BIBLIOGRAPHY OF THE GEOLOGY OF INDONESIA AND SURROUNDING AREAS

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I. REGIONAL GEOLOGY

(Simandjuntak, 2000)

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I. REGIONAL GEOLOGY

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1. Indonesia Regional Geology

2. SE Asia Regional Geology, Tectonics, Paleobiogeography

3. Volcanism, Volcanic rocks geochemistry

4. Modern depositional environments, Oceanography, Indonesian Throughflow

5. SE Asia Carbonates, Coral Reefs

Chapter I of the Bibliography 7.0 contains 316 pages with >2405 titles of papers on the regional geology of Indonesia and adjacent SE Asia-Pacific, as well as general papers that do not fit in any of the regions or specialist categories that are listed separately. It is subdivided in five chapters, I.1-1.5.

I.1. and I.2. Indonesia and SE Asia Regional Geology

Chapters I.1 and I.2 include >1530 references of textbooks and papers on the regional geology and tectonics of Indonesia and SE Asia. Chapter I.1 focuses on the regional geology of Indonesia, while chapter I.2 includes more of the regional geology of the broader SE Asia region and of the SE Asia mainland (Malaysia, Thailand, Myanmar, Vietnam, SW China, etc.). The reason for including the latter in this Indonesia-focused bibliography is that many of the geological zones of mainland SE Asia continue into parts of western Indonesia, so the tectonic history and stratigraphy of these areas are relevant to understanding parts of Sumatra, Borneo, etc..

Figure I.1.1. Present-day subduction zones, oceanic basins and major ophiolites in the SE Asia-New Guinea-West Pacific region (Zahirovic at al. 2014).

Numerous papers on Paleozoic-Mesozoic faunas and floras are also included here, especially those that help identify faunal and floral provinces that are indicative of paleoclimate and latitudinal positions of plates through time. Paleobiogeographic patterns and tectonostratigraphic successions are key tools for underpinning and constraining plate reconstructions of SE Asia, especially in the pre-Cenozoic.
Although the Van Bemmelen (1949) Geology of Indonesia book is generally viewed as the most significant textbook on the geology of Indonesia, its tectonic interpretations are outdated (and were actually already controversial at the time of publication).

The pioneering book and maps of Warren Hamilton (1979) 'Tectonics of the Indonesian Region' (U.S. Geol. Survey Prof. Paper 1078) were the first interpretations of Indonesia tectonics in a plate tectonic framework and remains an unrivalled masterpiece. The book still contains some of the most comprehensive descriptions of the geology of Indonesia, and many of Hamilton’s interpretations have withstood the tests of time.

![Figure I.1.2. Two key textbooks on the geology of the Indonesian region.](image)

The main patterns of the geologic evolution of SE Asia are reasonably well understood, but many details and exact timing of events are still debated.

**Indonesia/ SE Asia Basement blocks, suture zones**

The area of the Indonesian archipelago and surrounding SE Asia- Australia/ New Guinea is a very complex mosaic of continental and microcontinental blocks, active and extinct volcanic arcs and associated subduction complexes (commonly with ophiolites, marking suture zones where former ocean basins were consumed) and old and young oceans and marginal ocean basins (Figure I.1.3)

The patterns of Pretertiary Basement are masked and complicated by later events, like the formation of widespread Tertiary basins (mainly since Middle-Late Eocene time), breakup of margins by marginal basins creation, metamorphism due to magmatic activity, offsets by several large strike slip fault zones, etc.

Mainland SE Asia is also a complex collage of continental blocks, all of which probably once part of the Gondwana supercontinent, but separated from the NW Australia- New Guinea margin during successive episodes of Devonian- Jurassic rifting and seafloor spreading (S China, Indochina, Sibumasu, W Burma, etc.). After Northward drift from the S Hemisphere to equatorial latitudes (recorded by changes in flora and fauna from colder to warmer climates), the various Gondwanan-origin blocks amalgamated with mainland Eurasia during multiple Late Paleozoic- Eocene episodes of collision.
Figure I.1.3. Recent interpretation of SE Asia-Indonesia basement terranes. It differs from earlier versions mainly in recognition of West Sumatra, SW Borneo and Semitau blocks as separate units from the Sibumasu-East Malaya-Indochina blocks that amalgamated to form the Sundaland core in Triassic time (Metcalfe 2013).

Multiple suture zones that separate continental blocks or continental and arc volcanic terranes have been recognized across SE Asia. Most of these sutures represent former subduction zones along the South Eurasia and West Pacific margins, and many contain ophiolitic rocks that represent remnants of upper mantle, oceanic crust and pelagic sediment cover of closed former ocean basins (Paleo-Tethys, Meso-Tethys, Neo-Tethys/Indian Ocean). These are accompanied by volcanic-plutonic arc systems and intensely deformed accretionary complexes.
Figure I.1.4. Tectonic setting of Indonesia between two major Pretertiary continental blocks (Sundaland/Eurasia and Australia-New Guinea) (Barber 1985).

Figure I.1.4. summarizes the main tectonic elements of the greater Indonesian region:
1. Two major, converging Pretertiary continental blocks: Sundaland/Eurasia in the NW and Australia-New Guinea in the SE;
2. Cretaceous and younger accretionary crust along the Sundaland and New Guinea margins (including the Woyla terranes of West Sumatra, East Java, Meratus Range and further East in East Kalimantan, West Sulawesi, all of North Borneo;
3. Cenozoic oceanic marginal basins (South China Sea, Sulu Sea, Celebes Sea (possibly including North Makassar Straits) and North and South Banda Seas)
4. Microcontinental blocks that rifted off both Sundaland (Palawan (4), Sumba (11), Timor allochthon (12));
5. Microcontinental blocks that rifted off Australia-New Guinea (Banggai-Sula (6), Seram-Buru (9), etc.)
6. Major oceanic plates: northward subducting Indian Ocean in the SW and the westward subducting Pacific Ocean/Philippine SeaPlate in the NE.
Western Indonesia (‘Sundaland’) is a complex of Late Paleozoic-Triassic continental blocks that amalgamated by the closing of the Paleotethys Ocean suture in Late Triassic time. After a long period of relative quiescence Sundaland was affected by widespread Middle Eocene-Early Miocene rifting, creating many hydrocarbon-bearing sedimentary basins (e.g. Hutchison 1984, 1986, Hall and Morley, 2004, Sunarjanto et al. 2008, Pubellier and Morley 2014, Rangin 2015).

The present-day configuration of Eastern Indonesia formed much later, and is still evolving. It is a collage of relatively small continental microplates derived from the Australia-New Guinea Gondwanan margin, remnants of extinct volcanic arcs, active volcanic arcs and Cenozoic oceanic marginal basins.

**Marginal basins and ‘sliver terranes’**

Today the ~7400 km long East Asian/West Pacific active margin is an area of extensive marginal oceanic basins, from North of Japan to SE Asia (Tamaki and Honza 1991). They formed by back-arc extension, presumably during rollback of the subducting Pacific Ocean slab(s), collapsing and hyperextending the overriding plate towards the retreating hinge line.

In several examples the extension and spreading appeared to have initiated by ‘splitting’ of an active magmatic arc system. If this arc was in an active continental margin setting, this process will remove the entire forearc area from the continental margin, which then becomes an isolated continental sliver terrane (e.g. Palawan, West Sulawesi, Sumba-Timor Banda Terrane, Sulu Ridge, Sinta Ridge, etc.)

The majority (possibly all) of the known Indonesian marginal basins has already been reduced in area by subduction along one or more of their margins. Older marginal basins may already have been consumed completely (‘Proto-South China Sea?’).

Marginal basins may be flanked by zones of rifted continental or accretionary crust with sedimentary basins, formed during the same rollback/extensional episodes (e.g. 400-800 km wide rifted zones along the South China Sea; Clift et al. 2002).
Cenozoic marginal basins in and around Indonesia, with ages of oceanic crust formation, are shown on Figure I.1.6. They include:

- **South China Sea** ~32-15 Ma (Barckhausen and Roesser 2004, Song and Li 2015, Sibuet et al. 2016);
- **Sulu Sea** ~18-15 Ma (late Early Miocene) (Lewis 1991, Hutchison 1992, 2005);
- **Celebes Sea- Makassar Straits**: ~48-35 Ma (M-L Eocene) (Rangin et al. 1989, Gaina and Muller 2007);
- **North Banda Sea** ~13-7 Ma (Middle- Late Miocene) (Hinschberger et al. 2000);
- **South Banda Sea** 6.5-3.5 Ma (latest Miocene- Early Pliocene) (Hinschberger et al. 2001);
- **Moluccas Sea** Eocene? (seafloor now already mostly subducted).

Figure I.1.6. marginal oceanic basins in the Indonesia- New Guinea region and their ages (Harris, 2003). The Sulu Sea shown here as Oligocene is more likely of Miocene age, the South China Sea seafloor spreading was in Late Oligocene- Early Miocene.

**Tectonic models of the Indonesian region**

Numerous authors have attempted syntheses of geologic and tectonic evolution of the Indonesian Archipelago, dating back to the 1800's. (Earle 1845, Volz 1912, Elbert 1913, Abendanon 1914, 1915, etc.). (Figure I.1.7). Unfortunately all of the pre-1970's tectonics models should now be viewed as largely obsolete, and mainly of historic interest, although many of these models were driven by perfectly valid geological observations.

Many of the earliest tectonic theories proposed for Indonesia/ SE Asia were reviewed in Blom 1934 and Umbgrove (1934, 1938) and Katili (1971). Umbgrove (1938) lamented that ‘in the last decades at least one or two new hypotheses have been suggested every year to explain the structure of the East Indian Archipelago’. Despite Umbgrove's lament, this trend has continued until today, and new models continue to be published every year (see Plate reconstructions chapter below).

Many of the early 1900's discussions on tectonics of the Indonesian Archipelago involved geosynclines or discussed the merits of Wegener's theory of continental drift, a concept that had been around since 1915, but was not generally accepted until around 1968.
Figure I.1.7. Example of old tectonic model for Indonesia (Volz, 1912). The suggested regional fault patterns have little or no basis in reality.

Many of the European geologists working in the Indonesian region in the 1920's-1930's were early 'mobilists', believing in Wegener's then-controversial model of horizontal plate movements, and recognizing the Indonesian region as an area between the converging Asian and Australian continents, as initially suggested by Wegener himself in 1915, 1922 (Wing Easton 1921, Brouwer, Molengraaff, Van Waterschoot Van der Gracht (1928), Smits Sibinga 1927, 1933; Figure I.1.8, Escher (1933), etc.). However, other prominent Dutch structural geologists of that era (Umbgrove 1935, Van Bemmelen 1933, 1949, etc., and Kuenen 1950) were skeptics of continental drift.

Mention should be made here of the theories of the 'grand master' of the geology of Indonesia, R.W. van Bemmelen. He opposed continental drift and later also plate tectonics, until his death in 1983. Instead he proposed his 'undation theory' in 1932, which he continued to promote this, with some modifications, until 1978. This theory explained all tectonics as the result of vertical, mantle-driven uplifts, followed by lateral gravitational sliding of the cover of uplifted 'undations'. This theory never found much acceptance in the geological world.

For more details on the history of Wegener's and Van Bemmelen's theories in the 'Netherlands Indies' see Barzilay (2008, 2009, 2010).

Many newer tectonic models have been proposed since the the 'Pre-Plate tectonics era', and new models continue to be proposed and debated today. Whilst these are all valuable exercises in integrating large amounts of geologic data, the long-term 'success rate' of any (plate-)tectonic models of the Indonesia/SE Asia region has not been very high, although elements of many of them continue to be accepted.

But much progress has been made, especially after the advent of plate tectonics theory and plate reconstruction models since the 1970's. But parts of Indonesia's geology and tectonic history remain poorly understood and subject to continued debates, so it is unlikely we have reached a 'final answer' today.
Figure I.1.8. Early depiction of orogenic belts in the Indonesian region, and 'Wegener style' suggestion of converging Asian and Australian continents (Smit Sibinga 1933).

Current tectonic models agree on the convergence of the three major tectonic plates in the Indonesian region (Eurasia, Indian Ocean-Australia- New Guinea and Pacific), and that most or all of the continental blocks in SE Asia rifted from the North Gondwana margin at different times. However, models vary in many other details. Areas that appear to generate the most debate include the recent history of areas in Eastern Indonesia (Timor, Seram, Sulawesi, the Birds Head of West Papua, etc.), but also the Pretertiary history of Western Indonesia (Sumatra, Java, Kalimantan) will probably yield surprises with further geological and geophysical studies.

Figure I.1.9. Active subduction zones and major fault zones of the Indonesian region, the junction of three major tectonic plates: (1) relatively stable Sunda (Eurasia), (2) North-moving Australia- Indian Ocean and (3) West-moving Philippine Sea- West Pacific Plates. Arrows indicate major plate movement directions and velocities relative to Eurasia (Socquet et al. 2006).
**Present-day major tectonic plates and GPS plate motions**

Today Indonesia is at the convergence of three major tectonic plates: Eurasia in the West, Pacific (Philippine Sea) in the NE and Australia in the SE. The East Sulawesi-Banda Sea region is the 'triple-junction', where the three plates converge (Figure I.1.9).

Since ~1993 GPS satellite positioning technology has allowed determination of any position of any location in the world with <2-3mm accuracy. Differences in distance between GPS stations over time can now be measured, which then allows reconstruction of relative movement rates of these stations, and thus determine directions and relative surface velocities of tectonic plates.

Plate boundaries derived from present-day relative plate motion are not necessarily the same as historic plate boundaries or tectonic sutures. For instance:

1. the Timor Trough was the plate boundary between the North-moving Australia-Indian Ocean plate and the Eurasia/Banda Arc plate for 10's of millions of years, but since it locked up ~3 Million years ago, Timor and parts of the Banda Arc and Banda Sea now move largely with the Australian Plate (e.g. Fig. I.1.10).
2. much of the oblique convergence between the Indian Ocean Plate and Eurasia in Sumatra is taken up by the Great Sumatra Fault zone, which thus acts as a present-day plate boundary. However, this fault zone appears to follow the thermally weakened zone of the modern volcanic arc and probably does not reflect an older basement terrane boundary.

![Figure I.1.10. Example of GPS-derived present-day plate motions (arrows) and plate boundaries (Bock et al. 2003). Showing velocities of ~3-10 cm/year relative to International Terrestrial Reference Frame ITRF2008. These rates translate to plate motions of 30-100 km/Myr)](image)

A selection of key papers of GPS studies in the Indonesian region is shown in the table below.
Present-day earthquake hypocenters and Seismic tomography

An important component in the recognition of major fault zones, and in particular subduction zones, is the distribution patterns of earthquake hypocenters (e.g. Hamilton 1974).

The discovery of belts of deep earthquake hypocenters in lower crust and mantle that form landward dipping zones under active continental margins is commonly attributed to Russian and Japanese seismologists Benioff and Wadati in the 1950's. However, this pattern of landward dipping planes of deep earthquake hypocenters (now known to reflect subducting slabs of oceanic lithospheric plates) was already known in the Indonesian region in the 1930's (Visser 1937, Berlage 1937, 1939; Figure I.1.11).

Also in the 1930's the dipping earthquake belts were noted to be associated with active volcanic arcs and with strong negative gravity anomalies outboard of the arcs, which was first discovered by 'the diving Dutchman' Vening Meinesz (1933, 1934), who interpreted these as zones of 'crustal downbuckling' (Escher 1933, Visser 1937). These 1930's geologists in Indonesia came very close to discovering plate subduction, a key component of the revolutionary plate tectonics theory of the 1960's.

Significant later contributors on earthquake distribution patterns in the Indonesian region include Fitch, Cardwell and Isacks, McCaffrey, Hamilton, Das, Schoffel, Spicak, and others.

![Figure I.1.11. Depths of earthquake epicenters along land-ward dipping plane, now known as Wadati-Benioff zone (Berlage 1937). North of Java deep earthquakes down to ~6km, no deep earthquakes under Sumatra.](image)

The relatively recent technology of 'seismic tomography' (which is a high-resolution 3-D seismic velocity model of the mantle derived from now a large database of earthquake hypocenter locations and and travel time data) helps visualize the presence of relatively high-velocity and relatively cool subducted slabs in the mantle.


Numerous other papers use seismic tomography data to solve more local tectonic issues, like magma plumbing under volcanoes, slab rupture, etc.
*Geologic history and Tectonostratigraphic belts*

The older tectonic history of Indonesia is recorded in the geology of the various provinces. Unraveling the mosaic of continental plates, suture zones, volcanic arcs through time, etc., is an ongoing process. For more details on the plate tectonics of the region see also Chapter I.2- Regional geology of SE Asia.

One useful tool is the concept of tectonostratigraphic belts or provinces, which are zones with similar stratigraphies and unconformities that record geologic settings and tectonic events.

Long before the formulation of the theory of plate tectonics, the pattern of separate continental crustal blocks of Eurasian-affinity in West Indonesia and Australian-affinity blocks in East Indonesia, was recognized in the 1920's-1930's. An elegant depiction by Umbgrove (1938; Figure I.1.12) shows these provinces, and where they are separated by the 'Timor- Seram- East Sulawesi geosyncline'. (zone A in Fig. I.1.12.). This 'geosyncline' is characterized by continuous Permian- Cretaceous deep marine facies and is now understood to represent the suture zone of the Mesotethys Ocean that closed around Eocene time.

![Image of tectonostratigraphic belts](image_url)

*Figure I.1.12. Tectonostratigraphic provinces in Indonesia, as understood by Umbgrove (1938), identifying areas with similar Late Paleozoic- Eocene tectonostratigraphy. A = Timor- Seram- East Sulawesi geosyncline, B = New Guinea- North Australia- Sula Islands, C = Central and SE Borneo- W Sulawesi, D = Malay Peninsula, Riau archipelago- Bangka- Belitung, E = Sumba, F = Banda Sea, G = Java- Sumatra.*
**Paleomagnetic studies**

Paleomagnetism is another powerful tool to constrain plate tectonic reconstructions. Many sedimentary and igneous rocks contain magnetically susceptible iron minerals that are still oriented in the direction of the magnetic field of the time in which the rocks formed. Paleolatitude of a rock sample can be derived from the inclination of the paleomagnetic orientation, and rotations since rock formation from the declination.

Interpretation of paleomagnetic data is not always unequivocal or easy. Operators need to verify that:
- sample locations are representative for regional deformation, and are not affected by local deformation;
- the paleomagnetic signal was not reset during younger thermal events;
- correct paleo-pole position is used;
- correct polarity of the magnetic field (normal or reversed) at the time of rock formation is used.
- conclusions on paleolatitude are corrected for (1) depositional dip and (2) inclination shallowing (compaction of sedimentary packages may reduce dip angles, and thus underestimate paleolatitude).

A map of paleomagnetic directions in Indonesia was compiled by Mubroto et al. (1993). Another useful review of paleomagnetic data, including chapters on the Indonesia/SE Asia region, is the book of Van der Voo (1993).

Pioneering studies in various parts the Indonesian region were by Haile (1977, 1978, 1979; Seram, Sumatra, Sulawesi, West Kalimantan), Nishimura & Suparka (1997), Sasajima et al. (1978, Sumatra, West and North Sulawesi), and Otofuji et al. (1981; North Arm Sulawesi).

Several independent paleomagnetic surveys concluded that 'South Sundaland' (Malay Peninsula - Borneo-East Sumatra) acted as a single block that underwent ~30-50° counterclockwise rotation since the Late Cretaceous (most likely between Late Eocene-Middle Miocene) (Haile et al. 1977, Untung et al. 1987, Schmidtke et al. 1990, Fuller et al. 1991, 1999, Sunata and Wahyono 1991, Richter et al. 1999)). This Cenozoic CCW rotation of Borneo was incorporated in plate reconstruction models of Hall (1996 and others), but has since been questioned by Murphy (1988), Hutchison (2010), Tjia (2012) and Marshall (2016).

Paleomagnetic studies from the East Indonesian region include
- Timor (Chamalaun 1977, Wensink and Hartosukohardjo 1987, 1990, Panjaitan and Hutubessy 1997, 2004);
- East Sulawesi ophiolite (Mubroto 1994);
- Birds Head West Papua (Giddings et al. 1993);
- Misool (Thrupp et al. 1987);

Paleomagnetic data suggest significant, opposing rotations of the western parts of Sulawesi:
1. clockwise rotations of the North Arm in Middle Miocene-Pliocene (Otofuji et al. 1981, Surmont et al. 1994);

Paleomagnetic work in Central Java on the Late Cretaceous(?) - Early Miocene 'Old Andesites' of the Southern Mountains suggest a 10° or more northward shift of the Southern Mountains volcanic arc (Mahfi 1984, Bijaksana et al. 2003, Ngkoiimani 2005, 2006, Sunardi 2010).

Paleomagnetic data from mainland SE Asia suggest most Paleozoic rocks were probably affected by resets during Late Carboniferous and Cretaceous thermal events (Powell et al. 1980, Metcalfe 1993, Van der Voo 1993).

Numerous additional papers from mainland SE Asia, The Philippines and the SW Pacific region are listed in the Bibliography.
Paleobiogeography as a plate reconstruction tool

Compositions of faunal and floral assemblages are partly controlled by paleoclimate/paleolatitude at the time of deposition. Some taxa or groups are limited to warm, low latitudes, others are restricted to cooler, temperate climates and show 'anti-tropical' geographic distributions.

Faunas/floras from comparable climate belts may show provinciality if they were geographically separated by land masses or deep oceans that impeded migrations between areas. Once the reasons for such paleobiogeographically-controlled provinciality of fossil assemblages are understood, they can then be used for paleogeographic reconstructions, they may then may provide constraints on the reconstruction of the mosaic of tectonic blocks in SE Asia.

Analyzing faunas/floras for paleobiogeographic patterns of plate tectonic significance can be tricky:
- Age: faunas/floras may be different due to different ages, and are not necessarily from different paleogeographic provinces;
- Depositional facies: may be different because they are from different depositional facies, and do not necessarily reflect different paleogeographic provinces;
- Taxonomy is quite important: closely related assemblages may have different sets of genus/species names because fossils were identified by different specialists, but in reality are comparable. By contrast, imprecise determinations or lumping species into higher taxonomic units may suggest similarities between faunas/floras, where in reality all species are different and represent different faunal/floral provinces.
- Even when different faunas/floras reflect different paleoclimates this does not necessarily mean they are on different tectonic plates. Instead this may reflect a gradual paleolatitudinal transition on the same plate, or short-term climate warming-cooling events in the same area.

Figure I.1.13. Distribution of Late Carboniferous-Early Permian floras on a Permian reconstruction, showing Cathaysian floras in SE Asia and Gondwanan floras in Australia-India (Stauffer 1985).
Some of the most frequently used fossils with perceived paleobiogeographical significance include:

1. Early Permian floras with distinct low latitude 'Cathaysian'/ Eurasian assemblages and higher latitude/ Gondwana *Glossopteris* floras (Figure 1.1.13; Asama 1976, 1984 and numerous papers). However, there are examples of mixed floras (West Papua), suggesting these floras may reflect paleoclimate zones rather than paleo-position on tectonic plates (e.g. Scotese 2011, Figure 1.1.14).


3. Late Triassic brachiopods: 'peri-Gondwanan'/ 'Southern Tethys assemblages with *Misolia* are found from Oman through the Himalayas to East Indonesia (Misool, 'Fatu Limestone' of Timor, Seram, Buru, East Sulawesi) and the NW Australian margin (Ager and Sun 1988, Dagys 1993; Figure I.1.15), but *Misolia* is not known from the Late Triassic of West Sumatra or NW Borneo (e.g. Krumbeck 1914);

4. Late Triassic pelagic bivalves *Monotis salinaria* (low-latitude Tethyan; Timor, Seram) versus *Monotis subcircularis* (mid-latitudes; NW Kalimantan, Indochina, etc.) (Silberling 1985);

5. Late Triassic ammonites (incl. *Juvavites, Neotibetites*), corals, sponges (incl. *Heterastridium, Lovcenipora, Tubiphytes*), etc. from Timor, Buru, Seram, etc., have long been known to be very similar to the Alps and Himalayas (e.g. Diener 1916), suggesting uninterrupted (Meso-)Tethyan connections in relatively low latitudes (= maximum size of Mesotethys);
6. Middle- Late Jurassic bivalves and ammonites: Sundaland (Sumatra, NW Borneo) with low-latitude Asian affinity Jurassic shallow marine sediments with bivalve Parvamussium, foram Pseudocyclammina lituus, etc. (Fontaine et al. 1983). In New Guinea and the Sula islands are Middle- Late Jurassic marine facies with higher-latitude 'North Gondwana/ Austral' fossils characterized by the Late Jurassic pelagic bivalve Malayomaorica and Middle Jurassic Macrocephalites ammonite assemblages, none which is known from Western Indonesia (Fig. 1.1.16 of Umbgrove 1938; Enay and Cariou 1999);
7. Early Cretaceous larger foraminifer *Orbitolina* and (rare) rudistid molluscs. These shallow marine, typical low-latitude Tethyan fossils are widely distributed in West and South Sumatra, Kalimantan, Central Java and West Sulawesi, but are not known from New Guinea or NW Australia, suggesting relatively wide separation at that time.

8. Eocene larger foraminifera: biogeographic separation of *Pellatispira* in SW Pacific- West Indonesia-Neotethys (including Sumba, Seram and Banda Terrane of Timor) and *Lacazinella* in NW Australia- New Guinea and related terranes like Misool and the Banggai-Sula block (Lunt, 2003);

9. The Eocene- Miocene palynological record of SE Asia contains evidence of floral migration events that can be tied to plate tectonic events (Morley 1998, 2000, Lelono 2012). The arrival of Gondwanan migrants in Indonesia in the Eocene such as *Dacrydium*, *Casuarina* and *Podocarpus* may be tied to the collision of India and Asia. Miocene migrations like distinct increase of Myrtacea pollen at 17 Ma may be tied to the collision of New Guinea with Eastern Indonesia arc/ microcontinents. Dipterocarps, important contributors to oil source rocks on Sundaland in Eocene-Oligocene time, did not occur in New Guinea until until after the Miocene collision.

**Plate Reconstructions**

The ultimate synthesis of the tectonic evolution of an area is a series of plate reconstructions. Ideally these reconstructions incorporate all known information on the geology of individual plates, especially tectonostratigraphy (stratigraphic successions, ages of unconformities/ deformational events, positions and ages of magmatic arc activity, etc.), paleomagnetic data, paleobiogeographic indicators, etc. (e.g. Figs. I.1.17, I.1.18).


![Figure I.1.17. Example of part of Early Cretaceous (146-135 Ma) reconstruction of Golonka (2006), the time of maximum separation between Australia-New Guinea and SE Asia.](image-url)
Notable papers with alternative plate reconstructions that differ in details from the above, include:
- N. Haile et al. (1973): SE Asia subduction zones
- P. Stauffer (1974-1986)
- T. Barber (1985 and others)
- Daly, Hooper et al. (1987, 1989, 1991)
- Nishimura & Suparka (1990): Eastern Indonesia at 4, 17 Ma
- C. Rangin, Jolivet & Pubellier (1990): SE Asia in past 43 Myrs
- Gorur & Sengor (1992): NW Australian shelf breakup events tied to collision events in Tethysides
- L. Ricou (1994)
SW Borneo Block

One major ‘bone of contention’ in recent plate reconstruction models is whether there is a separate SW Borneo Block that rifted off the NW Australia margin in Late Jurassic time (‘Argoland’) and collided with SE Asia in mid-Cretaceous time (Hall 2011, 2014, Metcalfe 2013; e.g. Figure I.1.2.), or whether SW Borneo/Kalimantan has been part of ‘Sundaland’ since its amalgamation in Late Triassic time (most older papers like Umbgrove 1938 (Figure I.1.1), Zhou et al. 2008, and global models of Scotese 2001 and others, Golonka 2006 and others, Gibbons et al. 2015, Zahirovic et al. 2016, etc.). Metcalfe (1998 and others) viewed SW Borneo as a separate plate, but derived from the Indochina/CathaysiaLand margin.

Problems with the recent scenario of SW Borneo Block as a Gondwanan terrane that was added to Sundaland in Cretaceous time include:

1. Gravity and seismic data of the Sunda Shelf (the proposed area for the suture zone) show good continuity between Sumatra and Kalimantan (e.g. Figure 1.1.5), with no obvious evidence for a basement suture/terrane boundary;

2. There is no stratigraphic support from Borneo for this scenario. The only area on the island where Permian-Jurassic rocks are not destroyed by Cretaceous magmatism, metamorphism and uplift/erosion is in the NW Kalimantan- SW Sarawak border area. This area shows Sundaland-affinity imbricated Carboniferous-Early Permian sediments, unconformably over lain by Late Triassic-Cretaceous sediments with low-latitude floras and faunas of Indochina affinity/unconformities (Zeijlmans van Emmichoven 1939). This Permian-Cretaceous tectonostratigraphy is definitely not Gondwanan, but fits well with other parts of Sundaland that were affected by the Late Triassic Indosinian orogeny (Sumatra, Bangka, Malay Peninsula, etc.) (see also additional papers on Borneo in Chapter V).

DOTSEA (2005) kinematic reconstructions

An interesting exercise by the DOTSEA project (Pubellier et al. 2005). shows kinematic reconstructions of SE Asia back to 15 Ma, by simple back-tracking of measured present-day GPS plate motions (directions and velocities), assuming these have been constant since then. In a series of maps they restored areas of oce anic crust that have been subducted. Interesting elements of the 15 Ma restoration map, that are not part of most ‘mainstream’ interpretations, include (1) the position of Birds Head well North of New Guinea and (2) a significant area of consumed (oceanic?) crust in the North Makassar Straits basin, which at that time may have been double the width. (Figure I.1.19).
Figure 1.1.19. Kinematic reconstruction of the Indonesian region for 15 Ma (Middle Miocene), built from back-tracking present-day GPS plate motions. Yellow areas are areas of oceanic crust that are now subducted. (Pubellier et al. 2005; DOTSEA project; part of 15 Ma map).

**Some suggested reading: Indonesia/SE Asia tectonics (not a complete listing of all relevant papers)**


**Pre-plate tectonics models**

**Plate Tectonics syntheses: Indonesia**
Satyana 2003, 2009, 2012, Gaina and Muller 2007,

GPS plate motions SE Asia
Chamot-Rooke et al. 1999, Rangin et al. 1999, Wilson et al. 1999,

GPS plate motions Indonesia
Genrich et al. 1996, Walpersdorf et al. 1988, Kreemer et al. 2000,

GPS plate motions Sumatra

GPS plate motions Java
Tregoning et al. 1994, Abidin et al. 2009, Meilano et al. 2012,
Hanifa et al. 2014.

Earthquakes hypocenters
Berlage 1937, 1939, Hamilton 1974, Cardwell and Isacks 1978, 1981,
Das et al. 2000.

Tomography velocity models
Hafkenscheid et al. 2001, Replumaz et al. 2004, Tregoning and Gorbatov
2004, Richards et al. 2007, Spakman and Hall 2010,
Widiyantoro et al. 2011, Hall and Spakman 2015, Huang et al. 2015,
Wu and Suppe 2016, 2017, Van der Meer et al. 2012, 2018

Paleomagnetism Indonesia
Fuller et al. 1991, 1999, Sunata and Wahyono 1991,
Panjaitan and Mubroto 1993, Mubroto 1994, Richter and Fuller 1996,
Wensink 1987) Van der Voo 1993, Mubroto et al. 1993,
Nishimura and Suparka 1997, Mubroto and Ali 1998,

Paleobiogeography - Permian

Triassic
Ager and Sun 1988, Dagys 1993

Jurassic
Westernmann 1993

Cretaceous
Uhlig 1911.
**I.3. Volcanism, Volcanic rocks geochemistry**

Chapter I.3 of the Bibliography focuses on papers on regional volcanism in the Indonesia- West Pacific region. Many additional papers that are specific to a single region will be under the chapter for the area in which they are located. Most of the papers on volcanics of Java island are listed in Chapter III.3.

Papers on individual eruption events and volcanic hazards are not included in this Bibliography, unless they contain significant geological information.

![Figure I.3.1. Active volcanic centers of the Indonesian region can be grouped in Sunda Arc and Banda Arc of Sumatra- Java- Lesser Sunda Islands, and the Sangihe Arc and Halmahera Arc West and East of the Molucca Sea (Smithsonian map).](image)

Indonesia, with its 128 active and numerous extinct volcanoes, is one of Earth's most volcanically active regions of the world (Figure I.3.1). Partly because of some of the largest eruptions in recorded history (Tambora 1815, Karakatau 1883) the country has attracted volcanological studies for over 130 years. The extensive report by Verbeek (1885-1885) on the geology of Krakatau volcano in Sunda strait and the sequence of events around the 1883 eruption made Verbeek a worldwide celebrity (Figure I.3.2).

Volcanic arcs form above subducting oceanic slabs, generally where the Wadati-Benioff zone reaches a depth of ~100km (England et al. 2004). This depth may vary along strike (e.g. average 90 km in West Java, closer to 150km depth in Central and East Java, East of 108°E; Syracuse and Abers 2006), and in dip direction.

In Indonesia active volcanism occurs along three main arc segments, Sunda-Banda, Sangihe and Halmahera (Figure I.3.1). The first two of which were probably once a continuous system, related to the same North-moving subducting Indian Ocean- Australian plate.

Active and extinct arc systems may be classified by age and by subducting oceanic plates:
- from South: Mesotethys, Neotethys, Indian ocean- Australian (Cretaceous, Eocene, Oligo-Miocene and Recent arcs of Sumatra, Java, SE Kalimantan, West Sulawesi, etc.);
- from East: Pacific Ocean/ Philippine Sea Plate (Halmahera?, Philippines, West Sulawesi)
- from North- NW: 'Paleo-Pacific? (Kalimantan Triassic and Cretaceous arcs), 'Proto-South China Sea' (Kalimantan Oligocene- Middle Miocene arcs), Celebes Sea (North Sulawesi), Philippine Sea Plate (New Guinea Late Miocene- Pleistocene).

Figure I.3.2. Remnant of Krakatau volcano in Sunda Strait, after the 1883 eruption (Verbeek 1885).

**Preservation of volcanic edifices**

Many of the active volcanoes of Indonesia build up to elevations of 3000m, some are up to 3700-3800m in height (Kerinci on Sumatra, Semeru on Java, Rinjani on Lombok). However, the preservation potential of these volcanic cones in the geological record is rather low.

After volcanic activity ceases, erosion of volcanic edifices tends to be quite rapid, and most of the volcanic material ends up in a wide mantle of eroded volcanoclastics. Most of what will be preserved in the geologic record at the eruption site will be the basal volcanic deposits and the underlying intrusives (feeder pipes, dikes and granitoids that formed the deeper magma feeder system) (Figure I.3.3).

Figure I.3.3. Successive stages of erosion, from active volcano (top) to completely eroded (bottom). CF, PF, MF, DF= Central, Proximal, Medial and Distal facies of volcanic deposits (from Isnawan and Bronto 1997).
Volcano spacing in Indonesian volcanic arcs

In volcanic arc systems volcanic activity at the surface is not continuous along the entire arc, but tends to be in discrete volcanic eruption centers, that are separated by areas of no volcanism. The spacing between volcanic centers is often quite at regular, with distances of around 70 km, both in Pacific hotspot seamount chains and in Pacific volcanic arcs above subduction zones. Some authors suggested volcano spacing tends to be close to (but generally slightly less than) the underlying lithospheric thickness (Vogt 1974, Mohr and Wood 1976).

