 1080 fathoms, 10 miles S of ‘Sandalwood Island’ (= probably Sumba, but lat-long closer to South Bali; unlikely from Java Sea). Many now viewed as species. Associated with common Rotalia, Uvigerina, Bulimina, Globigerina, diatoms, ostracods, sponge needles, etc.)
(In samples from continental shelf and slope of W Bay of Bengal Asterorotalia trispinosa abundance ranges from 0-31%, with highest abundance near outfall region of Ganges-Brahmaputra Rivers and decreases away from river mouths. Abundance of A. trispinosa indicates warmer and marginally hypersaline environment)

(28 foramin species in mangrove surface sediment on W coast of Malay Peninsula. Calcareous forms mainly Ammonia beccarii and Buccella frigida. Agglutinated species mainly Arenoparrella and Haplophragmoides)

(Diatom assemblages in fining-upward m-f sandy deposits of 2004 tsunami at Phra Thong Island, Thailand: (1) lowermost sand mainly unbroken beach and subtidal species that live attached to sand grains; (2) shift to marine planktonic species in middle of the bed and (3) mix of freshwater, brackish, and marine species near top. Trends are consistent with expected changes in current velocities of tsunami through time)

(online at: https://www.j-micropalaeontol.net/14/165/1995/jm-14-165-1995.pdf)  
(Deep water Late Pliocene- Pleistocene benthic foraminifera from Sonne cruise SO67 core on Manihiki Plateau in SW Tropical Pacific (2612m water depth). Dominated by Nodogenerina, Cibicidoides wuellerstorfi, Oridorsalis umberatus, Pleurostomella, Dentalina, etc. Remarkable absence of 'high-productivity taxa' Bolivina, Bulimina, Chilostomella and Uvigerina, suggesting low flux of organic matter to sea floor)

(Distribution of oceanic diatoms in W Philippine Basin. Ethmodiscus rex dominant species. 68 species in 4 assemblages, related with North Equatorial Current and Kuroshio Current patterns)

('Benthic foraminifera and relation to water quality off southwest part of Morotai Island, North Moluccas'. Seafloor samples from 16-36m off Morotai, N Moluccas, with 28 species of benthic foraminifera, dominated by abundant Amphistegina spp. and Operculina spp. Also Alveolinella, Calcarina, Heterolepa, Baculogypsinoideaes, Elphidium, Peneroplis, Schlumbergerella and Sorites)


(Example of occurrences of tube worms at cold gas seeps and hot hydrothermal vent sites in SW Pacific and S Java deepwater seafloor settings (also known from Sumatra forearc, etc.))
(Spectacular photographs of modern coastal marine diatoms, including Indonesian material on Plates 30-33 (Semarang, Sumatra))

(Nearshore to offshore sediments from SW coast of Thailand clarify submarine sediment transport during 2004 Indian Ocean tsunami. Benthic foraminifera showed seaward migration after tsunami event (brackish agglutinated foraminifera in post-tsunami foreshore to offshore, transported offshore with tsunami backwash). Offshore planktonic and benthic species slight evidence of landward migration by tsunami)

('Benthic foraminifera related to marine environments around Damar Island, Pulau Seribu'. 64 species of benthic foraminifera from 11-37m depth around Damar Island reef, S part of Thousand Islands. Common forms associated with coral reef incl. Amphistegina lessonii, A. radiata, Sorites marginalis, Heterostegina and Calcarina calcar)

('The relation between foraminifera and water depth of waters SE of Seram Island, Moluccas'. Nine samples between 512-1177m water depth, with 95-100% planktonic foraminifera. Rare benthic foraminifera incl. Bulimina, Bulimina, Bolivinella, Bolivinella)

('Community structure of foraminifera in surface sediments and correlation with environmental conditions in offshore waters of Balikpapan, Makassar Strait'. Foraminifera from 6 seafloor samples off Balikpapan. (no water depths for samples (54-73m?), no species identifications))

(Palynomorphs from soil material used for construction of base of Borobudur monument. Collected from alluvial deposits in open area, not covered by dense vegetation. Absence of marsh and aquatic elements like Typha and Nymphaea in samples suggests not derived from lake or marsh)


Bibliography of Indonesia Geology, New for Ed. 7.

(online at: https://sites01.lsu.edu/faculty/swarny/wp-content/uploads/sites/30/2018/02/Thomas-et-al.-2018-QI.pdf)
(Palynological data indicate climatic conditions at sea level around Gulf of Papua remained warm, wet and stable for past 14.5 kyr, with sea surface T >14 °C)

(online at: www.repository.naturalis.nl/document/548339)


(On distribution and origin of recent SE Asian mountain plants)


(Malesian (= Indonesian) mountain flora reached Indonesian archipelago along three migration routes, called Sumatra, Luzon and Papuan tracks)

(Re-description of some modern freshwater ostracod species from Sulawesi and Sumatra, originally described by Moniez (1892) (Strandesia, Hemicypris, Cypretta))

(Recent Cyprinotus, Hemicypris and Heterocypris from ponds in W Indonesia, etc.)


(Trends in foraminifera assemblages along 80 km length of macrotidal river E of Darwin, N coast of Australia. Due to tidal transport and resuspension, most foraminiferal thanatocoenoses in river contain many small marine forms, while % of large and heavy marine forans, like Quinqueloculina, decreases upstream)

(Deepsea core SW of Sumba with ~300,000 yr sediment record)

(Carbon isotopic composition (δ13C) of terrestrial leaf waxes in sediment cores from LakeMatano spanning 53 kyr. During Marine Isotope Stages 1 and 3, more negative δ13Cwax values indicate closed-canopy rainforests dominated in Sulawesi, in wetter, less seasonal climate. More abundant open canopy vegetation and possible expansion of C4 grasses between 29-14 ka BP, indicating more arid climate in Marine Isotope Stage 2 (incl. Last Glacial Maximum). Higher elevations maintain rainforest refugia during regionally arid time intervals when C4 savannas and grasslands expanded at lower elevations)

(online at: http://journal.unpad.ac.id/bsc/article/view/8267/3814)

('Fungal spores in Recent sediments of the Mahakam delta from, East Kalimantan'. Terrestrial and marine fungal spores present in delta front sediments, incl. Monoporisporites, Inapertisporites, Biporipsilonites)

(online at: http://journal.unpad.ac.id/bsc/article/view/8280/3827)

('Abundance of pollen and spores in channels deposits of the Mahakam Delta'. Abundance of pollen higher in tidal channel deposits than in distributary channels. Oncosperma tigillarium and Nypa fruticans palmae pollen dominate in distributary channels, Rhizophora and Avicennia mangrove pollen dominant in tidal channels)

(online at: http://journal.uit.ac.id/index.php/JGEET/article/view/689/627)

(Shallow core from Mahakam River before delta plain. Common pollen, rel. rare, simple foraminifera (Oolina, Ramulina, Stictogongylus vandiemenensis, etc.))

(online at: http://journal.unpad.ac.id/bionatura/article/viewFile/7465/3426)

('Oncosperma tigillarium is part of the palino character of delta plain in Mahakam Delta, Kalimantan’. O. tigillarium pollen of coastal palm tree widespread in Recent delta plain samples, but absent in delta front, therefore good indicator of (upper) delta plain environment)

(online at: www.jclmm.com/qk/201410/5.pdf)

(Benthic foram assemblages from shallow marine environments around NW Penang Island dominated by Ammonia (~80% of fauna), followed by Elphidium (~3%). Rare agglutinated taxa and Bolivina)


(Water depth dominant factor controlling foram assemblage composition and δ18O. Differences in proportion of agglutinated and porouselar tests in shallow-water zone controlled by terrestrial runoff from nearby river systems (Mekong and N Borneo rivers) and seasonal currents. Dominance of Melonis barleeanus at sites of active cold methane seepage in southern SCS)
(online at: https://www.sciencedirect.com/science/article/pii/S1674987118300471?via%3Dihub)  
(d18O and Mg/Ca of Globigerinoides ruber, Gs sacculifer, Pulleniatina obliquiloculata and Neogloboquadrina dutertrei from 60 coretop sediment samples from Indonesian Throughflow region suggest calcification within mixed layer for G. ruber (0-50m) and G. sacculifer (20-75 m), and within thermocline (~75-125m) for P. obliquiloculata and N. dutertrei)  

(Distribution closely linked to water masses)  

(online at: http://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/186675/1/mfskugm%20057002_021.pdf)  

(Modern distribution pattern of allochthonous ostracods in South China Sea: limited to continental shelf and slope, and around reef islands, suggesting ostracods have not travelled far from source areas. Turbidites probably principal agent responsible for downslope transport of ostracods)
**X.2. Tertiary (30)**


Evans, D., W. Muller, S. Oron & W. Renema (2013)- Eocene seasonality and seawater alkaline earth reconstruction using shallow-dwelling large benthic foraminifera. Earth Planetary Sci. Letters 381, p. 104-115. (Reconstruction of M Eocene tropical sea surface T seasonality using Nummulites djokjdjokartae from Nanggulan, C Java (~39-37 Ma). Results indicate 5-6 °C annual T range, implying greater seasonality in M- Eocene (Bartonian) than in modern time. Seasonal surface ocean cooling facilitated by enhanced Eocene tropical cyclogen-indued upper ocean mixing, as suggested by recent modelling results)

Hanagata, S. & T. Nobuhara (2015)- Illustrated guide to Pliocene foraminifera from Miyakojima, Ryukyu island arc, with comments on biostratigraphy. Palaeontologia Electronica 18.1.3A, p. 1-140. (online at: http://palaeo-electronica.org/content/pdfs/444.pdf) (Extensive descriptions and illustrations of Pliocene open marine benthic and planktonic foraminifera from outcrop samples of SW Pacific island E of Taiwan)

Jacques, F.M.B., G. Shi, T. Su & Z. Zhou (2015)- A tropical forest of the middle Miocene of Fujian (SE China) reveals Sino-Indian biogeographic affinities. Review Palaeobotany Palynology 216, p. 76-91. (M Miocene Fotan flora of S Fujian, just above basalt with 14.8 ± 0.6 Ma radiometric age, considered to represent tropical rainforest based on occurrence of Dipterocarpaceae and other tropical-subtropical elements, Closer affinities to Indian Neogene than other Chinese paleofloras. During M Miocene Climatic Optimum tropical and subtropical vegetation moved N to S Fujian)

Kase, T., Y. Kurihara, Y.M. Aguilar, H. Pandita, A.G.S. Fernando & H. Hayashi (2015)- A new cerithioidean genus Megistocerithium (Gastropoda; Mollusca) from the Miocene of Southeast Asia: a possible relict of Mesozoic Eustomatidae. Palaeontological Research 19, 4, p. 299-311. (New, large cerithiform gastropod genus/ species Megistocerithium magoi described, based on specimens from M Miocene Nyalindung Fm of W Java and Philippines. Intertidal sandy mudflat dweller (mangrove grazer?). M. magoi possibly relict of Mesozoic Eustomatidae)

(Lucina-type bivalves reported from late Jurassic- late Miocene methane-seep deposits worldwide. Elliptiolucina hetzeli associated with asphalt seeps in Late Miocene sediments of Buton, Indonesia (Martin, 1933, Beets 1942) and E Pliocene seep deposits of Leyte, Philippines (Kase et al. 2007, Majima et al. 2007))

(Tertiary palynological zonation of Pearl River Mouth basin, northern South China Sea. Warmest paleoclimate in M Miocene (common tropical mangroves of Florschuetzia cf. levipoli- Dacrydiumites florinii assemblage), coldest in Late Oligocene (Alnipollenites- Pinuspoleenites assemblage). Tertiary biozonation similarities with SE Asia, but calibration of Oligo-Miocene Florschuetzia zones younger than Morley 1977)


Lelono, E.B. (2007)- Zonasi polen Tersier Indonesia Timur. Lembaran Publikasi Lemigas 41, 1, p. 1-8. ('Tertiary pollen zonation of East Indonesia'. Differences of pollen assemblages between Papua (Australian plate) and Sulawesi-Java (Sundaland/Asian plate) necessitate separate palynozonation for E Indonesia: (1) 1. Spinizonocolpites bacularus (Paleo-Eocene). (2) Metroxylon salomonense (M Miocene). (3) Foveosporites spp; (4) Nothofagidites emarcida (Late Miocene; 3 sub-zones), (5) (6) Malvacipollis diversus (Pliocene), (7) 'Garcinia cuspidata type' (Late Pliocene) (8) Proteacidites spp. (Pleistocene))

(Australian pollen Dacrydium may have dispersed into SE Asia prior to E Oligocene via Ninety East Ridge and Indian plate, and subsequent distribution across Sunda region and Indochina was limited by paleoclimate, explaining why it is present in some areas of Sunda region, but not others. Dispersal of Casuarina remains unresolved; migration via India unlikely as it is not known from Indian subcontinent)


(Atjehella jacobi n.sp., a Pliocene ostracod species from Java')


(Aragonitic shells of Burdigalian and Tortonian molluscs from C Java and E Kalimantan analyzed for δ18O and δ13C ratios. Depleted δ18O and δ13C ratios in brackish water samples. Also chemosymbiotic species show depleted δ13C ratios. Seagrass communities yield comparatively enriched δ13C ratios. Stable isotope ratios may provide additional evidence for distinguishing paleoenvironments)

Renema, W. (2015)- Spatiotemporal variation in morphological evolution in the Oligocene-Recent larger benthic foraminifera genus 


(Genus Cycloclypeus ranges from Oligocene- Recent, first appearing in E Rupelian of Java and Kalimantan (C. koolhoveni). Late Oligocene- Recent C. eidae to C. carpenteri lineage in Mediterranean and Indo- West Pacific provinces. C. annulatus derived from C. eidae as separate lineage in late Early-M Miocene)


(online at: npnr.niscair.res.in/bitstream/123456789/...

(E Neogene radiolaria from N Indian Ocean and Andaman-Nicobar islands show influx of colder water immigrant species in early Middle Miocene (~12.5-16 Ma))


(online at: http://palaeontologicalsociety.in/vol48/v1.pdf)  

(Ten low-latitude radiolarian events identified in E-M Miocene sections of Andaman- Nicobar islands)


(online at: www.episodes.org/index.php/epi/article/download/62122/48423)  

(ODP Hole 757B, Ninetyeast Ridge, SE Indian Ocean, with well-oxygenated deep-sea benthic foraminifera (Cibicides cicatricosus, C. pseudoungerianus, Oridorsalis umbonatus) dominant in late Oligocene- E Miocene, but declining through M Miocene as Site 757 became under influence of Indonesian Throughflow with water masses from Pacific Ocean. Nuttallides umbonifera major increase at ~11 Ma, coinciding with increase in Nd isotope values, indicating substantial transport of deep Pacific water to Indian Ocean through Indonesian seaway. N. umbonifera decreases drastically during 3-2.8 Ma, coinciding with closure of Indonesian seaway and switch in shallow ITF source from warm, saline S Pacific to cool, fresh N Pacific thermocline water)


(online at: https://www.e-periodica.ch/digibib/view?pid=egh-001:1925-1926:19#284)  

(‘On an East Indies Lepidocyclina with multi-chambered embryo’. Lepidocyclina (probably Eulepidina) from E Miocene at Sungi Tjengal, N margin of Gumai Mts, S Sumatra, with multi-chambered embryo (not unusual aberrant growth in orbitoidal foraminifera, with no apparent ecological or biostratigraphic significance; JTvG))


(‘The nature of the Tertiary fauna of the Netherlands Indies’. Early attempt of interpretation of the nature of Indonesian Tertiary faunas by student of K. Martin)
(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0TkIUS0F0Zkt5T0k/view)
('Evolution of an embryon'. Evolution of Late Oligocene- Miocene Lepidocyclina embryo can be measured as 'degree of curvature', which can then be used for age determination and correlations. With example of values in East Java- Madura stratigraphy)

(Course notes for first sequence stratigraphy course in Indonesia)

(online at: https://pdfs.semanticscholar.org/fc9d/05e55c75424d1fd9590ca8ec7cbfe39d4a51.pdf?_ga=2.250484229.20981469.1529357724-1507267566.1529357724)
(Holotype of Globorotalia barisanensis Le Roy 1939 from M Miocene Lower Palembang Fm in upper Kassikan section, Tapung Kiri River, C Sumatra, is non-keeled species, transitional between Gr. peripheroacuta and Gr praefohsi (zones N10-N11). Holotype should be viewed as senior synonym of Gr. peripheroacuta, but more practical to conserve latter name)
X.3. Jurassic-Cretaceous (8)

Belford D.J. & V. Scheibnerova (1971)- Turonian foraminifera from the Carnarvon Basin, Western Australia, and their palaeogeographical significance. Micropaleontology 17, p. 331-344.
(Presence of E-M Turonian planktonic foraminifera Praeglobotruncan stephani, P. hagni, P. imbricata, P. helvetica and Hedbergella spp from wells in Carnarvon Basin show Tethyan character)

(online at: www.ccop.or.th/download/as/52as2.pdf)
(Mesozoic vertebrate footprints found in several SE Asia countries with Indochinese redbeds, incl. in six Late Triassic- E Cretaceous formations in NE Thailand. Also in Laos, Malay Peninsula Singapore (Sentosa), Cambodia)

(E Cretaceous primitive ceratopsian dinosaur Psittacosaurus widespread in Asia, from W Siberia, Mongolia, China to Thailand, and possibly Japan. Psittacosaurus signifies Barremian-Albian time, ~105-125 Ma)

(Brief review of radiolaria studies from Cretaceous of C Java (Karangsambung), M Cretaceous from S Sulawesi (Bantimala), Jurassic-Cretaceous from SE Kalimantan (Meratus Range), M-L Triassic and E Cretaceous from W Timor (Nefokoko, Kefamenanu, Kolbano) and M Jurassic from Rotti island)


(online at: www.jstage.jst.go.jp/article/geosoc1893/62/732/62_732_490/_pdf)
(Incl. circum-Pacific 'Aalenian' (Late Toarcian?) ammonite distribution map, showing distribution of Hammatoceras in E Indonesia)

(E Cretaceous Muderong Shale from S Carnarvon Basin outcrop and wells with restricted marine Ammobaculites spp. Haplophragmoides- Miliammina- Verneuilinoides association)

(online at: https://www.sciencedirect.com/science/article/pii/S019566711730366X)
(New family of wasps Myanmarinidae established from species discovered in M Cretaceous (E Cenomanian, ~99 Ma) Burmese amber from amber mines in Hukawng Valley of Kachin State, Myanmar)
X.4. Triassic (16)

(online at: https://archive-ouverte.unige.ch/unige:8438)

(Involutinid benthic foram Aulotortus friedli reported from U Triassic (Norian-Rhaetian) carbonates from capped seamount in Sambosan Accretionary Complex. From shallow-water limestone clasts in debris flow along Kumagawa River)


(Selection of age-significant Triassic microfossils from Thailand and adjacent regions. Ammonites and thin-shelled molluscs (Daonella, Halobia, Monotis) most important. With 5 plates and range chart)

(Vietnamese Triassic flora belongs to coastal floristic assemblage of SW Pacific. Affinities of plant-fossil assemblage with Krusin flora of NW Borneo)

(Permian-Triassic boundary defined by first appearance of conodont species Hindeodus parvus, also bivalve Claraia. In S Chian Permo-Triassic boundary marked by two volcanic ash beds)

(Marine conodont fossil species, Hindeodus changxingensis restricted to very narrow stratigraphic interval from Permian-Triassic extinction event into very earliest Triassic ('disaster species?'). Geographically widespread in Tethyan Region)

(Four new species of conodont genus Hindeodus just above Permian-Triassic boundary in S. China; boundary based on first appearance of Hindeodus parvus. Change in conodont biofacies at P-T boundary from Neogondolella (Clarkina)-dominated faunas to Hindeodus-dominated faunas, associated with increase in silt)

(online at: https://archive-ouverte.unige.ch/unige:84250)
(U Triassic carbonates of Sambosan Accretionary Complex in SW Japan: (1) limestone clasts embedded in volcaniclastic matrix with microbialite-rich Ladinian?- Lower Carnian reef biota; (2) sponge-dominated Late Carnian- Norian (Rhaetian?) reefs (built on top of basalts of low-latitude Panthalassic seamount).
Paleogeographic affinities with S. Tethys. Limestone commonly as clasts in volcanoclastic breccias, probably mass-movement deposits from seamount collapse in mid-oceanic realm (very few ooids?)


(M-L Triassic (Ladinian?-Carnian) reef limestone from Sambosan Accretionary Complex, Shikoku Island, SW Japan, with scleractinian corals, calcified sponges, calcareous algae, foraminifera and microproblematica (older than previously identified reef limestones in Sambosan Complex))


(Ur Triassic sponge-coral- Tubiphytes reef limestone from Sambosan Accretionary Complex at Shikoku Island, Japan, with two types of reefs, Ladinian?- E Carnian and Late Carnian-Rhaetian? Strong paleobiogeographic affinity of Late Triassic W Panthalassa reef biota with those of S Tethys Ocean)


(During Late Triassic carbonate platforms expanded on continental shelves and island arcs in Tethys realm and coeval mid-oceanic shallow-water environments of Panthalassa domain. U Triassic limestone of Sambosan Accretionary Complex, SW Japan, suggests typical Sambosan platform probably carbonate bank with submerged margins and mosaic of microfacies in platform interior instead of atoll-type platform)


(Ten U Triassic coral taxa, incl. Retiophyllia, from limestones of Sambosan accretionary complex of Japan, with remains of reefs and carbonate sediment deposited on Pacific volcanic atolls. High degree of endemism; some paleogeographic connection with W Tethys, Pamir Mts and Timor (Craspedophyllia ramosa Roniewicz))


(Study of internal structure of U Triassic ammonites from Timor (Tropitida, Placites spp., Cladiscitidae, Phylloceratidae and Arcestidae))


('Contribution to the study of the paleoflora of SE Asia (Cambodia, Laos, Vietnam)')
X.5. **Paleozoic (15)**

(Incl. Ordovician conodonts from shallow tropical Lower Setul Lst from Langkawi Island (Tremadoc- Ashgill), Thung Song Lst of mainland Thailand and Ko Tarutao, Karmberg Lst of central S Tasmania)

(*Panderodus nogamii* (formerly *Scolopodus nogamii*), first described from N Korea, also in Lw Ordovician of Thailand, Malaysia, N and S China, Australia and Argentina. It ranged through M- early U Ordovician and was restricted to shallow water carbonates in tropical- subtropical paleolatitudes of Greater Gondwana)

(Incl. mention of *Djambi* flora of Sumatra, which it may be regarded as transitional flora with taxa characteristic of both Euramerica (e.g. medulosaleans and marattialean ferns) and Cathaysia (e.g. *Tingia, Cathaysiodendron*) realms)

(online at: https://gsmpubl.files.wordpress.com/2017/04/bgsm2016003.pdf)
('Taxonomy of the Permian radiolarian genus *Pseudoalbaillella* from Pos Blau, SW Kelantan, Peninsular Malaysia. Seven species of Permian *Pseudoalbaillella* radiolarian genus in chert between Gua Musang and Cameron Highlands, SW of Kelantan. Association of *Pseudoalbaillella* with *Hegleria mammilla* indicates *Pseudoalbaillella globosa* Assemblage Zone (early M Permian; Roadian))

(Foraminifera from U Devonian reef complex and overlying Lower Carboniferous in N Canning Basin of NW Australia 20 species of tournayellids and endothyrids. Striking resemblance to microfaunas of Russia, Kazakhstan and South China)

(Permian-Triassic boundary characterized by massive extinction of marine fauna. In non-marine sections in E Australia, top of coal measures used as top Permian. Carbon isotopic (δ13C) shift of either organic matter or carbonates may be used to delimit P-T boundary)


(Revised scheme of Permian plant geography. Contrary to prevalent opinion views Sumatra (Jambi) and West Irian Jaya floras as 'mixed Eurogondwana' floras, and mapped in 'subtropical humothermic belt' with 'Gondwanan' India- Australia floras)

End-Permian mass extinction now well dated at 252.6 ± 0.2 Ma (U-Pb) and Permian-Triassic GSSP level is dated by interpolation at 252.5 Ma. Conodonts evolved rapidly in first 1 million years following mass extinction leading to high-resolution conodont zones. Nature of double-phased Late Permian extinction (at Guadalupian-Lopingian boundary and P-T boundary, linked to large igneous provinces, suggests superplume activity that involved geomagnetic polarity change and massive volcanism)


(Permian brachiopod successions in five major paleobiogeographical realms. For Gondwanaland and peri-Gondwanan regions including Cimmerian blocks, Bandoproductus, Cimmeriella characteristic of Cisuralian (E Permian). Lower Permian brachiopods from Mengkareng Fm in Sumatra (Crippa et al. 2014) viewed as Sakmarian in age and grouped with S Thailand- Malaysia Cimmerian/ Sibumasu faunas)

(Recalibration of Permian and Triassic spore-pollen palynozones and numerical ages from high-precision radiometric dating of tuffs)