On Java volcano spacing is rather irregular in West Java, but in East Java volcanoes they are fairly regularly spaced at ~70km (Figure I.3.4.). In the East Sunda- West Banda island arc volcano spacing from Bali-Sumbawa averages 68 km, Flores is highly irregular, but in the East Banda Arc the average is 72 km (Ely and Sandiford 2010).

![Figure I.3.4. Many of the active volcanoes of the Sunda Arc on Java are spaced at ~70 km apart.](image)

Volcanic centers of the Sangihe Arc on and south of Sangihe Island are evenly spaced at ~50 km apart.

Lateral shift of volcanic eruption centers

As noted by several authors, some of the larger volcanic complexes on Java show remarkable southward shifts in eruption centers through time, i.e. in the direction towards the subduction zone (Neumann van Padang 1936, ). While the modern arc runs North of the Late Oligocene- earliest Miocene ‘Old Andesites’ arc fo the Southern Mountains, the Quaternary edifices of Slamet, Sumbing- Sundoro, Ungaran- Merbabu- Merapi, Lamongan, and Semeru all show a North-to-South migration (Figure I.3.4).

There is no generally accepted explanation for this yet, but it probably involves slab rollback and/or relative northward movement of the upper plate.

This is not the same as the >50km northward shift of the axis of arc magmatism on Java from the Late Oligocene- Early Miocene ‘Old Andesites’ system of the Southern Mountains of the axis of the Pleistocene-Recent Sunda Arc. This was probably not a continuous, gradual process; these two may be two unrelated volcanic episodes/ belts, with a temporal gap in volcanism between 11-18 Ma (Bellon et al. 1989) or longer.
**Geochemistry of volcanic rocks**

Numerous papers have been written on major elements, trace elements and isotope geochemistry of volcanic rocks and gases from the Indonesian volcanic arc systems, dating back to the early 1900's.

Commonly reported trends in geochemistry of volcanic products include:

1. an overall increase in $K_2O$ and alkali % with depth to the Benioff zone depth, with low-K 'volcanic front' lavas and medium-high K 'Rear Arc' lavas, often with leucite-bearing volcanics, above the deeper parts of the Benioff zone (Rittmann 1953, Hutchison 1975, 1976, 1981, Soeria-Atmadja et al. 1988, Sendjaja et al. 2009). However, there is rather high variability in this trend and some authors questioned its validity (Leterrier et al. 1990, Abdurrachman et al. 2015);

2. Many volcanic complexes go through a similar evolution from Early Stage basalt or basaltic andesite, Middle Stage andesite and Late Stage dacite;

3. Many arc volcanic rocks appear to be contaminated with continental crustal rock or sediment material, as indicated by common dacite/ rhyolite, high Rb/Sr ratios, etc. (e.g. Van Bergen et al. 1993, Abdurrachman and Yamamoto 2012).


Variations in composition of lavas along Sunda-Banda Arc reflects underlying the lateral change from continental crust in the Sumatra - West Java segment, transitional (Gondwanan?) accreted crust in Central and East Java, while an oceanic island arc developed from Bali to Sumbawa and farther East (Hamilton 1978).

**Mineral deposits**

The magmatic arcs of Indonesia (and The Philippines, New Guinea) are host to numerous porphyry copper-gold and and epithermal gold-silver deposits (Figure I.3.5). Some key papers include Taylor and Van Leeuwen (1980), Carlile and Mitchell (1994), White et al. (1995), Soeria-Atmadja et al. (1998), Garwin et al. (2005), U. Hartono (2009), MacPherson and Hall (2002), Maryono et al. (2018) and others.

![Figure I.3.5. Cenozoic volcanic arcs and main porphyry Cu-Au (green) and epithermal Au (yellow) deposits (De Waele et al. 2009)](image-url)
Eight of the 15 identified volcanic-plutonic arc systems are associated with commercial mineral deposits, others may have potential (Hartono 2009).

Most of the giant Au and Cu deposits in the Indonesia - West Pacific region formed in Miocene- Pleistocene arc systems. For more detail see also Chapter XI.4.

**Older Volcanic Arc systems of SE Asia- Indonesia**

Most of the volcanism in the modern Sunda- Banda Arc appears to be quite young, mainly since 6-3 Ma. However, up to 15 older, extinct volcanic-plutonic arc systems have been recognized in Indonesia, dating back to Permain time (Fig. I.3.6).

The most prominent of the older, extinct arc systems in the Indonesian region, in order of increasing age:

1. Early Miocene East-Central Kalimantan Volcanic belt (‘Kelian Volcanics’; ~23-20 Ma), >400 km long, (Abidin and Sukardi, 1997) (= Proto-South China Sea subduction from North);

2. Late Oligocene- earliest Miocene ‘Old Andesites' of Sumatra and Java (= Indian Ocean- Australia plate subduction from South) (many papers, incl. Smyth 2005, Bronto 2009 and others);

3. Middle-Late Eocene ‘Great Indonesian Arc' from Sumatra and Java to SW Sulawesi and displaced terranes of Sumba, and Banda Terrane of Timor (= Neotethys/ Indian Ocean subduction from South) (Charlton 2000, Harris 2006, etc.);

4. Late Cretaceous (~Campanian?) igneous- volcanic system from North Kalimantan to NW across the Anambas- Natuna area, then North to South Vietnam and the Yanshanian active margin of South China (= Paleo-Pacific subduction) (e.g. Hutchison 2005, Amiruddin 2009);

5. Late Cretaceous (mainly ~80-100 Ma) 'Sumatra-Meratus Arc', 2000 km long, from Myanmar- Andaman across West and South Sumatra, NW Java, the Java Sea into the Meratus Mountains (Figure I.3.7) (= Neotethys subduction?) (Katili 1974, Carlisle and Mitchell 1994, McCourt et al. 1996, Hartono 2012);
6. Mid-Cretaceous (Aptian- Albian) granite belt of the Schwender Mountains granitoids of Kalimantan, also continuing NW across the Sunda Shelf, along the Indochina coast to the Yanshanian system of the East China margin (= Paleo-Pacific subduction);

7. Late Triassic (=earliest Jurassic?) belt of ‘tin granites’, from Thailand- Malay Peninsula and continuing into the Indonesian tin islands Bangka and Belitung (Figure I.3.8) (probably mainly post-collisional granites parallelling a slightly older Permian-Triassic arc magmatic belt linked to Paleotethys subduction) (numerous papers);
Figure I.3.8. Distribution of Late Triassic- Early Jurassic and Cretaceous tin granites (Eastern and Main Range provinces) from Myanmar, Thailand, Malay Peninsula to the Indonesian Tin Islands Singkep, Bangka and Belitung (Cobbing et al. 1986, in Searle et al. 2016).
8. Late Permian-Middle Triassic ‘Gondwanan’ magmatic arc, represented by a well-defined belt of granitoids that define a that extends from the East Australian/East Gondwana active margin into New Guinea island, and into microcontinents derived from this margin like the Birds Head, Banggai-Sula (Figure I.3.9) (= Paleo-Pacific subduction) (Amiruddin 2007, 2009, Jost et al. 2018).

Figure I.3.9. Late Permian-Middle Triassic granitic plutons along East Australian margin, continuing into North Papua New Guinea, West Papua, Birds Head and the Banggai-Sula islands, are remnants of the same magmatic arc, reflecting Paleo-Pacific subduction along the East Gondwana margin (Amiruddin 2009).

9. Earliest Permian intermediate volcanoclastics in West Sumatra associated with the famous 'Jambi Flora' have been interpreted as part of an Early Permian volcanic arc (Figure I.3.10; Cameron et al. 1980, Pulunggono and Cameron 1984, McCourt et al. 1996). Barber and Crow (2003) suggested this was an Early Permian volcanic arc that probably formed at margin of Cathaysian Block. However, the lateral extent of these Early Permian volcanic rocks appears to be rather limited, and the presence of coal beds and rich plant fossils is not necessarily typical of volcanic arc deposits (= possible rift volcanism?).
Figure I.3.10. Distribution of Permian- Tertiary magmatic arcs on Sumatra (McCourt et al 1996).

Some suggested reading- Indonesia volcanism (not a complete listing of all relevant papers)


I.4. Modern environments, Oceanography

Chapter I.4 of Bibliography 7.0 contains >350 papers on modern depositional environments and processes in Indonesia. Indonesia is home to an extreme variety of environments, from glaciated mountain peaks above 4800m in the West Papua foldbelt, volcanoes up to 3800m high, to 6 km deep oceanic basins. It has been a study area for many types of modern environments, like tropical rainforests, peat swamps, coral reefs, deltas, deep marine environments, oceanography, etc.

The Indonesia/SE Asia region is also home to some of the highest diversity land and marine life ('evolutionary hotspots'; Renema et al. 2008, De Bruyn et al. 2014).

Studies of modern environments are important as analogs of ancient deposits of the Indonesian region, in accordance with Lyell's fundamental geologic principle 'the present is the key to the past'. However, it should also be realized that present-day conditions of humid-tropical climate and relatively high eustatic sea-level may not be typical for much of the geologic record:

1. The present-day 'ice-house climate', with rapid eustatic sea level oscillations, existed only since the beginning of the Oligocene; most of the Triassic- Eocene deposits reflect warmer 'greenhouse' conditions;
2. The present-day eustatic sea level is relatively high, and sedentation is still adjusting to the rapid Holocene sea level rise since 18,000 years ago, which created broad flooded shelf regions;
3. Changes in faunal and floral communities;
4. Changes in plates positions and resultant oceanographic patterns: today the Indonesian region restricts oceanic circulation between The West Pacific and Indian Oceans, but this was much less restricted before the Miocene collisions of frontal areas of the North-moving Australian continental plate.

Figure I.4.1. Thermohaline circulation patterns through the Indonesian seas, dominated by 'Indonesian Throughflow' of water from Pacific Ocean to the Indian Ocean. With estimates of total volume transport in Sv (= million m³/sec). Main inflow at Makassar Straits (8-9 Sv) and also at Lifamatola Passage West of Halmahera (1.5 Sv). Outflow through Timor Sea, Ombai (Savu Sea), and Lombok Straits (Gordon 2005)
**Indonesian Throughflow**

A topic of great academic interest has been the 'Indonesian Throughflow', the yearly flow of up to 15 sverdrups (>15 million m3/second) of relatively warm and low saline Pacific Ocean water to the Indian Ocean through the Indonesian Archipelago (Figure I.4.1). The main Throughflow pathway is through Makassar Strait, then partly through Lombok Strait, partly into the South Banda Sea and exiting through the Timor and Ombai passages.

Numerous papers have been published on the oceanography of the Throughflow, a selection of which is in the current Bibliography (papers by Gordon et al., Ffield, Fieux, Godfrey, Hendrizan, Sprintall et al. Susanto et al. Waworuntu et al., and many others).

Changes in the Indonesian Throughflow probably had a significant impact on regional and global climate. The Northward movement of Australia-New Guinea in Neogene time resulted in progressive narrowing of the Indonesian seaways, causing a switch at ~3-5 Ma in the main source of water flowing through Indonesia from warm South Pacific to colder North Pacific waters. This created an area of unusually warm ocean water in the SW Pacific ('Indo-Pacific Warm Pool'; Nathan and Leckie, 2009) and decreased Indian Ocean sea surface temperatures, leading to aridification of Northern Australia and East Africa. (Cane and Molnar 2001, Srinivasan and Sinha 1998), Christensen et al. 2017).

**Deltas, sediment yields**

Indonesia and SE Asia are also known to host major delta systems, driven by the abundant tropical rainfall and high weathering rates and therefore high river discharge. Rivers draining the major islands of Indonesia supply 20-25% of the total sediment discharge to the world oceans although the land area that they drain is ~2% of the world total (Milliman et al., 1999). (Figure I.4.2).

![Figure I.4.2. Estimated sediment discharge (MTons/year) from six Indonesian islands (from Milliman et al., 1999, in Nummedal et al. 2003).](image)

The largest delta systems in the Indonesian region are found around New Guinea (Mamberamo, Fly), Borneo (Mahakam, Baram, Rajang, Barito) and Sumatra. Not all have typical delta morphologies (e.g. the NE Sumatra river deltas).
A recent review of delta systems in SE Asia is by Nummedal et al. (2003). Numerous other studies of modern deltaic sedimentation are in this Bibliography, in both this chapter and under the areas that they are in. Most studies are from the large systems of East Kalimantan and North Borneo.

Figure I.4.3. Major delta systems around Borneo island (Graves and Swauger 1997, in Baillie et al. 2004)

Delta plains in SE Asia are typically dominated by mangrove vegetation and peat swamp forests, but in many areas the original vegetation has been severely modified by human activity (70% of mangrove areas in Mahakam delta converted to shrimp-ponds between 1980-2000).

One of the best studied modern delta systems in SE Asia is the Mahakam Delta of East Kalimantan. It is a classic example of a mixed tide-fluvial- dominated system, with relatively straight distributary channels that bifurcate in downstream direction, and with meandering tidal channels (Figure I.4.4).

It may be noted that the modern Mahakam delta formed only in Late Holocene time, since the major sea level rise after the Last Glacial Maximum. It is a much smaller system than the underlying Middle Miocene-Pleistocene Paleo-Mahakam delta complex (e.g. Figure I.4.5.). Also, the Mahakam River/ Delta today does not feed any of the slope channels and submarine fans along the adjacent Makassar Strait margin, that are all of Pleistocene and older ages (Salier et al. 2003, 2004, 2006, 2012, 2013).
Figure I.4.5. Schematic cross section of Upper Pleistocene (0-270 ka) stratigraphy of the offshore Mahakam Delta- Kutei basin, East Kalimantan. The modern Mahakam delta is underlain by several much larger Pleistocene 'lowstand delta' systems that extended farther basinward, and that were connected to slope channels and basin floor fan depositional systems (Saller et al. 2003).

Storms et al. (2005) noted that the present day sediment load of the Mahakam River is insufficient to explain the sediment volume of subaerial and subaqueous Mahakam delta, suggesting hydraulic conditions in the past may have been different. Geologists from Total noted that Late Miocene Paleo-Mahakam delta sediments are often coarser grained, with more high-energy fluvial flooding events, have higher sand percentages and show less tidal influence (Wiweko and Giriansyah, 2000).

Except for the Solo River delta of NE Java, fluvial-dominated 'bird-foot' deltas (but partly a man-made feature) are rare in SE Asia. Instead, most of the Indonesian deltas are heavily influenced by tidal processes (Mahakam, Rajang, Fly, Mekong), as expressed by widely flaring distributary channel mouths. The Baram Delta of NW Borneo is a wave-tide dominated delta system (Lambiase 2002 and others). Some of the small deltas along the North coast of Java are also wave dominated systems.

Most of the modern (Holocene) delta systems of Indonesia have been in their present positions only for ~6000 years, when the rate of Holocene sea level rise after the Last Glacial Maximum lowstand started to slow down. Older Pleistocene delta systems are now buried on the Sunda Shelf and along the shelf margins (e.g. Molengraaff paleo-delta)

**Pleistocene ‘shelf-margin lowstand deltas’**

Large, but probably relatively short-lived and now submerged ‘lowstand delta’ systems formed seaward of the present-day deltas around the Sundaland shelf margins during Pleistocene glacial lowstand intervals. Some of these have been studied:
- at the North edge of Sunda Shelf/ S side of South China Sea (Paleo-Mekong, Molengraaff River, Paleo-Sunda River, etc.) (Hanebuth et al. 2003)
- at the East side of Java Sea platform/ Flores Sea (Paleo-Barito?)
- at the NW end of Malacca Straits/ Andaman Sea (fed by confluent Sumatran and Malay Peninsula rivers) (Emmel and Curray 1982).

**Oligo- Miocene delta systems**

Large delta systems formed along parts of the Late Oligo-Miocene margins of Sundaland and the Late Paleogene Sundaland intra-cratonic rift basins. Numerous papers on these systems are in the Bibliography, under the respective regions. These delta systems formed the main hydrocarbon reservoir formations in:
- Central Sumatra: Sihapas/ Lakat delta system(s);
- South Sumatra: Early Miocene Talang Akar delta system;
- NW Java basin: Early Miocene Talang Akar/ Lower Cibulakan delta,
- NE Java (Middle Miocene Ngrayong System)
- East Kalimantan Kutai, Sangatta and Tarakan Basins: Middle Miocene- Pliocene systems (Cibaj et al. 2006-2015) papers).

Quaternary glacial-interglacial changes
Most of Indonesia today is in the tropical-humid climate belt. This means that, without human interventions, most of the land areas would be covered by tropical lowland and montane rainforests. Numerous studies on Quaternary pollen, microfaunas and sediment types tend to agree that glacial periods were different:
1. average temperatures in equatorial regions was colder by 3-4°C during glacial periods (Verstappen 1982, Visser et al. 2003, 2004);
2. increased aridity and seasonality over most of Indonesia, causing an increase in savanna vegetation and a decrease and fragmentation of tropical rainforests (Verstappen 1975, 1976, 1982, Heaney 1991, Van der Kaars, Flenley?, Morley? Barmanwidjaja et al. 1993, Gathorne-Hardy et al. 2002);
3. thinning of the vegetation cover increased physical erosion over chemical weathering, generating more coarse-grained erosional products (Verstappen 1975, 1976, 1982, Liu et al. 2012);
4. eustatic sea level was lowered by up to -125m, causing river channels incision, basinward shift in sedimentation areas, with an increase in sediments reaching the shelf edge, feeding submarine fan systems.

In the Pleistocene of Thailand the deposition of widespread alluvial fans and upland river terraces was tied to glacial periods of reduced forest cover and increased coarse sediment production. A similar situation has been described from Sumatra (Verstappen 1975)

Today we live in an interglacial period of high sealevel, following a period of rapid Holocene sea level rise of probably >120m. This means that today may not be typical of most of geologic time:
- land areas are rimmed by relatively wide continental shelves, which are drowned lowstand floodplains;
- relatively widespread Holocene reefal carbonate provinces, brackish mangrove and freshwater peat swamps;
- little or no land-derived sediment reaches the outer shelf and deep marine basins (e.g. Gayet et al. 1990).

Some suggested reading - Modern environments (not a complete listing of all relevant papers)
General text books: Van der Stok et al. 1897, 1922, Ecology of Indonesia series, Gupta 2005
Oceanographic Expeditions: Expedition Reports: Challenger (Brady 1884, etc.), Siboga (Weber 1902), Snellius (Kuenen 1935, etc.) and Snellius II (Van Hinte et al. 1989)
Fly River Dalrymple et al. 2003
I.5. SE Asia Carbonates, Coral Reefs

This sub-chapter I.5 of Bibliography 7.0 contains 260 papers on both modern carbonate depositional environments and carbonate distribution in the fossil record of SE Asia. Many additional papers on carbonate formations are in the chapters of the regions in which they are located.

Modern coral reefs/ carbonates

Modern corals and coral reefs are widespread across Indonesia/ SE Asia. In fact, Eastern Indonesia is commonly viewed as a marine 'center of origin', meaning the area of highest biodiversity of corals and other marine life (Figure I.5.1; Bellwood et al. 2005, Keith et al. 2013 and others). Some authors claimed over 500 coral species to be present in the Indonesian region (e.g. Bellwood 2005), but after some recent taxonomic revisions that number may be closer to 320 species (Johnson et al. 2015).

Figure I.5.1. The East Indonesia- South China Sea- Philippines 'hotspot' area boasts the highest number of coral species in the world (red area= >500 species; Bellwood et al. 2005).

The Indonesia archipelago has long been a research area for the study of modern coral reefs. The most comprehensive review of modern coral reefs at 31 areas across Indonesia is by Kuenen (1933). Other early papers were by Wichmann (1912), Molengraaff (1922, 1930), Gerth (1925, 1930), Verweij (1930, 1931), and Umbgrove (1928-1947). More recent studies of coral reefs from a geological perspective include Scrutton (1975, 1976), Longman et al. (1993), Jordan (1998), Park et al. (2010), etc..

Corals are known to thrive primarily in tropical, shallow marine waters (photic zone; typically <40-100m water depth; Verweij 1930, 1931) that are clear and of normal salinity. Modern reefs are generally not found far outside ~32° North and South of the Equator, but some Paleogene-Miocene reef corals appear more widely distributed than today (up to ~50°N; Gerth 1930).

Coral reefs generally do not develop near rivers/ deltas, due to the influx of muddy sediments, nutrients and fresh water, in areas that may be viewed as marine 'ecological deserts'. Excessive wave actions also inhibits coral growth (Moll 1986).

Some coral species, especially solitary corals, survive in deep water, as was demonstrated by dredgings of the Challenger and Snellius marine expeditions in Indonesian deep waters in the late 1800's and early 1900's.
During some time intervals, or in certain areas, carbonates formed that are dominated by other organisms:

1. Larger foraminifera banks: Eocene- Oligocene limestones in Indonesia are often dominated by larger foraminifera, with or without coralline algae (Wilson and Rosen 1998). Examples include Eocene Nummulites limestones and Permian fusulinid limestones. Such facies have been called ‘foramol’ by Wilson and Vecsei (2005))

2. Halimeda- algae buildups: The presence of modern Halimeda reefs in the East Java Sea were attributed to high-nutrient influx from upwelling along the Indonesian Throughflow (Roberts )

3. Carbonates dominated by rhodolit algae appear to be relatively common, or dominant, in the Middle Miocene of the tropical Pacific and Indonesia (Bourrouilh and Hottinger 1988, Halfar and Mutti 2005);

4. Sponge- microbial reefs are most common in Triassic and Jurassic times.

**Tertiary carbonates**

Tertiary carbonates are widespread across Indonesia, especially of Late Eocene and latest Oligocene- Middle Miocene ages. Numerous papers on these formations are in the Bibliography, either in this chapter, but mainly under the respective regions.


There are numerous oil and gas fields in Oligocene-Miocene reefal buildup reservoirs in the Cenozoic basins of Indonesia: Natuna Basin, North and South Sumatra, NW Java, East Java, Java Sea, West Sulawesi, East Kalimantan, Makassar Straits, West Papua). Similar carbonate plays are found around Indonesia: offshore Sarawak (Luconia province), The Philippines, offshore Vietnam and the Gulf of Papua. Renewed interest in Tertiary reefal limestone exploration came with new oil and gas discoveries in the East Java Basin in the early 2000's.
Miocene carbonate buildups and platforms are also known from the margins of NW Australia (Davies et al. 1989) and NE Australia (Ehrenberg 2004, 2006, Eberli et al. 2010), but no hydrocarbon accumulations have been identified there yet.

**Pre-Tertiary carbonates**

Pre-Tertiary carbonates are relatively rare in Indonesia. Most of the references on individual carbonates are found in the chapters on areas in which they occur.

*Late Carboniferous- Permian*

Late Carboniferous- Permian limestones with fusulinid foraminifera are known from Sumatra, Kalimantan, West Sarawak (Terbat Limestone) and Timor (papers by Fontaine, etc.).

The Early-Middle Permian of West Sumatra includes probably the only true reefal Permian limestones in Indonesia (Guguk Bulat, W Sumatra).

*Late Triassic*

Across the Tethys region Triassic sponge and coral reefal limestones are most common in the Norian and Rhaetian (Flugel 1982, 2002, Bernecker 2005, ). This observation may also be valid for the Indonesian region.

Late Triassic shallow water carbonates have been reported from Sumatra (Gafoer and Fontaine 1989), Bangka (De Neve and De Roever 1947), 'Fatu Limestones' of Timor (Vinassa de Regny 1915, Flugel 2002, Haig et al. 2007), East Sulawesi (Cornee et al. 1994, 1995, Martini et al. 1997), Buru (Gerth 1910, Wanner 1923), Seram (Wanner et al. 1952, Martini et al. 2004), Banda Sea (Sinta Ridge ;Villeneuve et al. 1994) and the Kubor terrane of Papua New Guinea (Skwarko et al. 1976, Kristan-Tollman 1986, 1989).

Fractured Upper Triassic limestones are hydrocarbon reservoirs on Seram Island (Kemp et al. 1992, 1995, Nilandaree et al. 2001, 2005) (but commonly erroneously called Jurassic; Charlton and Van Gorsel 2014).

*Late Jurassic*

Late Jurassic muddy carbonate mounds and are present in West Sumatra (Beauvais et al. 1985, Gafoer and Fontaine 1989) and NW Kalimantan- SW Sarawak (Bau Limestone). Deep water pelagic limestones of these ages, often with calpionellids, are relatively widespread across Eastern Indonesia (East Sulawesi, Timor, Seram, Buru, etc.).

*Early Cretaceous*

Early Cretaceous shallow marine carbonates with *Orbitolina* are known from West and South Sumatra ('Woyla Terranes'), Central Java and Kalimantan.
I. REGIONAL GEOLOGY

I.1. Indonesia Regional Geology

(Compilation of temperature data from petroleum wells in Indonesia. With two map sheets 1: 2,500,000. See also updated version by Thamrin & Mey, 1987)

(Previous models of Wadati Benioff Zone (derived from earthquake hypocenters) in Java-Sumatra deemed too simple. In Java hypocenter depths recorded >500 km, while in Sumatra earthquakes all <300 km deep. In C and E Java area aseismic area between 300-500 km interpreted as tear zone in subducting plate)

(online at: https://nl.wikipedia.org/wiki/Wikipedia:GLAM/Expedities/Mediadonaties#/media/File:UB_Utrecht_-_CARTO_I1_L2_-_1914.jpg)
(‘Geological overview map of the Netherlands East Indies’. First geological overview map of Indonesia, 120x225cm, commissioned by Netherlands Royal Geographical Society. Compiled from published and unpublished maps by many authors. Java and Sumatra rel. complete, but much of Kalimantan, Sulawesi and New Guinea still uncharted territory)

(‘Mega-folds in the East Indies Archipelago’. Chapter in Abendanon's 183-page book on his global tectonic theory of 'mega-folds': recently uplifted mountain chains, caused by shrinking of Earth globe, accompanied by extensional central rifts, gravity sliding, etc. Examples of 'mega-folds' in Indonesia in Sulawesi, Timor and Sumatra. In C Sulawesi Mountain chain W of Lake Poso looks like almost flat peneplain now uplifted to 2000m, cut by ~N-S faults/ rift valleys like Poso Depression. Timor also recently uplifted foldbelt with central graben. Etc. Very few illustrations)

(First tectonic interpretation of Indonesia. Presence of crystalline schists across E Indonesia suggests area from Borneo to New Guinea may all be parts of one ancient continent, here named Aequinoctia, extending from Sulawesi to Tasmania)

(Review of Cenozoic stratigraphic successions in NE Java, Jambi-Sumatra, NE Sumatra and E Kalimantan. One of first attempts to tie these local stratigraphies to global low latitude planktonic foram zonations)

(New paleomag from Sorong Fault Zone, Obi and Taliabu. Sula Platform Coniacian- Santonian paleolatitude at 19°± 6°, similar to Misool, suggesting Sula/Taliabu and Misool parts of single microcontinent, >10° farther N than expected if attached to Australia, implying region separated from Australia before Late Cretaceous. Obi contains rocks of Philippine Sea and Australian origin. Volcanic arc at S edge Philippine Sea Plate collided with New Guinea at ~25 Ma, changing Philippine Sea-Australian plate boundary from subduction to strike-slip)

(Reconstructions of W Pacific 45-10 Ma. Area N of Sorong Fault Zone ~40° CW rotation and 15° N-ward motion since ~25 Ma. Prior to 22 Ma collision between Australia (New Guinea)- Philippine Sea open Equatorial seaway between Indian and Pacific oceans. Connection mostly closed by initiation of Halmahera Arc at 11 Ma)


(Permian-Triassic granitoid plutons and volcanics exposed in E Indonesia, in belt from Banggai Sula in W through Birds Head (Netoni, Anggi, Maransabadi), Birds Neck, Central Range of W Papua (Eilandten, Idenburg) to PNG (Strickland and Kubor Granodiorites) in E, then belt continues S to E Australia through Cape York, NE Queensland to New England Fault Belt. Syn-collision and volcanic arc I and S-type granites)

Amiruddin (2009)- A review on Permian to Triassic active or convergent margin in southeasternmost Gondwanaland: possibility of exploration target for tin and hydrocarbon deposits in the Eastern Indonesia. J. Geologi Indonesia 4, 1, p. 31-41. (online at: www.bgl.esdm.go.id/dmdocuments/jurnal20090104.pdf)
(Permian-Triassic magmatic-volcanic belts signify active Paleo-Pacific margin along New Guinea (Banggai, Netori, Anggi, Kwatisor, Kubor, etc. granites)- E Australia part of SE Gondwanaland. Granitic plutons of S-type and may be tin-bearing. Back-arc basins of S Papua and Galilee-Bowen-Gunnedah-Sydney basins filled by fluvial, fluvio-deltaic to marine Permian-Triassic sediments, locally with coal, unconformably overlain by marine Jurassic-Cretaceous)


Audley-Charles, M.G. (1965)- Permian palaeogeography of the northern Australia-Timor region. Palaeogeogr. Palaeoclim. Palaeoecology 1, p. 297-305. ('Autochthonous' Permian rocks of Timor believed to be detritus from Kimberley region of N Australia. This conflicts with suggestions of large crustal dislocations immediately N of Australia recently advocated on basis of regional paleomagnetic studies)

Audley-Charles, M.G. (1966)- Mesozoic palaeogeography of Australasia. Palaeogeogr. Palaeoclim. Palaeoecology 2, p. 1-25. (Broad Triassic-Cretaceous paleogeographic sketch maps of Indonesia- N Australian region, following recent studies on Timor. Rather different from more recent work (incl. Audley-Charles 1988, etc.; e.g. conclusions: 'the spatial relationships between N Australia, Timor and the other parts of the archipelago have not greatly altered since the Middle Triassic' and 'the contention of some authors that continental drift has occurred between the N coast of Australia and SE Asia, is strongly contradicted by stratigraphic evidence, and by paleogeographic history of the region as developed in this article')


Audley-Charles, M.G., D.J. Carter & A.J. Barber (1974)- Stratigraphic basis for tectonic interpretations of the Outer Banda Arc, Eastern Indonesia. Proc. 3rd Ann. Conv. Indon. Petroleum Assoc. (IPA), Jakarta, p. 25-44. (Outer Banda Arc islands (Timor, Tanimbar, etc.) are imbricated N margin of Australian shelf and slope on which overthrust Asian elements and major olistostrome have been superimposed, all emplaced from N)


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

(Brief account on fieldwork on coastal outcrops of Halmahera region by University of London)

(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))

(SE Asia consists of cratonic Sundaland core of continental fragments that had stabilized by end-Mesozoic. Additional terranes added through Late Mesozoic- Tertiary in Sumatra, Borneo, E Indonesia and Philippines. Early Tertiary widespread extension, followed by Late Tertiary compression, resulting in favorable locations for hydrocarbon generation and accumulation)


(Description of two examples of melanges from Banda arc (Timor Bobonaro melange) and Sunda arc (Nias, Oyo melange, with common ophiolitic blocks). Evidence from Australian continental shelf S of Sumba shows large quantities of diapiric melange generated in accretionary complex. Comparable diapirs in Timor accreted at earlier stage. Evidence from Timor and Nias shows diapiric melange can be generated well after initial accretion process was completed)

(Conference volume with many benchmark papers on tectonics of Eastern Indonesia)

(Most gold deposits in SE Asian arcs formed during tectonic reorganization intervals rather than steady-state subduction: (1) 25 Ma collision of Australian craton with Philippine Sea plate arc; (2) M Miocene/ 17 Ma mineralization following maximum extrusion of Indochina and cessation of S China Sea spreading; (3) majority and largest deposits formed since 5 Ma during plate reorganization with change in relative motion between Indian-Australian and Pacific plates between 5- 3.5 Ma following Philippine arc- Eurasia collision in Taiwan)

(Five main depositional cycles in Eocene- Recent of Java, Sumatra: (1) M Eocene- E Oligocene (P11-P17), followed by uplift, block faulting, volcanism; (2) Latest Oligocene- E Miocene (P22/N3- N7?, ending with volcanism- uplift?; (3) late E Miocene- M Miocene (N8- N10-11; poorly known); (4) M- Late Miocene (N11/12-N14/17), followed by uplift, faulting; (5) Pliocene-Recent, starting with major transgression at Miocene-Pliocene boundary, N18. Major Late Pliocene- Recent volcanic phase)

(Vintage regional seismic profiles and interpretation NW Australia- Sunda Arc)

(Review of GEODYnamics of S and SE Asia (GEODYSSSEA) project, a network of 42 GPS stations across SE Asia, observed between 1994-1998)


(Vintage Indonesian basins map and basin summaries by Stanvac (Standard Oil NJ) geologist)

(Sunda Arc example of large 'marginal fault', deduced from dipping earthquake zones below volcanic arc, landward dipping at ~35° at intermediate depths of 70-300km, steepening with depth to 61° between 300-700km. Philippine Islands example of similar 'oceanic fault' (now called 'Benioff zones'))

(Old, but still interesting discussion of Australia- E Indonesia paleogeography)

(Old, but still interesting discussion of tectonics- structure of East Indonesia, NW Australia, etc.)

(First text to notice deep earthquakes in Indonesia are concentrated in plane dipping toward Asian mainland (now known as Benioff zone or Wadati-Benioff zone; should have been named 'Berlage zone'?;JTvG))

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)

('The explanation for gravity anomalies, deep sea troughs, geosynclines, mountain building and volcanism near local plastic deformation of the earth’s crust’. Reply to Van Bemmelen (1936) critical remarks on Bijlaard (1935) theory)

(Second part of discussion between Van Bemmelen and Bijlaard on tectonic theory for Indonesian region)

('Geological problems in the Malayan Archipelago'. Overview of pre-1934 tectonic theories on Indonesia, without new synthesis or opinion)

(Review of tectonic settings of mineral deposits, with example of SE Asia- W Pacific arc system. In Indonesia all known mineral deposits lie within magmatic arcs and formed during or shortly after magmatic activity, but only 6 out of 15 Cenozoic magmatic arcs are known to contain significant mineralization)

(online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2001JB000324)
(GPS surveys suggest tectonics dominated by interaction of 4 blocks: Sunda Shelf (moves 6 mm/yr SE rel. to Eurasia), S Banda Arc (CW rotation rel. to Sunda and Australia), Birds Head (rapidly moves WSW, subducting beneath Seram Trough) and E Sulawesi (CW rotation, transferring E-W Pacific motion into N-S shortening across N Sulawesi trench. Crustal blocks all experience significant internal deformation)

(online at: https://www.biodiversitylibrary.org/item/150066#page/686/mode/1up)
('From the Moluccas'. First brief report by Boehm from his geological travels in E Indonesia in 1900-1901, and first report on Mesozoic fossils in 200 years since 'stone fingers' (belemnites) described by Rumphius. Mainly on visit to S coast of Sula Islands, with M Jurassic dark grey clayey limestones rich in ammonites (Sphaeroceras), belemnites and Inoceramus, also lower Cretaceous with Hoplites. No figures)

(online at: https://www.biodiversitylibrary.org/item/150077#page/796/mode/1up)
('More from the Moluccas'. Continuation of paper above, on visits to Ambon, Buru, Misool. On Ambon Mesozoic sandstone-limestone, etc. Jurassic of Sula and Misool islands with fauna of European character and rel. undeformed. No figures)
('Geological results of a trip in the Moluccas'. Brief, early report on widespread Triassic and Jurassic marine sediments on islands of E Indonesia, noticing similarities of rocks and faunas with those from European Alps)

('Contributions to the geology of the Netherlands Indies'. Series of mainly paleontological papers from E Indonesia. Listed individually)

('News from the Indo-Australian Archipelago, etc.' Early overview of Mesozoic macrofossil localities in E Indonesia: Sula islands (Jurassic belemnites, Macrocephites, etc.), W Cenderawasih Bay (Wendesi M Jurassic ammonite Phylloceras), New Guinea N Coast (Walcckenaer Bay ammonites and Inoceramus), Buru (Jurassic Perispininctes, Late Triassic Tissotia), Ceram, etc. Remarkable similarities of Molaccas Mesozoic and Spiti Fauna of Himalayas)

('Brief overview of tectonic history, involving W-ward displacement of Sundaland, and shared Paleozoic-Mesozoic petroleum systems between N Australia, New Guinea, Timor and other parts of eastern Indonesia')

('On the phases of mountain formation in the Indies Archipelago')


('Brief review of very deep marine deposits in East Indies, including Danau Fm of Borneo (Molengraaff, 1910, 'probably Jurassic', but could be E Cretaceous: JTvG) and Permian, Triassic and Lower Cretaceous abyssal deposits of Timor')

('On the tectonics of the Eastern Moluccas'. Early, brief overview of tectonics of the E Moluccas. See Brouwer (1917) for English version)

('Travel notes of geological reconnaissance trips to various islands of the Moluccas')

(online at: https://ia601908.us.archive.org/30/items/verhandelingenva3191geol/verhandelingenva3191geol.pdf)  
('Geological reconnaissance in the East Moluccas'. Brief overview of reconnaissance trips in E Indonesia islands)

(online at: www.dwc.knaw.nl/DL/publications/PU00012350.pdf)
(Early review of E Indonesia tectonics. Among recent significant discoveries is the presence of large overthrusts on Timor and adjacent islands, probably continuing along entire outer belt of Banda islands to Babar, Yamdena, Seram and Buru. The Sula Islands, Obi and Misool do not show overthrust structures. No figures)

('Phases of mountain building in the Moluccas'. Early, dated overview of Indonesia tectonics. No maps, figures)

(online at: https://www.digizeitschriften.de/dms/img/?PID=GDZPPN00045446X)
('On mountain building and volcanism in the Moluccas'. Brief discussion of geology East Indonesia. First author to note the apparent relationship between extinction of volcanoes in Alor-Wetar sector of the Banda Arc adjacent to mountain-forming processes on Timor)

('Brief overview of our knowledge of the geological formations and mountain building movements in the east Indies archipelago East of Java and Sulawesi'. Early overview of distribution of Paleozoic- Mesozoic- Tertiary rocks across E Indonesia)

(online at: www.dwc.knaw.nl/DL/publications/PU00012138.pdf)
('On a variety of different age volcanic-plutonic rocks in E Indonesia)

('Rel. comprehensive overview of 1917 state of knowledge of East Indonesia geology)

('Newer views on the geology of the East Indies Archipelago'. Brief review of recent developments. No figures)

(online at: www.dwc.knaw.nl/DL/publications/PU00012027.pdf)
('Curving rows of islands of Moluccas similar to many chains of Alpine structure. Rows of islands of Moluccas may be grouped into (1) zone characterized by outward-directed overthrusts (Timor-Ceram row); (2) marginal zone without overthrust tectonics (Sula-islands, Misool, W New Guinea S of Mac Cluer Bay (= Bintuni) and probably also Kei-islands; (3) inner zone with young active volcanoes)

(online at: https://www.digizeitschriften.de/dms/img/?PID=GDZPPN002505738)
('The horizontal movement of the island belts in the Moluccas'. Brief response to H. Stille critique of Brouwer (1917) paper on mountain building and volcanism in the Moluccas. Stille questioned presence of important horizontal movements on Timor, Timor, etc., but Brouwer insists they are important)

(Early attempt to explain deep basins and uplifted islands of E Indonesia)

(Brief discussion; summary of 1922 lecture)

(First 'text-book' on the geology of Indonesia, based on series of lectures at University of Michigan)

Brouwer, H.A. (1926)- Structure of the East Indies. Proc. 2nd Pan-Pacific Science Congress, Australia 1923, p. 784-.

Brouwer, H.A. (1926)- Volcanic action and mountain building in the Dutch East Indies. Proc. 2nd Pan-Pacific Science Congress, Australia 1923, p. 856-.


(online at: http://repository.naturalis.nl/document/549383)  
(Overview of occurrences of Paleozoic in Indonesia. Pre-Carboniferous rocks known only from New Guinea. Carboniferous and Permian in N Sumatra, C and S Sumatra, Timor, Savu, Roti, Luang, Babar, New Guinea)

('Orogenic evolution or next consolidation in the East Indies'. Early review of orogenic history of Indonesia, with special reference to Sulawesi (junction of two arcs) and Timor (with large nappe tectonics))


(online at: https://drive.google.com/file/d/0B7j8hPm9Cse0RGQxdGlTsN0alE/view)  
(Includes chapter on Seram arc and Banda Sea. With Hamilton (1979) one of first to suggest Banda sea formed by longitudinal extension))

(online at: www.repository.naturalis.nl/document/552406)  
(‘On the geology of the NE Indies archipelago’. Brief descriptions of islands Bacan, Mandioli, Kasiruta, Obi Besar, Manipa and Sulabesi. No figures)


Cardwell, R.K. & B.L. Isacks (1978)- Geometry of the subducted lithosphere beneath the Banda Sea in Eastern Indonesia from seismicity and fault plane solutions. J. Geophysical Research 83, B6, p. 2825-2838. (Earthquake data fault plane solutions suggest two lithospheric plates descending into upper mantle beneath Banda Sea: (1) along Banda arc, laterally continuous slab that subducted at plate boundary defined by Java trench-Timor Trough-Aru Trough system; (2) descends to SW to ~100 km depth in Seram Trough region and may be joined to Banda subduction system by W extension of New Guinea Tarera-Aiduna fault zone. Banda arc slab contorted at E end of arc where trench and line of active volcanoes curve NE. Contortion appears to be lateral bend in subducted slab that is continuous from surface to depths of 600 km)


(Gold mineralization in andesitic arcs, active for 3-20 My intervals from Cretaceous- Pliocene. Fifteen major arcs; known ore bodies in six mid-Tertiary- Pliocene arcs. Indonesia arcs total ~7,000 kms in length. Individual arcs or segments of arcs characterized by specific mineralization types reflecting arc basement related to earlier collisions and reversals in tectonic polarity and erosion level)


(Report on ongoing geological research along nine SEATAR mega-regional transects)


(Sediment isopach maps and summaries of SE and E Asia basins)


(GPS over SE Asia revealed Indochina, Sunda shelf and part of Indonesia behave as rigid 'Sundaland' platelet, which rotates clockwise relative to Eurasia. Sundaland E-ward velocity of ~10 mm/yr on S boundary increasing to 16-18 mm/yr on N boundary)


(Review of widespread Pleistocene tektites, distributed several 1000 km across SE Asia and Australia. Tektites remarkably similar in composition. Probably caused by major meteorite impact, probably on moon. Size and shape of tektites interpreted to reflect higher T portion of crater ejecta descended over SE Australia and lower T portions were strewn progressively over SW Australia-Indonesia and further North. 'Glass pebbles' locally known as billitonites, philippinites, australites, javanites, philippinites, etc.)


(E Indonesia interpreted in terms of rel. simple three plate indentation model)


(Postcollisional extension common in E Indonesia orogenic belts, starting <5 My after compressional deformation (Timor area, Gulf of Bone in Sulawesi, Wandamen -Wondiwoi Terrane of W Papua). Extension results from decoupling of subducting oceanic lithosphere from unsubductable continental lithosphere. Superimposition of extension is virtually unavoidable consequence of arc-continent collision)


(online at: https://pdfs.semanticscholar.org/7a4a/60abf67172f74729c322539e1e4c62ff2d78.pdf)
(Interpretations of last 35 My of tectonic evolution of E Indonesia, with plate reconstructions at 5 My intervals. Oldest reconstruction predates collisional deformation between N-moving Australian continent and E-W oriented, S-facing subduction zone extending from S margin of Eurasian continent E-wards. Beginning at ~30 Ma the Australian continental margin commenced collision with subduction zone along restored N margin, from Sulawesi in W to PNG in E. At ~24 Ma present-day pattern of oblique convergence between N margin of Australia and Philippine Sea Plate began. From ~18 Ma S-directed subduction commenced at Maramuni Arc in N New Guinea. Sorong Fault Zone strike-slip system active from ~12 -6 Ma)


(E Indonesia continental fragments with Australian/Gondwanan affinities remarkably uniform Permo-Triassic tectonostratigraphy, ranging from granitoid belt in N, through continental platform, to intracontinental rift system in S. In rift system complementary upper and lower plate rifted margins recognised in N and S Banda Arcs. N granitoid belt initiated in mid-Carboniferous, intracontinental rift system began in latest Carboniferous- earliest Permian. Extension in N rift margin ceased in M Carnian, with decline in igneous activity in granitoid belt to North. Sibumasu Terrane originated on Gondwanaland margin, rifted away in E Permian. Gondwanan E Indonesia acted as continental connection between Sibumasu/Indochina and Australia in Permian- Triassic, permitting limited floral- faunal interchange between Gondwanaland and SE Asia until final separation in Late Triassic. M Carnian structural event in E Indonesia may be related to this separation)


(Timor, Tanimbar and Seram perceived structural complexity may be overstated. Proposes inversions of Permian-Jurassic grabens as fundamental structural style)


(online at: www.iagi.or.id/fosi/berita-sedimentologi-no-24-timor-and-arafura-sea.html)

(Paleogeographic maps of S and E Banda forearc (Savu to Kei islands, incl. Timor-Tanimbar) and adjacent parts of NW Australian continental margin for E Permian, M-L Permian, E-M Triassic, Late Triassic, and E, M and Late Jurassic. Three main rift phases (E Permian, Late Triassic and M-Late Jurassic) separated by quieter tectonic intervals with low facies diversity)


(Alternative plate reconstruction of Paleogene of Indonesia- NW Australia, suggesting E Sundaland and Gondwanaland/ NW Australia remained attached until final separation by rifting in Paleogene. Main driver for model is similarity of Paleogene rifting in both Sundaland and on Timor island, which is interpreted as part of the Australian continental margin)


(New East Indonesia plate reconstructions at 1 My intervals from 30 Ma- Present. Main differences between previous reconstructions are >30° CCW rotation of Bird’s Head since ~6 Ma, and origin of backarc spreading in N and S Banda Basins by process of ‘fixed slot’ subduction geometry, not trench rollback. Four phases: (1) 30-18 Ma: Collision, then indentation of ‘Greater Sula Spur’ promontory into E continuation of Sunda Arc subduction system; (2) 18-12 Ma: Terranes N of Sorong Fault Zone move WSW relative to Australia, with motion of Pacific plate. (3) 12-6 Ma: Development of proto-Banda Arc by fixed-slot backarc spreading in N Banda Basin; (4) 6-0Ma: Collision around Banda Arc and rotation of Bird’s Head)


(Unorthodox non-plate-tectonic model for SE Asia tectonics, etc.)

(Extensive Cretaceous-Paleocene regional unconformity from Indochina to Java may be due to subduction-driven mantle processes. Cessation of subduction, descent of N-dipping slab into mantle, and consequent uplift and denudation of sediment-filled Late Jurassic- E Cretaceous dynamic topographic low help explain extent and timing of unconformity. Sediments started to accumulate above unconformity from M Eocene when subduction recommenced under Sundaland)


(online at: http://searg.rhul.ac.uk/pubs/clements_hall_2011%20Sundaland%20emergence.pdf)

(Detrital zircons from Eo-Oligocene sandstones of SW West Java derived from local volcanic sources and Sundaland. Populations with ages of 50-80 Ma (from two discrete volcanic arcs in Java and Sulawesi), 74-145 Ma (E-M Cretaceous granites of Schwaner Mts of SW Borneo), 202-298 Ma (Permian-Triassic Tin Belt granites), 480-653 Ma and 723-1290 Ma (Proterozoic SE Asia basement once part of Gondwana). M Eocene sediment derived mainly from Tin Belt, Late Eocene and younger Borneo source more important. Microcontinental collision at Java margin (~80 Ma) halted Cretaceous subduction and resulted in elevation of large parts of continental SE Asia)


(Study of formation waters from 400 SE Asia wells. Majority fresh or brackish meteoric to connate waters)


(Tertiary basins of Sunda Shelf of SE Asia formed in ?Mid- Late Eocene and accumulated thick syn-rift lacustrine and low salinity organic-rich shales through Late Paleogene. Towards end Oligocene- E Miocene marine transgression throughout region. Syn-rift sediments most important hydrocarbon source rocks)


(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0Yi13a19UM20tQ0k/view)

(Interpretation of five gravity profiles through Sumatra and Java, based on broadly spaced gravity data from Vening Meinesz and BPM (see also Van Bemmelen 1954))


(Response to Van Bemmelen(1954) critique of Collette (1954) paper)


(draft online at: www.corbettgeology.com/corbett_and_leach_1997.pdf)

(On Indonesia- New Guinea- Philippines gold deposits. Includes discussions of Masupa Ria, Kalimantan, Wetar, etc.)
CoreLab/ PERTAMINA (1995)- The petroleum geology and economic assessment of the foreland basin areas of Eastern Indonesia. 5 vols. *(Unpublished)*

*(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1995a27.pdf)*

 (>3000 exploratory wells drilled since 1870 in W Indonesia with 750 discoveries. By 1992 over 300 producing fields in 11 basins and 100 fields shut-in or abandoned. Published work is of regional nature. Lithostratigraphy mainly based on pre-1960’s work, with terminology varying between companies. Biostratigraphy handicapped by lack of age diagnostic fossils in E Miocene and older sediments in most of Sumatra and Natuna. Java-Kalimantan older section more marine with age diagnostic fossils, but errors in age determination due to reworking. Propose correlative framework using sequence stratigraphy)


*(Hydrocarbons in Sumatra, Natuna, Sunda Basin, Lombok, Barito, NW Java, possibly also E Java basins all tied to M Eocene source rocks, mainly lacustrine, limited to Paleogene rifts)*

*(Sunda Arc extends from Himalayas to Banda Arc. Variations along arc function of direction and speed of convergence across subduction zone and sediment thickness on underthrusting plate. Highly oblique convergence may lead to lateral terrane transport and opening - closing of marginal basins like Andaman Sea)*

*(BP plate reconstruction. evolution. India collision and indentation led to major clockwise rotation of SE Asia. Sumatran basins opened due to back arc extension in Eocene. Closure of marginal ocean basin resulted in major contractional event in Late Oligocene. Gulf of Thailand basins and Andaman Sea opened in response to rotation of Indochina and oblique convergence at Sunda trench. Inversion S end of these basins and uplift in Borneo coincided with collision of Reed Bank Terrane with Borneo. Opening of Makassar Straits, Kutai, Tarakan and Barito basins in Eocene. Inversion of these basins result of collision of Australia and Australia-derived microplates in Late Miocene/Pliocene. Pliocene foldbelt and foreland basin formation in New Guinea result of oblique arc collision. Basin evolution of SE Asia not result of lateral extrusion in front of India indenter; main effect of collision is CW rotation of Indochina and extension along Sumatran active margin. Includes Oligocene arc polarity reversal in Sumatra, Timor is part of NW Australian margin, etc.)*

*(Late 1980’s BP plate reconstructions of Tertiary of SE Asia since 55 Ma. (see also Daly et al. 1991))*

*(Same paper as Daly et al. (1987) above. With reconstructions since 70 Ma. N-ward motion of Australia started at ~50 Ma, at about same time as India-Eurasia collision and initiation of SE Asia Tertiary basins formation. Sumatra back-arc basins geometry of pull-apart basins between dextral strike-slip displacement. Banda-Celebs Sea (erroneously) viewed as trapped Mesozoic Indo-Australian oceanic crust?, Kutai- Tarakan- Barito-Makassar Straits basins viewed as Eocene back-arc extension along Pacific margin. Etc.)*


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

(Symposium commemorating 50th anniversary Van Bemmelen (1949) book Geology of Indonesia)

(The most recent, concise overview of Indonesian geology by collective of 25 Indonesian geologists. Much of book also as online chapters on Wikipedia)

(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 data set of relocated earthquakes >400 km under Indonesia, developed by Schoffel and Das 1999. Slab thickens, shortens and weakens before penetrating below 670 km by shearing along conjugate fault planes on upper and lower portions of seismic zone)

(Two 1:10 million scale isogam maps based on published data and Royal Dutch Shell gravity surveys:(1) Caribbean Sea and surroundings; (2) SE Asia, including Indonesia, Philippines and New Guinea)

(New zircon ages of igneous rocks in E Indonesia. Biotite-cordierite dacites (ammonites) from Ambon Pliocene (3-4 Ma), with inherited material from ~150-430 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). Bacan diorite ~330 Ma. On Seram Triassic siliciclastic Kanikeh Fm sst same zircon age spectra as metasediments of Tanusa and Tehoru complexes. Sirga Fm quartz clastics in New Guinea Lst several units of different ages, derived from local uplifts in Eocene-Oligocene)

(‘Some remarks on the stratigraphy of the Moluccas and the value of paleontological age determinations’. Early discussion on significance of Mesozoic fossils of Buru and age of Buru Limestone)

(Review of continental rift systems, with examples from Tertiary basins of Sundaland. In intracratonic setting sedimentation typically non-marine during active graben formation; later regional subsidence may give rise to
marine transgression in rifts near cratonic margins. Best potential source rocks in non-marine rifts lacustrine shales, with TOC up to 20%. Volume of oil generated may be very large for depocentre of limited areal extent. Long distance migration from oil kitchens (20 km) not common in continental rift settings. Basin size typically 20-60 km wide and 70-300 km in length)


Elbert, J. (1911)- Die Sunda-Expedition des Vereins fur Geographie und Statistik zu Frankfurt am Main. Festschrift zur Feier des 75 jahrigen Bestehens des Vereins. Hermann Minjon, Frankfurt, vol. 1, XXV, p. 1-274. ('The Sunda-Expedition of the Frankfurt Geographic Society, etc'. Report of 1910 geographic expedition lead by Johannes Elbert to Bali, Lombok, Salayer, Tukang Besi, Muna, Buton, Rubia, Mengkoda, and parts of Java and Sumatra. Main purpose of expedition was to explore geographic relationship between Asia and Australia)


Ernst, W.G, S. Maruyama & S. Wallis (1997)- Buoyancy-driven, rapid exhumation of ultrahigh-pressure metamorphosed continental crust. Proc. National Academy Sciences USA 94, p. 9532-9537. (online at: www.pnas.org/content/94/18/9532.full.pdf) (Preservation of ultrahigh-pressure (UHP) minerals formed at depths of 90-125 km require unusual conditions. Our subduction model involves (1) underflow of continental crust embedded in cold, largely oceanic crust-capped lithosphere, (2) loss of leading portions of high-density oceanic lithosphere by slab break-off as increasing volumes of microcontinental material enter subduction zone, (3) buoyancy-driven return to mid-crustal levels of thin (2-15 km thick), low-density slice, (4) uplift, backfolding, normal faulting and exposure of UHP terrane. Intracratonal position of most UHP complexes reflects consumption of intervening ocean basin and introduction of sialic promontory into subduction zone. UHP metamorphic terranes consist chiefly of transformed continental crust (otherwise could not return to shallow depths). UHP paragneisses contain crustal diamonds. Banda Arc used as example)


(‘On the indirect relationship between volcanism and Vening Meinesz’ belt of negative gravity anomalies in E Indies’. (Escher supports Vening Meinesz’ idea of significant horizontal movements of crust in the Indonesian region, but disputed by Van Bemmelen 1933 and many other papers)


(‘The paleontology and stratigraphy of Netherlands East Indies’. Commerative volume at 80st birthday of Prof. Dr. K. Martin. Voluminous book with 20 chapters summarizing ‘state of knowledge’ of paleontology and stratigraphy in Netherlands East Indies. With listings of species and fossil localities and stratigraphic tables. No illustrations of fossils)


(Includes shallow sparker profiles in Indonesia, illustrating Neotectonics of Lampung Bay (faults cutting Pleistocene sediments), Neotectonics and diapirism off N Madura (Neogene-Recent compressional anticline, a diapiric structure and possible gas chimneys) and Seabed erosion of Sunda Shelf W of Kalimantan (incl. 20m deep/ 600m wide buried lowstand channels)


(New GETECH processing method ERS-1 and GEOSAT satellite gravity recovers gravity anomalies with wavelengths down to 10 km)


(One of first papers applying plate tectonics concepts to Indonesia. New focal mechanisms from shallow-focus earthquakes in Indonesian-Philippine region suggest dominant thrust and normal faulting rather than strike-slip faulting. Along Sunda and Philippine arcs most activity between ocean trench and line of active volcanoes. Mechanism solutions from earthquakes in this zone all thrust type (underthrusting beneath island arc))

Fitch, T.J. (1972)- Plate convergence, transcurrent faults and internal deformation adjacent to southeast Asia and western Pacific. J. Geophysical Research 77, p. 4432-4460.

(Earthquake data used to delineate convergence and transcurrent fault zones in Indonesia. Weber Deep erroneously interpreted in earlier Fitch papers as E continuation of Java Trench. See also comment by Audley Charles and Milsom 1974)


(Authors agree with Audley Charles and Milsom that Timor is product of collision of Banda island-arc system with continental shelf of Australia and New Guinea. Advancing arc has ramped up onto shelf, bulldozing shelf strata and incorporating them into imbricated and melanged material riding at front of arc. Timor trough, like Java trench with which it is continuous to W, is angle between gently dipping undersliding southern plate and wedge of shuffled material above it to N)


(28 new focal mechanisms for intermediate and deep-focus earthquakes in Indonesia-Philippine region. At intermediate depths of Sunda and Philippine arcs descending slab of lithosphere is under extension. Deep-focus
mechanisms beneath Sunda arc suggest descending slab is under compression at great depth. In Banda Sea and N Celebes regions seismicity indicates possible contortions in underthrust slabs)

(Good overview of geology and hydrocarbon plays in Indonesian Tertiary basins)

(Australasian strewn-field shows radial sequence of tektite shapes ranging from rel. large unmodified impactite (Muong Nong type in S Laos, E Thailand), through dumb-bells and discs (thailandites, indochnites; 400-1000 km from impact site), and spheres (phillipinites, billionites, javanites; 1000-3000 km from impact) to ablated button shapes (australites). Shapes of tektites from mainland SE Asia derived from uncongealed spinning glassy fragments passing through atmosphere. Sequence extends from suspected impact area in NE Cambodia to SE, to SE Australia and Tasmania)


(Good collection of papers on SE Asia tectonics, basins and hydrocarbon plays)


(Genetic classification of 63 SE Asia basins. Over 35 billion bbl oil found, another 35 remains to be found. Four of 11 recognized basin types contain 84% of all SE Asian oil: ocean margin, backarc, wrench and suture-related basins)

(Reconstruction of tectonics and depth history of Indonesian seaway and associated SE Asian back-arc basins. All marginal seas N of Australia formed in back-arc setting, with Caroline (37-24 Ma) and Celebes Seas (48-35 Ma) opening N of N- dipping subduction zone, and Solomon Sea (42-33 Ma) S of S- dipping subduction. Several major tectonic events N of Australia at ~45 Ma, related to relocation of subduction zone NW of Australia under Philippine Sea plate due to collision and accretion of old Pacific plate material to N-subducting Australian plate. Negative anomalous depth of several back-arc basins is ~650-800m (range 300-1100m), accompanied by negative regional heatflow anomalies, suggesting mantle-driven dynamic topography. Tomography shows marginal basins with negative dynamic topography underlain by massive buried slab material, suggesting negative dynamic topography and heatflow anomalies due to basin formation above slab burial grounds)

(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1997008.pdf)
(Majority of gold in SE Asia in porphyry (64%), low-sulfidation epithermal (17%), carbonate-base metal-gold (7%) and skarn (4%) deposits. 90% of these deposits (>95% of gold) associated with 14 middle to late Cenozoic magmatic arcs)

(Gold and copper deposits in SE Asia and W Pacific largely in M-L Cenozoic (25-1 Ma) magmatic arcs. Twenty major arcs and several less extensive Cenozoic arcs form complex border to Sundaland core and N margin of Australian continent. Three major plate reorganizations at ~45, 25 and 5 Ma, characterized by collisional events that changed plate boundaries and motions. Most deposits developed during episodes of plate reorganization. Hydrothermal systems active for durations of <100,000 years)

(Descriptions of major Cenozoic volcanic arcs and associated mineral deposits from Japan through Philippines to Indonesia/New Guinea)

(GPS measurements show Australian continent has accreted to Banda arc. Timor Trough now mostly inactive. Most of Australia- Eurasia convergence appears to occur as N-ward translation of Banda Arc, with shortening on Flores and Wetar thrusts)

Geological Survey of Indonesia (2008)- Gravity anomaly map of Indonesia, 1: 1,000,000.

Geological Survey of Indonesia (2009)- Peta Cekungan sedimen Indonesia/Sedimentary basin map of Indonesia, based on gravity and geological data, 1:5000,000. Geol. Survey Indonesia, Bandung.
(online at: www.grdc.esdm.go.id)
(Map of Indonesia sedimentary basins, color-coded by age and labeled by basin type)

Geological Survey of Japan (2004)- Digital geologic map of East and Southeast Asia, 1: 2,000,000, 2nd ed. Digital Geoscience Map Series G-2, CD-ROM.

(online at: http://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/124954/1/b38p2n332p03.pdf)
(Depth distribution of earthquakes revealed zone of rare seismicity at intermediate depth in eastern Sunda arc)


(E Indonesia tectonic blocks in GIS format)


(Summary of 1:5M map; map not included)

(Thermal models and structural constraints derived from seismic and gravity data used to explain seismogenic behaviour in Sunda subduction zone. With respect to Java, oblique subduction of young oceanic crust shifts seismogenic coupling zone roughly 40 km trenchward offshore of N Sumatra and increases width of locked megathrust. Prominent positive gravity anomaly offshore Java caused by shallow mantle wedge underlying forearc basin. Serpentinized mantle wedge would limit width of coupling zone to 30–40 km, compared to N120 km off Sumatra. Sumatra remains therefore most vulnerable for future megathrust earthquakes, while shallow mantle wedge may limit violence of rupture off Java)


Griffiths, J.R. & C.F. Burrett (1973)- Were South-East Asia and Indonesia parts of Gondwanaland? Nature Physical Sci. 245, p. 92-93. (Brief comments on recent Ridd et al. (1971) and Audley Charles (1972) SE Asia plate reconstructions, in which India has been placed adjacent to W Australia and against Antarctica)

Grunau, H.R. (1965)- Radiolarian cherts and associated rocks in space and time. Eclogae Geol. Helvetiae 58, p. 157-206. (online at: https://www.e-periodica.ch/digbib/view?pid=egh-001:1965:58#3) (Review of radiolarian cherts worldwide, incl. descriptions of ?Jurassic Danau Fm and Cretaceous Lupar Fm of Borneo, and similar rocks from Sumatra, Triassic and Cretaceous of Seram, Cretaceous of Timor, Jurassic-Cretaceous of E Sulawesi and Triassic of Malay Peninsula. Radiolarian cherts typical deep water 'geosynclinal' deposits (mainly Tethys eugeosyncline), typically intensely folded and associated with turbidites and ophiolites. As already concluded by Molengraaf (1909) these are remnants of former ocean basins)

Guntoro, A. (1995)- Tectonic evolution and crustal structure of the Central Indonesian region from geology, gravity and other geophysical data. Ph.D. Thesis University College London, p. 1-335. (Unpublished) (Central Indonesian Region represents a transition between mainly Eurasian elements of W Indonesia and Pacific-Australian elements of E Indonesia. Bounded by two subduction zones: in W by pre-Tertiary subduction zone at SE Sundaland margin, to E by E Tertiary subduction zone (Selayar-Bonerate ridge). Variations in gravity demonstrate that continental crust in CIR was attenuated by subduction roll-back and then subjected to rifting by extensional forces. Extension in Makassar Strait, C Java Sea and E Java Sea in Eocene, forming marginal basins. Bone Bay opened due to collision between Banggai- Sula microcontinent and Sulawesi in M Miocene and was followed by CW rotation of Java, Sumbawa and Flores which caused opening of Flores Sea)

(online at: http://dspace.library.uu.nl/handle/1874/591)
(On large-scale history of subduction win Tethyan region from Mediterranean to Indonesian archipelago by combining plate tectonic reconstructions with independent seismic tomography results. Plate tectonic reconstructions of Tethyan region generally agree on first-order motions. E Tethyan region characterised by active subduction of various oceanic basins. Subduction zones models from regional tectonic reconstructions, converted into seismic velocity anomalies, which are compared to tomographic images of mantle structure)

(Generally good agreement between modeled tomography velocity structure and Rangin (1999) and Lee & Lawver (1995) plate reconstructions)

(Tomography, mainly on Western Tethys)

(Early paper on plate tectonics application in SE Asia, focused around W Borneo- Malay Peninsula)

(Review of recent paleomagnetic work in SE Asia. Cretaceous rocks from W Kalimantan suggest this part of Borneo lay on equator, as Malay Peninsula with which it formed part of single plate, which subsequently rotated ~45°. Late Mesozoic radiolarian cherts from SW arm of Sulawesi also indicate low latitudes and CCW rotation of 35°. At W end of Seram late Cenozoic Kelang Fm rotated probably anticlockwise ~ 80°. Triassic rocks from S C Seram high magnetic inclination, indicating origin in higher latitudes (~26°) than today (see also Haile 1978, 1981))


(Summary of paleomagnetic results from Borneo, Sumatra (40° CW rotation since Mesozoic, 34° of which accomplished since Oligocene), Sulawesi, Sumatra, Sumba, Timor, Seram (Seram at 12°S in Late Triassic, rotated CCW 98° since then). Late Mesozoic of W Kalimantan and SW Sulawesi little change from present latitude, but 49° and 33° CCW rotation)

(Seram 74° anticlockwise rotation since Late Miocene. Timor Permian Crihas Fm higher paleolatitude (34°) than Maubisse Fm (27°), but within margin of error. SW Sulawesi E Cretaceous radiolarian chert formed at ~3° and, with Kalimantan and Malay Peninsula, may have rotated 30-40° anticlockwise since Jurassic. Similar cherts from E arm Sulawesi formed at 42°S)


Hall, R. (1998)- Cenozoic tectonics of South East Asia: myths, models and methods; reconstructions, implications and speculations. In: Offshore South East Asia Conf. (OSEA98), Singapore, SEAPEX, p. 69-72. (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)


Hall, R. (2002)- Cenozoic geological and plate tectonic evolution of SE Asia and the SW Pacific: computer-based reconstructions, model and animations. J. Asian Earth Sci. 20, 4, p. 355-431. (Most comprehensive of R. Hall papers on SE Asia- SW Pacific plate reconstructions from Early Eocene (55 Ma)- Recent. See also updated/ expanded version of Hall (2012))

to changing forces at the plate boundaries. Continental growth mainly by arrival of continental fragments at subduction margins, with subordinate contributions from ophiolite and sediment accretion or arc magmatism)

(online at: http://www.ingentaconnect.com/content/nhn/blumea/2009/00000054/f0030001/art00026#)
(SE Asia grew incrementally by addition of continental fragments, mainly rifted from Australia, and added to margins of Sundaland as result of subduction. Sundaland almost permanent land area from beginning of Mesozoic. Addition of continental fragments of SW Borneo and later East Java-W Sulawesi formed larger emergent land area by Late Cretaceous. Subduction resumed at Sundaland margin in Eocene, leading to widespread rifting within Sundaland and formation of Makassar Straits. Australia began to collide with SE Asia at ~25 Ma, effectively closing former deep ocean between two continents)

(online at: http://searg.rhul.ac.uk/pubs/hall_2009_SE%20Asia%20hydrocarbon%20basins.pdf)
(Almost all hydrocarbon basins in SE Asia began to form in Early Cenozoic and filled with Cenozoic sediments. Most are rifted basins formed by regional extension on continental crust. Weakness of Sundaland lithosphere, unusually responsive to changing forces at plate edges, meant that basins record complex tectonic history)

(Eurasian margin in SE Asia surrounds Sundaland continental core. Continental growth since Cretaceous in episodic way, related primarily to arrival of continental fragments at subduction margins, after which subduction resumed in new locations. There have been subordinate contributions from ophiolite accretion, and arc magmatism. Relatively small amounts of material accreted during subduction from downgoing plate. In E Indonesia the wide plate boundary zone includes continental fragments and several arcs. (This paper is first of several versions that show Early Cretaceous age of addition of SW Borneo Block to Sundaland and Late Cretaceous addition of E Java-W Sulawesi accreted block outboard of Meratus-C Java trend))


(Jurassic-Recent Indonesia tectonic reconstruction. Sundaland core of SE Asia is heterogeneous assemblage of Tethyan sutures and Gondwana fragments. Fragments that rifted from Australia in Jurassic collided with Sundaland in Cretaceous and terminated subduction. From 90-45 Ma Sundaland surrounded by inactive margins with localized strike-slip deformation, extension and subduction. At 45 Ma Australia began to move N and subduction resumed beneath Sundaland. At 23 Ma Sula Spur promontory collided with Sundaland margin. From 15 Ma subduction hinge rollback into Banda oceanic embayment, major extension, and later collision of Banda volcanic arc with S margin of embayment. Sundaland has weak thin lithosphere, highly responsive to plate boundary forces and hot weak deep crust flowed in response to tectonic and topographic forces and sedimentary loading. Gravity-driven movements of upper crust, unusually rapid vertical motions, exceptionally high rates of erosion and massive movements of sediment characterized region)

(Most of SE Asia not rigid plate or multiple rigid microplates bounded by lithospheric faults. Sundaland formed by collision of Sibumasu and E Malaya-Indochina in Triassic and other fragments rifting from Australia in late Jurassic- E Cretaceous were added in Cretaceous (now in Borneo, Java, Sulawesi))
(online at: www.sciencedirect.com/science/article/pii/S0040195112002533)
(Mesozoic- Cenozoic plate tectonic reconstructions. Luconia-Dangerous Ground continental block rifted from E Asia and was added to E Sundaland N of Borneo in Cretaceous. Banda (SW Borneo) and Argo (E Java- W Sulawesi) blocks separated from NW Australia and collided with SE Asia between 110- 90 Ma. At 90 Ma Woyla intra-oceanic arc collided with Sumatra margin. Subduction beneath Sundaland terminated at this time. Between 90-45 Ma Australia remained close to Antarctica and there was no significant subduction beneath Sumatra and Java, while Sundaland was surrounded by inactive margins with some strike-slip deformation and extension, except for subduction beneath Sumba- W Sulawesi between 63- 50 Ma. At 45 Ma Australia began to move N; subduction resumed beneath Indonesia and has continued to present. Cenozoic deformation influenced by deep structure of Australian fragments added to Sundaland core, shape of Australian margin formed during Jurassic rifting, and age of now-subducted ocean lithosphere)

(online at: http://searg.rhul.ac.uk/pubs/hall_2012%20Sundaland%20&%20Wallacea.pdf)
(Plate tectonic and paleogeographic reconstructions since 80 Ma)


Hall, R. (2013)- The palaeogeography of Sundaland and Wallacea since the Late Jurassic. J. Limnology 72, 2, p. 1-17.
(online at: www.jlimnol.it/index.php/jlimnol/article/view/685)
(Asia-Pacific boundary active continental margin until M Cretaceous. Subduction ceased around Sundaland in Late Cretaceous. From ~80 Ma most of Sundaland emergent and connected to Asia. One or more India-volcanic collisions in Eocene may have preceded India-Asia collision. During Late Cretaceous- E Cenozoic no significant subduction beneath Sumatra, Java and Borneo, until ~45 Ma when Australia began to move N; also time widespread rifting within Sundaland. During Paleogene E and N Borneo largely submerged. By E Miocene proto-South China Sea had been eliminated by subduction leading to emergence of land in C Borneo, Sabah and Palawan. Microplate or terrane concept of slicing fragments from New Guinea followed by multiple collisions in Wallacea implausible. Neogene subduction drove extension and fragmentation of Wallacea)

(Mainly summary of recent Royal Holloway group research. In E Indonesia subduction zones at different stages of development, from mature examples like Banda system that began to roll back from ~16 Ma, to younger systems such as N Sulawesi. Close relationship between subduction and extension, causing both dramatic elevation of land regions with exhumation of deep crust, and spectacular subsidence of basins. Many metamorphic rocks in Indonesia proved to be younger than previously suggested (SW Borneo, N and C Sulawesi, Seram). Triassic igneous and metamorphic rocks at W end of Schwaner region and N of Pontianak suggesting suture between Sundaland and SW Borneo further E than previously postulated)

(online at: http://searg.rhul.ac.uk/pubs/hall_2014%20Sundaland%20origin.pdf)
(Updated version of SE Asia plate tectonic reconstruction. Core of SE Asia was assembled from continental blocks that separated from Gondwana in Paleozoic and amalgamated with Asian blocks in Triassic. Some fragments rifted and separated from Asia and later re-amalgamated with western part of SE Asian continental core in Mesozoic. Fragments of Cathaysian/Asian continental crust form parts of N Borneo and offshore shelf N of Sarawak and E of Vietnam. Other continental blocks rifted from Australia in Jurassic (SW Borneo, E Java-W...
Sulawesi, Sabah-NW Sulawesi, S Sulawesi-Sumba) and Woyla intra-oceanic arc of Sumatra and were added to Sundaland in Cretaceous. Subduction ceased around Sundaland in early Late Cretaceous.