(online at: https://d28rz98at9flks.cloudfront.net/72990/Rec2013_046.pdf)
(Calibration of Late Permian palyno-zones with radiometric ages of associated tuffs. Dulhuntyispora parvithola zone APP5 spans >5 Myrs (~254.4- 263 Ma). Latest Permian Playfordiaspora crenulata and Protohaploxypinus microcorpus palynozones APP6 between ~252-254.4 Ma) (see also Laurie et al. 2016)


(Gigantopterid plants characteristic floral element in Permian Cathaysian floras. However, in China oldest known occurrences later than in N America (Artinskian) and Sumatra/Indonesia (Asselian-Sakmarian). New gigantopterid Gigantonoclea cf. mira from basal Permian (Asselian) strata in N China Block represents oldest unequivocal evidence for gigantopterids)
X.6. Quaternary Hominids, Mammals and associated stratigraphy (299)


(Quaternary Int)  


(Toba eruption on Sumatra may have caused human population bottleneck and modern human races may have differentiated abruptly only 70,000 years ago (see also commentary by Gathorne-Hardy 2003))


(~73 ka Toba eruption larger than previously estimated, and caused millennium of coldest temperatures of U Pleistocene. Genetic studies suggest real population bottleneck during first half of last glacial period, but no mass extinctions. We are descendants of few small groups of tropical Africans who united in face of adversity)


(online at: http://hopsea.mnhn.fr//pc/thesis/M2_Ansyori_MIRZA.pdf)  

(Older archeological assemblage in Song Terus cave in Weru, Pacitan, S Mountains of S Java ranges in age from ~300-80 ka (M-L Pleistocene). Late Pleistocene faunas of upper Terus Layer (80-120 ka) resemble Punung fauna of Badoux. Big fauna dominated by Cervidae, Bovidae and Suidae. Tropical forest environment)


(Mojokerto child (Perning I), Java, discovered in 1936, has been assigned to Australopithecus and multiple species of Homo modjokertensis, etc. Developmental age range probably 4-6 years)


(Ngandong 5 and 9 skulls are adults, 8 an older juvenile and 2 is a juvenile. Adult cranial contours and pattern of contour development similar between Ngandong adults and other H. erectus adults. Nothing to suggest that Ngandong transitional in vault shape between H. erectus and H. sapiens, despite relatively large brain)


(Principal components analysis of calvarial shape suggest regional differentiation between N Asian and SE Asian H. erectus. Most recent SE Asian fossils (e.g. Ngandong) conform to SE Asian pattern)


(Hominin presence outside Africa started at ~1.6-1.8 Ma (H. erectus). Includes discussion on reliability of ages of Sangiran hominin (‘poo-poo everything’; JTvG). Earliest hominins at Sangiran older than 1.0 Ma and probably 1.3 Ma or older)


(online at: http://digitallibrary.amnh.org/handle/2246/6077)
(Archeological excavations in E Timor in 1968-2002 provided new material of Late Pleistocene and recently extinct gigantic murine (rat) Coryphomys (originally described by Hooijer 1965))

(Analyses of multiple morphological characteristics suggest H. floresiensis (~65-90ka) is closest to early hominins (>1.75 Ma; Homo habilis?), suggesting probably long-surviving relict of early hominin lineage, with hitherto unknown migration out of Africa. Not recent descendants of either H. erectus or H. sapiens)

(New well-preserved hominid skull found in 1993 from Bapang (Kabuh) Fm at Tanjung village, Sangiran region, C Java. Relocated to basal or middle part of Bapang Fm)

(Same paper as Aziz, 2000)

(No strong support for linear progression in neurocranial skull shape from Sangiran to Ngandong via Sambungmacan/Ngawi)

(Two evolutionary scenarios for small-bodied Homo floresiensis on Flores in Late Pleistocene: (1) H. floresiensis was dwarfed descendent of H. erectus, or (2) remnant of older lineage, perhaps descended from H. habilis. Could be either)

(Geometric morphometric analyses of LB1 cranium shows Homo floresiensis is distinct from healthy modern humans and from those with pathological conditions (hypothyroidism, Laron syndrome, microcephism), and is most similar to Homo erectus (but smaller))

(Skull shapes of Homo erectus from Sangiran, Ngandong, Sambungmacan, and Ngawi, and compared to H. erectus from outside of Java. Asian H. erectus fossils can be distinguished from African/Georgian ones. Late Indonesian H. erectus from sites like Ngandong, distinct from all other H. erectus groups, including older C Java fossils. Younger Sangiran fossils more closely approach Ngandong/Sambungmacan/Ngawi pattern)

(Facial characteristic of restored Sangiran 17 skull do not support hypothesis of Thorne and Wolpoff of regional continuity between H. erectus and Late Pleistocene Australians)

Bae, C.J. (2010)- The late Middle Pleistocene hominin fossil record of eastern Asia: synthesis and review. American J. Physical Anthropology 143, Suppl. 51, p.75-93. *(Traditionally, M Pleistocene hominin fossils that cannot be allocated to Homo erectus s.l. or modern H. sapiens in E Asia, classified as archaic, early, or premodern H. sapiens. Increasing number of M Pleistocene hominin fossils currently being assigned to H. heidelbergensis, but little evidence in E Asia to support assignment to H. heidelbergensis. Best to continue to use term archaic H. sapiens)*


Bartstra, G.J. (1987)- Late Homo erectus or Ngandong man of Java. Palaeohistoria 29, p. 1-7. *(Review of Ngandong man ('Homo soloensis') from 'High Terrace' deposits of Solo river in Kendeng zone of Java. Generally regarded as last representative of Homo erectus in SE Asia. Associated with rich mammal fauna, mainly bovids, indicative of open forest environment. Oldest Solo terrace sediments in C Java must date from beginning of N-ward directed drainage pattern and probably Late Pleistocene in age. U-series ages from Ngandong bone samples mainly between ~40-80 ka. No in-situ stone implements, but nearby surface finds small chalcedony artefacts ('Ngandong Industry'))*


Bibliography of Indonesia Geology, New for Ed. 7.

(Recent review of history of hominids in SE Asia)

(Discussion of lithic stone tool industries reportedly associated with Homo erectus in various regions of island SE Asia. Two categories: (1) 'chopper/chopping-tool industries' characterized by Java Pacitanian industry and supposedly work of Homo erectus; (2) 'pebble and flake industries' more characteristic of early Homo sapiens)


(Giant fossil ape Gigantopithecus blacki from SE Asia survived until ~100,000 years ago. Known only from isolated teeth and lower jaw fossils. Carbon isotopes of tooth enamel from N Thailand suggest Gigantopithecus was forest-dweller with vegetarian diet. Demise possibly due to forest reduction during glacial periods)

(Elegant general review of hominid evolution)


(Analysis of thousands of Holocene (~11-5 ka) hominid stone tools from upper ('Keplek') levels of Song Terus cave in Southern Mountains of Central Java)


(‘The faunal assemblages associated with Homo erectus sites at Sangiran (M Pleistocene, Java’). Homo erectus in fluvial deposits outcropping in several localities. Thirteen taxa of M Pleistocene mammals determined. Lithic tools rare at these sites. Mechanical action of water responsible for accumulations)
Bouteaux, A., A.M. Moigne & K. Setiagama (2008)- Etudes archeozoologiques de sites javanais du Pleistocene: les sites de plein air du dome de Sangiran (Java central) et le site en grotte de Song Terus (Java est). In: Archaeozoology of the Near East VIII, Travaux Maison de l'Orient et de la Mediterranee, 49, p. 79-97. (online at: www.persee.fr/doc/mom_1955-4982-2008_act_49_1_2702) (‘Archeozoologic studies at Pleistocene sites of Java: Sangiran Dome (C Java) and Song Terus cava (E Java’)


Brongersma, L.D. (1958)- On an extinct species of the genus Varanus (Reptilia, Sauria) from the island of Flores. Zoologische Mededelingen 36, 7, p. 113-125. (online at: www.repository.naturalis.nl/document/149846) (Late Pleistocene(?)) lizard Varanus hooijeri n.sp. from cave deposits on Flores, collected by T.L. Verhoeven. Associated with Mesolithic flake and blade industry)


(E Pleistocene stone tool assemblage from Mata Menge in Soa Basin, Flores, is oldest Palaeolithic stone assemblage in well-dated stratigraphic context in SE Asia. 91% of 459 artefacts made from volcanic rocks)


(Leang Bulu Bettue cave and rock-shelter in SW Sulawesi with relicts of Late Pleistocene (~30-22ka) Homo sapiens. Include previously unknown items of personal ornamentation, portable art, etc., fashioned from body parts of endemic animals)


(Rock shelter at base of limestone cliff in SW Sulawesi with evidence of Late Pleistocene (~31-20 ka) human habitation (stone artefacts, pottery, etc.))


('The rodents of the Plio-Pleistocene of Thailand'. 20 Late Pliocene- Pleistocene rodent localities in Thailand, with 41 species, most of them extant species in Thailand or in Sundaland)


(Study of rodent fossils from 20 fissure fill and cave deposits. English version of 1997 French thesis)


(Late Eocene primate Siamopithecus eocaenus from Krabi coal mine in Peninsular Thailand is anthropoid. Large primate, of body size estimated between 8-9 kg, with many shared dental characters with other Asian taxa such as Fondaungia, Amphipecthus, and Myanmpithecus (amphipithecids))


( Oldest mammalian fossils of Thailand in late Eocene Krabi basin, Peninsular Thailand (27 taxa). Species association indicates humid tropical forest. Nong Ya Plong Late Oligocene locality with many groups of mammals, all new. Several M-L Miocene mammalian localities in N Thailand, incl. first hominoid fossils (orang-utan-like, 12, 8 Ma) in SE Asia. Pliocene and Pleistocene fossils were recovered from caves and fissure fills, with micromammals indicating cooler climate than today from Pliocene- M Pleistocene, with mixture of grasslands with forests. More humid climate with tropical rain forests appears after E Pleistocene, in relation with monsoon development and led to explosion of Rattus group in region)


(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3107645/pdf/rspb20102062.pdf)


(online at: www.pnas.org/content/97/8/4102.full.pdf)


(Reports of fossil teeth, etc., of E Pleistocene humans in SE China (Longgupo, etc.) and interpreted as related to Homo erectus probably erroneous; instead belong to an unknown ape species, living in forested region)


(Tham Khuyen Cave deposits in N Vietnam with hominin teeth dated as 475 ± 125 ka (electron spin resonance). Teeth represent Homo erectus and Gigantopithecus blacki. Co-occurrence demonstrates >1 million years of co-existence of these two species throughout E Asia in E-M Pleistocene)


(Global Quaternary Megafauna Extinction (QME) event eliminated 2/3 of all mammal genera, with most well-dated extinctions occurring between ~50-30 ka. Java probably had fully modern fauna by 120 ka. In Indo-Pacific hominin impacts probably major factor behind most large vertebrate extinctions and range restrictions in the past 130 kyr and probably earlier ones)


(Late Pleistocene Deep Skull from Niah Cave in Sarawak the oldest (> 50 ka) anatomically modern human from island SE Asia)


('The tools of Pithecanthropus')

(Human tooth from Ma U'Oi Cave, N Vietnam, interpreted as archaic Homo, with characteristics transitional between H. erectus and H. sapiens. Associated fauna characteristic of Stegodon-Ailuropoda (Panda) complex, of estimated late M Pleistocene- Late Pleistocene age)


(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3437904/pdf/pnas.201208104.pdf)

(Modern human cranium from Tam Pa Ling (Cave of Monkeys), ~260 km NNE of Vientiane, Laos. Sediments minimum age of 51-46 ka. Maximum age of ~63 ka from U-dating of bone. Establishes evidence for fully modern humans in mainland SE Asia by ~50 ka)


(Movius Line is no longer appropriate view of Early Paleolithic of E and SE Asia, and should be disregarded. E Asia not isolated throughout E-M Pleistocene, but open to immigration during interglacials. M Pleistocene 'Acheulean' stone tool assemblages possibly present in Ngembang (Sangiran) C Java)


(Five Pleistocene terraces along Irrawaddy River, unconformably over tilted Pliocene- E Pleistocene 'Upper Irrawaddy Beds'. Contain 'Anyathian' Paleolithic stone tools)


(Results of American SE Asian Expedition for early Man)


(On Homo sapiens fossils from Gunung Sewu area, Southern Mountains of Java (Song Terus, Song Keplek, Goa Braholo), and their funeral practices)


(Vertebrate fossils from new locality in sand quarry near Sumberdadi, ~30 km N of Mojokerto, E Java, include Stegodon trigonocephalus cf. ngandongensis, Bibos palaeosondaicus, Axis lydekkeri, Rusa sp. and crocodile remains. Advanced stage of Stegodon suggests late M - Late Pleistocene, comparable with Ngandong fauna)