Hall, R. & C.K. Morley (2004)- Sundaland Basins. In: P. Clift, P. Wang et al. (eds.) Continent-ocean interactions within the East Asian marginal seas, American Geophys. Union (AGU), Geophys. Monograph 149, p. 55-85. (Continental core of Sundaland, comprising Sumatra, Java, Borneo, Thai-Malay Peninsula and Indochina, was assembled during Triassic Indosinian orogeny. Region includes extensive shallow seas, is not significantly elevated, but not stable for long time. Today surrounded by subduction and collision zones. Cenozoic deformation recorded in numerous deep sedimentary basins along highlands. Sediment fill mostly locally derived. Conventional basin modeling fails to predict heat flow, elevation, basin depths and subsidence history of Sundaland and overestimates stretching factors. Can be explained by interaction of hot upper mantle, weak lower crust, and lower crustal flow in response to changing forces at plate edges)


(Record of Cenozoic subduction volcanic activity at SE Asia margins. Stratigraphic record in Indonesian region reflects complex tectonic history, including collisions, changing plate boundaries, subduction polarity reversals, elimination of volcanic arcs and extension. Growth of region in episodic way by addition of ophiolites and continental slivers, and as result of arc magmatism)

(Tomographic images of mantle structure N and NE of Australia show anomalously fast regions, interpreted in terms of current and former subduction systems)

(Tomographic images of mantle show high seismic-velocity anomalies, interpreted as subducted slabs. Several generally flat deeper anomalies not related to present subduction. Mainly discussion of potential Tertiary subducted slabs around NE Australia-New Guinea)

(online at: www.ipa.or.id/download/news/IPA_Newsletter_07_2005_9.pdf)

(Review of tomography and tectonic interpretations of Greater Indonesian region)

(online at: https://pdfs.semanticscholar.org/5a2c/ccdb9a1eb5e74a2e0fa57d5381f9fd8d6c1ee.pdf)
(Five suture zones: (1) Molucca (Pliocene- Recent Halmahera and Sangihe arcs collision), (2) Sorong, (3) Sulawesi (Late Oligocene- E Miocene West and East Sulawesi continent-continent collision), (4) Banda (Banda Volcanic arc and N Australia collision) and (5) Borneo sutures (E-M Miocene S China- N Borneo collision), each with relatively short history)

(Preliminary report on Hamilton's major work, superseded by Hamilton (1978))

(online at: www.gsm.org.my/products/702001-101358-PDF.pdf)
(Early paper on plate tectonic interpretation of Indonesia, following assumptions that subduction zones are characterized by ophiolite, melange, wildflysch and blueschist, that intermediate and silicic calc-alkaline igneous rocks form above Benioff zones, and that truncations of orogenic belts indicate rifting. SE Asia and 'Sundaland' are aggregates of small continental fragments. Philippines, Sulawesi and Halmahera consist of Mesozoic? and Cenozoic island-arc subduction and magmatic complexes and lack old continental foundations)

(online at: http://pubs.usgs.gov/imap/0875b/plate-1.pdf)

(online at: http://pubs.usgs.gov/imap/0875c/plate-1.pdf)
(Map showing earthquake epicenters and depth recorded from 1961-197, with interpreted subduction zones)
(Early plate tectonic interpretation of Indonesia)

(As above. Outer-arc ridge between Java-Sumatra and active Java Trench is top of wedge of melange and imbricated rocks whose steep-moderate dips are sharply disharmonic to gently dipping, subducting oceanic plate beneath. Wedge has grown by scraping off of oceanic sediments and basement against and beneath its toe, and by internal imbrication. Outer-arc basin behind ridge originated from Paleogene continental shelf-and-slope assemblage whose seaward side was raised by melange stuffed beneath it by Neogene subduction. Banda Arc now colliding with Australian-New Guinea continent. Sumba is microcontinental fragment derived from Java Shelf. Philippines are product of aggregation of segments of various island arcs)

(online at: http://pubs.usgs.gov/imap/0875d/plate-1.pdf)
(Reprinted with corrections in 1981. Mainly surface geology with structural elements, not 'terrane map')

(online at: http://pubs.usgs.gov/pp/1078/report.pdf)
(Classic, first comprehensive overview and synthesis of Indonesia tectonics in plate tectonics context, both land and offshore areas. An aging, but unrivaled masterpiece on geology of Indonesia, still with abundant good information, observations and insights. First to interpret Banda Sea as Neogene extensional basin. Etc.)

(Discussion of plate tectonics, with many examples from Indonesia. Modern Sunda volcanic arc system, involving subduction of Indian Ocean lithosphere beneath Sumatra and Java, was inaugurated only in middle Tertiary time. Variations in composition of lavas along Sunda-Banda Arc reflects continental crust in Sumatra segment, transitional crust in Java and mature oceanic island arc developing from Bali to Sumbawa Much of the older geology records subduction in quite different tectonic systems. Sumatra may have rifted from what is now medial New Guinea in M Jurassic time. Java constructed entirely by post-Jurassic subduction-related processes of magmatism and tectonic accretion. Etc.)

(Thorough review of plate tectonic elements and processes in zones of convergence, with examples from Indonesian region. Overriding plates generally rel. undeformed. Subduction systems along continental margins typically inaugurated by reversal of subduction after island arc or continental mass collision. High-pressure metamorphism only where crustal material subducted beneath overriding plate. Sunda Arc system changes along strike from continental in Sumatra to transitional in Java to mature oceanic island arc in Bali and Lombok. Sumatra Block separated from New Guinea in mid-Jurassic. Etc.)

(Same paper as above)

(Subducting oceanic plates not fixed. Hinges roll back into oceanic plates and slabs sink more steeply than inclinations of Benioff zones. Common regime in overriding plates is extensional; leading edges crumpled only in collisions. Shear coupling between subducting slabs and overriding plates limited to shallow depths. Subduction cannot occur simultaneously beneath opposite sides of rigid plate. Inception ages, collisions,
polarity reversals and stage of petrological evolution vary greatly along continuous arc systems. Back-arc basins form by spreading behind migrating arcs. Etc.)

(Splitting in S-waves from local earthquakes across Sumatra- Java subduction zone between 75- 300km depth show trench parallel fast directions. Deeper local events shows larger time-lags and significant variation in fast direction. Significant differences between slab subducted beneath Sumatra and older slab beneath Java)

('Study of Quaternary reef terraces between Sunda Strait and Timor island: vertical crustal movements and sea level variations')

(Many Indonesian islands have emerged Holocene coral reef platforms in sheltered beach setting, reflecting mid-Holocene sea level highstand, ~3m above present-day sea level. Vertical movements identified by coral reefs 'outside stepping' (uplift; Banda Arc from Alor to E) or 'inside stepping' (subsidence, e.g. S Sunda Strait))

(Comprehensive overview of names, definitions, ages and type localities of 1856 formations used on Geological Survey maps in Indonesia. Many formation names used through Indonesia by other authors, oil industry, etc., not included)

(SE Asia has large Tertiary basins and major strike-slip faults on and around Indochina Peninsula. Basins in different orientations and intersected by strike-slip faults. Creation mechanism is collision of Indian plate with Eurasian continent and rotating stress regime created by collision. Rotating stress mechanism began in Eocene when Indian plate first contacted Eurasian continent forming Ranong fault in Thailand. As stress field increased and propagated N-ward from collision zone stress field in Indochina rotated. No figures)

(Comparison of free-air gravity with sediment thickness of SE Asia sedimentary basins shows no correlation due to differences in crustal structure under basins in extensional vs. convergent regimes. Thickened crust in convergent regimes creates negative anomalies)

(Review of structure and tectonic development of Eastern Indonesia. Complex area for which at least seven different tectonic frameworks have been proposed)
(online at: http://geology.byu.edu/home/sites/default/files/2003-geodynamic-patterns-opt.pdf)
(Ophiolites in E Indonesia- New Guinea region suggest strong correlation with marginal basin development and closure. Most ophiolite slabs represent fragments of oceanic lithosphere with subduction zone component as indicated by petrochemistry and occurrence of boninite)


(Many litostratigraphic names used in Indonesia may be considered as informal because they do not meet requirements of stratigraphic rules or were never formally proposed. Recommends Geological Survey must take immediate steps towards standardization of stratigraphic nomenclature in Indonesia !)

(Overview of SEATAR Banda Sea crustal Transect. Banda Sea underlain by oceanic crust, believed to be Cretaceous age. Oldest Banda Sea volcanics 12 Ma)

(Indonesian Archipelago 13 terranes (accretionary terranes excluded). Proto-Kalimantan and Sumatra basement include island arcs and amalgamated in Late Triassic along Bentong-Raub suture to form Sunda Platform. In Paleogene SW Sulawesi rifted from E Kalimantan to collide with oceanic crust to E. In Tertiary W Sulawesi magmatic arc came into existence. Sulawesi Ophiolite from oceanic crust pushed W by Banggai-Sula terrane and blocked by Tertiary W Sulawesi arc. Sumba, Buton, Seram and Timor terranes result of rift-drift from NW Australia in Jurassic. Banggai-Sula, Bacan and Buru terranes formed by Sorong Fault slicing off NW Irian Jaya and moving W. NW Australia /Irian Jaya passive margin, moving N behind front of oceanic crust. It collided with N Irian Jaya island Arc in Oligocene, after which polarity of subduction changed to S)

(online at: http://www.gsm.org.my/products/702001-101431-PDF.pdf)
(Same paper as Hartono & Tjokrosapoetro (1984) above)

(On relationship between K-content of andesite volcanoes and depth of seismic (Benioff) zone below volcano. One of first ‘new plate tectonics’ concepts applied to Indonesia)


Hayes, D.E. (1984)- Marginal seas of Southeast Asia- their geophysical characteristics and structure. In: Origin and history of marginal and inland seas. Proc. 27th Int. Geological Congress, Moscow 1984, VNU Science Press, 23, p. 123-154. (Identification and dating of magnetic lineaments in oceanic crust below marginal basins if SE Asia relatively difficult and associated with uncertainties, because small basin sizes and limited age range of ocean floor makes it difficult to identify a unique sequential pattern. Also, basins formed in low geomagnetic latitudes, where magnetic lineations tend to have low amplitudes and more difficult to map)


Heliani, L.S., Y. Fukuda & S. Takemoto (2004)- Simulation of the Indonesian land gravity data using a digital terrain model data. Earth Planets and Space 56, 1, TERRAPUB, Tokyo, p. 15-24. (online at: https://www.terrapub.co.jp/journals/EPSPDF/2004/5601/56010015.pdf) (Indonesian gravity field neither accurately nor comprehensively determined, especially land data. This study proposes solution to data unavailability by means of simulation technique)


Ridges that separate N and S Banda basins derived from single continental block. Weber Basin deepest basin in region (7400m); migrated to NE in Late Pliocene- Pleistocene. With plate reconstructions of last 15 Myrs

(E Indonesia M Miocene- Recent plate reconstruction model, involving Late Miocene- Pliocene opening of Banda Sea)


(in Japanese) online at: www.journalarchive.jst.go.jp/...)


(Comparison of arc-continent collisions in four areas: Timor (initial stage), Taiwan, Papua New Guinea and Corsica (most advanced stages))

(On diagenesis of clay minerals in clastic reservoirs in West Indonesian basins)


(In W Indonesia basins top of overpressure is mostly located near top of sag phase deposits. Top of 'hard' overpressure in several areas at onset of smectite-illite transformation. Almost all carbonate build-ups located below sag deposits low overpressure to normal hydrostatic pressure regime)


(online at: www.gsm.org.my/products/702001-101353-PDF.pdf)

(Early paper on tectonic evolution of Sundaland in terms of plate tectonic model. Interesting paleo-tectonic maps of Sundaland since Permian. Infers W Borneo has been part of 'continental' Sundaland since Permian, with opposing subduction systems under Sundaland for Permian-Cretaceous)


(Twenty belts of ultramafic assemblages identified in SE Asia (not including E Indonesia), but fewer than half can be classified as ophiolite. Complete ophiolite sequences only in NE Borneo and Philippine Islands; others incomplete or dismembered)


(online at: https://www.jstage.jst.go.jp/article/jpe1952/26/Supplement/26_Supplement_S221/_pdf)

(Three major tin granitoid belts in SE Asia: (1) West (Phuket to Tenasserim). Tin associated with Cretaceous adamellite, granite and pegmatite; (2) Main Range (Bangka to S Thailand). Tin associated with Late Carboniferous and Late Triassic granite; (3) East (Billiton to Pahang-Trengganu). Tin-tungsten associated with Permian-M Triassic adamellite-granite)


(Substantial overview of Precambrian-Recent rocks distribution from Burma to W Indonesia)


(NE Asia complex array of granitoid belts, mainly of Mesozoic age. Eastern belt (E Malay Peninsula, Bangka and Billiton?) is Andean-type Permian-Late Triassic calc-alkaline volcano-plutonic arc (peak ages ~222 Ma and 250 Ma). Probably underlain by continental basement (isoclinally folded Carbo-Permian metasediments, Permian limestones, Namurian shales and sandstones). Abundant volcanic and plutonic activity through Permian and ending active history in Late Triassic with subaerial ignimbritic flows. Narrow central belt of Permian-Triassic granitoids and metamorphic complexes with local Cretaceous granites. Main Range E margin is serpentine-marked Bentong-Raub suture zone. Main Range batholith Sn-granite mainly Late Triassic (~230 and 200 Ma), but with E Permian (~280 Ma) granites; grades W-ward through Penang, Langkawi, and peninsular Thailand to higher level plutons. N Thailand granites mainly Triassic. Main Range and N Thai granites no volcanic associations, and tied to collision and closure of central marginal basin in Late Triassic. Triassic granites and some Cretaceous granites associated with tin, tungsten and antimony deposits, thought to be recycled from continental infrastructure of Sundaland)


(72 Tertiary basins in greater SE Asia developed by extensional tectonics, combined with wrench control. With exception of marginal seas sedimentation kept pace with subsidence. Basin unconformities, transgressions, regressions good correspondence to global sea level changes, but may be artifact of overdependence on SE Asian basins for compilation of eustatic curves)


Hutchison, C.S. (1989)- The Palaeo-Tethyan realm and Indosinian orogenic system of Southeast Asia. In: A.M.C. Sengor (ed.) Tectonic evolution of the Tethyan Regions, Kluwer, Dordrecht, p. 585-644. (Extensive review with Paleozoic- Mesozoic reconstructions of SE Asia. SE Asia is composite of Precambrian continental blocks, overlain in part by Paleozoic carbonate-dominated platforms. Major suture in Song Ma, N Vietnam, welded Indosinia and S China blocks in E Carboniferous to form E Asian Continent together with N China Block. E Asian Continent in equatorial latitudes in Permian and developed Cathaysian Gigantopteris flora. W Borneo Basement is detached part of E Asian continent. Paleo-Tethys suture/ Indosinian orogenic system extends S from Dien Bien Phu through Thailand into Peninsular Malaysia (Raub-Bentong). All terrains E of suture have Cathaysian affinities, those to W are of Permian Gondwana affinity. Suture closed in Late Triassic. Most Jurassic-Cretaceous age formations are of continental molasse facies. S Sumatra contains Cathaysian flora at Djambi, but N Sumatra strong affinities with Gondwana part of Malay Peninsula. An Indosinian suture may separate the two, but not well defined)


(Early Paleogene Sundaland landmass extended as far SE as W Sulawesi. Cratonic nature of Malay Peninsula and China did not extend into or beyond Borneo region of Sundaland, where pre-Eocene outcrops are dominated by Cretaceous rocks. Deep water sediments, melange and ophiolite terrains characteristic of non-cratonic SE peninsula of Sundaland. India collided with Eurasia by 45 Ma (anomaly 1), spreading ceased at NW Wharton Basin, etc. Push of India resulted in clockwise rotation of Sundaland. Regional event causing major Eocene unconformity on and around Sundaland)

(Triassic ‘Indosinian Orogeny’ suturing of Gondwanan and Cathaysian blocks closed Paleotethys Ocean. W Malaysia Sinoburalaya block has Carboniferous-Permian mudstones with glacial dropstones and is traced into Sumatra. Cathaysian E Malaya block Late Permian Gigantopectris flora and fusulinid limestones with andesitic volcanism, similar to W Sumatra block (also E Permian volcanism, fusulinid limestones and early Cathaysian Jambi flora). S-SSE trending central Peninsular Malaysian Triassic orogenic belt swings SE from Singapore to Bangka, then E to Billiton. Paleo-Tethys suture (Bentong-Raub Line) unlikely to continue S along Paleogene Bengkalis Graben, which transects NW-SE orogenic fabric of Sumatra. Oroclinal bending of Indosinian Orogen, from NW-SE in Sumatra to Peninsular Malaysia, attributed to Paleocene collision of India and indentation into Eurasia. Bending accomplished by clockwise rotation and right-lateral shear parallel to orogenic grain. Mesozoic Paleotethyan sutures transformed into Paleoocene and younger shear zones)


(Major review of SE Asia oil-gas, coal and mineral deposits)


(N-wards movement of Indian-Australian plate caused (1) cratonic India to begin its collision with continental Eurasia in Eocene, causing CW bending of pre-Tertiary fabric of Sundaland, predominantly by right-lateral wrench faulting, and (2) cratonic Australia to begin collision with Indonesian island arcs in Miocene, causing CCW bending, accomplished by left-lateral faulting (e.g. Sorong Fault). Fracture systems displaced microcontinents SE-ward from Sundaland and W-ward from Australia- New Guinea. N-S Indosinian fabric of Peninsular Malaysia bends East through Bangka and Billiton. Triassic correlation of NW Borneo possibly with E Vietnam. Most but not all Cenozoic structures follow pre-Tertiary fabric. Etc.)


(Second edition of 1989 textbook of SE Asia geology; with relatively minor revisions)


(online at: https://gsmpubl.files.wordpress.com/2015/04/hgsm2014001.pdf)

(Brief review of SE Asia tectonic history, mainly of Sundaland area (Malay Peninsula- Thailand- Sumatra). Key events Late Triassic collision Sibumasu and E Malaya/Indochina after Permian E-ward subduction beneath E Malaya and development of E-M Triassic Semanggol-Mutus basin foredeep. M-Late Triassic tin granites of Peninsular Malaysia continue in curve through Bangka and Billiton. Late Cretaceous- Paleocene belts of migmatites and plutons. Oroclinal bending of N Sundaland from E-W fabric in Billiton- Borneo to N-S in N Peninsular Malaysia, resulted from indentation of India. Much of Borneo rotated ~50° CCW between 30-10 Ma and ~40° between 80-30 Ma, caused by collision between Australian plate and Indonesian arc at Timor)


(Review of geology and geophysics along regional transect including Sulu Sea, Celebes Sea, Molucca Sea, Philippine Sea)
*(Good review of present-day earthquake distribution and tectonic belts of Indonesian region)*


*(>10 km of Eocene- Recent sediment in Gorontalo Basin which is underlain by pre-rift section of sedimentary origin. Pre-break-up section evidence of older collision that may be related to collision of Mangkalihat-NW Sulawesi microplate with NE Sulawesi. Integration of this observation with onshore geology of SE Sulawesi indicates likely Late Cretaceous collision. Eocene- Miocene in Gorontalo Basin mainly extensional tectonics with late compression estimated approximately at 5.5 Ma)*

*(GIS-based digital tectonic elements map and sediment thickness map of SE Asia. Map available from SEAPEX)*

*(Timor-Aru Trough is not deeper than 3.6 km and is extension of Java Trench. Underlain by continental crust. Data strongly support trough is surface trace of subduction zone)*

*(Compilation of paleomagnetic data Japan, Philippines, Indonesia. E Mesozoic Sumatra was 10-20°S of present latitude; in Late Mesozoic drifted N with 30° CW rotation, reaching present position by E Tertiary)*

*(Unpublished)*  
*(Study of metamorphic rocks Timor-Tanimbar (Banda Outer Arc) region)*


*(Ultramafic rocks exposed in E Indonesia in E Kalimantan, Sulawesi, Halmahera, Banda Arc and Papua. Mostly derived from peridotite layer of ophiolite rocks; but some believed to be from orogenic peridotite. Source of nickel laterite, nickel sulfide deposits, also cobalt, chromite, platinum group metals and lateritic iron ores. E Sulawesi Ophiolite (Cretaceous-Oligocene age) occupies large part of E Sulawesi, resulted from Late Oligocene accretion to Sundaland margin and Late Miocene collision with Banggai Sula microcontinent)*

Kadarusman, A., Y. Kaneko, T. Ohta & S. Maruyama (2003)- The geology and tectonic of the Banda Arc, Eastern Indonesia. Proc. 32nd Ann. Conv. Indon. Assoc. Geol. (IAGI) and 28th HAGI Ann. Conv., Jakarta, 17p. (Non-magmatic S Banda arc from Timor to Tanimbar exposes one of youngest high P/T metamorphic belts in world. Deformation and metamorphic grade increase towards center of 1 km thick crystalline belt. High P/T metamorphic rocks extruded as thin sheet into space between overlying ophiolites and underlying continental shelf sediments (‘wedge extrusion model’). Quaternary uplift, marked by elevation of recent reefs, ~1260 m in Timor, decreasing toward Tanimbar in E. Exhumation of high P/T metamorphic belt started in W Timor in Late Miocene time and migrated east. Quaternary rapid uplift to rebound of subducting Australian continental crust beneath Timor after break-off the oceanic slab fringing continental crust)

Katili, J.A. (1970)- Large transcurrent faults in Southeast Asia with special reference of Indonesia. Geol. Rundschau 59, p. 581-600. (Large transcurrent faults present in Taiwan-Philippine region and in the area between Sulawesi and E New Guinea, with mainly sinistral movement. Sumatran fault-system 1650km long, dextral lateral displacement. On Java smaller transcurrent faults with strike more or less parallel to island. Palu-Kuro Fault (‘Fossa Sarasina’) in C Sulawesi also sinistral transcurrent fault. Dextral transcurrent fault of ~100 km length in Gorontalo area, N Sulawesi. In W Papua E-W trending Sorong Fault. Two groups of transcurrent faults in SE Asia: NW-SE and E-W. Indonesian Archipelago is being protruded SE-ward, with major block movements along Philippine and Sumatran fault-zones)

Katili, J.A. (1971)- A review of the geotectonic theories and tectonic maps of Indonesia. Earth-Science Reviews 7, p. 142-165. (Good review of tectonic syntheses proposed for Indonesia from 1920’s to 1970. Long ago Indonesian Archipelago recognized as place of intersection of two of large mountain systems and zone between Asian and Australian continents. They also realized that Indonesian island arcs represent early stage formation of mountain belt with systematic relationship of active tectonic and magmatic features to deep submarine trenches. New concept of plate tectonics best basis to explain features of Indonesian island arcs)


Shelf Anambas (~86 Ma), Tembelan (~85 Ma) and Natuna (~75Ma). Permian granites near Jambi, S Sumatra ~276-298 Ma. With map of volcanic arcs of Paleozoic- Tertiary ages)

(Tertiary mineralization more significant in Sulawesi, Halmahera, Irian Jaya than Sumatra, Java, Lesser Sunda islands, possibly because Pacific Plate richer in metals than Indian Ocean)


Katili, J.A. (1975)- Volcanism and plate tectonics in the Indonesian island arcs. Tectonophysics 26, p. 165-188. (Reconstruction of outward migration of Indonesian volcanic arcs from Permian-Cretaceous- Oligo-Miocene to Recent)


(No significant hydrocarbons in accretionary wedge of W Indonesia. Sumatra fore-arc basin lacks coarse quartz-rich reservoirs; hydrocarbon source rocks are immature. Arc-trench system of E Indonesia different. Two phases in Banda Arc: (1) Indian-Australian plate oceanic crust subducted under Banda oceanic plate, (2) subduction of Australian continental crust into Banda Arc subduction zone. Oceanic crust dipping in Sumatra-Java Trench covered by thin pelagic sediments, but parts of shelf-slope sequences of Arafura Platform carried into Tanimbar Trench and Aru Through. Consolidated lower part of sequence greater shear strength and little material from there scraped off and incorporated in wedge. If rich in organic material, tectonic processes in trench and beneath wedge will mature organic material. If reservoir rocks exist in front of wedge, migration and accumulation possible. Oil and gas in subduction complex of E Sulawesi may be explained in same way)

(Same paper as above)

(Tectonic development of Indonesian archipelago as SE margin of Eurasian plate can be followed since Late Paleozoic from continental nucleus located between Sumatera and Kalimantan Archipelago developed E-ward until it attained present position as represented by Banda volcanic arc. During Late Paleozoic and throughout Mesozoic development of Sunda Arc system regular and always had arcuate shape of volcanic arc around continental margin. Tertiary more complicated)

('Geology'. First general geology textbook in Indonesian language, with numerous illustrations from Indonesia)


(online at: http://frisetgeotam.com/index.php/NIGM/article/viewFile/164/159)
(Four types of Quaternary tectonic deformation. Marine terraces around Bangka and Billiton on stable Sunda Shelf formed by Quaternary sea level highstands. Post-glacial strandlines at 0.5-1m (3500 BP), 1.5-2m (5000 BP), and 5m (6000 BP) above present sea level)


(online at: http://adsabs.harvard.edu/abs/2013AGUFM.T41B2574K)
(Summary of main structural elements of E Indonesia, from Sulawesi in W to W Papua in E, across N part of Banda Arc. N boundary of 'Birds Head' of W Papua is sinistral Sorong strike-slip fault zone with >48km displacement over last few Myrs. W boundary fault of Cendrawasih Basin defines E boundary of Birds Head and corresponds to Wandamen Peninsula with high-P metamorphic rocks with exhumation ages from 4-1 Ma. Birds Head and Pacific Plate coupled, so Birds Head completely detached from Irian Jaya. Etc.)
(see also later version by Rutherford & Qureshi 1981)


('Earthquake activity in Indonesia- regional perspective')

(see also 2nd Edition, 1998)

(online at: www.iagi.or.id/fosi/berita-sedimentologi-no-35-palaeogene-of-the-eastern-margin-of-sundaland-part-1.html)


(Pre-plate tectonic synthesis of Indonesia. Stratigraphic and structural features of Indonesia suggests major differences between E and W parts. In E Indonesia extensive Paleozoic ('Variscan orogeny') land mass development, modified by later regeneration and epeirogenic movements. No trace of Paleozoic/ Variscan orogeny in W part, but widespread effects of Pacific orogeny (Mesozoic))

(online at: http://archive.org/details/geologyandgeophy032600mbp)  
(Same as Klompe (1957) paper above)

(On Permian- Triassic volcanics of C Sumatra, Triassic Pahang volcanics in Malay Peninsula and W-C Borneo. Two zones of Late Paleozoic- E Mesozoic volcanic activity: (1) northern, more acid zone in Malaya and C Borneo, and (2) southern, more basic zone in Sumatra. Djambi volcanites do not originate from Malaya, but form part of autochthonous series. This, and lack of indications for thrust movements in west C Sumatra, make occurrence of postulated sheet structures in Djambi and other parts of west C Sumatra rather doubtful. 'Perfect correlation between Permian volcanic series of Jambi and Silungkang Fm', Padang Highlands, W Sumatra, but different from Pahang Volcanics of Malay Peninsula)

(Same paper as Klompe et al. (1957), above)


Koning, L.P.G. (1952)- Earthquakes in relation to their geographical distribution, depth and magnitude. I. The East Indian Archipelago. Proc. Kon. Nederl. Akademie Wetenschappen, Amsterdam, B55, 1, p. 60-77. *(First of series of papers on global distribution of earthquakes. Deep-focus earthquakes in Indonesia not arranged in single inclined surface, sloping to depth of 600 km and dipping towards continents, as previously suggested, but two separate seismic zones: (1) from W coast of Sumatra to Java, Lesser Sunda Islands to New Guinea and (2) J-shaped belt in NE part)*

Koomans, C. M. (1938)- On tektites and pseudotektites from Dutch East Indies and Philippines. Leidsche Geol. Mededelingen 10, p. 63-80. *(online at: www.repository.naturalis.nl/document/549606)* *(Some reported tektites in Indonesian region are true extra-terrestrial tektites (billionites, Java, Thailand, Luzon), others are 'pseudo-tektites' (pebbles of volcanic glass/ obsidian; Palembang, Garut, Gunung Kiamis))*


GPS measurements of surface deformation show convergence between Australian Plate and Sunda Block in E Indonesia partitioned between megathrust and continuous zone of back-arc thrusting extending 2000 km from E Java to N of Timor. Partitioning occurs via CCW rotation of arc segment called Sumba Block, and left-lateral movement along major NE-SW strike-slip fault W of Timor. Also W-ward extension of back-arc thrust for 300 km onshore into E Java, accommodating slip of ~6 mm/yr)


(Review of variations in character along Sunda subduction zone from N Sumatra to East of Java. Off Sumatra wider seismogenic zone with larger earthquakes. Variations controlled by increasing age of crust of subducting plate from W to E, decrease in thickness of sediment cover from W to E, topography of downgoing plate, etc.)


(GPS and seismicity data show Java Trench delineates Australian plate (AU)- Sunda block boundary W of Sumba, but E of Sumba, convergence distributed over back-arc and Banda Sea and no subduction at Timor Trough. In New Guinea most motion is strike-slip in N part of island, delineating Pacific- Australian plate boundary. Some trench-normal convergence at New Guinea Trench, evidence that strain is partitioned to accommodate oblique Pacific- Australia motion. Sulawesi Trench may take up some of AU-Sunda motion)


(Early criticism on Van Bemmelen's newly proposed, controversial tectonic 'undation theory')


(Two types of deep water basins in Indonesia, each with two sub-groups)


(Sandbox compressional deformation modeling of crustal buckling)


Granitoid/ E Triassic- E Cretaceous (247-143 Ma), (3) Eastern Granitoid/ U Permian- U Jurassic (264-216 Ma). In Kalimantan 4 groups: (1) Natuna-Semitau-Sanggau/ Triassic-Jurassic, (2) Meratus/ Carboniferous-Cretaceous, (3) Schwaner/ Cretaceous- E Tertiary, (4) C Kalimantan Tertiary Arc/ Late Eocene- E Miocene. Also Java, Lesser Sunda Islands, Sulawesi- Banggai Sula (3 groups) and W Papua (2 groups: (1) Birds Head/ Permian-Triassic and (2) Papuan foldbelt U Pliocene). No maps

(online at: www.ccop.or.th/download/pub/CCOP-geoheritage-book.pdf)
(Proposed geological monuments in Indonesia)

('The tektites of Indochina'. Old but extensive review of distribution of Pleistocene glass tektite field from Indochina to W Indonesia and Australia. Variously called billitonite, australite, etc. See also Verbeek 1897, Von Koenigswald 1960, Chapman 1964, Stauffer 1978, Ford 1988, etc.)

('The geology of Netherlands Indies, with a short chapter on the geology of the Philippines'. Early overview of Indonesia geology for travelers; nothing new)

(3D S-velocity model of SE Asian- W Pacific upper mantle with 400-km lateral resolution. Hard to interpret?)

(Banda basin underlain by oceanic crust, previously interpreted as trapped oceanic basin which was once continuous with Late Jurassic Argo abyssal plain (Bowin et al., etc.). Newly identified magnetic reversal ages, heatflow data, etc., suggest Celebes and Sulu Seas may have been continuous with Banda basin, and are all part of dissected Cretaceous-Eocene oceanic basin (Banda and Sulu Seas basins age now commonly accepted to be Late Miocene- Pliocene (Hamilton 1979, Hinschberger et al. 2001); JTvG))

(Paleocene (60 Ma)- Recent plate reconstructions of SE Asia)


(Reconstructions of SE Asia region from 60- 5 Ma. Impact between Greater India and SE Asia in NW part of SE Asia, probably from M Eocene- E Miocene, W of Burma block, so no reason to assume Sumatra, Malay Peninsula, and Kalimantan should extrude to SE along left-lateral Mae Ping and Three Pagodas fault zones as suggested by Peltzer and Tapponnier (1988). Opening of C Thailand basins, Gulf of Thailand, and Malay Basin require dextral megashear zone to compensate relative motion between Indochina and Malay Peninsula, which may extend into W Kalimantan and serve as boundary between Indochina block and Kalimantan)

('Gravimetry and tectonics of the Netherlands Indies')
(online at: www.ccop.or.th/download/pub/CCOP-geoheritage-book.pdf)
(Book describing geological monuments and proposed monuments in Indonesia and other Asian countries)

(N Banda-Molucca area at junction of three converging plates, a mosaic of remnant and active island arcs and continental and oceanic fragments. NW-SW late Neogene thrusts and anticlines in NE part of S Halmahera. S of Halmahera several sinistral, transcurent, reverse faults prolong Sorong fault. From deep Salawati basin to N Buru large tectonic zone with mud diapirs. Due to collision, possible remnants of Molucca Sea Plate outcrop in E arm of Sulawesi and Obi Island. Good cross-sections Seram- Halmahera area)

(Cross sections through E Asian basins S China Sea, Philippines, NW Borneo, etc.)