Bibliography of Indonesia Geology, New for Ed. 7. 417 www.vangorselslist.com 8/6/18
Djubiantono, T. (1993)- Umur alat batu Kedungcumpleng di daerah Kaliuter, Solo, Jawa Tengah. Proc. 22nd Ann. Conv. Indon. Assoc. Geol. (IAGI), Bandung, 1, p. 292-303. ('Age of the Kedungcumpleng stone tools in the Kaliuter area, Solo, Central Java'. Pleistocene correlations and chronostratigraphy and correlations of sections in Kaliuter area, 30km N of Solo. Kedungcumpleng site in Jaramillo paleomagnetic episode (0.87-0.97 Ma), and considered site with oldest hominin stone tools in Java today)


Duangkrayom, J., S.Q. Wang, T. Deng & P. Jintasakul (2017)- The first Neogene record of Zygolophodon (Mammalia, Proboscidea) in Thailand: implications for the mammutid evolution and dispersal in Southeast Asia. J. Paleontology 19. 1, p. 179-193. (online at: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/ etc) (New material of Zygolophodon from Tha Chang sand pits in NE Thailand, of probably Late Miocene age, is first record of zygodont proboscidean in SE Asia)


Eckhardt, R.B., M. Henneberg, A.S. Weller & K.J. Hsu (2014)- Rare events in earth history include the LB1 human skeleton from Flores, Indonesia, as a developmental singularity, not a unique taxon. Proc. National Academy Sciences USA 111, 33, p. 11961-11966. (online at: www.pnas.org/content/111/33/11961.full.pdf) (Homo floresiensis is regional variant of Homo sapiens. Abnormal features of specimen LB1 not necessarily typical of whole assemblage (disputed by Westaway et al. 2015))
(Human colonization of New Guinea Highlands pre-dated 35 ka. Plant food use dates from at least 31 ka, i.e. in earliest millenia of human presence. Humans persisted in intermontane valleys through Late Glacial Maximum)

(About challenges of chronological framework of early human settlements of Java, from oldest Lower Pleistocene Homo erectus up to dispersals after Last Glacial Maximum)

(online at: https://jurnal.arkeologi.kemdikbud.go.id/index.php/kalpataru/article/view/41/18)
('Lithic technology characteristic of progressive Homo erectus based on artifact assemblage from Matar Site, Bojonegoro. New Matar site on E banks of Solo River (equivalent of 20m terrace of Ngandong?) with stone tool assemblage of 'progressive Homo erectus'. Flakes and massive tools such as bola, spheroidal, polyhedrons, and chopper-chopping tools)

(online at: www.persee.fr/docAsPDF/befeo_0336-1519_1999_num_86_1_3409.pdf)
('The industrial assemblage of Song Keplek, East Java; a new view on stone tools of modern man at the beginning of the Holocene in Indonesia'. Song Keplek stone tool assemblage from Punung area ~6000-4000 years old)

(online at: www.persee.fr/docAsPDF/arch_0044-8613_2007_num_74_1_3914.pdf)
(‘Rel. long history of prehistoric stone tool making in Sumatra, incl. Acheuleen tools from Ogan River tributaries in S Sumatra, possibly from Homo erectus)

(online at: http://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers17-07/010041012.pdf)

(online at: www.persee.fr/doc/asean_0859-9009_2000_num_6_1_1683)
(‘Review of major Late Paleolithic lithic (stone tool) assemblages in Indonesia and Philippines)

(online at: www.persee.fr/docAsPDF/arch_0044-8613_2010_num_80_1_4175.pdf)
(‘Prehistoric unity and diversity of Java and Sumatra’. Prehistory of Indonesia from 20000- 5000 BP. Java marked by technical heterogeneity in produced stone tools, Sumatra more homogenous technical choices, with a unifacial pebble shaping which still belongs to Hoabinhian tradition)

(The first indications of an Acheulean facies in South Sumatra'. Paleolithic stone tools from Ogan River tributaries)

(The Togi Ndrawa site, Nias Island, Noth Sumatra: the first record of a Hoabinhian cave settlement in Indonesia'. Late Pleistocene- E Holocene classic Hoabinhian pebble artefacts, forest and coastal fauna and human bones in Togi Ndrawa cave, NE Nias)

(M Pleistocene terrace of the Mekong River S of SW Laos with stone tools. Terrace T.II contains coarse pebble formations, yielding most abundant lithic industry and also yielded abundant 0.77 Ma age tektites)

(No evidence to support hypothesis that Toba supereruption at 73.5 ka caused bottleneck in human, animal or plant populations)

(Late Pleistocene (~30ka) flaked stone tools from shelter at base of limestone cliff E of Tompokbalang in Maros District, S Sulawesi)


(The human femur Kresna 11 compared to those from Trinil'. Thigh bone named Kresna 11 discovered in 1992 from the 'Grenzbank' horizon in Sangiran Dome shows several Homo erectus features, similar to Trinil)


(Fragmented Homo erectus skull from Kabuh Beds at Grogol Wetan site. Ar-dating indicates 0.78 ± 0.29 Ma. Second hominin skull from Kabuh Beds at Bukuran site)

(Few or no Paleolithic fossils found on Borneo (unlike Sulawesi, Java, etc.) and some may be Chinese drugstore imports. Niab cave in Sarawak rel. rich record of human and associated fossils dating to ~35 ka. MPlleistocene tektites of coastal NW Brunei cannot be used for dating of 'Jerudong Terrace', as most or all are reworked into younger gravel terraces)
(online at: http://www.sciencedirect.com/science/article/pii/S0277379117302470)  
(Laili Cave in Laleia, Timor-Leste, preserves oldest human occupation in Wallacea (~43-45 ka), earlier than other Pleistocene sites known in Wallacea. Pleistocene humans used abundant local chert and engaged in mobile broad-spectrum foraging)

Heaney, L.R. (1985) - Zoogeographic evidence for Middle and Late Pleistocene land bridges to the Philippine islands. Modern Quaternary Research in Southeast Asia 9, p. 127-143.  
(In Sunda shelf region rel. widespread faunal distribution, corresponding strongly with M and Late Pleistocene land bridge formation. Number of species corresponds with size of island area. Elephant species rel. widespread in SE Asia Pleistocene, probably because they are strong swimmers and do not necessary indicate land bridges. Unlikely there was a land bridge between Asia and The Philippines, except M Pleistocene connection from NE Borneo to Palawan. Therefore unlikely that Homo erectus reached Philippines)


(online at: www.pnas.org/content/111/33/11967.full.pdf)  
(LB1 type specimen of Homo floresiensis ('hobbit') viewed as anomalous specimen in small-bodied Australomelanesian Homo sapiens population, possibly afflicted by Down syndrome. Conclusion disputed by Westaway et al. 2015)

(Book critical of Homo floresiensis ('hobbit') interpretations, claiming it to be much younger than reported and be 'normal' dwarfed Homo sapiens island population. Also 2011 2nd Edition)

(Pleistocene mammal faunas from Java three successive faunas based proboscidean genera: (1) E Pleistocene Mastodon- Geochelone fauna, (2) early M Pleistocene Stegodon- Homo erectus fauna and (3) late M Pleistocene Elephas- Homo sapiens fauna. Stegodon- Homo erectus fauna contains elements from successive migration waves and different ecological settings. Introduce model for endemic evolution in Java and newly discovered Pleistocene mammal locality in W Java)

(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0VWdxUXpQI9fYlU/view)  
(Review of Von Koenigswald (1940) and Weidenreich (1945) monographs on Java hominids)

(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0alp1ZkJOMzhlwQkU/view)  
(Rhinoceros tooth from Paleolithic (Late Pleistocene?) refuse-heap at Binjai Tamiang, 15km from mouth of Tamiang River in N Sumatra. Mound composed of layers of Meretrix mollusc shells alternating with ashy layers with stone tools and remains of land mammals, fish and crabs. Evidence of cannibalism. Rhinoceros tooth comparable to material from Sibrambang cave (Padang Highlands))

(online at: http://repository.naturalis.nl/document/150691)

(Study of collection of teeth excavated by Dubois in late 1880's from Lida Ajer and other caves in Padang Highlands, C Sumatra. Includes orang-utan skulls and some hominid teeth indistinguishable from modern humans (may be oldest known Homo sapiens in Indonesian region (~70ka;Westaway et al. 2017). Also extensive study of Pleistocene orang-utan teeth from Java and S China)


(online at: http://repository.naturalis.nl/document/148880)

(Review of fossil Hipopotamus from Asia. Three species in Pleistocene of Java, formerly recored as Hipopotamus antiquus, H. simplex and H. namadicus by Von Koenigswald here renamed Hippopotamus sivalensis koenigswalda (E Pleistocene Djetis fauna, rel. small, Trinil, Mojokerto, Kedung Brubus), H. sivalensis sivajavanicus and H. sivalensis soloensis n.ssp (M-U Pleistocene, descended from H. koenigswalda)


(Presence of big-teeth humans resembling Australian aboriginals and Melanesians may once lived in Malaya-Indonesian region, as evidenced by Wajak man of Java (Dubois 1920) and subfossil man from Gua Lawa Sampung and Bojonegoro as described by Mijsberg (1932). View disputed by Von Koenigswald 1952)


(online at: www.repository.naturalis.nl/document/150080)

(Three new forms of large Pleistocene rat fossils collected by Verhoeven in cave deposits at Liang Toge near Warukia, Manggarai, W Flores: Papagomys armandvillei besar, P. verhoeveni and Spelaeomys florensis. Associated with Mesolithic flake and blade industry)


(online at: http://repository.naturalis.nl/document/148964)

(Apes (Pongidae) from the Indonesian region include Late Pleistocene gibbons (Symphalangus and Hylobates) from limestone caves in Padang Highlands, C Sumatra, collected by Dubois. Possibly also incave material from C Java (Pacitan) and Sarawak)


(online at: www.repository.naturalis.nl/document/148851)

(Pleistocene monkeys (Presbytis, Trachypithecus, Macaca) from limestone caves in Padang Highlands , C Sumatra, and cave deposits on Java)


(online at: http://palaeoworks.anu.edu.au/pubs/Hope&Haberle05.pdf)

(Humans have been in highland valleys of New Guinea for at least 30,000 years and presumably occupied savannah plains that then connected New Guinea to Australia for 50,000 years or more)


(Stone artifacts from T4 terrace deposits in Bose basin, S China, associated with tektites dated to 803 ± 3 ka and represent oldest known cutting tools in E Asia, compatible with Acheulean technologies in Africa. Stone
tool- tektite horizon also contains abundant charcoal and silicified wood fragments, suggesting episode of forest burning initiated by tektite event)


Hyodo, M., H. Nakaya, A. Urabe, H. Saegusa, S. Xue, J. Yin & X. Ji (2002)- Paleomagnetic dates of hominid remains from Yuanmou, China, and other Asian sites. J. Human Evolution 43, 1, p. 27-41. (Geomagnetic data suggest Homo erectus-affinity Yuanmou, SW China, hominid remains from early Brunhes chron ~0.7 Ma. Hominid fossils from Sangiran and Mojokerto, Java, do not exceed 1.1 Ma in age)


Ingicco, T., G. van den Bergh, J. de Vos, A. Castro, N. Amano & A. Bautista (2016)- A new species of Celebochoerus (Suidae, Mammalia) from the Philippines and the paleobiogeography of the genus Celebochoerus Hooger, 1948. Geobios 49, 4, p. 285-291. (Celebochoerus is said (pig family) with large upper tusks, previously only known from Plio-Pleistocene of Sulawesi. Canine fragment of Celebochoerus from Cagayan Valley, Luzon, named Celebochoerus cagayanensis n. sp.. Probable migration route from Philippines to Sulawesi, possibly out of Taiwan)

Jacob, T. (1966)- The sixth skull cap of Pithecanthropus erectus. American J, Physical Athropology 25, 3, p. 243-259. (New find of skull cap of Pithecanthropus erectus from upper Trinil beds of Sangiran, C Java. Pithecanthropine characteristics, with cranial capacity ~975 cm3. Absence of cranial base does not necessarily indicate that specimen was victim of cannibalism)


Kaifu, Y., H. Baba, T. Sutikna, M.J. Morwood, D. Kubo, E.W. Saptomo, Jatmiko, R. Due Awe & T. Djubiantono (2011)- Craniofacial morphology of Homo floresiensis: description, taxonomic affinities, and evolutionary implication. J. Human Evolution 61, p. 644-682. (Description of LB1/1 Homo floresiensis cranium. Reductive trend in facial skeleton comparable to H. sapiens, but craniometrically different. LB1 most similar to older Homo erectus from Sangiran and Trinil, consistent with hypothesis that H. floresiensis evolved from early Javanese H. erectus with dramatic island dwarfism)


Kealy, S., J. Louys & S. O’Connor (2015)- Islands under the sea: a review of early modern human dispersal routes and migration hypotheses through Wallacea. J. Island Coastal Archaeology 11, 3, p. 364-384. (Review of possible Late Pleistocene human migration routes across Wallacea, the transitional island biogeographic zone between Sundaland (SE Asia) and Sahul (Australia-New Guinea))

Keates, S.G. (2004)- Notes on the Palaeolithic finds from the Walanae Valley, southwest Sulawesi, in the context of the Late Pleistocene of island Southeast Asia. In: S.G. Keates & J. Pasveer (eds.) Quaternary Research in Indonesia, Chapter 7, Modern Quaternary Research in Southeast Asia 18, Balkema, Leiden, p. 95-110. (Stone artefacts from Walanae Valley, SW Sulawesi, may represent earliest human (Homo sapiens) activity in early part of Late Pleistocene (first identified as Cabenge flake industry by Van Heekeren in late 1940’s). With review of Late Pleistocene stone tool industries in other parts of Indonesia)


(online at: http://royalsocietypublishing.org/content/royprsb/280/1760/20130338.full.pdf)
(Homo floresiensis from Late Pleistocene of Flores has extremely small endocranial volume (LB1 type specimen ~400cc). Hypotheses discussed: (1) H. floresiensis experienced dramatic brain size reduction from the Homo erectus (~1000 cc) in isolated insular setting; (2) species derived directly from more primitive and smaller-brained form such as Homo habilis (~600 cc) or Australopithecus (~400 cc))

(Modern review of hominin distribution in Indonesian region)

(New subspecies of colobine monkey described by Jablonski and Tyler (1999) from near Krikilan, Sangiran dome, C Java, unlikely to be from Late Pliocene Lower Lahar volcanic breccia, but not found in situ, and probably from U Sangiran (Pucangan) or lower Bapang (Kabuh) Fms)

(Review of migration of hominids in Asia. Earliest hominins in Asia almost as old as first appearance of genus Homo in Africa. Most fossil materials from Asia are without reliable dates)

(online at: https://hal.inria.fr/halshs-00423519/document)
(Large mammal assemblage typical of Ailuropoda-Stegodon fauna in Cave of the Monk, N Thailand. Fossiliferous layer with gnawed bones resulted from mid-size burrowing animals, probably porcupine)

(online at: https://lkcnhm.nus.edu.sg/nus/pdf/PUBLICATION/)
(Elephant fossils rare in Peninsular Malaysia. 19 specimens recorded, all isolated dental materials of presumed Late Pleistocene and Holocene age)

(online at: http://unsworks.unsw.edu.au/fapi/datastream/unsworks:1693/SOURCE02)
(On extinction of large Pleistocene mammal species in SE Asia)


Louys J. (2011)- Mammal community structure of Sundanese fossil assemblages from the Late Pleistocene, and a discussion on the ecological effects of the Toba eruption. Quaternary Int 258, p. 80-87.
(Dog-sized giant rats coexisted with humans for 40,000 years on Timor)

(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4793331/pdf/peerj-04-1788.pdf)
(U-series dating of stegodon tusk from Pleistocene Ainaro gravels near Atambua, Timor, indicate presence of stegodons in Timor at or before 130 ka, pre-dating earliest evidence of humans on island)

(online at: https://www.jstage.jst.go.jp/article/ase/117/1/117_080411/_pdf)
(Morphometric analysis of skulls separates H. floresiensis (LB1) from all H. sapiens, while not possible to separate H. floresiensis from H. erectus. Neolithic skulls from Flores within range of modern humans and not related to LB1)

(The stone artifacts from the Stegodon fossil beds of Mengeruda on Flores, Indonesia’. Pleistocene volcanoclastic fossiliferous beds on Soa Plateau, W Central Flores, contains Stegodon (Hooijer 1957), also Pleistocene tektites and variety of stone tools, similar to ‘Sangiran industry’ of C Java and ‘Cabenge industry’ of Sulawesi (now dated at Mata Menge site as ~880 ka: JTvG))


(Discovery of Pleistocene mammalian fauna with Stegodon trigonocephalus and human stone tools at Olabula, Flores, by Verhoeven in 1957 were first East of Wallace Line)

(online at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0044541)
(Occurrence of crocodilian Gavialis cf. bengawanicus in E Pleistocene of Tha Chang sandpit, Nakhon Ratchasima Province NE Thailand. Associated with Stegodon and other E Pleistocene mammal fauna. Scenario for dispersal of Gavialis from Indo-Pakistan to Indonesia. Dispersal by sea less likely than dispersal through fluvial drainages. (not much on geological setting and age control; G. bengawanicus Dubois also known from Trinil, C Java, associated with Stegodon- Homo erectus fauna; Dubois 1908, Delfino & De Vos, 2010; HvG)

(New hominids ‘Homo floresiensis’ from Flore, dated at ~18,000 yrs, very small but dentally adult. Commonly interpreted as insular dwarf derived from Homo erectus, but far too small to derive from Homo erectus by normal dwarfing. H. floresiensis most likely microcephalic Homo sapiens with advanced stone tools)

(Jerimalai rock shelter in E Timor with large assemblage of Pleistocene stone artefacts and shell fish hooks dated to 42,000 yrs BP, one of oldest known sites of modern human activity in island SE Asia. Little change in lithic technology over 42,000 year sequence until addition of new types and raw materials in M Holocene.
Assemblage dominated by small chert cores and implements rather than pebble tools and choppers (common in island SE Asia as opposed to mainland SE Asia). Jerimalai assemblage resembles Liang Bua assemblage of Flores, associated with Homo floresiensis; both possibly created by modern humans.


Meijer, E. & C.P. Groves (2006)- The geography of mammals and rivers in mainland Southeast Asia. In: M. Lehman & J.G. Fleagle (eds.) Primate biogeography- progress and prospects, Springer, New York, p. 305-330. (Late Pliocene- E Pleistocene environmental changes in mainland SE Asia split up many tropical species leading to diversification, maintained during Pleistocene by further glacial periods. During last glacial maximum this may have led to isolation of rainforest-dependent species in several refugia. M Pleistocene catastrophic comet collision around 0.77 Ma, with centre of impact in E Thailand or E Cambodia/S Laos, may have caused widespread extinction in mainland SE Asia in area possibly >1 million km2)


Meijer, H.J.M., L.W. van den Hoek Ostende, G.D. van den Bergh & J. de Vos (2010)- The fellowship of the hobbit: the fauna surrounding Homo floresiensis. J. Biogeography 37, 6, p. 995-1006. (Flores vertebrate fauna low species richness and disharmonic fauna, resulting from isolated position of island. H. floresiensis associated with common pygmy proboscidean Stegodon floresensis insularis, giant rats (Papagomys armandvillei, P. theodorverhoeveni, Spelaeomys florensis) and other murids, bats, Komodo dragon (Varanus komodoensis, V. hooijeri), and large number of birds (incl. giant marabou Leptoptilos). Between fossil-bearing localities Ola Bula Fm (~ 900-800 ka) and Liang Bua (~95–0 ka) gap of ~700 kyr)


Regional developments and interregional correlations, Proc. 18th Int. Senckenberg Conf., Weimar, Terran Nostra, Stuttgart, p. 176-178. (Extended Abstract) (online at: www.senckenberg.de/fiix/doc/abstracts/68_Moigne_etal_2.pdf) (Brief review of Bukuran and Ngebung 2 sites, Sangiran. Ngebung 2 with 'late Trinil HK' mammalian assemblage and dated as beginning of M Pleistocene (~0.9 Ma?)


Moncel, M.H., M. Arzarello, E. Boeda, T. Bonilauri, B. Chevrier, C. Gaillard, H. Forestier, Y. Li, F. Semah & V. Zeitoun (2018)- Assemblages with bifacial tools in Eurasia (third part). Considerations on the bifacial phenomenon throughout Eurasia. Comptes Rendus Palevol 17, 1-2, p. 77-97. (online at: www.sciencedirect.com/science/article/pii/S163106831630032X) (Bifacial stone tool technology believed to become widespread from 800-700 ka onwards, probably reaching Levant from Africa before moving toward Asia, then Europe. However, reality may be more complex. In Indonesia lithic pieces compatible with Acheulean traditions found without stratigraphic context in S Sumatra and associated with Homo erectus fossils at base of Kabuh Fm in Sangiran)


Morley, M.W. (2017)- The geoarchaeology of hominin dispersals to and from tropical Southeast Asia: a review and prognosis. J. Archaeological Science 77, p. 78-93. (Review of geoarchaeology of Late Pleistocene modern human dispersals into and out of SE Asia, incl. Indonesian localities Punung/Wajak (Java) and Liang Bua (Flores))


(Patjitanian stone tools from Java S Mountains contain both hand-axes and flake tools and may not be as old as previously suggested)


(online at: http://berkalaarkeologi.kemdikbud.go.id/index.php/berkalaarkeologi/article/view/96/142)
('Giant primate of Java: a new Gigantopithecus specimen from Semedo'. Two enigmatic mandible specimens found in 2014 at Semedo, SE of Tegal, C Java. Morphologically similar, but twice size of common primate’s jaw. Semedo specimens close to Gigantopithecus blacki)

(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2602669/pdf/rspb20071488.pdf)
(Hominid fossils from Liang Bua, Flores, Indonesia, including nearly complete skeleton dated to 18 ka and assigned to new species are probably *ME* endemic cretins, part of an inland population of *Homo sapiens*)

(online at: https://www.bu.edu/anthrop/files/2013/08/OConnellDeSilvaJHE2013.pdf)

(Date for arrival of human colonization of Sahul generally assumed to be at ~40,000 BP or 60,000 BP. Postulated arrival dates before~42-45 ka not well-supported by data)

(online at: https://www.journals.uchicago.edu/doi/pdfplus/10.1086/694252)
(Pleistocene pre-sapiens hominins opportunistic omnivores, probably constrained to environments with plentiful fresh water animals and plants; therefore rel. difficult to migrate across island archipelago. Homo sapiens probably able to subsist on marine resources and more easily moved through islands E of Huxley Line)

(First discovery of Late Pleistocene flake-based stone tools from Timor, in Lene Hara cave, Timor Leste (one of rel. many Late Pleistocene occurrences of small 'flake tool industries' in caves and rock shelters across E Indonesia region)

(Several archeological localities across Vietnam originally interpreted as of M Pleistocene age, but age control of many localities unreliable)

(Late Pleistocene dispersal of anatomically modern humans out of Africa. Routes obeyed limitations placed by drinking water and climate-permissive corridors. First spread N in Eemian interglacial (~125 ka). Reached Indonesian region by 75-81 ka. Crossed Wallace Line to reach Australia at least by 48 ka (possibly 60 ka)


Polanski, J.M., H.E. Marsh & S.D. Maddux (2016)- Dental size reduction in Indonesian Homo erectus: implications for the PU-198 premolar and the appearance of Homo sapiens on Java. J. Human Evolution 90, p. 49-54. (Recent recovery of hominin maxillary third premolar, PU-198 in collections from Punung Cave (E Java) was used to suggest Homo sapiens appeared on Java between 143-115, ka. However, PU-198 overlaps in premolar sizes between H. erectus and H. sapiens, and indicate reduction in premolar size between early and late Javan H. erectus. Question appearance of H. sapiens on Java between 143-115 ka)


Ancestors of New Guineans, Aboriginal Australians, Near Oceanians, Polynesian, Fijians, E Indonesians, and Mamanwa ('negrito' group from Philippines) inherited part of ancestry from Denisovans, an archaic hominin group from Siberia. However, mainland E Asians, W Indonesians, Jehai (negrito group from Malaysia), and Onge (negrito group from Andaman Islands) have not


Rightmire G.P. (2001)- Patterns of hominid evolution and dispersal in the Middle Pleistocene. Quaternary Int. 75, p. 77-84.