(Three 1:2.5M scale maps, with introductory notes and cross-sections, from Institut Francais du Petrole)

(Three main Cenozoic tectonic periods:(1) Paleogene- E Miocene extension with graben fill (2) quiescent period, (3) M Miocene- Recent folding/ inversion/ thrusting. Many folds on E Sunda Platform are inversions of Paleogene grabens)

(online at: www.repository.naturalis.nl/document/549456)
(Overview of Tertiary formations and correlations across the 'Netherlands Indies' in K. Martin memorial volume. With formation correlation table and Tertiary larger foraminifera range chart)

(Miocene shallowing and closure of Indonesian Seaway between Indian Ocean-Pacific related to plate-tectonic developments at S margins of Banda Sea. Model good agreement with 9.9-7.5 Ma history of shallowing and closure of Indonesian Seaway, as inferred from biogeographic patterns and thermal evolution of Miocene equatorial Pacific waters)

(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)

Longley, I.M. (1997)- The tectonostratigraphic evolution of Southeast Asia. In: A.J. Fraser, S.J. Matthews & R.W. Murphy (eds.) Petroleum Geology of Southeast Asia. Geol. Soc. London, Spec. Publ. 126, p. 311-340. (Tertiary tectono-stratigraphic evolution of SE Asia four phases: (1) 50-43.5 Ma: Start of India-Eurasia collision, reducing in convergence along Sunda Arc subduction system, resulting in extension in adjacent fore-arc and back arc areas; (2) 43.5-32 Ma: termination of oceanic subduction beneath India-Eurasia collision zone caused plate reorganization, producing second phase of rifting, with onset of extension in S China Sea and Makassar Straits failed rift. First major collision of Luconia Shoals block with subduction along NW Borneo margin; (3) 32-21 Ma): first phase of S China Sea seafloor spreading, rotations creating Malay Basin and inversion along Sunda Arc ending rifting in these basins; (4) 21–0 Ma: cessation of first phase of seafloor spreading in S China Sea caused by collision of Baram block with NW Borneo subduction system. Collisions in NW Borneo, Sulawesi and Timor areas, with rotation of Sumatra resulted in extensive structural inversion)

Longley, I.M. (2000)- Extrusion collusion and rotational confusion in SE Asian tectonic models. AAPG Int. Conf. Exhib. Abstracts, American Assoc. Petrol. Geol. (AAPG) Bull. 84, 9, p. 1458. (Abstract only) (In Paleogene SE Asia experienced rift phase with no significant transtension or transpression. Extrusion tectonics also fails to explain origin of backarc basins of Sumatra and Java, Malay Basin, etc. Paleogene evolution mainly driven by M Eocene plate re-organisation caused by India-Eurasia collision, with extrusion tectonics as Neogene modifier to basins formed by Paleogene rifting. Model suggests all Tertiary rotations in SE Asia are clockwise, initially due to opening of S China Sea and later due to effects of extrusion tectonics)


Lowell, J.D. (1980)- Wrench vs. compressional structures with application to Southeast Asia. SEAPEX Proc. 5, p. 63-70. (Criteria to distinguish between wrench and compressional faults. With examples of compressional faults in Kawengan, NE Java, and wrench structures in Pungut/ Tandun fields in C Sumatra)

Lukk, A.A. & V.I. Shevchenko (2008)- Island arcs, deep-sea trenches, and seismofocal zones of Indonesia and the Pacific Ocean; similarity and distinctions. Izvestia Physics Solid Earth, Russian Acad. Sci., 44, 2, p. 85-118. (Non-plate tectonic interpretation, suggesting island arcs, deep-sea trenches and seismofocal zones of Indonesia differ from those of Pacific ring proper)


MacPherson, C.G. & R. Hall (1999)- Tectonic controls of geochemical evolution in arc magmatism of SE Asia. Proc. 4th PACRIM Congress 1999, Australasian Inst. of Mining and Metallurgy (AusIMM), Melbourne, p. 359-368. (Retreats or advances in subducting plates trench hinge important control on presence or absence of magmatism. Several locations in SE Asia show magmatism with geochemical signature of subduction, but are far from active subduction zones. Such magmatism requires earlier period of mantle enrichment by subduction but may also result from localized extension. Adakitic magmatism occurred in tectonic settings where there is no evidence for subduction of young oceanic crust at that time)
(Review of SE Asia tectonics and associated mineral deposits. Timing and location of hydrothermal mineralization often related to major events at plate boundaries)


(online at: www.gl.rhul.ac.uk/seasia/ages/SEAsia_GIS.pdf)

(Alphabetical overview of Indonesian formation names and characteristics)

(Reprint of Marks (1956); see also 1961 Atlas. Useful overview of Indonesian formation names and characteristics. See also updated and expanded version by Harahap et al., 2003)

(Addendum to Marks (1957) lexicon. Compilation of location maps of type areas of stratigraphic formations, some with cross-sections)

(Brief overview of geological knowledge and ages of rocks of Indonesian islands, as known in 1883)

(‘Travels in the Moluccas, in Ambon, the Uliassers, Seram and Buru’. Report of 1891-1892 geological investigations on E Indonesia islands)

(‘A contribution to the geological history of the Indies Archipelago’. Lecture text; no illustrations)

(‘A second contribution to the development of the East Indies archipelago’)

(‘Mesozoic land and sea in the Indies Archipelago’. Early discussion of Mesozoic paleogeography of Indonesia. No maps or figures)

(online at: www.repository.naturalis.nl/document/552392)
‘When did the Indies Archipelago separate from the Tethys?’ Mesozoic faunas of Indonesia have significant numbers of European species but Eocene and younger mollusc faunas have no European species, suggesting there was no longer a ‘Tethys’ marine connections between the two


(online at: www.repository.naturalis.nl/document/549337)

‘When did the area of the Indies Archipelago separate from the Tethys? (a continuation)’. Follow up on Martin (1914) paper). Late Eocene and Neogene mollusc assemblages of Java (and Philippines, Burma, NW India) of Indo-Pacific/ Indo-Malayan character with few or no European species, suggesting no marine connections between the two


(Upper Triassic carbonates around Banda Sea (Sinta Ridge, C-E Sulawesi, Buru, Seram, Misool and off NW Australia (Wombat Plateau, W Timor). In Upper Triassic, Seram-Buru and E Sulawesi/ Kolonodale Block two separate entities, former located in more tropical position. Seram-Buru Block originated from Irian Jaya area, Kolonodale Block (E Sulawesi) from Australian NW Shelf/ Argo Abyssal Plain. No clear similarities between Triassic of Timor and Papua-New Guinea, NW coast of Australia, Wombat Plateau. Allochthonous Triassic of Timor sedimentary evolution different from that of Australian margin and microcontinents of Banda Sea)


(online at: www.iagi.or.id/wp-content/uploads/2012/04/Sandi-Stratigrafi-Indonesia-1996.pdf)

('Stratigraphic code of Indonesia'. Indonesian version of International Stratigraphic Guide)


(Compilation of heat flow data in SE Asia from published data as of 1988 and unpublished data obtained from combining published temperature gradient data of hydrocarbon exploratory wells with average thermal conductivity for individual basins estimated from published data)


(Active tectonics of Sumatra, Philippines, New Guinea fold-and thrust belt, Huon-Finisterre collision and San Cristobal trench can be understood in terms of upper plate deformation associated with oblique convergence. W Java may also exhibit partitioning of oblique subduction. Structures accommodating normal and shear components of motion often very close. Arc-parallel strain rates estimated for forearcs of region. In Sumatra oblique convergence results in NW translation and stretching of forearc area)


(U-Pb-He triple-dating age determinations for porphyry Cu±Mo±Au deposits, including. Modelling results for Indonesian porphyry deposits: (1) Grasberg (W Papua), emplaced at 800m at 3.1 Ma, exposed at surface 1.7 Ma; (2) Batu Hijau (SW Sumbawa), emplaced at 2400m at ~3.8 Ma, exposed at surface 1.23 Ma; (3) Ciemas (SW Java), emplaced at 5500m at ~17.8 Ma, exposure at surface 5.34 Ma)
(Radiometrically dated emergent coral terraces from SE Indonesia provide estimates of vertical strain in Banda Arc-continent collision complex. Roti island uplift 170m in last ~125,000 years. Late Quaternary surface uplift rates vary significantly along strike of Banda orogen. Vertical displacement rates greatest in young parts of orogen where shelf-slope break recently has been underthrust beneath orogenic wedge, as at Roti, and in older parts of orogen where retroarc thrust faulting occurs, as at Alor island)

(online at: https://link.springer.com/content/pdf/10.1186%2FBF03352270.pdf)
(GPS measurements across SE Asia show differential plate motions. Sundaland-South China is stable tectonic block, decoupled from Eurasia, moving S relative to India and Australia)

(online at: www.geologie.ens.fr/~vigny/articles/sunda_epsl.pdf)
(Sundaland stable tectonic block, moving E rel. to Eurasia at ~12 mm/yr; moves S rel. to India and Australia)

(About ongoing Banda Arc passive seismic experiment. Recorded >600 local earthquakes by June 2016 (see also Porritt et al. 2016))

(Arc-continent collisions taking place today in NE New Guinea and E Indonesia and Taiwan, all started between 7- 3 Ma. Evidence of older collisions in E Indonesia and New Guinea)

(online at: https://pdfs.semanticscholar.org/4f6d/18a4c0e67d6a95281d4f797bcd6ef2d7b42de.pdf)
(Tectonostratigraphies of Outer Banda Arc island suggest these were once part of Sundaland margin and that N and S Banda Sea basins are Late Cenozoic extensional features (first author to propose the slab rollback model for Banda Seas, subsequently supported with tomographic data by Spakman and Hall 2010; JTvG). Three separate tectonostratigraphic groups (1) Sundaland margin (SW Sulawesi, Sumba) (2) Birds Head/ Sula Spur; with Late Paleozoic granites similar to central PNG; and (3) Banda Association (Buton, Buru, Seram, W Kai, Banda ridges, E Sulawesi; rifted from Gondwanaland in Jurassic)

(Seismicity associated with arc-continent collision in E Indonesia testifies to past N-directed subduction of Indian Ocean lithosphere beneath Banda Sea. Shallow-intermediate seismicity around Banda Arc supports subduction of two separate slabs, but between 150-500 km continuous 'shoehorn' shape. This shape confirms presence of subducted lithosphere beneath Seram in N, as well as beneath Timor in S. This is incompatible with subduction of two unconnected plates, and implies rapid E-wards retreat of subduction trace (first author to suggest 'roll-back' of subducting Indian Ocean slab as mechanism for creation of Banda Sea; JTvG))

(Review of ophiolites in New Guinea and farther East)

(Interesting comparisons between Caribbean oroclinal system and Banda Sea region of E Indonesia)

(Late Miocene-Mid-Pliocene compression resulted in emplacement from N of large thrust sheets on deformed Australian margin near Timor. During last 3 Ma compression unimportant but vertical movements common and rapid. In N Timor and Banda volcanic arc, uplift is occurring where gravity data suggest there should be subsidence. Possible explanation of high gravity values is cold, dense, subducted slab which is now sinking independently after rupture near continental margin. Because of rupture, sinking slab no longer exerts downward pull on overlying lithosphere which now rebounds isostatically)

(Geology of Sunda and Banda arcs not all in accord with classic plate tectonic models; many unanswered questions)

(Terminations of Sunda, Philippine and New Guinea trenches in E Indonesia associated with presence of blocks of thickened crust. Transition between Sunda Trench and Timor-Tanimbar Trough consequence of collision with NW Australian continent. S termination of Philippine Trench defined by presence of oceanic plateau. New Guinea Trench terminates in W at N-trending Mapia Ridge seafloor rise. No clear indications of present day subduction along N margin of New Guinea and subduction may have ceased in W-most part of New Guinea Trench and oceanic crust of Ayu Basin W of Mapia Ridge and N of Birds Head postdates active subduction)

(High-density ophiolitic rocks outcropping on islands around Banda Sea in many cases associated with strong gravity anomalies and steep gravity gradients. Bouger gravity levels and gradients over extensive E Sulawesi Ophiolite generally low. Most positive anomalies in Banda Arc due to ophiolites superimposed on steep regional gravity gradient but in W Seram spatial separation between two. On Buru gradient >10 mGal/km suggests presence of shallow, very dense rocks, despite absence of ophiolites in outcrop. Ophiolite distribution on Sulawesi and around Banda Sea compatible with ?Oligocene collision that produced Sulawesi orogen, which collapsed following collision with Australian-derived microcontinent)

(Many of the islands surrounding Banda Sea are fragments of 'East Sulawesi Microcontinent' (ESM), which rifted off Australia-New Guinea margin in Late Triassic or E Jurassic, to collide with Eurasia margin in E...
**Miocene.** Parts of this continent are now in E Sulawesi, Buru, Buru and Seram and share Late Triassic bituminous marine shale deposits. Parts of Timor similar as well. Late Triassic of Sula Spur and New Guinea in continental facies and with granite intrusions, so clearly still part of Gondwana. In `bacon-slicer model' Sula Spur therefore must have rifted off New Guinea at later date


(Ages of subduction zones bordering five collisional orogens suggest subduction may have initiated by foreland thrusts and backthrusts. Examples used include Late Jurassic at N Sunda Arc (Sumatra- Malaya), end-Miocene in Negros trench (Philippines) and incipient S-ward subduction of e Banda Sea beneath Timor)


(Island chain from Timor and Babar to Ceram and Buru much alike in geological structure: nucleus of thrust-faulted Permian- Eocene, covered by Neogene-Pleistocene that is not folded but generally uplifted high above sea level. Two main thrust sheets on Timor: lower 'Tethys sheet' (Triassic-Cretaceous oceanic deposits) and upper 'Fatu sheet' (Permian- Eocene in different facies; shallow marine limestones, schists, serpentinites, often found as isolated blocks). With simplified geologic map and cross-section of Central Timor)


(Geology chapter in The seas of the Netherlands East Indies' book. Early overview of morphology and bottom sediments of Indonesian Seas, distribution of coral reefs, etc. Earliest recognition of incised Pleistocene river channels on Sunda Platform)


(On timing of rifting and uplift events of Sundaland, constrained by palynology and sequence stratigraphy. Makassar/ Java Sea rifts initially formed at start of M Eocene (~49 Ma), with non-marine deposition and low paleo-elevations, followed by marine deposition in second rift phase in Late Eocene. Extensive uplift in Borneo began in latest E Miocene, and further uplift at ~8 Ma. N and W rifts of Sunda region initiated in Late Eocene, with synrift phase ending at ~31 Ma. Some rifts, especially in W Natuna and Malay Basin, characterised by Oligocene deep lake systems, which persisted for >6 Myrs)


(Discussion of main phases of plant dispersal into and out of SE Asia in relation to plate tectonics and changing climates. Late Cretaceous poorly understood, but Paleocene topography mountainous, and climate probably seasonally dry. India's drift into perhumid low latitudes in Eocene brought dispersal into SE Asia of megathermal angiosperms which originated in W Gondwana, starting at ~49 Ma, and with terrestrial connection after~41 Ma. Oligocene seasonally dry climates except along E and SE seaboard of Sundaland, but with collision of Australian Plate with Sunda at end-Oligocene widespread perhumid conditions in region. With Late Miocene strengthening of Indian monsoon, seasonally dry conditions expanded. Some dispersals from Australasia after collision with Sunda. Pleistocene refuge theory applies to SE Asian region)

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.


(Paleogeography and sedimentation rates for Sunda region. Paleogeographic maps for 10 E Miocene-Pleistocene time slices. In M Miocene bulk of sedimentation across Sunda region on enlarged Proto-Mahakam Delta (4 times larger than today's Mahakam Delta) with minimal sedimentation off Sarawak. In latest Middle-Late Miocene sedimentation rates increased off Sarawak and sharply reduced in Makassar Straits; interpreted to reflect redirection of sediment transport as result of Borneo uplift and capture of Proto Mahakam River by Sarawak rivers in Late Miocene)


(Generalized paleogeography maps of Sunda shelf for 10 time slices from E Miocene (23 Ma)- Pleistocene. Maximum development of 'Proto-Mahakam' delta at ~15-12 Ma, at time of limited clastic deposition rates along N Borneo margin (major deltas here Late Miocene- Pliocene). (abbreviated version of Morley et al. 2016))

Mubroto, B., Sartono & H. Wahyono (1993)- Sebaran arah kemagnetan purba di Indonesia, scale 1:5,000,000. Geol. Res. Dev. Centre (GRDC), Bandung. ('The distribution of ancient magnetism directions in Indonesia'. 1:5M scale map compilation of paleomagnetic direction data from Indonesia. Includes Birds Head paleolatitudes for Late Carboniferous Aifat Fm (47°S), E Permian Aifat Fm (46°S), Late Permian Ainin Fm (35°S), and Late Triassic-Jurassic Tipuma Fm (42°S))


(online at: http://iopscience.iop.org/article/10.1088/1755-1315/118/1/012003/pdf) (Brief review of possible different melange types of W Sumatra, Java, Timor. Remnants of Cretaceous subduction zone at Ciletuh, Luk Ulo and Meratus formed along S margin of Sundaland subduction and are known as tectonic melanges. Younger melange complexes in Sunda arc (Nias) and Banda arc (Timor) more likely diapiric melange)


Murphy, R.W. (1987)- Southeast Asia: a tectonic triptych. In: M.K. Horn (ed.) Trans. 4th Circum Pacific Energy and Mineral Resources Conf., Singapore 1986, p. 395-400. (SE margin of Eurasia has been compressional margin since Late Paleozoic, onto which dozens of arcs and microcontinents from Gondwanaland accreted. Map showing 10 Triassic-Recent magmatic arc systems. Late Cenomanian- E Turonian accretion of Meratus ophiolite cuts obliquely across older E-W trending arcs. Throughgoing wrench faults W of Sunda Strait right-lateral, those to E are left-lateral. Etc.)

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www.vangorselslist.com
July, 2018
Murphy, R.W. (1992)- Southeast Asia: linkage of tectonics, unconformities and hydrocarbons. In: M. Flower, R. McCabe & T. Hilde (eds.) Southeast Asia structure, tectonics and magmatism, Symposium Texas A&M University, College Station, 5p. *(Extended abstract only)*

*(SE Asia reconstruction, modification of Hall (1996). Sunda and Philippine Sea plates treated as rigid blocks between 50-15 Ma. Borneo CCW rotation, required by paleomagnetic data, probably Late Cretaceous in age)*

*(Similar to paper above. Modified plate reconstruction of SE Asia between 50-15 Ma. In this interpretation Sunda block and Philippine Sea Plate treated as relatively rigid blocks and Indochina extruded ~700km between 35-15 Ma. Right-lateral movement along Sumatra Fault/ Andaman/Sagaing system is paired with left-lateral movement along Red River Fault and its precursor, West Baram Line. No large-scale CCW rotation of Borneo between 20-10 Ma, as suggested by Hall (1996) model)*

*(SE Asia 2539 heat flow measurements, but contribution of heat flux from active volcanoes overlooked in regional heat-flow maps)*


*(Collection of papers dealing with tectonics, deposits, paleoenvironments of Permian- Eocene Tethys Ocean(s), now consumed in Alpine- Himalayan- SE Asian foldbelts)*


*(Overview of Mio-Pliocene carbonate distribution in Indonesia)*

*(Elegant overview of Indonesia Tertiary geology, basins and hydrocarbons)*

*(Review of historic earthquake distribution along Sunda Arc, from Andaman Sea to Lesser Sunda Islands)*


(SE Asia paleogeographic maps at 3, 17, 25 Ma)

(Outer non-volcanic arc in E Indonesia formed as a marginal part of the Australian continent in S hemisphere before Upper Jurassic. Timor and Sumba did not reach present positions until M Miocene or later. Ambonites on Wetar date time of collision between Australian Plate and proto- Banda Arc at 3 Ma, etc.)

(Model of tectonic evolution of E Indonesia, with reconstructions of 4 and 17 Ma)

(Mainly summary of activities of IGCP project 355. Paleomagnetic work on Sumatra suggests Sumatra was part of Gondwanaland in Triassic (off NW Australia), with paleolatitude close to 38°S and 62° CW rotation between Triassic and E Tertiary. Diagrammatic SE Asia reconstructions of 40, 25, 17 and 3 Ma, with implications for circulation of Indo-Pacific region. Neogene Indonesian seaway effectively closed in early M Miocene (17-15 Ma) and completely severed by ~6 Ma, preventing interchange between surface water of tropical Pacific and Indian oceans)


(Discussion of collision of Australian continent with East Sunda- Banda island arcs, back arc Banda Basin, back arc thrusting, etc. Banda Basin probably formed as slices of N New Guinea were transported W with Pacific plate and collided with island arc in E Sulawesi)

(New relocations of 25,000 earthquake hypocenters in Indonesian region, using telesisemic double-difference relocation algorithm. Average epicenter relocation shift 6.2 km)

(Relocation of hypocenters of earthquakes between April 2009 to May 2015)


(GPS measurements from 14 sites in active E Sunda-Banda arc during 2001-2003. Most blocks move in same direction as Australian lower plate, but at different rates. Block boundaries may exist between Lombok and Komodo, Flores and Sumba, Savu and W Timor, and between Timor and Darwin. Timor Trough may account for 20 mm/yr of motion between Timor and Darwin. Major transverse fault off W Timor separates Savu/Flores/Sumba block from Timor/Wetar Block. Flores thrust moves E Sunda arc N relative to Asia, by decreasing amounts to W. Back-arc Wetar Thrust system takes up most of plate convergence between Australia and Asia)


(GPS velocities suggest three Sunda Arc-forearc regions, ~500 km long, with different amounts of coupling to Australian Plate. Movements relative to SE Asia increases from 21% to 41% to 63% E-ward. Regions bounded by deformation front to S, Flores-Wetar backarc thrust system to N and poorly defined structures on sides. Suture zone between NW Australian margin and Sunda-Banda Arcs still evolving with >20 mm/yr of movement measured across Timor Trough between Timor and Australia)


(Tomography data of SE Asia generally uses global seismic data. Japan-Indonesia Seismic NETwork (JISNET) seismic stations in C to W Indonesia used to better understand seismic structure of area. Claim better resolution data, but poorly illustrated: small, low resolution time slices, no cross sections)


(Online at: www.jstage.jst.go.jp/article/jgeography1889/53/6/53_6_249/-_pdf)

(Brief review of Paleozoic outcrops in Indonesia; in Japanese)


(Present regime of oblique subduction in SE Asia initiated in M Eocene. Resulting dextral shear drove basin genesis and development. Effects identified from Malay Basin to C Thailand in East. Late Eocene-Oligocene phase formed rifts in C Sumatra, later spreading N to Mergui Basin and S to Sunda Basin. In Oligocene, dextral shear initiated Thailand basins and Malay Basin. Subsidence- extension continued until late M Miocene. Late Oligocene-E Miocene back arc basins subsidence extended out from initial rifts possibly due to withdrawal of heat beneath basins by cold subducted slab. Transpressional deformation started in Sumatra basins in M Miocene and continued through Late Miocene- Pliocene, resulting in uplift of Barisan Mts. Sumatra forearc transferred to Burma Plate with establishment of dextral Sumatra FZ in Pliocene)


(Cenozoic SE Asia three major tectonic events: collision of India- Eurasia, rotational history of Philippine Sea plate and ongoing collision of Australia with E Indonesia. Models of Eocene India-Eurasia collision imply extrusion along major strike-slip faults or crustal thickening and block rotation)

Small ocean basins, or marginal seas, mainly located on W margin of Pacific Ocean. Tectonically they belong to Eurasian and Indo-Australian crustal plates to W and are bounded on E side by island arc-trench systems. Basins generally reach normal oceanic depths, but also contain seamounts, linear seamount chains and areas of submerged continental crust (rises). No evidence of mid-ocean ridge systems. Marginal basins also characterized by high regional gravity anomalies, high heat flow and linear magnetic anomalies. Geological data suggest formation of marginal seas by rifting of volcanic arc from adjacent continent, possibly by generation of oceanic crust by mantle upwelling immediately behind andesitic island arc, producing asymmetrical seafloor spreading. In Indonesian region: Andaman Sea, Sulu Sea, Celebes Sea, Banda Sea, and South China Sea basins


(Different heavy mineral assemblages from Mesozoic granites of Sumatera, Bangka and Kalimantan. With overview of Mesozoic granites in W Indonesia)

(Mainly on heavy minerals from samples around Mesozoic granitoids of N Sumatra (Sibolga (~264 Ma; M Permian) and Tanjung Balai; both magnetite-hematite-chalcopyrite dominated), Bangka (Triassic; cassiterite-wolframite-ilmenite-dom.) and C Kalimantan (Kuala Kurun; magnetite-chalcopyrite-ilmenite-dom.))


(Overview of Indonesia sedimentary basins. Classified by maturity for petroleum exploration into mature (14), semi-mature (9) and frontier (18) basins)


PERTAMINA/CORE LAB (1998)- The petroleum geology and hydrocarbon potential of the foreland basin areas of Irian Jaya and Papua New Guinea. 4 volumes. (Unpublished multi-client study)


Peucker, E.B. & M.W. Miller (2004)- Quantitative bedrock geology of East and Southeast Asia (Brunei, Cambodia, eastern and southeastern China, East Timor, Indonesia, Japan, Laos, Malaysia, Myanmar, North Korea, Papua New Guinea, Philippines, Far-eastern Russia, Singapore, South Korea, Taiwan, Thailand, Vietnam). Geochem. Geophys. Geosystems 5, 1, Q01B06, p. 1-8. (online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2003GC000619) (Quantitative analysis the area-age distribution of sedimentary, igneous and metamorphic rock outcrops, based on 1997 CCOP digital surface geology maps of E and SE Asia. Sedimentary rocks 73.3%, volcanic rocks 8.5%, plutonic rocks 8.8%, ultramafic rocks 0.9% and metamorphic rocks cover 8.6% of surface area)

Pigram, C.J. & H. Panggabean (1984)- Rifting of the northern margin of the Australian continent and the origin of some microcontinents in Eastern Indonesia. Tectonophysics 107, 3-4, p. 331-353. (Classic paper linking New Guinea Jurassic-Cretaceous rift-drift stratigraphy to E Indonesian microcontinents like Buton, Buru-Seram and Banggai-Sula. New Guinea N margin rifting began at ~230 Ma. Onset of seafloor spreading (marked by post-breakup unconformity) ranges in age from 185 Ma in PNG to 170 Ma in Irian Jaya and continues to young in SW direction along W margin of Australian continent, reflecting opening of Indian Ocean off W Australia. By end Jurassic N margin of Australian continent faced seaway which linked proto-Indian and Proto-Pacific oceans, which was separated from pre-existing Neo-Tethys and Panthalassa oceans by microcontinents, now preserved in E Indonesia. Banggai-Sula and Buton rifted off PNG side of margin, Birds Head closer ties to N Queensland, NE Australia)


(Early paper on 'plate rupture' (slab breakoff) under Timor during Late Miocene- E Pliocene collision of Australian continental lithoshere and trench of Banda Arc, leading to uplift of 'outer Banda Arc')


(Rupture of continental plate subducting below forearc produces fold-thrust mountain belt with fast overthrusting of nappes. Post-rupture plate unflexing provides mechanism for foreland basin formation. Accounts for origin of Timor Trough, its imbrication and contemporaneous extension in outer arc, as well as reversal of subduction direction after emplacement of nappes)


('Contribution of slab melts to arc magmatism: examples from South-East Asia and experimental approach’. Adakitic magmas product of melting of basaltic oceanic crust. Examples from Philippines and Borneo)


(online at: www.gsm.org.my/products/702001-101658-PDF.pdf)

(Discussion of diachronous opening of Tertiary marginal basins along E part of the Sundaland: (1) Proto S China Sea and S China Sea (with rifted off continental Palawan Block), (2) NW Sulu Sea, separated by Cagayan Arc; (3) late E Miocene Sulu Sea back-arc basin (W Mindanao and Sulu arc continental basement); (4) M Eocene Celebes Sea basin (N Arm of Sulawesi), Late Miocene N Banda Basin, Pliocene S Banda Basin. Basin closures started in E Miocene)


(NW New Guinea at least two marginal basins, both formed in back-arc settings. Older basin opened between M Jurassic- E Cretaceous, a remnant of which is now preserved as New Guinea Ophiolite. Its obduction started at 40 Ma and finally emplaced on Australian margin at ~30 Ma. Younger basin active in Oligocene- M Miocene and obducted in E Pliocene. W edge of Philippine Sea also hitherto unexplained Oligocene deformation of Philippine arc. Extensive area of oceanic crust extended Australian Plate N of craton. As Australia began N-ward drift in E Eocene, this lithosphere was subducted. Thus, portion of Philippine Sea Plate carrying Taiwan-Philippine Arc to present site may have actually been in contact with ophiolite now in New Guinea and obduction led to deformation of Philippine Sea Plate. Neogene Plate kinematics transported deformed belt in contact with Sunda block in Late Miocene-Pliocene)

Pubellier, M., A. Deschamps, A. Loevenbruck et al. (2001)- How plate kinematics creates and sweeps away supra subduction ophiolites? EOS Transactions AGU, 82, 47, Fall Mtg. Suppl. (Abstract only)


(online at: www.geologie.ens.fr/~rooke/NCRpdf4web/Pubellier&al-2003.pdf)

(Nice set of Indonesia cross-sections and reconstructions at 2, 4, 6, 10, 15 and 20 Ma; part of DOTSEA project. Mamberamo Basin shown as Miocene back-arc basin above S-ward subducting Caroline Plate)

(On mechanism of Tertiary accretion processes in SE Asia. Early stages illustrated in E Sunda arc where subduction of Sunda Trench is blocked in Sumba and Timor region, and flipped into Flores Trough. Another stage, where part of upper plate basin has disappeared is in Celebes Sea (and Makassar Basin?). Next stage is consumption of marginal basin where both margins collide and accretionary wedge is thrust over margin, as in NW Borneo and Palawan. These events predate arrival of conjugate margin of large ocean, which marks beginning of continental subduction as observed in Himalaya-Tibet region. Closure generally diachronous through time. Ophiolite obducted in such context generally of back-arc origin rather than relict of vanishing large ocean, which is rarely preserved)

(Majority of SE Asia ophiolites originated in backarc or island arc settings along edge of Sunda (Eurasia) and Australian cratons, or within Philippine Sea Plate. Ophiolites accreted to continental margins during Tertiary. Relatively 'autochthonous ophiolites' resulted from shortening of marginal basins like S China Sea or Coral Sea, and 'highly displaced ophiolites' developed in oblique convergent margins. Some ophiolites in front of Sunda plate represent supra-subduction zone basins formed along Australian Craton margin in Mesozoic)

(Major review of origin and evolution of Cenozoic basins of Sundaland. All basins in supra-subduction setting, but many different types, rift basins most widespread. Rift basin initiation is diachronous, with basins >45 Ma developing in E, and <45 Ma in C and N Sundaland, due to earlier onset of subduction rollback in Sulawesi-Celebes Sea area. Andean margin growth in NW Sundaland, Proto-South China Sea slab-pull and Andean margin collapse in NE Sundaland)

(SE Asia kinematic reconstructions back to 20 Ma, mainly driven by restoring plate motions from present-day GPS data. Rel. detailed maps and discussion of E Sunda margin (Philippines to N Sulawesi), S Sunda margin (Sumatra forearc) and S China Sea- Vietnam margin)


(History of Sundaland tectonic interpretations. Sundaland is mosaic of microplates, initially accreted in Late Triassic. Zone of weakness between rigid microplates in Sumatra locus of extensional tectonism, high heatflow and subsequent compression, which lead to optimum conditions for generation and trapping of Tertiary oils)

(Generic overview of Indonesian mineral resources, hydrocarbons, geothermal prospects, etc.)

(Subducted slab morphology from tomography and seismicity of Sunda-Banda Arc suggests three zones: (1) W Sunda (Sumatra), with slab-like image penetrating to ~500 km below W Sunda arc, but no seismicity below 250 km; (2) E Sunda (Java-Flores), with seismic gap between 300-500 km, but slab continuous and penetrating into lower mantle ;and (3) Banda arc, with seismicity down to ~650 km, slab dips gently and does not penetrate into lower mantle. Along back-arc side of Sunda-Banda arcs heat flow decreases from W to E)
(Early P-wave seismic tomography imaging study of Indonesian region)

(online at: https://epic.awi.de/38705/2/south-china-sea_1990.pdf)

(Celebes and S China Seas rifted from Asian continental margin in Paleogene. Now completely subducted Proto-S China Sea probably same origin. Basins resulted partly from Indo-Asian collision and partly from slab-pull forces along Sunda Trench. Neogene collision of Banggai Sula Block with S margin of Celebes Sea in Sulawesi forced progressive closure of basins. Proto S China Sea was first to subduct below Cagayan Ridge in E Neogene, inducing opening of Sulu Sea and spreading reorganisation in S China Sea. Following collision of Cagayan Ridge with rifted margin of S China Sea in E Miocene, the Sulu Sea initiated subduction along Sulu Archipelago and Celebes Sea along N Sulawesi Trench. Paleogene was period of stretching of Eurasian margin and opening of marginal basins, in Neogene mainly progressive subduction of these oceanic basins)

(online at: www.searchanddiscovery.com/documents/2015/30408rangin/ndx_rangin.pdf)

(Both West and East Sunda block margins affected by Late Eocene-E Miocene continental crust thinning just before E Neogene impingement of Philippine Mobile Belt and Indian Ridges. This extension was controlled by subduction retreat along Sumatra Java trench and its E extension in C Sulawesi. Early M Miocene (15 Ma) multiple collisions around S China Sea (Banggai Sula- E Sulawesi, Mindanao Zamboanga microcontinent-Philippine Mobile Belt, Mindoro Palawan- Philippine Mobile Belt, Luzon-Taiwan), causing end of spreading in Sulu and S China Seas)

(Set of paleotectonic reconstructions since M Eocene (43 Ma), showing steps in convergence of Sundaland, Philippine Sea Plate and Australia-New Guinea plate)

(W boundary of Philippine Sea Plate (PH) wide deformation zone that includes stretched continental margin of Sundaland, Philippine Mobile Belt and continental blocks around PH-Australia-Sunda triple junction. 80% of PH-Sunda convergence absorbed in Molucca Sea double subduction system and <20% along continental margins of N Borneo. In triple junction between Sundaland, PH and Australia plates, from Sulawesi to Irian Jaya, preferential subduction of Celebes Sea induces CW rotation of Sulu block, which is escaping toward Celebes Sea from E-ward-advancing PH Plate. Undeformed Banda block rotates CCW with respect to Australia and CW with respect to Sundaland. Kinematics of this block enabled to compute rates of S-ward subduction of Banda block in Flores Trench and E-ward convergence of Makassar Straits with Banda block. Deformation compatible with E-ward motion of Sundaland with respect to Eurasia determined by GEODYSSSEA, not with assumption that Sundaland belongs to Eurasia)


Rangin, C., M. Pubellier & L. Jolivet (1989)- Collision entre les marges de l'Eurasie et de l'Australie: un processus de fermeture des bassins marginaux du Sud-Est Asiatique. Comptes Rendus Academie Sciences, Paris 309, p. 1223-1229. ('Collision between the margins of Eurasia and Australia: a process of closing of marginal basins of SE Asia'. Convergence between Philippine Sea and Indo-Australian plates interpreted as E-M Miocene collision between two thinned continental margins with marginal basins floored by oceanic crust. This 'soft collision' initiated progressive subduction and closure of these basins and predate 'hypercollision' between Eurasia and Australia)

Rangin, C., W. Spakman, M. Pubellier & H. Bijwaard (1999)- Tomographic and geological constraints on subduction along the eastern Sundaland continental margin (South-East Asia). Bull. Soc. Geologique France 170, 6, p. 775-788. (Tomographic model suggests rel. continuous active margin from Taiwan to Java before collision of Banda Block with Sundaland in M Miocene. N-dipping slab below Timor- Banda Arc reflects new subduction after this collision (12-0 Ma). Shortening within Sunda Block accommodated by subduction of SE Asia marginal basins that opened in Paleogene. Closure of Sulu and Celebes basins is recent, whereas subduction of Proto-South China Sea marked by 300 km long slab below Borneo)


Richter, B.W. (1996)- The Tertiary tectonic evolution of Southeast Asia; insights from paleomagnetism and plate reconstructions. Ph.D. Thesis, University of California, Santa Barbara, p. 1-247. (Unpublished) (Paleomagnetic studies of parts of mainland SE Asia. Shan Plateau of Myanmar 33± 8° CW rotation relative to S China Block since M Cretaceous= 15.4 ± 5.4 ° CW rotation relative to Indochina Block. Peninsular Malaysia CCW declinations, similar to Borneo, Celebes Sea and Sulawesi, supporing hypothesis that much of Sundaland region rotated 33-40° CCW as rigid block since M Cretaceous. Java-Australia boundary probably passive margin until M Oligocene, so N-ward movement of Australia since Late Eocene initially pushed Borneo N-ward, driving CCW rotation of Borneo and Malaysia. Philippine Sea Plate rotating CW and moving NW through much of Tertiary, and arc fragments of this plate collided with Borneo through Tertiary)

sub-blocks, some of which moved N. This indicates deformation of Sibumasu dominated by oblique Indian Ocean Plate subduction, while deformation of Indochina dominated by extrusion, driven by Indian Craton)

(Paleomagnetic data from Thailand- E Myanmar suggest ~45° CW rotation since Cretaceous. Peninsular Malaysia, Borneo, SW Sulawesi and Celebes Sea mainly CCW declinations)

('On deep earthquakes in the Indies Archipelago'. Study of 22 intermediate and deep earthquakes, only 2 with good data. No sweeping revelations)


(In Indonesia shallow earthquakes widely distributed. Deeper earthquakes in narrower, rel. linear belts with deeper ones epicenters farther into Asian continent)


(Data from 28 earthquakes in SE Asia between 1934-1954 suggest earthquakes (1) at crustal-depth dominated by transcurrent movements; (2) at intermediate depths mainly reverse fault movements and (3) at deep levels mainly normal fault movements)

(online at: www.knmi.nl/bibliotheek/kn mipubmetnummer/knimipub102-76.pdf)
(In SE Asia fault movement and earthquake-generating stresses associated with deep-seated earthquakes are located in essentially vertical plane, those of shallow earthquakes in essentially horizontal plane. Eight seismic zones of ~2000km length: (1) Sumatra- Sunda Strait (NNE-SSW horoizontal pressure), (2) Java- Timor and (3) N Sulawesi (N-S horizontal pressure), (4) Philippines, (5) Solomon Islands, (6) E New Guinea, (7) W New Guinea and (8) Moluccas)


(Comprehensive hydrocarbon systems study Eastern Indonesia)


Robertson/ Fugro (2006)- Cenozoic isopach of Southeast Asia. Multi-client study, 8p + map (Unpublished)
(Russian point of view on 40+ sedimentary basins and petroleum content of Indo-Pacific region)

(Variations in buoyancy of subducting lithosphere control subduction rate, slab dip and position of volcanic arc. More buoyant slab segments correlate with slower subduction rates and steeper slab dip. In Banda and S Apennine subduction systems subduction slowed and ended shortly after entry of continental lithosphere into trench. Time period of ~10 m.y. needed for model subduction rates to slow to near zero, longer than ~3 m.y. observed in Banda systems. Possible explanation is slab break-off or formation of large slab windows during the last stages of subduction allowing slab to steepen rapidly into final position)


(online at: www.dwc.knaw.nl/DL/publications/PU00014881.pdf) 
(Similarities between the Antilles and Southern Moluccas islands chains already noted by Wichmann (1887), Martin (1890), etc. In both areas Mesozoic and Tertiary radiolarian deposits. No good maps, etc.)