At onset of Quaternary Homo erectus spread across Old World from Africa. Populations persisted in Far East until late in M Pleistocene, while H. erectus disappeared relatively early in West. Episode of hominid speciation in mid-Quaternary gave rise to anatomically more modern hominids called Homo heidelbergensis. Relationships of H. heidelbergensis to Neanderthals and recent humans still need clarification


(Morphological study of Ngandong hominid skulls from Solo River 20m terrace at Ngandong, originally described as Homo soloensis Oppenooth 1932. Here interpreted as advanced forms of Homo erectus ('Homo erectus s.l.', not H. erectus s.s.')(conclusion followed by many subsequent researchers, but validity questioned in older (Dubois 1937, Von Koenigswald 1956) and more recent studies, e.g., Zaitoun et al. 2010?, M. Westaway et al. 2015)


(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1986/5083...)
(Review of hominid material from Pleistocene of Java and latest Pliocene- Pleistocene migration routes of hominids into Indonesian region from Asia. Migrations into Java probably aided by Pleistocene sealevel lowstands and exposed Sunda Shelf. Migrations into East Indonesia and Philippines probably not until Late Pleistocene)


(online at: https://scholarspace.manoa.hawaii.edu/bitstream/10125/16759/1/AP-v9n1-96-110.pdf)
('The Paleolithic of East Cambodia': Review of crude pebble-culture stone tools in terrace deposits along E bank of Mekong River, over distance of 200km (some made of silicified wood). At Chhep in conglomerates of oldest terrace deposits (40-45m), associated with tektites (tools below tektites; e.g. Sorensen 2001))

(Review of evidence for early human occupations of mainland SE Asia from ~1 Ma to U Pleistocene)

(Homo erectus widespread and highly variable species from which later hominids emerged. Review of relevant specimens from Sangiran, other Javanese sites and Zhoukoudian Lower Cave (China) shows concept 'erectus' masks evidence of taxic diversity in Asian hominid fossil record and raises questions about non-Asian specimens belonging to single species)

‘About the first human settlements in the South Pacific’. First arrivals of Homo sapiens in Australia >40ka, possibly 50-60 ka. Debate whether these anatomically modern H. sapiens came from recent ‘out of Africa’ migration (Out-of-Africa hypothesis) or evolved locally from last Indonesian H. erectus (multiregional hypothesis). Morphometric differences between most recent Indonesian H. erectus and ‘robust’ Australian fossil H. sapiens from Kow Swamp and Cohuna clearly distinct, questioning local direct evolution


(online at: http://hopsea.mnhn.fr/pc/brochures/2007HOPseaFL.pdf)
(Brief review of Pleistocene climate trends on Java. Between ~1 and 0.2 Ma climate rel. cooler and drier and yielding majority of hominid fossils)


(Earliest Palaeolithic implements in Java Island >1 Ma old, postdating oldest Homo erectus fossils. Acheulean-like tools in early M Pleistocene (‘Sangiran flakes; 1.0-0.8 Ma), flake tools assemblages in late M/early U Pleistocene sites and development of cave occupations at end Pleistocene and E Holocene. Environment, mostly forested in E Pleistocene, changing climate during M Pleistocene, then at start of Late Pleistocene. Tectonic and volcanic activities affected local climate, paleogeography and floras. Associated vertebrate faunas reflect periods of contact with mainland (increased biodiversity) and periods of isolation (endemism))


(The stratigraphic position of Ngebung 2 excavation site, Sangiran Dome)


(online at: http://unesdoc.unesco.org/images/0022/002291/229174e.pdf)
(Review of ‘journey’ of Homo erectus and Homo sapiens across Indonesian archipelago since 1.5 Ma)


(Well-preserved ~1.75m long extinct testudinid tortoise from E Pleistocene lower Kali Glagah Fm, N of Bumiayu, originally collected by Van der Maarel 1932 and part of Java Satir Fauna of ~1.5Ma. Here identified as Megalochelys cf. sivalensis. Giant tortoise also known from Myanmar, Flores, etc.)


(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/404/253)

Bibliography of Indonesia Geology, New for Ed. 7. 434 www.vangorselslist.com 8/6/18

(Turtle fossil identified as *Orlitia borneensis* from Solo river bottom in Sambungmacan, eastern C Java, presumably eroded from M Pleistocene fluvial deposits one river bank. *O. borneensis* had wider distribution in past, but Java population would have become extinct by end of M Pleistocene)


(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1986/5083...)

(Brief review of Pleistocene Java mammal assemblages and issues regarding dating and interpretation)


(The Mesolithic of Indonesia: a cultural heterogeneity)


(*Homo sapiens may have colonized Indonesian Archipelago in early U Pleistocene. Most reliable evidence only since ~45 ka (Paleolithic sites with artifacts in Gunung Sewu, S Java)*)


(online at: http://balaiarkeologiyogya.com/berkalaarkeologi/article/view/20/37)

('Proboscidea fossils from Semedo site: its correlation with biostratigraphy and human arrival in Java'. Semedo site in Tegal district of C Java rich in vertebrate fossils, with high percentage and several species of Proboscidea (elephantoids): *Sinomastodon bumiayuensis*, *Stegodon trigonocephalus*, *Stegodon 'pygmy' semedoensis*, *Stegodon hypsilophus*, *Elephas* (Archidiskodon) planifrons and *Elephas hysudricindicus*)


(Review of archeological work in the Indonesian region before 1950, incl. Paleolithic-Neolithic stone tools, bronze drums and other object, megalithic remains, fossilized human remains)


(online at: https://journals.lib.washington.edu/index.php/BIPPA/article/view/11773/10402)

(*E Paleolithic sites with Lannathaian flaked pebble tools of Lampang Basin, N Thailand, probably 1.2- 0.8 Ma: in highest (oldest) Terrace 1 deposits, overlain by basaltals older than Matuyama- Brunhes magnetic boundary (K-Ar dating of basaltals unsuccessful)*)

(online at: http://naturtijdschriften.nl/download?type=document&docid=523347)
(Mojokerto skull from E Java, described by Von Koenigswald (1936) as Pithecanthropus modjokertensis, is juvenile skull, but not possible to determine if early (Homo erectus erectus) or late (Homo erectus soloensis) Javanese form (Dubois 1940 considered this to be rel. young Homo wadjakensis= H. soloensis))

(Flores classic Mata Menge site age: tuff sealing top of fossil layer (with Stegodon florensis and in-situ stone artefacts) with fission track age of 800 ± 70 Ma, while pink tuffaceous silt immediately below main fossil deposit dated as 880 ± 70 ka. Tangi Talo site with pygmy Stegodon sondaari and giant tortoise and FT age 900 ± 70 ka. Around 680 ka lake increased in size one leading to deposition of thin-bedded freshwater limestones of Upper limestone. Tektite at surface of Dozu Dhalu site with in-situ artefact and Stegodon florensis)

(New species of primitive deer Lagomeryx and Stephanocemas from late M Miocene (13.4-13.2 Ma) coal layers of Mae Moh Basin, N Thailand. Paleoenvironmental studies of Mae Moh mammalian taxa (cervid, bovid, suid, rhinoceros and proboscidean indicate range of habitats from woodlands to grasslands in a C3-plant-dominated environment. Isotopic samples support herbivores lived in a low-seasonal climate)

Suraprasit, K., Y. Chaimanee, T. Martin & J.J. Jaeger (2011)- First castorid (Mammalia, Rodentia) from the Middle Miocene of Southeast Asia. Naturwissenschaften 98, 4, p. 315-328
(late M Miocene age Steneofiber fossils from coal mines in Mae Moh and Chiang Muan, N Thailand)

(online at: https://www.app.pan.pl/archive/published/app60/app20120061.pdf)
(Bovid fossils from late M Miocene (~13.3 Ma) of Mae Moh Basin of NW Thailand, assigned to new species Eotragus lampangensis n.sp.. First report of Eotragus from SE Asia. Foraged mainly between grassland and forest)

(online at: http://zooneks.pensoft.net/articles.php?id=8309)
(Rich late M Pleistocene vertebrate fauna with 15 mammal and 10 reptile species in fluvial terrace deposits of Khok Sung, NE Thailand. No Ailuropoda, but with Gavialis bengawanicus. Fauna comparable to three other late M Pleistocene faunas, one with age >169 ka. In M Pleistocene of SE Asia two faunal associations: Java and mainland SE Asia. Thailand pathway for Sino-Malayan migration event from S China to Java)

(General review of hominid evolution in last ~2 Myrs. Heterogeneity among 'early African Homo erectus' and no clear link to Asian Homo erectus group. Pithecanthropus (now Homo) erectus now reckoned to be ~0.7- 1.5 Myr old. First truly cosmopolitan Homo is H. heidelbergensis, known from Africa, Europe and China 600 kyr ago. Homo sapiens originated in Africa)

(Fossil primates in Late Eocene Pondaung Fm in C Myanmar. Two large-bodied primates, Pondaungia cotteri and Amphipithecus mogaungensis. Some authorities believed they are primitive anthropoids, others regarded them as adapiforms or non-primate)

(Study of Sangiran 17 Homo erectus skull, interpreted to show similarities with Late Pleistocene Australian hominid)

(online at: http://hopsea.mnhn.fr/pc/thesis/M2%20Archie_TIAUZON.pdf)

(The large mammal faunas of late Middle Pleistocene from Thailand in a phylogenetic, paleoecological and biochronological framework'. Late M Pleistocene (~170 ka) large mammal fauna with giant panda, Ailuropoda Hyena, Crocuta, Orang-utang, Pongo pygmaeus Sus barbatus, etc.)

(Giant panda in latest M Pleistocene of N Thailand. Progressively disappears in SE Asia related to increase in temperature and rainfall)

(online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5577490/pdf/rspb20171278.pdf)
(New vertebrate fossil deposits on Sumba. Pleistocene deposit at Lewapaku in interior highlands may be close to 1Ma old, with small Stegodon sumbaensis Sartono, tooth of Varanus komodoensis and fragments of giant murids. Holocene cave deposits at Mahaniwa (~2000-3500 BP) with large rats and extinct frugivorous Varanus hooijeri. Sumba Quaternary vertebrate fauna comparable fauna of Flores)

(Monkey fossil from Sangiran. See also Jablonski & Tyler1999 and Larick et al. 2000: not as old as assumed?)


(M Pleistocene paleontological- archeologicaal Mata Menge site in Soa basin represents lake shore deposits, aged ~0.80-0.88 Ma. Common Stegodon florensis bones from aged animals that probably died natural death. Despite abundance of stone artefacts in same layers no evidence for butchering. FT age of overlying white tuff 0.75 ± 0.07 Ma (Morwood et al. 1998). Fossils all in 0.5-1.5m thick 'Unit B'; overlying Unit C tuffaceous siltstone and sand unfossiliferous)


(Review of numerous archeological objects from 'Bronze-Iron Age' period, which follows Neolithic in Indonesia)


(‘The bone tools industry of Ngandong’, C Java)


(Fossil porcupine molars from Sangiran (C Java), collected by Von Koenigswald. Three assigned to new species (Hystrix gigantea n. sp.), one may belong to Hystrix brachyura Linnaeus)


(Isolated porcupine teeth and two mandible fragments collected by Van Koenigswald from M Pleistocene of Sangiran, C Java, represent new species Hystrix vanbreei. Also present at Trinil)

Van Weers, D.J. (2003)- The porcupine Hystrix (Acanthion) brachyura punungensis subsp. nov. from Late Pleistocene fissure deposits near Punung, Java. Scripta Geol. 126, p. 217-225.

(Cheek teeth and mandibular fragment of porcupines from Late Pleistocene fissure deposits near Punung considered new subspecies, Hystrix brachyura punungensis subsp. nov. M Pleistocene specimens allocated to Hystrix brachyura subsp.; those from the Holocene to Hystrix javanica)


(First paper on Pleistocene hominin artifacts from Flores (mainly surface scatters); see also Bednarik 2000)


('Proto-Negrito in the caves of Flores'. Late Pleistocene or E Holocene hominin remains)

(First report of E Pleistocene Stegodon fossils associated with hominid stone tools in Flores)


(M Pleistocene site of Sangiran where tigers co-occurred with machairodonts (Hemimachairodus zwierzyckii and Homotherium ultimum) and large Merriam’s Dog (Megacyon merriami). Tigers did not increase body mass before Ngandong faunal level)


Von Koenigswald, G.H.R. (1952)- Evidence of a prehistoric Australo-melanesoid population in Malaya and Indonesia. Southwestern J. of Anthropology 8, 1, p. 92-96. (Comment on Hooijer (1950) paper of same title, who suggested presence of big-teeth people resembling Australian aboriginals and Melanesians may once lived in Malaya-Indonesian region. vK disputes this)

Wang, W., C.J. Bae, S. Huang, X. Huang, F. Tian, J. Mo, Z. Huang, C. Huang, S. Xief & D. Li (2014)- Middle Pleistocene bifaces from Fengshudao (Bose Basin, Guangxi, China). J. Human Evolution 69, p. 110-122. (Paleolithic handaxes dated at 803 ka based on association of Australasian tektites. Tektites all from between mottled sandy red clay in upper Terrace 4 at 185.95-187.06m asl. Tektites fresh, with sharp edges do not look redeposited (but in-situ nature of tektites questioned by Langbroek 2015))

Wang, W. & C.J. Bae (2015)- How old are the Bose (Baise) Basin (Guangxi, southern China) bifaces? The Australasian tektites question revisited. J. Human Evolution 80, p. 171-174. (Disagree with Langbroek (2015) comments on Wang et al. (2014). The 275 tektites from stone artifact-bearing laterite of upper Terrace 4 show no signs of abrasion and are in-situ, while tektites from younger gravel bed in T3 do show rounding)

Wang, W., S.J. Lycett, N. von Cramon-Taubadel, J.J.H. Jin & C.J. Bae (2012)- Comparison of handaxes from Bose Basin (China) and the Western Acheulean indicates convergence of form, not cognitive differences. PlosOne 7, 4, e35804, p. 1-7. (In Bose Basin stone artefacts, including handaxes, limited to middle and upper units of 4th terrace, associated with tektites dated by 40AR/39AR to 803 ± 3 ka old and also limited to 4th terrace. Rel. relatively high levels of shape variability in Bose handaxes)

Wang, W., J.Y. Mo & Z.T. Huang (2008)- Recent discovery of handaxes associated with tektites in the Nanbanshan locality of the Damei site, Bose basin, Guangxi, South China. Chinese Science Bull. 53, 6, p. 878-883. (176 stone artifacts in laterized sediments of top of Terrace 4 of Youjiang River at Nanbanshan, Bose basin, S China. Two handaxes associated with 155 fresh, unabraded and sharp-edged tektite pieces (average length 29 mm) in 60cm thick horizon, suggesting tektites buried immediately after airfall event, and artifacts and tektites deposited simultaneously 803 ka. More stone artifacts unearthed above tektite layer, indicating early humans survived event)


Westaway, K.E. & C.P. Groves (2009)- The mark of ancient Java is on none of them. Archaeology in Oceania 44, 2, p. 84-95.
(online at: www.pnas.org/content/112/7/E604/full.pdf)  
(Mandibular characteristics of Homo floresiensis from Liang Bua, Flores, close to early hominins, and not pathological H. sapiens as suggested in Henneberg et al. and Eckhardt et al. 2014 papers)

(online at: www.jstor.org/stable/pdf/j.ctt169wd9c.16.pdf)  
('Late' Homo erectus from sites like Ngandong/ Sambungmacan/ Ngawi, Java, often viewed as advanced H. erectus or sometimes as 'archaic' H. sapiens, but may be separate species Homo soloensis. Etc.)

(Reinvestigation of Lida Ajer cave in Padang Highlands, W Sumatra, which yielded Late Pleistocene human teeth (Dubois 1890), associated with rich rainforest fauna. Enamel-dentine junction morphology, enamel thickness and comparative morphology show that teeth belong to anatomically modern humans (Homo sapiens). Dating of bone-bearing sediments and U-series/ electron spin resonance dating of Pongo mammalian teeth place modern humans in Sumatra between 73-63 ka. Evidence of rainforest occupation by H. sapiens at ~70 ka is ~20 ka earlier than assumed timing of dispersal of modern humans across SE Asia)

(online at: http://jgsm.geologi.esdm.go.id/index.php/JGSM/article/view/126/333)  
(Mandible of Stegodon trigonocephalus at Cipanaruban River near Pasir Cabe paleontological site (Von Koenigswald 1933), ~6 km E of Subang. Presumably part of Cisaat Fauna, E Pleistocene)

(Fossil analyses indicate Pleistocene vertebrate faunas on Flores fauna most likely from Java, not Sulawesi (characteristics of Stegodon, giant tortoise and hominids that look like descendants of Homo erectus)

(Analyses of Homo erectus fossils, incl. Indonesian material. Shows evolutionary changes in increased cranial capacity and mandibular and dental features. Late end of H. erectus range difficult to define, as evidenced by difficulty in agreeing on whether Ngandong (C Java) samples are H. erectus or H. soloensis or H. sapiens)

(Homo erectus and Homo sapiens part of single evolving lineage in past two million years)

(online at: http://hopsea.mnhn.fr/pc/thesis/M2_DONAN_S_Y.pdf)

(Suggested links between Javanese E Pleistocene Homo erectus and Australian Late Pleistocene Homo sapiens crania (Thorne, etc.) questionable. Hybridization of two species unlikely: no chronological overlap and phylogenetic analysis indicate no close genetic relationship between Ngandong-like population from Java and late Pleistocene Australian fossils from Willandra Lakes)
(Reevaluation of the Ngawi 1 skull (Homo erectus, Java, Indonesia); 3D imaging and multivariate analyses). M-L Pleistocene Ngawi 1 skull found in 1987 morphologically close to 'late Homo erectus' Ngandong and Sambungmacan hominids. Morphological characteristics of Ngawi skull not directly comparable to Chinese (Sinanthropus) and African Homo erectus (H. ergaster), but one African individual (Olduvai 9) fits well in Ngangong-Ngawi group)

(Summary of Zaim 2002 paper. Dwarf Stegodon tooth from E Pleistocene of W Java, probaby of Satir or Ci Saat fauna indicates E Pleistocene island in this part of W Java)


(Acheulian lithic assemblage rich in handaxes from Fengshudao (Guangxi province, S China), adjacent to N Bose basin. Age from tektite dating ~800 ka. Artifacts manufactured from quartzite, sandstone, volcanic rocks, chert and quartz)

(online at: http://repository.kulib.kyoto-u.ac.jp/dspace/handle/2433/199762)
(Rhinoceros sondaicus (Java rhino) discovered in upper part of E Pleistocene Irrawaddy Fm. Species widespread in upper M Pleistocene- U Pleistocene of Laos, Vietnam, Cambodia, Thailand, Java, Sumatra, and Borneo, and probably originated in E Pleistocene in continental Asia)

(Skull and mandible of Dicerorhinus gwebinensis n.sp. from upper Irrawaddy sediments (Plio-Pleistocene) in C Myanmar. More similar to extant species D. sumatrensis (Sumatran rhinoceros) than to other species of genus)

(8 species of fossil rhinoceros in Neogene of C Myanmar: M-L Miocene 'Diceratherium' naricum, Brachypotherium spp., etc. Latest Miocene -Pleistocene onset of extant genera Rhinoceros and Dicerorhinus. Dispersed to island SE Asia from continental Asia during E-M Pleistocene periods of low eustatic sea level)
XI. HYDROCARBONS, COAL, MINING (66)

XI.1. Hydrocarbon Occurrences/Assessment (9)


(Lateral reservoir drainage is hydrodynamic flow type driven by differences in overpressure and can lead to hydrodynamically tilted hydrocarbon-water contacts. Tilted contacts present in fields in Lower Kutai Basin, Arun Field in N Sumatra, Vorwata Field in Bintuni and BD Field of East Java)

(In Indonesia 974 exploration and appraisal wells drilled from 2002-2015, 617 onshore and 357 offshore. Of 676 new field wildcats 310 encountered hydrocarbons, adding in-place resources of 18,500 MMBOE. Discoveries in W Indonesia in 5 plays: (1) Paleogene rift sections of Sumatra, W Java, W Natuna; (2) pre-Cenozoic fractured basement in S Sumatra, W Java, E Java; (3) Oligo-Miocene carbonate build ups of E Java and U Kutai; (4) Mio-Pliocene deep-water turbidites of N Makassar and Tarakan; (5) Mio-Pliocene growth-faults of delta progradation of Tarakan Basin. In E Indonesia in 2 plays (Jurassic and Miocene). With details on significant discoveries and dry wells)


(Play assessment: 563 plays in 1954 prospects and 2173 leads in 43 sedimentary basins in Indonesia. Total in-place resources at P90 is 45.5 BBO and 155 TCF (cut-off of big resources is 500 MMBO for oil, 1 TCF for gas). Current oil production in Indonesia ~810,000 BOPD, against demand of >1.5 MMBOD)

(Brief review of hydrocarbon exploration in Indonesia until 1985)


(online at: www.lemigas.esdm.go.id/pubifikasi/read/scientific/1) (Porosity depth models derived from core samples from 549 wells in 8 producing sedimentary basins in W Indonesia)

XI.2. Hydrocarbon Source Rocks, Oils and Gases (9)

('Indications of biogenic 'swamp gas' in waters of the Mahakam Delta. Numerous indications of biogenic methane in shallow seismic profiles and cores in shallow sediments of Mahakam Delta distributary channels)

(online at: http://ejournal.mgi.esdm.go.id/index.php/jgk/article/view/201/191
('The distribution pattern of gas charged sediment in seabed of waters of Sidoarjo, East Java'. Belt of biogenic shallow gas-charged sediments on shallow seismic profiles off Porong Delta, Madura Straits)

(online at: http://archimer.ifremer.fr/doc/00109/22074/19716.pdf)
('Occurrence of methylotrophic methane-producing bacteria in deep-sea sediments from Makassar Strait (Indonesia'). Competition between sulfate reducing and methane producing bacteria one of main factors controlling biogenic methane genesis in anoxic marine sediments. Methylotrophic methanogenic bacteria found in shallow marine sediments, and methanogenic bacteria able to produce methane from methylamines in sediments from oceanic trench at depth of 2000m in Makassar Strait)

(online at: www.bgl.esdm.go.id/publication/index.php/dir/article_detail/719)
('Interbedded black shale and limestone of M Miocene Baong Fm in N Sumatra Basin similarities with Barnett Shale of Fort Worth Basin, therefore Baong Fm may also become commercial gas resource)

('Application of organic petrology in basin analysis and hydrocarbon exploration in several basins in Indonesia and Australia'. Brief review of organic petrology in Miocene of S Sumatra, Triassic of W Timor and Permian-Triassic of Bowen Basin, NE Australia)

('Geochemistry of 22 oils from C Sumatra basin. Two groups, both sourced from lacustrine facies in Pematang Fm: (1) Minas, Oki and Libo fields (with botryococcane, heavy C-isotopes, etc.); (2) Kotabatak area, Kotagarao, Nusa, NW Minas (Telisa Fm) (no botryococcane, light C-isotopes, etc.))

(online at: http://ccsenet.org/journal/index.php/mas/article/view/15690/11133)

('Comprehensive review of petroleum geochemistry of Indonesian basins. Oils of W Indonesian basins three broad families: (1) lacustrine (C Sumatra, Sunda-Asri, partly W Natuna, and W Sulawesi offshore/N Makassar Straits);(2) fluvo-deltaic (S Sumatra, W Java, E Java, Barito, Kutai, Tarakan), and (3) marginal-shallow marine (N Sumatra. W Sulawesi onshore). Most oils from E Indonesia basins marginal-shallow marine;
sourced from Neogene (Salawati, Banggai), Jurassic (Bintuni), Triassic-Jurassic (Timor, Buton, Seram, Timor). Both thermogenic and biogenic gases


XI.3. Coal (20)


Biagioni, S., V. Krashevskya, Y. Achnopha, A. Saad, S. Sabiham & H. Behling (2015)- 8000 years of vegetation dynamics and environmental changes of a unique inland peat ecosystem of the Jambi Province in central Sumatra, Indonesia. Palaeogeogr. Palaeoclim. Palaeoecology 440, p. 813-829. (Study of 7.3m peat core a 733 cm-long core from Air Hitam peatland in Jambi Province. In last ~7800 years site covered by dipterocarp-swamp mixed rainforest during first 2000 years, after which freshwater swamp taxa more important, in particular Durio trees. At ~4500 years ago swamp vegetation shifted to pole forest with Pandanus thickets in response to change from minerotrophic to ombrotrophic conditions)

Bowe, M. & T.A. Moore (2015)- Coalbed methane potential and current realisation in Indonesia. In: AAPG Asia Pacific Region GTW, Opportunities and advancements in coal bed methane in the Asia Pacific, Brisbane, Search and Discovery Art. 90234, 5p. (Extended Abstract) (Estimates for CBM potential ranged up to 450 TCF, but realisation of resource limited so far. Main CBM targets Miocene coal seams in S Sumatra and Kutai Basins. S Sumatra coal seams generally thicker (5-25 m) than Kutai Basin and laterally continuous over 10s of km. 54 PSCs since 2008. 84 CBM core and pilot wells drilled by 18 operators. Gas contents generally higher in Kutai Basin (2-10 m3/t) than in S Sumatra Basin (<3 m3/t). Gas saturations tend to be >80% at depths >300m. Gas dominated by biogenically-derived methane)


Esterle, J.S. (1999)- Can peats be used to discriminate local subsidence from regional tectonism? Examples from Sarawak, Malaysia and Sumatra, Indonesia. In: H. Darman & F.H. Sidi (eds.) Tectonics and sedimentation

(Holocene peats of E Sumatra and Sarawak started forming at ~6000 BP and are models for formation of coal measures. Two modes of peat accumulation, one where it keeps up with clastic sedimentation (rel. high preservation potential), and one where it outstrips clastic sedimentation (rel. poor preservation potential))


(SE Asia Cenozoic coal-bearing basins grouped in five regions: N Sundaland, S Sundaland, Philippines, W Myanmar and E Indonesia; first three discussed here. Most significant coal deposits of SE Asia in Neogene of S Sundaland (Borneo, Sumatra), over extensive coastal plains in regressive setting. Coal deposits of N Sundaland (i.e. SE Asian continental) in small disconnected non-marine grabens, and are areally restricted. S Sundaland resided mainly within ±10° of equator, with paleoclimate conducive to ever-wet conditions. N Sundaland resided >10°N of equator, probably monsoonal with annual dry periods. Etc.)