('Presentations on the geology of Netherlands East Indies'. Classic, comprehensive lecture series, summarizing 1927 state of knowledge of geology of Indonesia)

('The geology of Netherlands Indies'. Concise, early textbook on the geology of Indonesia)

Rutten, M.G. (1952)- Geosynclinal subsidence versus glacially controlled movements in Java and Sumatra. Geologie en Mijnbouw 14, 6, p. 201-220. 
(online at: https://drive.google.com/file/d/0B7j8bPm9Cce0S2czQkxZN3B5cE0/view) 
(Mainly critique of Smit Sibinga (1949) Pleistocene glacial cycle interpretation)

('The Cenozoic of Western Indonesia')

(Seismicity-based study of variations in depths of 410km and 660km mantle discontinuities under Indonesia)


(Example of N-S megaregional seismic line from S of Lombok to East Borneo)

('Sedimentation cycles in western Indonesian basins’. Four main sedimentary cycles in Eocene-Recent of Java, Sumatra, Kalimantan)


(Mainly brief review of Spakman & Hall (2010) on how Banda arc is formed above single horseshoe-shaped subducted slab, reflecting slab rollback. Large intermediate-depth earthquakes may reflect rupturing of slab)


(Models for Paleogene rifting along W margin of Sundaland include purely extensional and strike slip fault control. Thermal anomalies in grabens parallel to subduction zone suggest back arc setting during rift phase, but other grabens not parallel to subduction zone. Different orientations suggest basins in W Indonesia developed by different tectonic system in Eocene-E Miocene. Sandbox modeling shows pre-existing basement structures fundamental control element on rifting)

(online at: http://citation.itb.ac.id/pdf/pdf/A6162/A61013.PDF)
(Presence of marine Permian rocks around Banda Sea on Savu, Roti, Timor, Leti, Luang and Babar (outer Banda Arc), E Sulawesi, Sula Spur, West Papua suggests existence of Banda geosyncline in Permian time. Banda geosyncline bordered land mass which included Sahul shelf. Trend of geosynclines follows present geanticlinal ridge of Outer Banda Arc islands. Distribution of Permian rocks and overthrust units in Timor suggests Permian geosyncline in SE Indonesia formed by two parallel basins, i.e. Sonnebait- Mutis in N (with neritic volcanic rocks of and Mutis overthrust units) and Kekneno basin in S)

('Stratigraphy of Indonesia. Course manual?)

(Somewhat 'different' tectonics paper. Tectonostratigraphic reconstructions of Permo-Carboniferous to Quaternary rock formations in Sumatra and Timor indicate very similar geotectonic elements)

('Intra-Miocene orogenesis in Indonesia')


(Discussion of M Eocene (~50Ma) and younger rift basins along E margin of Sundaland. Seismic sections across Makassar Straits, East Java Sea, Gorontalo and Bone Basins)


(At several areas in Indonesia geologic phenomena can not be explained by plate tectonics only. Uplifts in collision zones of Indonesia (Meratus (SE Kalimantan), Batui (E Sulawesi), Central Ranges of Papua, and Timor-Tanimbar uplifts may be caused by isostatic exhumation of once subducted microcontinents in collision zones. Compressional structures such as Samarinda Anticlinorium (E Kalimantan) and N Serayu fold-thrust belt (N C Java) may be related to gravitational gliding after hinterlands uplifts. Collision of microcontinents is by plate tectonics, but their subsequent uplifts of collisional through gravity tectonics)


(online at: www.iagi.or.id/fosi/files/2012/03/FOSI_BeritaSedimentologi_BS-23_March2012.pdf)

(Review of literature on the origin of the oceanic Banda Sea and Banda collisional zone)


(www.searchanddiscovery.com/documents/2012/30261satyana/ndx_satyana.pdf)

(Sundaland made up of terranes from N Gondwanaland, which rifted, drifted, and amalgamated in Late Paleozoic-Mesozoic. A number of SE Sundaland crustal masses accreted to original SE Sundaland (Schwaner Core) in 150-60 Ma. Starting at ~50 Ma (M Eocene), some of accreted mass of SE Sundaland rifted and drifted apart (SW Sulawesi, Flores Sea Islands, Sumba), due to transtension rifting related to tectonic escape of India-Eurasia collision and/or back-arc spreading by rollback of slower subduction, resulting in opening of Makassar Straits and Bone Basins, segmentation of E Java Basement and slivering of Sumba terrane)


(Examples of gravity tectonics (compressional structures not requiring tectonic shortening) in Indonesia: (1) Meratus Uplift, SE Kalimantan, (2) Samarinda Anticlinorium (E Kalimantan), (3) growth faults and toe thrusts in Tarakan offshore and N Makassar Basins, and (4) N Serayu Anticlinorium, C Java (reminescent of Van Bemmelen’s ‘undation theory’; JTvG))


(Cretaceous subduction under SE Sundaland more complex than previously considered. Subduction ceased in Bantimala and Meratus trenches in mid-Cretaceous due to docking of W Sulawesi and Paternoster-Kangean microcontinents, respectively. Late Cretaceous subduction migrated to Paternoster trench resulting in volcanic and magmatic rocks as well as forearc sediments in Meratus and Bantimala. Subduction in Ciletuh and Luk Ulo continued into Late Cretaceous. Bayat area may not be subduction continuation of Luk Ulo due to absence of subduction zone rock assemblages. Presence of NW Australian-derived microcontinents (W Sulawesi, Paternoster-Kangean, SE Java) opens petroleum possibilities in pre-Tertiary deposits)


(SE Sundaland recorded subduction of oceanic plate in Jurassic-Late Cretaceous (Meratus, Bantimala, Luk Ulo, Ciletuh). Subduction ceased in Bantimala and Meratus trenches in mid-Cretaceous due to docking of W
Sulawesi and Paternoster-Kangean microcontinents. In Late Cretaceous, subduction migrated to Paternoster trench, resulting in volcanic-magmatic rocks and forearc sediments in Meratus and Bantimala. In Paleogene Meratus and Bantimala separated by opening of Makassar Straits. Subduction in Luk Ulo and Ciletuh trenches continued into Late Cretaceous (but no Late Cretaceous subduction-related metamorphic rocks). Jiwo Hills, Bayat, not subduction zone, but part of SE Java Microcontinent that docked in E Cretaceous

(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 (rifted 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 Gondwanan 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))

(Collision following subduction and accretion of buoyant crustal masses and post-collision tectonics significant for basin formation and resultant petroleum systems. Examples of collisions important for petroleum geology: (1) Meratus (SE Kalimantan), (2) Buton and Banggai (E Sulawesi), (3) Seram, (4) Timor-Tanimbar, (5) Lengguru (Birds Head of Papua) and (6) Central Range of Papua)

(Extensive review of Indonesia collisional orogens: (1) Meratus: collision of Schwaner continental core with Paternoster micro-continent, (2) Sulawesi: collision of Banggai-Sula microcontinent and E Sulawesi Ophiolite, (3) Molucca Sea: collision of accretionary wedges of Sangihe and Halmahera arc-trench systems, (4) Seram: collision of Seram/N Banda arc and Bird’s Head micro-continent, (5) Lengguru: collision between Bird’s Head of N margin of Australian continent, (6) Papua Central Range: collision of island arc to S of Philippine Sea plate and N margin of Australian continent, and (7) Timor-Tanimbar: collision of Australian continent and Timor-Tanimbar/S Banda arc)

(online at: www.geologie.ac.at/filestore/download/JB0262_113_A.pdf)
('Geological overview of the Dutch East Indies archipelago'. One of earliest reviews of Indonesia geology and useful minerals by German Dr. Schneider)

(Relocated earthquakes hypocenters show (1) portion of Indonesian arc between ~110°E-123°E and >500 km deep, dips S at ~75° angle, direction opposite to upper part of N dipping slab, and (2) E of ~108°E seismic zone wider near 670km than near 500 km depth. The first suggests S-ward lateral flow in mantle, relative to plate motion vector. From contour of seismic zone along E portion of arc, average lateral shear strain rate in 300-670 km depth range is ~10-16s-1 over last 10-20 Myr)

(N-S trending SE Asian tin belt 2800 km long/ 400 km wide, from Myanmar- Thailand to Malay Peninsula and Indonesian Tin Islands Bangka- Belitung. Five granitoid provinces: (1) Main Range in W Malay Peninsula, S Peninsular Thailand and C Thailand (184-230 Ma; almost entirely biotite granite, 55% of tin production); (2) Northern Province of N Thailand (200-269 Ma; 0.1% of tin production, also mainly biotite granite); (3) Eastern Province of E Peninsular Malaysia- E Thailand (Malaysian part subdivided into E Coast Belt (220-263 Ma), Boundary Range Belt (197-257 Ma) and Central Belt (79-219 Ma; wide compositional range; tin deposits only in biotite granite in E Coast Belt) (3% of production); (4) Western Province in N Peninsular and W Thailand and Burma (22-149 Ma; biotite granite, 14% of tin production); (5) Granitoids of Indonesian Tin Islands (193-251 Ma) do not permit grouping into above units; most tin deposits associated with Main Range-like plutons)

(Nine global reconstructions of ocean basins and continental plates for E Cretaceous- Pleistocene times. Late Cretaceous and Early Tertiary plate reorganizations in Indian Ocean e result of progressive subduction of intra-Tethyan rift/ spreading system)

(Study of metamorphic complexes of S Sulawesi, Kalimantan, C Java)

(online at: https://repository.ugm.ac.id/135217/1/504-523%20P3O-02.pdf)
(Published exhumation models of high-P/low-T metamorphic rocks in subduction zones suggest buoyancy is only effective force to exhume rocks from deeply subducted levels to base of crust. Serpentinites are extremely buoyant and may facilitate exhumation. Requires rapid uplift and cooling to maintain high-P minerals in rocks. Presence of melange units intercalated with high-P metamorphics and chaotic occurrence of different metamorphic facies typically in subduction channel environment)

(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 glaucohane-quartz schist ~430-199 Ma (Silurian- E Jurassic), Barru 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)

(online at: https://qir.kyushu-u.ac.jp/dspace/bitstream/2324/26209/1/p039.pdf)
(Study of metamorphic complexes at Bantimala and Barru (S Sulawesi; High P), Luk Ulo (C Java; High P; pelitic schist, eclogite, blueschist), Meratus (S Kalimantan) and Nangapinoh area of Schwaner Mountains (W Kalimantan). Metamorphic rocks from S Sulawesi, C Java and S Kalimantan E Cretaceous ages (~110-130 Ma) and possibily derived from single subduction complex. Metamorphic rocks in Schwaner Mountains are metatonalite, with U-Pb zircon ages suggesting Late Triassic magmatic ages (~233 Ma), i.e. older than most
Schwaner Mts granitoids (Late Jurassic-Cretaceous), but within range of NW Kalimantan granitoids (Carboniferous-Triassic; 204-320 Ma)

(online at: www.seed-net.org/download/GeoE013_revised_060513.pdf)
(Metamorphic complexes as products of Cretaceous subduction outcrop in C Java, S Kalimantan and S Sulawesi. Mainly high-pressure metamorphic rocks from metabasic and sedimentary protoliths. Metabasic rocks from S Sulawesi and C Java basalts with both MORB and within-plate signatures. Metatonalites from Schwaner Mountains calc-alkaline arc volcanics; adakitic metatonalite age of 233± 3 Ma (Late Triassic))

(Two or three separate Cretaceous subduction zones in W Indonesia, with oceanic crust subducting under Eurasia plate (1) M-Lt Cretaceous Sumatra-Meratus arc, E and N-facing subduction, 2000 km long, with granitoid plutonism from W Sumatra (Sikuleh, Manunggal, Ulai, Garba and Sulan granites; 120-75 Ma), N of Java, to Meratus Mountains of SE Kalimantan; (2) S-facing subduction at NW Kalimantan, resulting in two granitoid plutonic arcs, i.e. late E Cretaceous Schwaner Arc and Late Cretaceous Sunda Shelf Arc. Both are parallel in E-W direction, ~1500 km long, in W-C Kalimantan, with Late K arc south of Early K arc. Cretaceous arc granitoid plutonism very different from Triassic granitoids of Bangka-Belitung)

(Potential volcaniclastic reservoirs present in Indonesia across range of stratigraphic intervals, but underexplored. Presence of volcanic material may enhance preservation and of organic matter and maturation of hydrocarbons. Porosity prediction still problematic. Examples of volcaniclastic reservoirs in Indonesia: Bengkulu, W, C and E Java, S Sulawesi, etc.)

(Zircon U-Pb ages from Karimunjawa Arch (SW Borneo Block) similar to those from Seram, suggesting similar source areas. Mesoproterozoic zircons in Karimunjawa Arch uncommon on Cathaysian Blocks, providing evidence against Cathaysian affinity for SW Borneo Block. Triassic zircons abundant in Karimunjawa Arch. Zircons suggest existence of local Permian-Triassic zircon source in E Indonesia and/or on Australia NW Shelf)


(70% of SE Asian basins frontier basins with no significant hydrocarbon production, but contain estimated 22% of recoverable oil reserves. Basins in regions of oceanic-continent convergence (N Australia, Sunda margin) more prospective than areas of oceanic plates convergence)


(75% of SE Asia oil reserves in basins with contemporary heatflow of 2 HFU or more)

(online at: http://d-nb.info/1023870339/34)
(Mainly collection of five papers on Java-Sumatra forearc regions. Geophysical models show significant variations of crustal and upper mantle structure of Sunda Arc subduction complex along-strike and across-strike of margin. Increased thickness of crystalline crust in Savu Sea attributed to approach of Australian shelf to trench. Offshore Lombok oceanic crust thickness 7 km thick and heavily fractured by normal faults. Crustal structure of Roo Rise oceanic plateau revealing crustal thickness of 15km, its subduction causing deformation of forearc and complex evolution of subduction processes)

(Brief summary of Indonesia geology, with schematic structural map and 1:5m geologic map)


(Review of Indonesian tectonics and relation to hydrocarbons, coal, geothermal potential. Indonesia triple junction convergence since Neogene. Pre-Neogene tectonics (1) Paleozoic- Mesozoic_Paleogene convergence in W Indonesia; (2) Mesozoic- Paleogene divergence in E Indonesia, producing allochthonous terranes in E Indonesia. Permian convergence recorded by Permian andesitic volcanics, similar to rocks present in W Kalimantan and E Main Range of Malay Peninsula. Similarities between E Indonesian microcontinents include Perno-Carboniferous metamorphics, Perno-Triassic plutons, overlain by Mesozoic passive margin sequence, E Cretaceous mostly missing, Late Cretaceous radiolarian calcilutites and Tertiary platform carbonates, etc.; generally regarded as derived from New Guinea. No plate reconstructions)

(C Indonesia nine tectonic provinces or belts: (1) W Sulawesi Magmatic Arc (Late Cretaceous- Paleogene flysch and arc volcanics and some probably Cretaceous granitoids); (2) C Sulawesi Metamorphic Belt (tightly folded schist, incl. blueschist, N-S fold axes, probably Late Cretaceous metamorphism); (3) E Sulawesi Ophiolite Belt (>1000km long belt from E Arm Sulawesi to Kabaena and Buton in SE, possibly up to 15km thick; in places with deformed Late Cretaceous radiolarian chert, K-Ar ages of ophiolite ~93-37 Ma; E Miocene obduction?); (4) Banda Micro-continents (Banggai-Sula, Seram-Buru platform, Misool-Birds Head, etc., terranes of Paleozoic metamorphic basement with Perno-Triassic granitic plutons, overlain by Late Triassic sediments, E Jurassic hiatus, M-L Jurassic passive margin sediment, etc.; originated from N Papuan margin); (5) Banda Sea floor (Cretaceous?)/ Sulawesi Sea floor (Eocene), (6) N Maluku Basin and Talaud-Tifore Ridge; (7) Minahasa- Sangihe Volcanic Arc; (8) W Halmahera Province (Tertiary Arc volcanics) and (9) E Halmahera Province (ophiolites of poorly known age))

(online at: www.gsm.org.my/products/702001-101022-PDF.pdf)
(Indonesian Archipelago developed during Neogene convergence of 3 megaplates, Eurasian craton, Pacific plate and Australian craton. Five major crustal elements, 4 orogenic belts: Sunda orogeny, (2) Banda orogeny, (3) Melanesian orogeny, (4) Talaud orogeny. ‘Transitional Complex’: between 3 major plates composed of 17 distinct units: E Sulawesi, Banggai-Sula, Timor-Tanimbar, Misool-Birds Head, etc.)
(Similar to other Simandjuntak (1993) above)

(Central Indonesia is triple junction of Indo-Australian, Pacific and Eurasian plate convergence. Seven tectonostratigraphic provices, various episodes of convergence and divergence. Reconstructions show Banda Microcontinent (which subsequently breaks up into Banggai-Sula, Tukang-Besi, Seram-Buru, Misool-Birds Head, etc.) attached to Papua New Guinea part of Australian continent in Triassic-Jurassic time (similar to Pigram, Struckmeyer reconstructions, but not Hall and others))

(Neogene tectonics of Indonesia marked by five different orogenic belts, Barisan, Sunda, Banda, Talaud and Melanesian)

(Overview of active tectonics across Indonesia and relation to tsunamis. Tsunamis triggered by earthquakes below seafloor, most of them over graben-like structures in areas of extensional tectonics, but transtensional zones also have tsunami potential)

(Tectonic development of Indonesia initiated by collision in Sumatra and Kalimantan in E Triassic of Paleozoic microcontinents detached from Gondwana, followed by reoccurring subduction systems until today. In Sumatra 3 terranes: (1) SE part of Sibumasu Terrane (Mergui, Togapuluh Mts and Kuantan-Duabelas Mts); (2) SE end of Lhassa-W Burma Terrane (Woyla, Sikuleh, Natal and Asai-Garba Terranes); (3) SE-most Malaysia Terrain (Gumungkasth-Lingga-Singkep). W Kalimantan and Meratus also parts of S-most China-Indochina terranes. Irian Jaya and PNG part of N Australian continental margin, which rifted in Triassic, followed by development of passive margin in Jurassic-Cretaceous and carbonate platform in Paleogene. At end-Paleogene promontory of Australian continent collided with oceanic island arc at S margin of Philippine Sea Plate. Prior to Neogene emplacement of allochthonous microcontinents from N margin of Australia in Banda Sea, E Indonesia was part of N Indian Ocean and S Philippine Sea plates, in which a number of oceanic island arcs formed in Paleogene. Six Neogene orogenic belts in Indonesian region. No reconstruction maps (refers to map of 1999 Indonesian-Japanese Geotectonics Working Group; Sato et al.))

(Seven distinctive Neogene orogenies in Indonesia: 1) Sunda Orogeny in Java and E Indonesia: normal convergence producing Andean type orogenic belt, 2) Barisan Orogeny: oblique convergence and dextral transpressional wrenching in Sumatra, 3) Talaud Orogeny in N Maluku Sea: double-arc collision with sinistral transpressional wrenching, 5) Banda Orogeny: M Miocene collision between Banggai-Sula, Tukangbesi-Buton and Mekongga Platform against E Sulawesi ophiolite belt; 6) Melanesian Orogeny in Irian Jaya and PNG: oblique convergence with thin-skinned tectonics, 7) Dayak Orogeny in Kalimantan: triple junction extensional tectonics with hot spots of Neogene volcanics)

(Discussion of young collisional and strike-slip belts of Indonesia)


Simons, W., B. Ambrosius, C. Vigny, A. Socquet, C. Subarya et al. (2003)- Crustal motion and block behaviour in S.E. Asia: a decade of GPS measurements. EGS-AGU-EUG Joint Assembly, Nice 2003, Abstract 10940. (SE Asia region was observed with 45 GPS site 'GEODYSSEA project (1991-1998). Additional GPS sites have set-up since 2000. High-quality GPS data set, spanning almost decade, combined into a kinematic model, with 100+ station motions in ITRF-2000. Highlights are relative motion and boundaries of Sundaland block. In Sulawesi, two micro-blocks confirmed and number of sites on E Malaysia, indicate small but consistent relative motion with respect to Sundaland block)


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)


(E Indonesia prospective hydrocarbon plays in Pre-Tertiary, mainly in microcontinental blocks of Australian origin and associated Pre-Tertiary rift basins)


(online at: http://library.dmr.go.th/Document/Proceedings-Yearbooks/M_2/1987/7...)


(Average heat flow in Tertiary Basins of W Indonesia ~1.95-2.58 µ Cal/cm² s, except in C Sumatra where heat flow is ~3.27 ± 0.9 µ Cal/cm² s. Less variability of heat flow in Java than in Sumatra basins. Lowest variability in S Sumatra, largest in C Sumatra. Variability probably reflects variation in amount of extension)


(Heavy minerals in seafloor sediments around Banda Arc region mainly mafic volcanic and sedimentary minerals, with some metamorphic minerals. Principal minerals hyperstene, augite, zircon, tourmaline, enstatite, garnet, chlorite and hornblende)


(SE Asia contains large number of lake basins producing significant amounts of oil and gas: Late Mesozoic-Early Tertiary basins of China, Early Tertiary basins of Malaysia-West Indonesia. Wax content commonly 10-35% in oils derived from lacustrine source-rocks, occasionally reaching 45%. Source rock petroleum generators dominated by Botryococcus and Pediastrum green algae)


(Earthquake focal mechanisms define eight stress domains: 3 in Sumatra (SI-SIII), 5 in Java region (JI-JV). Domains with similar states of stress occur in both regions in similar positions. Maximum compression perpendicular to trench in SI, SII and JI (depth range 0-165 km). Orientation of max. compression almost parallel to trench in SIII and JIII (depth 25-225 km). Focal mechanisms of domains SII, SIII, and JII, JIII different stress layers and overlap of earthquakes with different focal mechanisms from two different stress-state layers, parallel to Wadati-Benioff zone. Slab-dip-parallel extension observed in JIV (depth 225-315 km), slab-dip-parallel compression in JV (>400 km))


('The geological structure of the Eurasian border area')


('Discussion on merits of Wegener's continental drift theory (1912) in the Indonesian archipelago. Considers basic idea of horizontal movements of continents and associated polar wandering as valid. As did Molengraaff, SS struggles with origin of the configuration of the 'circum-synclinal Banda basin'. Remarkable conclusion: 'Various reasons to believe 'the Lesser Sunda islands, Sulawesi and the Moluccas are originally marginal
chains of Sundaland, from which they separated and developed their present position and character as result of collision with the Australian continent. No figures)

Smit Sibinga, G.L. (1928)- De geologische ligging der Boven-Triadische olie- en asfaltafzettingen in de Molukken. Natuurkundig Tijdschrift Nederlandsch-Indie 58, p. 111-121. ('The geological setting of the Upper Triassic oil and asphalt deposits in the Moluccas. Triassic oil and asphalt deposits in Moluccas in similar facies on Timor, Ceram, Buru, Buton and SE Sulawesi. Formed at edge of Mesozoic Sundaland craton. No figures)

Smit Sibinga, G.L. (1933)- The Malay double (triple) orogen, I. Proc. Kon. Akademie Wetenschappen, Amsterdam, 36, 2, p. 202-210. (online at: www.dwc.knaw.nl/DL/publications/PU00016394.pdf) (Discussion of orogenetic belts of Indonesia: Sunda Orogen, Molucca Orogen, Pelew orogen. One of early authors suggesting current geotectonic structure of the Indonesian region is result of N-ward movement of Australian continent (similar to Wegener suggestion; now commonly accepted, but rejected by Van Bemmelen 1933 and others), etc. ‘JTvG’)


Smit Sibinga, G.L. (1937)- On the relation between deep-focus earthquakes, gravity and morphology in the Netherlands East Indies. Gerlands Beitrage Geophysik, Leipzig, 51, 4, p. 402-409. (On zones of deep earthquakes that dip towards SE Asia mainland, recently identified by Berlage (now known as Wadati-Benioff zone), with apparent irregularities in Molucca Sea, etc.. Asiatic and Australian deep-focus earthquake hypocenter planes down to 700km, both with increasing focal depth towards continent, may be regarded as deep-seated fault- or thrust planes. Remarkable coincidence between morphological discrepancies, excessive negative gravity anomalies and active bathyseismic belt suggest intimate relationships and consequently great youth of these phenomena. With two maps)


Smit Sibinga, G.L. (1939)- The Malay Archipelago in Pre-Tertiary times. Proc. Sixth Pacific Science Congress, San Francisco 1939, p. 231-240. (Review of pre-Tertiary stratigraphy of Indonesia, from crystalline schists of pre-Paleozoic or E Paleozoic age through Silurian and Devonian, Carboniferous, Permian, Triassic, Jurassic, and Cretaceous, with observations on tectonics and paleogeography)
(‘The Malay Archipelago’. Part 1 of review of geology of Indonesian region)

(‘The Malay Archipelago’. Continuation of paper above. Brief reviews of geology of Timor, Mesozoic stratigraphy, etc. No new synthesis)

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


(Association of high-pressure metamorphic rocks and ophiolites in E Indonesia, SE Kalimantan and Java)


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))

(SE Sundaland marked by two tectonic sutures, separated by Paternoster microcontinent: (1) Jurassic accretionary remnant W of micro-continent (S Meratus Suture, with metamorphic belt extending offshore beneath Java Sea and N-ward to Mangkalihat Peninsula or to W part of C Sulawesi. Part of Jurassic high-P belt, overprinted by lower P and thermal metamorphism, in response to crustal thickening due to collision of Paternoster against Sundaland in E Cretaceous and subsequent Cretaceous calc-alkaline magmatism; (2) mid-Cretaceous accretionary complex E of Paternoster micro-continent, extending from Karangsambung, C Java, to Bantimala-Latimojong-Pompangeo in Sulawesi (HP metamorphic rocks ages ~100-128 Ma))

(online at: elib.pdii.lipi.go.id/katalog/index.php/searchkatalog/.../1194.pdf)
(Studies of metamorphic aureoles at base of dismembered ophiolites on Timor, Seram, etc., suggest ophiolite obduction is major mechanism for emplacement of southern Tethyan crust onto Australian continental margin)

(Not all metamorphic rocks in Indonesia are of pre-Tertiary age and of continental origin. Places like Timor and Seram have very young metamorphic rocks, formed during ophiolite obduction. Mutis Complex of Timor formed in oceanic setting near Jurassic spreading center)


(Indonesia three types of orogeny: (1) Sunda type, Late Mesozoic Cordilleran-type Meratus-Karangsambung orogen along rim of SE Sundaland and Neogene orogeny. Suspected collision of microcontinent in Meratus-Karangsambung orogen. (2) Makassar type, outboard of Meratus-Karangsambung orogen, Oligocene and Miocene orogenies as result of obduction events of E Arm of Sulawesi and docking of Australian-derived microcontinents onto Sulawesi; (3) Banda type, with repeated pre-collisional obductions of short-lived spreading ridges in front of Australian passive margins in Oligocene and Miocene)


('Indonesian geodynamics and human survival: from geography to the sciences of the earth system'. Three major tectonic theories for Indonesia: (1) undation theory, (2) plate tectonics and more recently (3) plume tectonics becoming fashionable)

Spakman, W. & H. Bijwaard (1998)- Mantle structure and large-scale dynamics of South-East Asia. In: P. Wilson & G.W. Michel (eds.) The geodynamics of S and SE Asia (GEODYSSSEA) Project. Sci. Techn. Report STR/14, Geoforschungszentrum, Potsdam, Germany, p. 313-339. (Tomographic results general agreement with previous findings (e.g. subduction of Indian plate below Sunda Arc), but do not find detachment of (or tear in) slab around 400 km below Sumatra. Sunda slab bends W toward Andaman island arc below N Sumatra. Subduction below Sunda arc imaged down to 1500km, indicating penetration into lower mantle. Subduction below Sulawesi is S extension of Philippines subduction. Slab also imaged below Halmahera (Molucca collision zone))


Spakman, W., C. Rangin & H. Bijwaard (1998)- Tomographic constraints on the tectonic evolution of SE Asia. In: AAPG Int. Conf. Exhib, American Assoc. Petrol. Geol. (AAPG) Bull. 84, 9, p. 1495. (Abstract only) (New 3D image of P-wave seismic velocity heterogeneity of lithosphere and mantle of SE Asia. Subducted oceanic slab found below most of Sunda arc but with varying depth penetration. A 500 km long slab under Burma separated from Andaman-Sumatra slab (~700 km deep) by 300-400 km wide gap associated with Andaman Basin. Central Sunda slab penetrates lower mantle to 1500 km, but subduction below Banda arc confined to 700 km. No clear slab imaged below W New Guinea; long N dipping slab under E New Guinea)
(Analysis of shallow (<100 km) seismological data. 11 domains of earthquakes identified. Two discrete recent subduction zones in region: N-dipping Banda subduction in S and S-dipping Seram subduction in N; no W-dipping subduction zone observed to interconnect Banda and Seram zones into a single bent subduction zone. Instead, area between them is cut by elongated domain of earthquakes corresponding to W-ward continuation of Tarera-Aiduna fault zone)

(Old, general overview of Indonesia geology)

(Report with three 1:7.5 M scale maps of geology, geologic provinces and oil-gas fields: 1 The Far East, 2 Southeast Asia, 3 Australia and New Zealand)

(online at: https://www.digizeitschriften.de/dms/img/?PID=GDZPPN002505746)
(‘The supposed young forward movements in the Timor- Ceram arc’. Discussion of Brouwer (1917 and 1920) papers, questioning the importance of horizontal movements. Not much new, no figures)

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

(‘The tectonic development of the SE Asian mainland and island areas’. Review of geology and tectonic development of Indonesian region, in chapter 3 of textbook on tectonic developments of Circum-Pacific regions (p. 67-122). Interpretations in framework of Stille's famous but outdated ideas of geosynclines and continental growth during 'Variscan', 'Cimmeride', 'Laramide', etc. orogenic cycles)

(‘The tectonic development of the Neo-Australian island world’. Chapter 5 of textbook on tectonic developments of Circum-Pacific regions)

(online at: www.gsm.org.my/products/702001-100611-PDF.pdf)
(Unconventional ‘Global Wrench Tectonics’ model for SE Asia tectonics, particularly NW Borneo margin)

(online at: www.ncgt.org/)
(Another unconventional SE Asia tectonic paper from ‘Global Wrench Tectonics’ school)


Sudradjat, A., H.D. Tjia et al. (eds.) (1989)- J.A. Katili Commemorative Volume (60 years). Geologi Indonesia 12, 1, p. 1-635. (19 papers in English, 5 in Indonesian, mostly on tectonic history and volcanism)

Suggate, S. & R. Hall (2003)- Predicting sediment yields from SE Asia: a GIS approach. Proc. 29th Ann. Conv. Indon. Petroleum Assoc. (IPA), Jakarta, IPA03-G-015, 16p. (Areas of Indonesia like New Guinea, Borneo, Sumatra, etc., produce very high volumes of sediments relative to size of its landmasses. Possibly tied to intense precipitation/ runoff and many areas of recent rapid uplift)


(LEMIGAS (2007) basins map lists 63 Tertiary sedimentary basins in Indonesia. Example of use of gravity data in S Kalimantan to determine basin outlines: propose to combine Pembuang and Barito basins)
(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)


(14 porphyry copper or molybdenum deposits known from SE Asia outside Philippines; Sabah (Mamut), N and W Sulawesi (Tapadaa, Tombuillillado, Sassak, Malala), Sumatra (Tangse + 4 non-economic; all associated with C Sumatra Fault Zone, Thailand (2; Triassic?)) and C Burma (Monywa). All except Thailand of Miocene and younger ages. Sabah and Sulawesi occurrences underlain by oceanic crust, similar to Philippines)


(Geothermal data from 929 wells in 20 Tertiary basins. Thermal conductivity increases with depth of burial and compaction. T gradient controlled by depth and T of heat source beneath basin. High heat-flow densities in C Sumatra, S Sumatra, Salawati Basin and Bintuni Basin may be caused by shallow magmatic diapirism)


(Abstract only. Mesozoic on Buru, Buton, Seram, E Sulawesi and plateaus off NW Australian Shelf. Precollision sediments record complicated rift-drift-history from higher latitudes at NW Australian margin and include source and reservoir rocks (e.g. Triassic sandstone and platform carbonates/ black shales), some with oil, oil seeps, asphalt. Sediments represent rifting off NW Australia. Widespread condensed oceanic sediments with Late Jurassic macrofossils overlie them. This sequence may be preceded by basaltic volcanic phase. E Cretaceous sediments pelagic with abundant radiolarians. Late Cretaceous 'couches rouges' facies rich in calcareous plankton. First Eurasian microfauna in Maastrichtian, indicating beginning of collision. Mesozoic pelagic microfaunas of NW-Australia typical Austral affinities (high latitude); those from Banda Arc mixed Austral-Tethyan elements, deposited in subtropical environment)


(In mobile regions of Indonesia average rate of Quaternary uplift, with or without attendant folding, 0.5- 1.0 mm/yr (common coral reefs uplifted to 500-1000m on Outer Arc islands like Sumba, Timor, Babar, Kai, Seram; also E Sulawesi, Buton, etc.). Subsidence occurs at rates of 2.0 mm/yr. Diastrophic movements in continental areas much slower. Wrench faulting most rapid movements, with rates of strike-slip of 5 mm/yr or more)
(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0Yj13aHFCa0w1cE0/view)  
(Field studies on 7 important strike-slip faults in Malay Peninsula, Sarawak, W Sumatra, W Java, C Sulawesi New Guinea and Seram, using fault-plane markings to determine the sense of displacement. Directions of regional compression, parallel to computed compressive stress directions. Directions of regional compression are 10°-190° (Sumatra and Java) and ~E-W for Philippines and islands E of Makassar Straits)

(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1978006.pdf)  
(Main known active faults in Indonesia: Sumatra Fault Zone (1600 km). Palu-Koro FZ, Sulawesi (700km), Irian FZ (1300km), central depression of Timor, Lembang Fault, W Java, Banyumas Depression of Java, active volcanoes and extensive limestone terrains (caving))

(Tectonic mobility of E Indonesia reflected in high topographic relief between mountinous islands (+5000m in W Papua) and adjacent deep oceanic sea floors (Weber Deep -7440m), zones of negative isostatic gravity anomalies, volcanic arcs earthquake belts and major wrench fault zones. Also uplifted Pliocene-Recent reef terraces on many E Indonesian islands, up to +1293m on Timor, with long-term uplift rates of 3mm/year)


(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.)