(Review of geologic setting and 160 years history of coal exploration and commercial production in Indonesia. Coal exploration and production of Eocene and Miocene coal started in late 1800's in SE Kalimantan and W and S Sumatra. Very limited production from World War 2 until 1980s when modern coal mining industry started to develop. In 2005 Indonesia became world's largest coal exporter)


(Modern and ancient Cenozoic peat cycles commonly evolve from inundated wetland assemblages to more elevated and well-drained forest. Changing floral compositions result from changes in substrate wetness during peatland aggradation in high rainfall settings. Includes some discussion of SE Asian peatlands)


('Petrology of coals from Sumatra and Kalimantan: types, ratings and applications')

Santoso, B. (2017)- Petrographic characteristics of selected Tertiary coals from Western Indonesia according to their geological aspects. Indonesian Mining J. 20, 1, p. 1-30.

(online at: http://jurnal.tekmira.esdm.go.id/index.php/imj/article/view/178/110)

(Tertiary coals from W Indonesia (Sumatra, Kalimantan, Java) similarities and differences. Coals dominated by vitrinite (detrovitrinite, telovitrinite), common liptinite (resinite, cutinite, suberinite) and rare inertinite (semifusinite, sclerotinite, inertodetrinite) and mineral matter. Differences reflect differences in climate and peat conditions. Vitrinite reflectance variations caused by variations in burial and effects of igneous intrusions)

(Three well drilling program for CBM evaluation in Late Miocene lignite- sub-bituminous coals of Muara Enim Fm indicates favourable gas content: average 3.55 m3/t (125.31 scf/t) at depth of 410- 812m


(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_1/1996/)

Van Diest, P.H. (1871)- De kolenrijkdom der Padangsche Bovenlanden en de mogelijkheden van de voordeelige ontginning. Stemler, Amsterdam, p. 1-76.

(online at: https://books.googleusercontent.com/books/...)

('The coal resources of the Padang Highlands and the possibilities of profitable exploitation'. Historic economic evaluation of Ombilin coalfield in West Sumatra. Ombilin coals relatively high in carbon (79-80%) and low in ash (0.27-0.95%), Sulfur 0.34-0.87%)


(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/289/260)


(Lateral variations in Plaie peat forest W of Samarahan, Sarawak. Peat thickness 0.2-2.3m, increasing to W)

XI.4. Minerals, Mining  (28)


('Volcanogenic Massive Sulphide deposits: characteristics and distribution in Indonesia'. Reprinted in Metalogeni Sundaland 1 (2014), p. 263-273. Polymetallic Massive Sulfide deposits always associated with volcanics and sediments. VMS deposits in Indonesia two types (1) Kuroko-type Sangkaropi (S Sulawesi, Cu-Pb-Zn), (2) Lerokis and KaliKuning (Wetar), with stratabound Au-Ag bodies of sedimentary exhalative origin)


(Radioactive minerals found in several areas in W and E Indonesia)


(online at: https://pubs.usgs.gov/cp/46/plate-1.pdf)

Harjanto, S., S. Virdhian & E. Afrilinda (2013)- Characterization of Indonesia Rare Earth minerals and their potential processing techniques. Conf. Tools for Materials Science & Technology 2013, Montreal, 9p. (In Indonesia REE minerals monazite, xenotime and zircon are associated with tin, uranium and gold in alluvial deposits. REE range from 30-400 ppm in sands on Bangka and Belitung REE minerals, and are by-product of tin ore mining and extraction. Also: lower grade monazite and xenotime as alluvial in Kampar and Riau Islands, REE minerals in uranium alluvial in W Kalimantan)


Molengraaff, G.A.F. (1910)- Das Vorkommen und die Gewinnung von Eisenerz in den Niederlandischen Kolonien. In: The iron ore resources of the world, 11th Int. Geol. Congress, Stockholm 1910, 2, p. 993-996. (online at: https://babel.hathitrust.org/cgi/pt?id=nyp.33433089972370;view=1up;seq=489) ('The occurrence and exploitation of iron ore in the Netherlands colonies'. Very brief listing of known iron ore occurrences in Indonesia: Gunung Besi (Sumatra; hematite), Teluk Betung (S Sumatra; magnetite), Banyumas (Java; iron sand) Gunung Tambaga (SE Kalimantan; hematite). None producing. All of questionable commercial value)

Muller, D. & D.I. Groves (2015)- Direct associations between potassic igneous rocks and gold-copper deposits in volcanic arcs. In: Potassic igneous rocks and associated gold-copper mineralization, 4th Ed., Mineral Resource Reviews, Springer, p. 97-90. (Examples of direct associations between potassic igneous rocks and copper-gold deposits include: (1) Late Oceanic Arc associations: Ladolam gold (Quaternary, Lihir Island, PNG); Emperor gold (Tertiary, Viti Levu, Fiji), Dinkidi copper-gold (Miocene, Didipio district, Philippines); and (2) Post-collisional Arc associations: Grasberg copper-gold (Pliocene, W Papua), Misima gold (Pliocene, Misima Island, PNG); Porgera gold (Miocene, PNG))


Rochani, S., Pramusanto, Sariman & R.I. Anugrah (2008)- The current status of iron minerals in Indonesia. Indonesian Mining J. 11, 2, p. 1-17. (online at: http://jurnal.tekmira.esdm.go.id/index.php/imj/article/view/590/452) (Indonesia iron resources include (1) primary iron ore (hematite, magnetite; 17%), (2) iron sand; commonly used for cement industries (8%) and (3) lateritic iron ore (limonite, from weathered ultrabasic rocks) used as coal liquefaction catalyst (75%). With listings of main iron sand deposits (10) and lateritic deposits (10) and primary iron ore deposits (10))


Setijadji, L.D., I.W. Warmada, A. Imai & K. Sanematsu (2009)- Investigation on Rare Earth Elements mineralization in Indonesia. In: 2nd Reg. Conf. Interdisciplinary Research on Natural Resources and Materials Engineering, Yogyakarta, p. p. 53-58. (REE most likely associated with Mesozoic granitic rocks in W Indonesian, i.e. Tin islands (Bangka, Belitung, Bintan and Singkep) and west C Kalimantan. Tin islands similar geology with REE-producing China and SE Asia granite belts)


XII. HISTORIC INTEREST, LINKS (22)

XII.1. Historic Interest, Biographies (22)

(In memoriam of G.L. Smit Sibinga, professor of physical geography in Amsterdam. Published series of (underappreciated?) papers on tectonics of Indonesian archipelago in 1920's and 1930's. Early supporter of Wegener's theory of horizontal movements of continents)

(online: https://sejarah-nusantara.anri.id/media/dasadefined/HartaKarunArticles/HK001/Doc_1_Eng.pdf)
(Report of travels by Portuguese VOC trading agent into interior of Central Sumatra, following discovery of tin-mines at headwaters of Siak and Kampar Rivers in 1670s)

(online at: dspace.library.uu.nl/handle/1874/34233)
('The Mines Department in the Netherlands East Indies, 1850-1950'. History of Geological Survey agency ('Dienst Mijnwezen') in Batavia, Bogor and Bandung during Dutch colonial era)

De Roever, W.P. (1962)- In memoriam Prof. Dr. Ir. J. Westerveld. Geologie en Mijnbouw 41, 10, p. 405-408.
(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0Q0szeFlCbEJxc1k/view)
(Obituary of J. Westerveld, geologist of 'Dienst Mijnwezen' (Geological Survey) from 1929-1935. Author of 2 S Sumatra map sheets in 1931, 1933, papers on 'welded tuffs' of Sumatra, geology of Bangka and tin granites, etc.)


(online at: https://www.jstage.jst.go.jp/article/jgeography1889/55/12/55_12_433/_pdf)
(List of papers on fossil and Recent molluscs of Indonesia published between 1923-1939)

('Revealing Borneo. Objects, photographs and documents of Swiss geologist Leupold in the Netherlands Indies 1921-1927'. Memorabilia from Geological Survey geologist Wolfgang Leupold, surveying in Tarakan, Bunyu, Bulungan, Berau and Mangkalihat areas of NE Kalimantan)

(online at: https://ia600402.us.archive.org/21/items/LandschaftsansichtenJavaLitho1853/Landschaftsansichten-Java_Litho-1853_150dpi.pdf)
('Eleven landscape views from Java drawn after nature by Franz Junghuhn'. Eleven classic paintings of Gunung Gamping, Gunung Sewu, Kawah Patua, Dieng Plateau, Guntur, Merapi, Sumbing, Gede, etc.)
KNGMG (1994)- Presentation of the Van Waterschoot van der Gracht medal to Prof. Dr. John A. Katili. Geologie en Mijnbouw 73, 1, p. 79-83.
(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0ZFNZcjRkSUpmeEk/view)

('Crusades over the deep sea basins of the Indies; one and a half years as geologist on board of H/M. Snellius')

(The life of Richard W. Murphy (1929-2010), 'colorful' Esso geologist with a long history in SE Asia)

(online at: https://pesd.fsi.stanford.edu/sites/default/files/WP_93_Lucarelli_revised_Oct_2010.pdf)

(online at: www.gsm.org.my/products/702001-101704-PDF.pdf)
(On advances in scientific understanding of continental shelf of Malaysia and nearby areas in last 50 years)

(online at: https://www.oalibrary.org/papers/view/0c6dc922-d7fb-49e8-870c-c0c5995d4175/)
(Memorial of Professor Felix Vening Meinesz (1887-1966), professor of Geodesy and Geophysics at University of Utrecht. Famous for pioneering marine gravity surveys, in particular his work in navy submarines in Indonesian region in 1930's. His discovery of narrow belt of unusually low negative gravity over trench/accretionary prism around Sunda-Banda active volcanic arcs interpreted as zone of 'crustal downbuckling', and was early indication of the subduction process)

(Obituary of Dr. Werner Rothpletz, geologist, who worked for BPM in Cepu and Birds Head/ New Guinea from 1933-1939 and for Geological Survey (Bandung) during Japanese occupation and from 1950-1960)

(online at: https://www2.uibk.ac.at/downloads/oeegg/Band_64_243_246.pdf)
(Obituary of Austrian geologist Rudolf Osberger (1924-1972). Worked as teaching assistant/ researcher at University of Indonesia (now ITB) in Bandung from 1952-1955, specializing in Tertiary corals. From 1955-1966 with Billiton tin company. Published several key papers in both fields)

(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0YW85b3Q5MEhSUUU/view)
(Preface to Van Bemmelen commemorative volume)

(online at: www.dwc.knaw.nl/DL/publications/PU00010942.pdf)
(Includes history of geophysical studies (gravity, earthquakes, etc.) in former Netherlands Indies)

(online at: https://gsmpubl.files.wordpress.com/2017/09/ngsm2017_02.pdf)  
(Adventures of Shell geologist during fieldwork in Sabah)

(online at: www.gsm.org.my/products/702001-101720-PDF.pdf)  
(Early history of geological mapping in Sabah two periods, each finalized by attempt at synthesis: (1) earliest work of pioneer explorers (1880-1890s) summarized in T. Posewitz (1892) and now of historic interest only; (2) work by professional geologists (early 1900-late 1930s), synthesized by Reinhard and Wenk (1951))

(online at: www.gsm.org.my/products/702001-101715-PDF.pdf)  
(Review of landmark publication by Reinhardt and Wenk (1951; Bull. No. 1 of 'Geological Survey Department of the British Territories in Borneo', based mainly on work for Shell before 1939. First to recognize Danau Fm of Molengraaff (1900) (in Sabah often called Chert-splilte Fm) as ophiolite suite)