(During Quaternary vertical displacement in Indonesian archipelago ranged from +2000m to -2000m). Most uplift vertical, as suggested by untitled appearance of most of highest terraces. Lateral slip movements response to convergence of SE Asia, India-Australia and Pacific plates. Influence of Pacific convergence reached W of Makassar Straits, Indian-Australian convergence only traceable in Java and Sumatra. Discussion of uplifted calcirudites at Banyuwangi, E Sulawesi raised reef terraces at Luwuk and Peleng island,etc.)

(online at: www.gsm.org.my/products/702001-100852-PDF.pdf)  
(Pre-Tertiary core of Sundaland contains numerous N-S striking regional faults. In Malay Peninsula Thai-Bentong- Bengkalis FZ coincides with Raub-Bentong suture, which existed since M Triassic. N-S faults of Sundaland functioned as (1) originators/ initiators of Tertiary basins (Mekong, Nam Con Son), (2) determinants of basin location (C Thailand, Gulf of Thailand, Balam-Pematang Trough, BengkalisTrough, Benakat Gully, etc.)
Asri, Seribu, Arjuna, basement depressions in Malacca Strait, and (3) modifiers of basin geometry (Peusangan fault in N Sumatra basin; dextral offsets of old series in Malay basin)

(Wrenching widespread in Sundaland. Principal stress directions from wrench patterns, well-bore breakouts and major earthquakes show most of Sundaland currently subjected to N-S stress. Towards margins stress trajectories deviate due to convergence of adjoining megaplates and SE extrusion of Indosinia. Until onset of M Miocene most wrenching transtensional, forming pull-apart depressions and modifying structure of large depocentres. Cessation of spreading in Philippine Sea and Caroline basins by M Miocene changed wrenching into transtension, accompanied by slip-sense reversals and structural inversion)

(Sundaland Oligocene transtension evolves into post-E Miocene transpression at Langhian time (~17-15.5 Ma), after end of S China sea spreading)

Tjia, H.D., S. Fujii, K. Kigoshi, A. Sugimura & T. Zakaria (1972)- Radiocarbon dates of elevated shorelines, Indonesia and Malaysia. Part 1. Quaternary Research 2, 4, p. 487-495. (Four radiocarbon dates of elevated strandlines in tectonically active areas of E Indonesia and E Malaysia indicate uplift rates between 4.5-9 mm/ year during past 24,000 yr. Date from S arm of Sulawesi indicates rate of uplift of 1.4-2.5 mm/ year. At Langkawi islands, W Malaysia, one of regionally common shorelines at 2 m above sea level dated at 2590 ± 100 yr BP)

Tjia, H.D., S. Fujii, K. Kigoshi, A. Sugimura & T. Zakaria (1974)- Late Quaternary uplift in Eastern Indonesia. Tectonophysics 23, 4, p. 427-433. (Radiocarbon dates of 15 samples from raised shorelines on various islands of E Indonesia suggest rates of tectonic uplift up to 12.5 mm/year)

Tjia, H.D. & K.K. Liew (1996)- Changes in tectonic stress field in northern Sunda Shelf basin. In: R.Hall & D. Blundell (eds.) Tectonic Evolution of Southeast Asia, Geol. Soc. London, Special Publ. 106, p. 291-306. (Tertiary basins of N Sunda Shelf underlain by normal and attenuated continental crust with moderate-high geothermal gradients >5°C/100 m. In Malay basin, U Oligocene and younger sediments >12 km thick; other basins, 4-8 km thick. Malay, Penyu and W Natuna basins are aulacogens meeting at triple junction that marks Late Cretaceous hot spot in centre of Malay Dome. Sub-basins developed as pull-apart basins within regional, N-NW striking, wrench fault zones. Initial basin subsidence Eocene-Oligocene, with extension prevailing until E Miocene. M-Late Miocene regional compression caused inversions of basin-fill. Some N-striking wrench faults indications of up to 45 km right-lateral displacement, possibly post-Miocene)


The Neogene in the Indies Archipelago. Substantial review of Neogene stratigraphy in Indonesia, with comments on 163 areas. Neogene sediments highly variable in thickness and intensity and timing of deformation. With map showing 11 Neogene tectostratigraphic regions A-M

(online at: www.repository.naturalis.nl/document/549704)
('Different types of Tertiary geosynclines in the Indies Archipelago'. Tertiary basins of Sumatra, Java and Kalimantan relatively rapid subsidence and sedimentation. Most of fill is neritic with some hemipelagic sediments, but no abyssal sediments. Subsidence and sedimentation starts in continental areas with fluvial-alluvial deposits. Tertiary basins not continuous 'geosynclines', but rel. independent basins)

('Timing and types of Tertiary folding in zone of negative gravity anomalies in the Indies Archipelago'. With information of Tanimbar stratigraphy from unpublished work by Weber; see Van Bemmelen 1949)

('On the origin of the Indies Archipelago'. Brief discussion on origin of Indonesian archipelago, mainly focused on gravity anomaly belts of Vening Meinesz. No new model proposed, but is skeptical about 'continental drift theory' of Wegener. With regional gravity anomaly map)


(Classic overview of geologic evolution Indonesian archipelago, with maps of tectonostratigraphic provinces from Permian- Eocene)

(Online at: https://archive.org/details/in.ernet.dli.2015.85833)
(Elegant overview of Indonesian seas, deep sea basins, volcanoes, structural zones, etc., with series of broad paleogeographic maps)

(Pre-plate tectonic explanation of origin of deep sea trenches by 'downbuckling of crust')


(W Borneo tectonically active from Triassic- Late Cretaceous. CCW rotation of ~90° since then. Tectonic activity resulted in uplift and erosion of basement rocks, formation of melange (Boyan, Lubok Antu), followed by sedimentation of shallow marine deposits and magmatism. In Java tectonic activities only since Late Cretaceous (Luk-Ulo Melange). Etc.)


(Incl. strong E-W trending gravity gradient along N coast Irian Jaya, etc.)


(Heat flows somewhat elevated in Tertiary basins of W Indonesia, with values decreasing from 130 mW/m2 in C Sumatra to 70 mW/m2 in E Kalimantan)


(Data from nine deep earthquakes confirmed existence of mid-mantle discontinuity beneath Java arc and also revealed its presence N to Kalimantan. S to P waves converted at discontinuity at depth range ~1080 km in W to ~930 km in E)


(online at: http://62.41.28.253/cgi-bin/...)

(The double causes of ground movements'. Preliminary unveiling of Van Bemmelen's 'undation theory', a tectonic theory that is variation of the oscillation-theory of Haarmann, but never found much acceptance. Crystallization processes in upper mantle trigger uplift ('geotumors'), subsidence and outward flows to re-establish hydrostatic equilibrium)


(Principal unveiling of Van Bemmelen's 'undation theory' and its application to the W part of the Sunda orogenic arc. With discussion of deep tectonic processes and also of geology of S Sumatra. See also critical discussion by Van Tuyn and Westerveld (1932))


('Clarifying comments on the undation-theory'. Reply to critical comments of Van Tuyn & Westerveld (1932))


(Attempt at a geotectonic analysis of SE Asia after the undation theory'. Historically interesting, but otherwise very controversial interpretation of SE Asia tectonics)
('Attempt at a geotectonic analysis of Australia and the SW Pacific after the undation theory'. Historically interesting, but otherwise very controversial interpretation of Australia-Pacific tectonics)

('The Neogene structure of the Malay Archipelago after the undation theory'. Historically interesting, but otherwise very controversial interpretation of Indonesia tectonics)

('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. (1935)- Over het karakter der jongtertiaire ertsgangen in den vulkanischen binnenboog van het Soenda systeem. Geologie en Mijnbouw 14, p. 21-25. (online at: https://drive.google.com/file/d/1YydzhGQK3nsnG_MkVDjsU0QQB5CrNviF/view)
('On the nature of the young Tertiary ore veins in the volcanic inner arc of the Sunda system'. During M-U Miocene Sunda Mountain system became geanticlinal. Associated intrusions of granitoid batholiths caused gold-silver mineralization. No figures)

('On the significance of the gravity anomalies in the Netherlands Indies'. Belt of negative gravity anomalies identified by Vening Meinesz and explained by him as downwarping/buckling of light sialic crust thought to be better explained with Van Bemmelen’s ‘undation theory’)

('Critical discussion of Bijlaard's theory on plastic deformations of the Earth's crust')

('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)

('The isostatic anomalies in the Indies Archipelago'. Discussion of models explaining belts of negative gravity anomalies by crustal downbuckling (Vening Meinesz, Bijlaard, Umbgrove, Kuenen). These models do not explain observed asymmetric thrust tectonics. VanB proposes alternative 'fixist' 'undation theory')

(Review of regional gravity anomalies and apparent relations to deep-focus earthquakes, with interpretation)

(Also in 1970 reprint edition by Martinus Nijhoff Publishers, with updated references list)
(Classic, monumental overview of pre-WWII knowledge of Indonesia geology, in 3 volumes. Still the most comprehensive compilation of geology of region. Excellent documentation of state of knowledge of regional geology and stratigraphy of Indonesia at end of colonial period. Many of the tectonic interpretations using the 'undation theory' model are controversial and outdated)

(Box set of 41 plates and Literature references list, accompanying vol. 1A)

(Comprehensive review of deposits of oil, coal, metals, industrial minerals in Indonesia, as known in 1949)

(Online at: https://drive.google.com/file/d/1VmYPZcRfi805lErwX2tKGVTeF7M89i6j/view)
(On relationships between igneous rock types and tectonic settings. Rather outdated)

(Similar title to Van Bemmelen 1939. Only vertical movements are result of endogenic forces; all other tectonic forces are reactions to gravitation: (1) 'epidermal' (within sedimentary cover: slumping, volcano-tectonic collapse (Tambakan Ridge folding N of Bandung), free gliding (Karangkobar, C Java, Seram, Timor, Jambi nappes), compressive settling in lows (Samarinda anticlinorium in E Kalimantan, Kendeng zone in E Java), etc.), (2) 'dermal' (includes crystalline crust; Flores, Npart of southern mountains from Lombok to W Java), (3) bathydermal' (sideways displacement mainly in lower crust; Sunda Straits) and (4) subcrustal (sideward displacements in base of crust or deeper). With examples from Indonesia)

(‘The geological history of Indonesia’. Popular summary of Indonesia geological evolution)

(‘Relations between volcanism and tectonics in Indonesia’. Summary of 1951 lecture. Uses Sunda Arc region as examples, but not much detail)

(Pre-plate tectonics text book on mountain building, primarily based on Indonesian geology and interpreted mainly in terms of the controversial 'undation theory'. Two parts: ‘Principles of mountain building’ (p. 1-35) and 'The orogenic evolution of the Earth's crust in Indonesia' (p. 36-167))

(Online at: https://drive.google.com/file/d/0B7j8bPm9Cse0QzA4cUJzVmlrNGM/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 ophiolithic 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 asthenolitic blisters at base of sialic crust. Etc. With Collette reply)

(‘The orogenetic evolution of Indonesia’. Another overview of Indonesia tectonic evolution in terms of Van Bemmelen's 'undation theory')

(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0N3RER1RoZ0J2d1E/view)
(Modification in Van Bemmelen's 'unique' tectonic views, now allowing some mobilism in his previously fixist 'undation theory'. Where 'mega-undations' (large mantle-driven uplifts) occur in continental areas, such as Gondwana, new oceanic basins will open up above a 'basaltic blister', with mid-oceanic rifts forming on crest by 'oceanization'. Overlying units drift sidewards under gravity, towards 'mega-undatory downwarps'. Not much on SE Asia)

(online at: http://igitur-archive.library.uu.nl/geo/2006-1215-204156/bemmelen_65_evolution.pdf)

(One of later papers by Van Bemmelen on his undation theory', first proposed by him in 1931, but debated from start and never found general acceptance. Unlike most of the rest of the world, Van B never accepted plate tectonics theory or subduction)

('Final?' review of Van Bemmelen's Undation theory, with short summary how it drives Indonesian tectonics)

(Review of global paleomagnetic data, including Sibumasu, Borneo, E Indonesia, etc.. Misool-Timor probably not continuously part of Australian Plate: Misool paleolatitudes 10-20° lower than predicted if remained with Australia. Good paleomagnetic data set for Borneo suggests all paleolatitudes close to Equator. Large rotations suggested for Cretaceous of Sumba and Timor, etc.)

Van Es, L.J.C. (1918)- De voorhistorische verhoudingen van land en zee in den Oost-Indischen Archipel, en de invloed daarvan op de verspreiding der diersoorten. Jaarboek Mijnwezen Nederlandsch Oost-Indie 45 (1916), Verhandelingen 2, p. 255-304.
(The prehistoric relationships of land and sea in the East Indies Archipeago and its influence on the distribution of the animal species'. Pliocene paleogeography of Indonesian archipelago)

Van Es, L.J.C. (1919)- De tectonieke van de westelijke helft van de Oost Indische Archipel. Jaarboek Mijnwezen Nederlandsch Oost-Indie 46 (1917), Verhandelingen 2, p. 15-144.
(‘The tectonics of the western half of the East Indies Archipelago’. Synthesis of Western Indonesia geology as known in 1917. With 4 map sheets)

Van Es, L.J.C. (1930)- Beschouwingen over een nieuwe geotektonische kaart van Nederlandsch-Indie. De Mijningenieur 11, 32p.
('Comments on a new geotectonic map of the Netherlands Indies'. Critical discussion of new tectonic map of Indonesia by Zwierzycki (1929-1930))


(online at: http://62.41.28.253/cgi-bin/) (Critical review of Van Bemmelen's (1932) new tectonic 'undation theory' and its application to the western part of the Sunda Arc. With discussion of Sumatra geology, which is not believed to fit 'undation theory')

(online at: www.dwc.knaw.nl/DL/publications/PU00015922.pdf) (First account of Vening Meinesz' well-known shipboard gravity work. Principal feature discovered is 'Axis of Vening Meinesz', a ~100 miles wide narrow strip of strong negative anomalies through whole archipelago (W of Sumatra, S of Java, islands of Timor, Tanimbar, Kei, Seram, then to North), bordered at both sides by fields of positive anomalies. With map of ship traverses and stations, and axis of negative gravity anomalies)

(online at: www.ncg.knaw.nl/Publicaties/Groen/pdf/03VeningMeinesz.pdf) (First report on marine gravity surveys in Indonesia and other areas)

(online at: www.dwc.knaw.nl/DL/publications/PU00016417.pdf) (Speculation on process of mountain building, mainly driven by VM's observation of long belts of highly negative gravity anomalies and associated earthquake centra in Indonesian region. Apparent crustal downbuckling and associated folding-thrusting are early stages of alpine-style mountain building. 'Probable that the earth's crust is pushing laterally under the islands of the Indonesia orogenic belt'. (No figures)

(online at: https://www.ncgeo.nl/downloads/04VeningMeinesz.pdf) (Includes chapters on 'Relation between geology and gravity field in the East Indian Archipelago' and 'Theories on the origin of the East Indian Archipelago' by Umbgrove (p. 140-182) and 'Relations between submarine topography and gravity field' by Kuenen (p. 183-194))

(online at: www.ncg.knaw.nl/Publicaties/Groen/pdf/04VeningMeinesz.pdf) (One of first Indonesia-wide gravity anomalies maps. Control density is limited, but clearly shows belts of negative anomalies outlining accretionary wedge belts, maximum positive anomalies for oceanic basins, etc. First paper to suggest trenches with their negative anomalies are site of seafloor 'downbuckling', later understood as subduction)

(Geophysical work in Netherlands Indies and other regions no clear data to support or negate the Wegener theory of continental drift)


(online at: www.dwc.knaw.nl/DL/publications/PU00017410.pdf)

(New regional isostatic gravity anomaly map of Indonesia. Shift of axis of Sunda-Banda trench minimum gravity zone between Sumba and Timor)


(online at: www.dwc.knaw.nl/DL/publications/PU00015922.pdf)

(Earthquake centres in 3 groups: (1) shallow (<60 km) in rigid crust and mostly in tectonically active areas; (2) intermediate shocks at depths of 60-300 km, and (3) deep shocks between 300-700 km. In many cases these centres are more or less located in inclined planes cutting surface in belts of strong tectonic activity. No deep shocks in Sumatra area. Deep earthquakes tied to convection currents in mantle)


(Early paper on belts of strong negative gravity anomalies and VM's theory of 'crustal downbuckling' (which came close to recognizing subduction). Main tectonic arcs of Indonesia caused by SSE movement of inner crustal block relative to crust outside arc and, for second tectonic arc, by movement of a NE block in E direction. Mantle convection currents may account for relative block movements and crustal compression and also explain deep and intermediate earthquake foci, the sinking of the deep basins, etc. North Makassar Straits, Celebes Sea and N and S Banda Seas positive isostatic anomalies of +50- +100 mgal (remarquably, no mention of Van Bemmelen work/theories)


('Preliminary account of a geological trip through the eastern part of the Indies Archipelago'. Early summary of Verbeek (1908) book)


('Moluccas Report- geological reconnaissance trips in the eastern part of the Netherlands East Indies archipelago'. Classic early geological reconnaissance survey of 250 islands in E Indonesia, and last of Verbek's voluminous reports on geology of parts of Indonesia. Includes brief paleontological reports by specialist paleontologists. 'Old schist formation' metamorphics rel. widespread. Permian present on Timor and adjacent islands, possibly also on Ambon and Babar. Locally bituminous Triassic brachiopod limestones on Ambon. Widespread marine Mesozoic sediments. Triassic- Jurassic rocks and faunas similarities with Himalyas and Alps, etc.)


(French edition of Verbeek (1908))


(Another model of Asia tectonic plates relative horizontal motions from GPS measurements)

(Landforms in Indonesia resulted primarily from plate tectonics. Greatest relief amplitudes near plate boundaries: deep ocean trenches at subduction zones and mountain ranges at collision belts. Living and raised coral reefs, volcanoes, and fault scarps are important geomorphic indicators of active plate tectonics)


(E Indonesia 3 main plates (Eurasian, Indo-Australian, Philippine-Pacific), 7 blocks (six from NE Gondwanan margin, Halmahera from Pacific plate). Timor and Kolonodale (or Argo) blocks came from NW Australian margin. Lucipara, Seram and Banggai-Sula blocks originated from W extension of PNG while Irian Jaya block is still linked to N Australian margin. Timor and Kolonodale blocks detached from Gondwana in Jurassic; Lucipara, Seram and Banggai-Sula detached from PNG in Neogene. All Gondwanan blocks collided with Eurasian active margin near Sulawesi. Timor and Kolonodale joined Eurasian margin by end Paleogene. Lucipara, Seram and Banggai-Sula collided with Sulawesi between M Miocene- M Pliocene and, with Kolonodale, suffered opening of N and S Banda back-arc basins by Late Miocene. Timor block moved S with S margin of S Banda basin and collided with N Australian margin in M Pliocene)


( Geodynamic reconstruction based on evolution of 4 continental blocks, trapped by convergence of Asian, Australian and Pacific plates: (1) Banda (= dismembered E Sulawesi, Buru, Seram, Sinta Ridge), (2) Banggai-Sula, (3) Lucipara (S Banda Ridges, Tukang-Besi Ridge + Kur, Tanimbar; Oligocene-E Miocene arc, with E Miocene metamorphism event) and (4) Halmahera. Main events: (1) Late Eocene-Oligocene collision Banda block- Sulawesi; (2) E Miocene collision Lucipara Block (incl. Tukang Besi)- Banda Block in Buton; (3) Late Miocene extension with opening of N. Banda, S. Banda, Savu basins; (4) E Pliocene collision Banggai-Sula- E Sulawesi; (5) Late Pliocene collisions of Australia and Banda and Irian Jaya blocks. Timor with its Late Miocene calc-alkaline intrusions in N was part of Banda Arc before M Pliocene collision with Australia)


(‘Earthquakes with very deep source in Netherlands Indies’. Describes Berlage (1937) observation that deep-focus earthquakes occur along inclined surface, dipping 30-40° from borders of ocean under continent in Indonesia)

Visser, S.W. (1937)- A connection between deep-focus earthquakes and anomalies of terrestrial magmatism and gravity. Terrestrial Magnetism and Atmospheric Electricity 42, 4, p. 361-362. (online at: www.agu.org/journals/te/v042/i004/TE042i004p00361/TE042i004p00361.pdf)

(Deep-focus earthquakes occur in well-defined areas. Loci deeper than 600km in Japan, Philippines, Moluccas, Java Sea, etc., all along inclined surface, sloping 30-40° from borders of ocean down below continents.)
Associated with axis of negative gravity anomalies of Vening Meinesz. May be related to current systems in inner earth (NB: first discovery of what later became known as Wadati-Benioff zone; JTvG))


Voris, H.K. (2000)- Maps of Pleistocene sea levels in Southeast Asia: shorelines, river systems and time durations. J. Biogeography 27, 5, p. 1153-1167. (Rather simplistic series of maps from Australia to Sri Lanka to Taiwan showing areas of exposed land in Indo-Australian region during periods of Pleistocene when sea levels were below present day levels)


Wakita, K. (1997)- Oceanic plate stratigraphy and tectonics in East and Southeast Asia. In: P. Dheeradilok et al. (eds.) Proc. Int. Conf. Stratigraphy and tectonic evolution in Southeast Asia and the South Pacific (GEOTHAI'97), Bangkok, Dept. Mineral Resources, 1, p. 388-401. (Components of ancient accretionary complexes include pillow basalt, limestone, radiolarian chert and shale, ultramafic rocks, glaucophane schist, etc. Radiolarian biostratigraphy useful for reconstruction of accretionary complexes, as shown in example of Luk-Ulo Melange of C Java. Lithologic successions in different tectonic units similar and reflect 'Oceanic Plate Stratigraphy' sequence: (1) birth of oceanic plate at oceanic ridge, (2) formation of volcanic islands near ridge covered by reefs (= Orbitolina Limestone?; HvG), (3) calcilutite sedimentation at flank of volcanic islands, (4) pelagic deposition of radiolarians on oceanic plate, (5) mixing with detrital clays to form hemipelagic siliceous shale, and (6) sandstone-shale near trench of convergent margin. Radiolarian biostratigraphy of Luk Ulo show Valanginian-Campanian oceanic chert deposition)

(Cretaceous accretionary complexes in W Java (Ciletuh), C Java (Karangsambung, Jiwo), S and C Sulawesi and SE Kalimantan (Meratus, Pulau Laut) reflect Cretaceous convergent SE margin of Sundaland craton, which was surrounded by marginal sea, with immature volcanic arc at periphery. Oceanic plate subducted beneath arc from S, carrying microcontinents detached from Gondwanaland. Accretionary wedge with fragments of oceanic crust. Jurassic shallow marine allochthonous formation was emplaced by collision of continental blocks in Bantimala, S Sulawesi. Collision exhumed very high pressure metamorphic rocks from deeper parts of accretionary wedge)

(Ancient accretionary wedges recognized by glaucophane schist, radiolarian chert and melange. Typical ‘Ocean Plate Stratigraphy’ (OPS) from old to young: pillow basalt (birth of oceanic plate at mid-ocean ridge), limestone (ridge covered by reefs), radiolarian chert (pelagic sediment), siliceous shale (mixed radiolarians and detrital grains in hemipelagic setting) and shale- sandstone (sedimentation at or near trench of convergent margin). Radiolarian biostratigraphy provides information on time and duration of ocean plate subduction)


(Sundaland surrounded by accretionary complexes and accreted microcontinents rifted from Gondwanaland. Cretaceous accretionary complexes in C Java, S Sulawesi and S Kalimantan similar components, but different histories. Luk-Ulo, C Java, subduction complex formed by continuous subduction of oceanic plate throughout Cretaceous. Meratus (S Kalimantan), also product of oceanic plate subduction in island arc setting. Bantimala, S Sulawesi, ocean plate subduction followed by collision of continental fragment)

(On processes of accretion of continental blocks in Tertiary in SE Asia and W Pacific. Subduction associated with back-arc extension, particularly in Indonesia and SW Pacific region. Arc-arc collisional complexes present in Taiwan, Philippines and Japan. Geological record of SE Asia and W Pacific provides modern analogue for geological and tectonic history of Central Asian Orogenic Belt)

(Earthquake data (ISC 1970-1986) used for interpretation of East Indonesia tectonics)


(‘Triassic fossils from the Moluccas and Timor Archipelago’. Late Triassic molluscs, corals, ammonites faunas from Misool (Carnian dark shales with Daonella), Serum (typical Tethys-Mediterranean Norian molluscs Monotis salinaria, Amonotis and brachiopod Halorella). From Serum limestone come corals Thecosomilia n.sp. aff. clathrata and Montivallia molukkana n.sp. and Pachypora intubulata n.sp. (= Lovcenipora vinassai; JTvG). Also Triassic fossils from Timor-Roti- Savu (generally deeper water facies, but potentially similar ‘alpine’ character with mainly Halobia, Daonella, but also ‘Pacific’ mollusc Pseudomonotis ochotica).
Timor/Roti/ Savu Triassic reminiscent of North Sumatra Upper Triassic described by Volz, 1899. First author to recognize Alpine/Tethyan affinities of Late Triassic bivalves and ammonites of Seram and Timor)

(online at: www.biodiversitylibrary.org/item/192869#page/159/mode/1up)
('Some geological results of a 1909 trip through the eastern part of the Indo-Australian Archipelago; preliminary communication'. Summary of journey to Misool (fossil-rich Mesozoic), C Halmahera (ultramafic rocks, ?Mesozoic red-brown radiolarite, Tertiary clastics), Obi (found M Jurassic Stephanoceras and other ammonites at W coast along Akelamo River, and Miocene fossil-rich clastics) and Timor (Permian rich in fossils, Eocene Alveolina- Nummulites limestones, etc.. No figures)

(online at: www.biodiversitylibrary.org/item/192869#page/766/mode/1up)
('News on the Permian, Triassic and Jurassic formations of the Indo-Australian Archipelago'. Short note on Timor Permian ammonites (incl. common Agathiceras), and U Triassic fauna of platy limestone of Bukit Kandung/ Lurah Tambang in W Sumatra, previously decribed by Boettger and interpreted as Eocene, with Myophoria, Cardita. Fauna very similar to Nucula Marl of Misool and probably of U Norian age. No figures)

(online at: https://www.digizeitschriften.de/dms/img/?PID=GDZPPN000456594)
(Early paper on the tectonics of the Moluccas, with focus on geology of Buru Island)

('The Malayan geosyncline in the Mesozoic’. Rel. lengthy review of Mesozoic stratigraphy and macrofaunas across Indonesia. No figures)

(online at: www.repository.naturalis.nl/document/549766)
(Listings of Paleozoic- Neogene echinodermata described from Indonesia. Permian of Timor richest in world with 320 species (50 blastoids, 270 crinoids). Number of Mesozoic species ~10% of Permian, mainly in Triassic. In Jurassic only two species, Pentacrinus rotiensis from Roti and Holecypus from Buru, Cretaceous similarly poor). Tertiary 85 species)

(online at: www.repository.naturalis.nl/document/549402)
(Comprehensive review of distribution of Mesozoic rocks and fossils in E Indonesia, Sumatra, Borneo, etc.. With correlation tables for Triassic, Jurassic and Cretaceous)

(‘Rock-building foraminifera from the Malm and Lower Cretaceous in the eastern East Indies Archipelago’. First description of Upper Jurassic calcispheres (Stomiosphaera moluccana, Cadosina fusca) from Timor, Misool, Seram, Roti, Buton and E Sulawesi. Marker species for Tethyan latest Jurassic (+earliest Cretaceous?) (NB: these are not foraminifera; JTvG)
(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 Taranera- 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)

(on line at: www.iagi.or.id/fosi/ )  
(Brief review of ongoing Indonesia research projects at University of London/ Royal Holloway group)

(on line at: https://babel.hathitrust.org/cgi/pt?id=uc1.$b34771;view=1up;seq=1)  
(‘The origin of the continents and oceans’. Third edition of classic book on continental drift theory and breakup of Pangea supercontinent after Late Carboniferous. Explanation for arcuate shape of Banda Arc by NW movement of Australia- New Guinea continent into Indonesian archipelago)

(‘Summary of paleomag data from E Indonesia. Timor: Permian is displaced terrane of Australian origin; Early Cretaceous deep sea sediment formed ~1000km to S, shifted N with N drift of Australia). Original position of Misool rel. to Australia was farther N than today)

(on line at: www.dwc.knaw.nl/DL/publications/PU00016993.pdf)  
(Great petrographic uniformity of tin-bearing and related granite rocks of Inner Malayan Arc (Malay Peninsula, Indonesia Tin Islands, etc.) Tin-granites end-stages of differentiation of acid magmas, with proportions of main constituents not essentially different from non- tin-bearing biotite-granites)

Westerveld, J. (1939)- Metaalprovincies in Nederlandsch Oost-Indie. Public address at the start of position of lecturer in economic geology at the University of Amsterdam. Amsterdam, 30p.  
(‘Metal provinces in the Netherlands East Indies’. Four main metallogenic provinces: (1) tin islands Bangka-Billition, etc. (2) Gold-silver mineralization on Sumatra, associated with ?Cretaceous intrusives, (3) W and S Sumatra gold-silver associated with post-Miocene intrusives and (4) nickel-iron in Banda Arc- E Sulawesi, associated with ultrabasic rocks. No figures)

(‘Phases of mountain building and ore provinces in Netherlands East Indies’.Review of tectonics of Indonesia and associated mineral deposits. W of New Guinea four concentric orogens: (1) Late Jurassic ‘Malaya orogen’, connecting W Borneo with E Burma through Malaya, with tin, gold and bauxite; (2) Cretaceous ‘Sumatra orogen’ (Sumatra-Java- SE Borneo), with Au-Ag-bearing base metals in Sumatra, iron laterites and diamond-gold placers in Borneo (3) M Miocene ‘Sunda orogen’ from W Burma through inner Sunda islands to W arc of Sulawesi, with epithermal Au-Ag-and Mn-ores; (4) Late Cretaceous- M Miocene ‘Moluccas orogen’ through outer Sunda islands and E arm of Sulawesi, with nickel and lateritic iron ores on peridotites. Good maps of ore deposits)


(Absence of measurable dynamic topography in SE Asia)


(online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2001TC900023)

(Models of dynamic topography generated by subducting slabs, predict ~1-2 km of subsidence on wavelengths of 100-1000 km. Existence of such subsidence important for understanding basin formation, relative sea level changes, etc. Analysis of SE Asia constrains maximum amplitude of dynamic subsidence to ~300m with range of 0-500 m, less than predicted. Distribution of anomalous subsidence suggests this may not be caused by dynamic topography and subducting slabs)


(Plate motions and reconstructions of subducted ocean floor used to analyse subduction kinematics and observed upper plate strain since 80 Ma along Sunda-Java trench. Upper plate advance and retreat is main influence on upper plate strain, but subduction of large bathymetric ridges also significant. Compression in Sundaland back-arc region linked to upper plate advance. Sundaland backarc extension correlates with (a) retreat of upper plate, and (b) advance of upper plate with more rapid advance of Sundaland margin due to hinge rollback. Subduction of large bathymetric ridges causes compression in upper plate, especially Wharton Ridge subduction under Sumatra between 15-0 Ma)


(Report on a 1888-1889 geographic reconnaissance trip to Indies Archipelago- part 1 (Java, Sulawesi) by first geology professor at University of Utrecht, A. Wichmann, supported by Netherlands Geographical Society. Mainly travel and scenery descriptions)


(Geological results of rocks collected during the 1899-1900 Siboga marine expedition around Banda arc islands, etc. Schists-phyllites-amphibolites on small islands between Seram and Kai strikingly similar to Seram pre-Upper Triassic (Valk 1945, p. 38))

$\text{#Widiyantoro, S., J.D. Pesicek & C.H. Thurber (2011)- Complex structure of the lithospheric slab beneath the Banda arc, eastern Indonesia depicted by a seismic tomographic model. Research in Geophysics 1, 1, p. 1-6.}$


(New seismic tomographic images of E Indonesia confirm previous observations of spoon-shaped structure of subducted slab beneath curved Banda arc. A slab lying flat on 660 km discontinuity beneath Banda Sea also well imaged. Data support scenario of Banda arc subduction rollback. Slab detachment beneath Buru also confirmed by new model)


(New seismic tomographic images across Sunda Arc from Java to Timor. Confirm previous observations of hole in subducted slab in upper mantle beneath E Java, which may be related to arrival of buoyant plateau near E Java at ~8 Ma. Images also suggest tear in slab below E-most part of Sunda arc, where downgoing slab is deflected in mantle transition zone, possibly related to arc-continent collision around Timor at ~3 Ma)

('S-wave travel time tomography and 3-D structure of the subduction zone beneath the Sunda Arc'. Tomographic imaging using S-wave traveltime show 3-D mantle structure below Sunda arc subduction zone. Lithospheric slab penetrates into lower mantle beneath Sunda arc. Under Sumatra deep slab may be detached from seismogenic slab, under Java slab in upper mantle is necking)


(Tomographic imaging reveals seismic anomalies below Sunda island arc, suggesting lithospheric slab down to at least 1500 km. Sunda slab forms E end of deep anomaly associated with past subduction of Mesozoic Tethys Ocean. Lithospheric slab continuous feature from surface to lower mantle below Java, with local deflection where slab continues into lower mantle. Deep slab seems detached from upper mantle slab beneath Sumatra)


(Tomographic inversions give images of subducted slabs. Beniof zone steep (60°N) below Java, gently dipping at 60° W below E Banda Arc. Sunda Arc slab below 300 km looks detached in Sumatra, possibly also in Java)


(Brief review of geodetic results and precision of 1994-1998 GPS project with 42 observation stations across SE Asia. Sundaland block does move E relative to stable Eurasian plate. Island of Biak moved >1 m horizontally due to two heavy earthquakes in 1996. Etc.)


('On GEODYSSSEA Geodynamics of SE Asia GPS project')


('The origin of the Malay Archipelago in the light of Wegener's hypotheses'. Early paper in support of Wegener's continental drift theory. Major differences in geology between W and E part of 'Malay Archipelago' lend support to model of series of drifting continental plates, with E Indonesian islands derived from Australia)
Wing Easton, N. (1921)- On some extensions of Wegener's hypothesis and their bearing upon the meaning of the terms geosynclines and isostasy. Verhandelingen Geologisch-Mijnbouwkundig Genootschap Nederland Kol., Geol. Serie 5, p. 113-133.

(General discussion of Wegener's continental drift theory, with few references to W Borneo geology. Mainly of historic interest, showing early support for Wegener in the Netherlands Indies)


(251 geothermal fields identified in Indonesia. 80% can be tied to volcanic processes, in four volcanic arcs)


(Most or all mafic-ultramafic assemblages in E Indonesia may be regarded as ophiolites, but complete suites only on Timor and E Sulawesi. W Timor ophiolites limited to Mutis Zone, where low-angle overtrusts of allochthonous units commonly have sheared/ serpentinized ultramafics at base. Overlying ultramafic base are metamorphics and Permian-Triassic limestones associated with volcanics that probably developed on ancient seamounts. Two parallel ophiolite belts in W Papua, where N-dipping subduction zone at N margin of Australian Plate during Late Cretaceous- Eocene changed to S-dipping subduction in M-L Miocene and later)


(online at: www.gsm.org.my/products/702001-101144-PDF.pdf)

(Model for Tertiary deformation of SE Asian plates, linking Wrench Tectonics and Plate Tectonics. Irian shear system, Sabah shear system, Trans-Borneo shear system, etc. Back-arc basins form along margins of major continental plates where there is large component of strike-slip movement due to oblique plate convergence)


(online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2016GL068050)

(Rift basins developed extensively across Sundaland since Eocene. Starting in E Miocene, basins in S Sundaland experienced poorly understood, widespread synchronous compression (inversion) and marine inundation, despite large drop in global sea level. Models suggest slab stagnates in transition zone beneath SE Asia before Miocene, but penetrated through 660 km mantle discontinuity during E Miocene and formed slab avalanche event, causing large-scale marine inundation, compression and basin inversion across S Sundaland (poor fit between subsidence predition model and observed subsidence?; also, most or all Sundaland basins timing of early inversion and inundation not synchronous?; JTvG))


(Triassic and Jurassic sandstones from outer Banda Arc islands Timor, Babar and Tanimbar texturally immature, with volcanic quartz. Heavy minerals mainly from acidic igneous and metamorphic rocks and also ultramafic material. Zircon populations similar to Triassic sandstones of Birds Head, not nearby Australian continent. Cretaceous sandstones from Sumba, E Timor and Tanimbar with zircons suggesting reworking of Triassic and Jurassic sediments, but also Jurassic and Cretaceous zircons. These represent fragments rifted
from Australian margin in Late Jurassic and added to SE Asia in Late Cretaceous which record volcanic activity associated with rifting and accretion to active Sundaland margin)

(Most Triassic-Jurassic sandstones of Banda Arc between Timor and Tanimbar quartz-rich and of recycled origin and/or continental affinity, but commonly texturally immature and with volcanic quartz and lithics. Heavy mineral assemblages dominated by rounded stable minerals, but also angular grains and origin from acid igneous and metamorphic sources. Detrital zircon ages Archean-Mesozoic, suggesting source mainly from Birds Head/ Sula Spur, W and C Australia in Triassic. In Jurassic new local sources close to Timor and recycled NW Shelf material. Tanimbar Islands and Babar sediment came from both Australian continent and Birds Head. Sandstones in Timor dominant acid igneous signature in E and metamorphic sources in W (NB: ignoring key papers on similar topic by Ely 2009, 2014, Zobell 2007, Kwon et al. 2014, JTvG))

(Same as Zimmermann and Hall 2016, above)

(‘Overview of the Triassic formations in Indonesia’. Lower- Middle Triassic found only on Timor; U Triassic present on Savu/ Roti, Timor, Leti/Babar, Ceram, Ambon, Misool, Buru, Buton, Borneo, Lingga, Sumatra and Malay Peninsula. Everywhere in Indonesia U Triassic developed in ‘Alpine facies’. With one overview map)


(‘Explanatory notes of the geotectonic map of the Netherlands East Indies’. With map at scale 1:5,000,000. Assumes all metamorphic rocks are Paleozoic or older and maps limited number of ’orogenic periods’: mid-Cretaceous (Sumatra), base Eocene?, Miocene (East), Late Pliocene (West part of archipelago))
I.2. SE Asia Regional Geology, Tectonics, Paleobiogeography


(Cretaceous- Cenozoic paleomagnetic data show negligible rotation of S China and CW rotation of Indochina, consistent with Tapponnier India indentation model. Malaya and Borneo data can be reconciled with model, but less straightforward. Large CCW rotation of S Tibet implies rotation with India during collision. M Cretaceous reconstruction of S margin of Asia shows continuity of geological features in Tibet and Indochina, with active subduction of Indian plate oceanic crust taking place to S at subtropical latitudes)

(Plate tectonic history of SE Asia, with emphasis on India-Andaman region. Tibetan and 'Sibumasu' continental blocks rifted from N margin of Gondwana Indo-Australia in Permian; Indo-Burma-Andamans, Sikuleh, Lolotii micro-continents in Late Jurassic. Tibetan and Sibumasu blocks drifted N in M-L Permian, opening Neo-Tethys. Indian and Australian continents separated in Cretaceous opening up Indian Ocean and closing Tethyan ocean. Etc.. Ophiolite trail on IBA does not represent E suture of Indian continent. Convergence between Australian continent and Indonesian Arc emplaced Lolotii continental rocks. Maubisse exotic blocks and ophiolitic rocks as nappes over Timor shelf, which possibly remained attached to Australian continent.)

(Tibetan and Sibumasu- W Yunnan continental blocks were located near proto-Himalayan part of Indian continent, rifted and drifted from N margin of E Gondwana continent in Late Paleozoic. Indo-Burma-Andaman, Sikule and Lolotii blocks rifted and drifted from same margin in Late Jurassic, followed by break-up of Australia-India-Madagascar continental block in Cretaceous)

(Late Triassic brachiopod Misolida widely distributed in S Tethys; recorded from Middle East to E Indonesia (Misool, Timor, Seram). Halorella/ Timorhynchia more typical of Late Triassic northern Tethys margin))

(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)

(Critical discussion of McCarthy 2005 paper that describes Pacific history in expanding earth model))

(Cimmerian terrane almost unbroken chain stretching >13500 km, from S Europe, via Middle East, Afghanistan, Tibet, SW China, Myanmar to W Indonesia. Example of 'sliver terrane' dwarfing other examples like Palawan Block in W Philippines and Lord Howe Rise in Tasman Sea. Dispersal from Gondwana in E Permian. Sibumasu lay offshore of Australia; Qiangtang and Lhasa off Greater India- SE Arabia)

(Permian chonetidine brachiopods allow distinction of five Permian Gondwanan faunal provinces: Andean, Paratitan, Austrazean (E Australia- New Zealand), Westralian (W Australia) and Cimmerian (Cimmerian terranes, from Tunisia, Himalayas, Thailand, Sumatra, Leti to W Papua). With description of Waterhouseiella n.gen. for Waagenites speciosus))

(Three provinces of SW Pacific Permian faunas: (1) Cimmerian (Arabia to Irian Jaya, Timor: cold earliest Permian with bivalve Eurydesma, etc., warm-tropical later in E Permian), (2) Westralian (cold earliest Permian followed by temperate faunas, with tropical elements only in Late Permian) and (3) Austrazean (E Australia- New Zealand, New Caledonia) cold and cool temperate conditions throughout Permian). Marine Triassic faunas two provinces: (1) Tethyan- cosmopolitan, (2) cool Maori Province in New Zealand (not including Torlesse))


(Conodonts, fusulinid foraminifera and ammonoids, commonly used for Permian correlations, are absent or rare in Gondwanan marine sequences. Marine faunas of Permian exhibit pronounced provincialism. W Australia marine sections 18 brachiopod zones and offer correlation interface between new global standard and extensive Permian sequences of Gondwana)


(Correlation tables of E Permian formations and faunas from Gondwanan and peri-Gondwana regions. Incl. Malay Peninsula and Timor Somohole ammonoid fauna (E Sakmarian?) and Binsnain brachiopod fauna (Late Sakmarians)

(Australian continent was major component of NE Gondwana in Permian. Surrounding what is now Australia, were additional elements of NE Gondwana that are now incorporated into New Zealand, New Caledonia, New Guinea, Timor, SE Asia, Himalaya and S Tibet. Pronounced provincialism of global marine faunas in Permian. Brachiopoda can be used to define Westralian and Austrazean provinces)

(Permian of 16 regions of NE Gondwana compared with Australian continent. Paleoclimatic changes and tectonic events: (1) Asselian- E Artinskian change from cold to temperate environments, associated with basaltic volcanism and initial rifting of peripheral N Gondwanan margin; (2) Late Artinskian-Kungurian warming with onset of carbonate deposition in several Cimmerian terranes. Basaltic volcanism in several terranes indicative of rifting and opening of Meso-Tethys; (3). Roadian (Late Ufimian) and (4) Wordian-Capitanian: widespread, subtropical, marine carbonates on Cimmerian blocks as they drifted N and on N parts of Meso-Tethys S margin. Equivalent carbonates in subsurface W Australia. Andesitic volcanism in E Australia; (5) Wuchiapingian: marine transgressions extending into NW basins of Australia; (6) Changhsingian: minor marine transgressive events in Trans-Himalaya with Selong section of Tibet most complete Permo-Triassic for S Meso-Tethys margin)

(First description of late E Permian articulate brachiopods in Birds Head. Assemblage similar to Thailand Rat Buri Limestone, suggesting geographical proximity of Thailand and Irian Jaya in E Permian)

(W Australian Permian brachiopod faunas mixture of Gondwanan, endemic Westralian and Asian (Tethyan) genera. Presence of Tethyan genera largely temperature dependent; no apparent geographical barriers to migration of such genera into intracratonic basins of W Australia. Paleotemperature curve indicates peak warm conditions in Sterlitamakian and Late Baigendzhinian and subtropical conditions in Dzhulfian)


(Australian E Jurassic ostracod faunas similar to W Tethyan and C European assemblages, probably indicating communication route along western Tethys, aided by action of western currents)

(Gigantopteris is typical Cathaysian flora, best developed in N and NE China and Korea, but also in Yunnan and extending S to Malay Peninsula (Johore). Gigantopteris species described from E Permian Jambi flora of W Sumatra by Jongmans & Gothan 1935 differ from typical Gigantopteris flora. Djambi flora may still belong to Cathaysian flora, but probably older than typical Gigantopteris flora. W New Guinea Permian flora most likely part of Glossopteris flora)

(Mainly on classification and evolution of 'Cathaysian' Permian Gigantopteris flora. C Sumatra Permian Jambi flora typical Asian Gigantopteris flora, not Gondwanan Glossopteris flora)

(Model of E Gondwanaland on basis of distribution of floras and faunas, lithofacies patterns and identification of Triassic magmatic arc that characterized E margin of Gondwanaland. Continental fragments that rifted from
N Australia-New Guinea in Jurassic identified as S Tibet-Burma-Thailand-Malaya and Sumatra. Sumatra attached to New Guinea through Triassic. Original site of deposition of Maubisse’ subtropical Permian limestones and tropical late Triassic limestones, overthrust onto N margin of Australia in late Cenozoic collision, is located in this greater Gondwanaland


(Reconstruction of continental blocks dispersal from E Gondwanaland from Latest Jurassic- Late Miocene. Burma-Malaya-Sumatra rifted off New Guinea in Jurassic and colliding with SE Asia in Late Cretaceous (clearly too late; JTvG), etc.)


Ben-Avraham, Z. (1978)- The evolution of marginal basins and adjacent shelves in East and southeast Asia. In: S. Uyeda (ed.) Active plate boundaries of the Western Pacific, Tectonophysics 45, p. 269-288. (In Mesozoic W Pacific Ocean and E Indian Ocean were parts of Tethys Sea, moving N relative to Antarctica, causing E-W Mesozoic ridge system, E-W trending magnetic anomalies and N-S transform faults. In Late Cretaceous-Eocene segments of spreading ridge gradually submerged at trenches to N, causing gradual change in direction of Pacific plate motion, separating Pacific and E Indian Ocean plates. Only remnant of Mesozoic ridge system today at W Philippine Basin)

(Plate reconstructions primarily driven by paleomagnetism)

(Global plate boundaries, showing 14 larger plates (incl. Australia, Eurasia, Pacific, Philippine Sea) and 38 small plates (in SE Asia-SW Pacific: Sunda, Burma, Molucca Sea, Banda Sea, Timor, Birds Head, Maoke, Caroline, Mariana, N Bismarck, Manus, S Bismarck, Solomon Sea, Woodlark, New Hebrides (Maoke Plate is newly-defined small tectonic plate in West Papua, underlying western Central Range/ Mamberamo area to Cenderawasih Bay)

(Cephalopod limestones of M Permian (M Guadalupian, Wordian) age at base of Hawasina nappes in Oman Mts are condensed sequence on N side of Arabian platform (or allochthonous unit thrust onto N margin). Ammonoid and conodont faunas remarkably similar to W Mediterranean (Siclily Sosio Lst) and Timor, suggesting unrestricted faunal exchange in Permian seaway along pelagic N margin of Gondwana (or distal margins of Cimmerian terranes?; JTvG))

(Three Paleoproterozoic crust-formation episodes in mainland SE Asia (2.5 Ga, 2.2-2.3 Ga and ~1.9 Ga), identified from zircons of Red River, Mekong, Salween and Irrawaddy Rivers)

(online at: http://library.dmr.go.th/library/Proceedings-Yearbooks/M_1/2002/6368.pdf)
(review of stratigraphy and fossils of Silurian- Permian of Shan-Tai (= Sibumasu) terrane of W Thailand. Rel. cool climate 'Gondwanan' faunas through E Permian. Includes carbonate-rich Ordovician, Silurian black graiotite shales, E Devonian carbonates and 'tentaculite' mudstones, E Permian pebbly mudstones, etc.)

(online at: http://library.dmr.go.th/library/Proceedings-Yearbooks/M_1/2007/12752.pdf)
(Scattered Cambrian- E Devonian lithofacies and biogeographic data from Himalayan area (Nepal, Xizang) consistent with Shan-Thai Terrane (= Sibumasu) having originally been E extension of former. E extension of S end of Shan-Thai Terrane in Sumatra is poorly known, with S half of New Guinea being a possibility)


(E Early Triassic ammonoid assemblages, incl. Timor, which is 'highly connected' with Afghanistan and S China, defining an equatorial tethyan group)

Cluster analysis of E Triassic ammonoid faunas. Timor grouped with Afghanistan, South China, Oman, Iran, etc., as S Tethyan cluster. (Very little detail on locations/origin of samples; JTvG)


Buerki, S., F. Forest & N. Alvarez (2014) Proto-South-East Asia as a trigger of early angiosperm diversification. Botanical J. Linnean Soc. 174, p. 326-333. (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)


Bunopas, S. & S. Khositanont (2004) Did Shan-Thai twice marry Indochina and then India?: a review. Bull. Earth Sci. Thailand (BEST) 1, p. 1-27. (Shan-Thai (= Sibumasu) and Indochina microcontinents migrated from W Australia since latest Devonian, to settle in Late Norian. During Late Triassic both microcontinents drifted up latitude and stayed in N Hemisphere. Pre-first continent-continent collision between Shan-Thai and Indochina occurred just under Equator as early as Early Triassic. Breakup of Pangea in Late Cretaceous time. At 45 Ma Himalayan extrusion, caused by 2nd continent-continent collision, began and have its paroxysm in M Miocene. Etc.)


(Extended version of Bunopas et al. 1991, Gondwana Research (2001). Collision of Sibumasu (Shan-Thai) and Indochina in late Norian terminatedPaleotethys in SE Asia, along suture zone from W Yunnan- Nan-Uttaradit-Sra Kaeo- Yala to Raub-Bentong at 23°N above Equator. Cenozoic CW rotation of Thailand of >30°)


(Two U Triassic (Carnian) palynoflora provinces: (1) Onslow of NW Australia (incl. European forms Camerosporites, Aulisporites, Enzonalasporites, Ovalipollis, Samaropollenites, Infernopollenites, Minutosaccus) and (2) Ipswich of S and E Australia. W Timor floras from U Triassic pelagic deposits placed in Onslow microflora. Suggests Onslow microflora assemblages, with minor variations, present from W Tethys to N Australian margin (W Timor))

(‘Tectonic problems in Indonesia’. Brief review of tectonics of Indonesia, with more detail on Tanimbar- Kai islands)

(Early paper describing amalgamation of Asia. Nine blocks defined. Paleogeographical, paleontological and tectonic evidence suggest Asia did not fuse completely until well into Mesozoic)

(Most small geological terranes in Indo-Pacific region rifted from Gondwana. Shan-Thai terrane rifted from Australia in Permian and collided with Indo-China in Triassic. Parts of Sumatra and Kalimantan may have rifted from Australia in Cretaceous and carried angiosperm flora N. Other terranes now in SE Asia and Pacific were part of Australian continent at various times in Cenozoic)

(Contiguity of Shan-Thai (=Sibumasu) Terrane and NW Australia suggested by faunal affinities in Late Cambrian trilobites, Ordovician molluscs, stromatoporoids, brachiopods and conodonts. Re-evaluation of E Paleozoic paleomagnetism places Shan-Thai against NW Australia. N China Block was next to N Australia/ New Guinea, rifted off in E Devonian or earlier. S China micro-vertebrates and conodonts suggest Shan-Thai still close to Australia in M Devonian)

(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1986009.pdf)


Burrett, C. et al. (2014)- 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 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-Tethyan Ocean.


Cai, J.X. & K.J. Zhang (2009)- A new model for the Indochina and South China collision during the Late Permian to the Middle Triassic. Tectonophysics 467, p. 35-43.

(Review of active subduction-collision boundary between Philippine Arc and Sunda margin, from Taiwan, S along Manila Trench, through thrust fault zone of Mindoro, to Negros Trench at E edge of Sulu Sea, then through thrust fault zone of Zamboanga to Cotabato Trench at E side of Celebes Sea/ Sangihe Arc)


(Review of stratigraphy/ fauna of marine Triassic outcrops of E Indonesia, New Caledonia, Australia and New Zealand. Including brief summaries of PNG (Yuat River gorge argillites with Anisian ammonites), Misool, Seram, Buru (Norian- Rhaetian Fogi Beds with Misolia), Timor-Roti and SE Sulawesi-Buton (late Norian Monotis subcircularis in Winto beds). No maps, strat columns)


(On link between large-scale Asian continent deformations and Indian slab subduction and breakoff. Formation of C Asian intracontinental faulting, the Bangong-Red River Fault and Altyn Tagh fault followed successive Indian slab breakoff episodes)


(online at: www.jodc.go.jp/info/ioc_doc/Workshop/015652eo.pdf)

(Overview of SE Asia tectonics and proposals by Katili et al. for SEATAR transect for future work)


(Geotectonic Map of E and SE Asia. Sheet 4: Philippines, Vietnam, S China, Sheet 5: Malaysia, W Indonesia, Sheet 6: E Indonesia)


(Tectonic maps E and SE Asia: Sheet 1: Shikhote Alin, Korea, NE China, Japan), Sheet 2: C and S China, Taiwan, Ryukyu arcs), Sheet 3: S China, Indochina, Malaysia, Myanmar), Sheet 8: W Pacific Ocean. Also available in digital format)


(Floral provincialism in S Hemisphere in Late Triassic characterized by Ipswich and Onslow provinces of E Gondwana here extended to NW Argentina. Previously considered part of Ipswich, but diagnostic Euramerican species in assemblages with Gondwanan taxa allows placing palynofloras in Onslow province)


(Focused on Western and Central Tethys; little or nothing on SE Asia/ Australia)
(Sambosan U Triassic shallow-water limestones remnant of mid-oceanic atoll on seamount in Panthalassan Ocean, accreted along with deep-water ribbon-cherts rocks to E margin of Asia in Late Jurassic- E Cretaceous. Seventeen microfacies distinguished. Foraminifers (incl. Triasina hantkeni) indicate Late Carnian- Rhaetian age. Tethyan affinity of faunas suggests Sambosan seamount located in low- middle-latitude of S Hemisphere during Late Triassic)


Chatterjee, S., C.R. Scotese & S. Bajpai (2017)-The restless Indian plate and its epic voyage from Gondwana to Asia: its tectonic, paleoclimatic, 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.)


(online at: https://academic.oup.com/gji/article/106/1/99/740584)
(Interesting 3-D displays of subducting slabs in W Pacific region (incl. Indonesia) (Benioff-Wadati zones of deep earthquake hypocenter distributions. Depth of deepest earthquakes decreases in W direction along Sunda Arc)


(Modeling of state of stress in Indo-Australian plate. Regional stress field along Sunda arc varies from compression seaward of and parallel to Sumatra trench to tension perpendicular to Java-Flores segment)

(Four granite provinces, each with its own pattern of cassiterite mineralization: 1) Main Range Province (Triassic), 2. Eastern Province, 3. Western (Peninsular Thailand-Burma) Province, 4. North Thailand Migmatitic Province. Peninsular Malaysia granites from Main Range and E Provinces two contrasted suites which correspond to I and S-types)


(online at: http://pubs.bgs.ac.uk/publications.html?pubID=804056)
(Extensive study of granites in Malaysia, Indonesia, Thailand and Myanmar. Not all granites have age-equivalent volcanics. Distinct belt. In Malaysian segment Permo-Triassic- lower Jurassic Eastern Belt with tin deposits (incl. Bangka- Bilitung calk-alkaline I-types in Indonesia) (mainly cassiterite-magnite skarns), while neighboring Central Belt more gold-bearing. Western Province Cretaceous granites with tin in S-type granites only. Rb-Sr ages for Bangka granites mainly ~220 Ma (213-229 Ma (Norian); in line with Priem and Bon (1982)). Some age results of 200 Ma, 251-252 Ma; Barber et al. 2005)

(Ordovician and Silurian paleogeographic maps, some with W Papua data control points)

(Paleogeographical reconstructions for 11 intervals from M Cambrian- end Permian through E Asia region, centred on continental blocks of N China, S China and Annamia (Indochina). Annamia and S China left Gondwana margin area together during Lower Devonian opening of Paleotethys Ocean, but shortly afterwards they separated into two, not to reunite until Triassic. Cambrian- Permian rocks in Japan largely represent active volcanic arcs which originally lay to SE of S China. Neotethys Ocean opened in M Permian, dividing Sibumasu and Tibetan terranes from Gondwana, and Palaeotethys Ocean started to close)

(Plate motion of India changed dramatically between 50-35 Ma, with convergence between India and Asia dropping from 15 to 4 cm/yr, coincident with onset of India-Asia collision. Apparent relationship between plates velocities and length of subduction zones along boundaries, probably reflecting importance of slab pull as driving mechanism)

(> 7 Mid-Devonian ‘Great Barrier Reefs’, including S. China plate (Vietnam-Hunan, ~1700 km), E Australia-New Guinea (spottily preserved isolated platforms; ~2000 km) and Canning Basin (~400 km))

(Bipolar bivalve genera probably existed through greater part of late Jurassic- Cretaceous, probably controlled by global climatic zonation. Examples of ‘anti-tropical genera: Buchia s.l. and inoeramids (Retroceramus) in latest Jurassic, Aucellina in E Cretaceous, etc.)


(Cenozoic Ice Age from ~43 Ma-Recent, preceded by warmer interval of ~70 My back into mid-Cretaceous time. Next older Mesozoic icy intervals are E Cretaceous (~105-140 Ma) and Jurassic (~160-175 Ma and ~188-195 Ma). Late Paleozoic Ice Ages waxed and waned between ~256-338 Ma. Iciness expanded during Late Devonian-E Carboniferous (353- 363 Ma). Ordovician-Silurian strong and short ice age between ~429-445 Ma. During Late Proterozoic-Cambrian, three or four ice ages (~520-950 Ma). At some localities glaciation occurred at low latitudes)

(Review of Gondwanan phytogeographic units for five Permian time slices. Nothing on SE Asia)

(Maximum paleobiogeographic differentiation of Triassic brachiopods in Late Triassic, with at least five biochores: Boreal, N Tethyan, peri-Gondwanian, Notal or Maorian and E Pacific. E part of peri-Gondwanan Tethys with Misolia, Timorhynchia)

(Latest Triassic-earliest Cretaceous distribution of bivalves in S Hemisphere. Tethyan Realm with Australian unit restricted to Late Triassic. Late Jurassic Maorian Province extends to Antarctic and W Pacific localities incl. Timor, Sula, Buru, Seram, but overall endemism diminishes from Oxfordian to Tithonian-Berriasian. Oxfordian-Kimmeridgian Malayamaorica has Austral distribution, reaching Australia-New Guinea. Austral Province of Indo-Pacific Region (South Temperate) strongly developed at beginning of Cretaceous, incl. Australia, New Zealand, New Guinea)

(online at: https://gsmpubl.files.wordpress.com/2014/09/ngsm1987003.pdf)
(Review of British Geological Survey program of radiometric dating of SE Asia granites (see also Cobbing et al. 1992))

(Present-day deformation distributed around Afanasy Nikitin Chain in Central Indian Basin (CIB; shortening) and within Wharton Basin (WB; strike-slip). N portion of NinetyEast ridge (NyR) major discontinuity for strain and velocity. Taking into account intraplate velocity field in vicinity of Sumatra trench, we obtain convergence rate of 46 mm/yr towards N18°E at epicentre of 2004 Aceh mega-earthquake. Predicted shortening in CIB and WB and extension near Chagos-Laccadive in agreement with deformation measured from plate reconstructions and seismic lines, suggesting continuum of deformation since onset of intraplate deformation around 7.5-8 Ma)


(online at: http://www.cugb.edu.cn/uploadCms/file/20600/papers_upload/20141011142419767420.pdf)  
(Sanjiang region in SE Tibet Plateau and NW Yunnan formed by amalgamation of Gondwana-derived continental blocks and arc terranes from Paleozoic-Mesozoic. E Paleozoic ophiolites (473-439 Ma) in Changning-Menglian belt indicate existence of Proto-Tethys ocean. Proto-Tethys succeeded in E Devonian by Paleo-Tethys. Changning-Menglian main ocean existed from M Devonian- M-Triassic. E-ward subduction of oceanic plate from E Permian to E Triassic formed >1500 km arc terrane from Yunnan to E Tibet. Numerous Late Triassic S-type granite plutons (230-219 Ma), produced W-Sn deposits. E-ward oceanic subduction of Mesotethys (Late Permian- M Cretaceous) produced E Cretaceous granitoids with skarn-type Pb-Zn and Sn-Fe deposits in Baoshan and Tengchong blocks. Neo-Tethys subduction (Late Cretaceous~50 Ma) beneath Tengchong block formed S-type granitoids with skarn-type and greisen-type Sn-W deposits. Etc.)

(Fourteen plate reconstructions and paleogeography maps of Tethys Oceans from mid-Permian-Tortonian. Maps do not include much of SE Asia)

(Siliceous and marine organic-rich deposits both result of high planktonic productivity, but sometimes associated, sometimes separate in space and time. Siliceous marine phanite family facies contains organic material and are blackish (vs red/green for radiolarite facies) and deposited generally in shallower environments. Paleogeographic analysis for three Mesozoic high sea-level intervals (Toarcian, Kimmeridgian and Cenomanian) show: (a) in Jurassic siliceous deposits closer to open ocean waters than organic-rich ones; (b) during Cretaceous times often associated)


(online at: http://dx.doi.org/10.5169/seals-166399)  
(Since collision of India with Eurasia at ~45 Ma in M Eocene, N-S intracontinental convergence continued at ~5 cm/year. Convergence accommodated principally by lithospheric thickening in widening zone between E transpressive sinistral megashear from Makran- Baikal and W dextral megashear from Sumatra to Tanlu Fault System. Lateral extrusion or escape was not major factor in accommodating India/Eurasia convergence)

(online at: www.ga.gov.au/metadata-gateway/metadata/record/81179/)


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 postrift 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)


(Belemnites display Boreal and Tethyan marine faunal realms from Early Jurassic- earliest Cretaceous. Austral marine realm was lacking. In late Barremian- early Aptian Austral Realm was initiated with first Gondwanan family, Dimitobelidae. Tethyan belemnite realm cannot be recognised after Cenomanian)


(In Late Jurassic, belemnite genera Hibolithes and Belemnopsis abundant and widespread in Tethys, characterizing Tethyan Realm from S Europe and Asia to Antarctica. Distinct S Hemisphere 'Austral' belemnite realm was absent, although some endemicity exists at species level. Late Jurassic Indo-Pacific belemnites dominated by Belemnopsis with Hibolithes as minor element of fauna)


(Triassic turbidites of Nanpanjiang basin reflect collision between S China and Indochina blocks. Turbidite system filled primarily from E to W. U-Pb ages and Hf isotope data for detrital zircons from M Triassic turbidites suggest provenance not from collisional orogen, but from poorly preserved arc at convergent plate boundary of S China. Zircon ages clusters: ~250-300 Ma, 350-400 Ma, 400-550 Ma, 900-1050 Ma and ~1600-1950 Ma. Andean-type (Paleo-Pacific subduction) Cathaysian margin of S China probable source for much of sediment of S China block. New model for Triassic tectonic evolution of S China)


(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)


(Biogeographic analysis of Permian- Triassic ammonoids in E Asia suggests Kikatami Terrane in NE Japan, was in equatorial realm near S China/ Khanka Terranes. Four ammonoid provinces in Permian: (1) Boreal, (2) Equatorial American, (3) Equatorial Tethyan (incl. S China, SE Asia, Iran, Timor; with E Permian perrinitids, M Permian Timorites, Waagenoceras?) and (4) Peri-Gondwanan (incl. Australia, Himalayas, Salt Range))


(online at: http://work.geobiology.cn/ebook/ )
('Recognition of the Kimmeridgian Stage in the Indo-SW Pacific: the Paraboliceras fauna from the Himalayas to New-Zealand'. Kimmeridgian Stage not easily recognizable in Indo-SW Pacific because of lack of European taxa. Faunal sequence of Spiti Shales in C Nepal shows faunas with Paraboliceras (previously thought be of Tithonian age) are diagnostic of Kimmeridgian. This endemic Kimmeridgian biogeographic association extends from Himalayas to New Zealand.)

(Jurassic ammonite faunas form basis for new biogeographical interpretation of U Bathonian- Tithonian/ Berriasian peri-Gondwanan faunas. Low diversity Austral ammonite fauna around E and S Gondwanaland, from Himalaya to Patagonia)

(M-L Jurassic Himalayan ammonite faunas rel. low diversity and dominance of indigenous genera. Faunas extending from Himalayas to Antarctica represent an actual biogeographical unit: Indo Pacific Realm. With Blanfordiceras wallichi in Tithonian)

(Review of paleomagnetic data of China region suggests major blocks probably in contact in Permian-Triassic, but Jurassic key age for present configuration. During Cretaceous, Chinese poles agree with poles from other continents transferred onto Eurasia. Much of China affected by small (~20°) rotations, interpreted as deformation caused by extrusion away from India collision)

(Brief descriptions of Triassic across Asia, incl. Malaysia and Timor)

(Subduction of Paleotethys Ocean and subsequent continental collision recorded in blueschists in Lancang SE Paleotethyan belt in SW China. Suyi 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)

(Changning-Menglian belt of W Yunnan is ~400km long, 60 km wide remnant of Paleo-Tethyan archipelago. With E Devonian- M-L Triassic volcano-sedimentary record, incl. flysch, radiolarites, MORB basalts, seamount carbonates. Flanked by Cathaysian Lincang-Simao massif in E (M-L Devonian paleolatitude ~38-43°S) and Gondwanan Gengma-Baoshan massif in W (Devonian paleolatitude ~0-4.5°S; with Permo-Carboniferous moraine deposits))

(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)


(Sibumasu province characterized by: (1) No reliable Gondwana cold-water biota or glacial deposits (interpreted glaciomarine pebble-bearing layers are debris flows; molluscs identified as Eurydesma are Schiziodus). Temperate and warm water fauna dominant; carbonates not common; (2) No tropical Cathaysian biotas and reef complexes. Absence of Late Paleozoic coal seams and occurrence of mixed Permian Cathaysian-Gondwana flora in W Yunnan suggest Sibumasu between equatorial coal swamp zone (Cathaysian flora) and S temperate coal swamp zone (Glossopteris flora); (3) Contains Peri-Gondwana and Cathaysian elements but also European, Ural and Boreal elements; (4) Common endemic genera and species)


(Paleozoic biogeographic history of Sibumasu block stages: (1) Cambrian-Ordovician with Australian faunal affinities; (2) Silurian-Devonian with Rhenish-Bohemian faunal affinities; (3) Carboniferous-Permian independent biotic province, different from both peri-Gondwanaland (no true E Permian glacial deposits) and Cathaysian biotas (no Permian coals) in Tethyan realm. Towards end Permian, Cathaysian elements more important, especially in E margin, indicating Cathaysian and Sibumasu biotas began to merge. Sibumasu rifted from Gondwanaland in M Ordovician or earlier and sutured to East Continent in Late Permian and E Triassic)


(Three main periods of activity in Cenozoic volcanic complexes of SE China, Vietnam, Thailand and S China Sea: E Tertiary, Miocene and Pliocene-Quaternary. First period characterized by potassic basalt (Vietnam) and tholeiitic bimodal (SE China) volcanism. Subsequent periods dominated by intraplate-type tholeiitic and alkaline volcanism and minor bimodal tholeiitic magmatism (basalts and rhyolites of the Okinawa Trough))


(Late Jurassic- Early Cretaceous vertebrate assemblages from Khorat Group of Thailand show strong provincialism)


(Alternative model for Cambrian- Triassic geodynamic evolution of SE Asia. Differs in Palaeotethys suture location in Thailand at Mae Yuam fault. Closure of E Palaeotethys related to S-ward oceanic subduction that triggered E Neotethys opening as back-arc, due to Late Carboniferous- E Permian arc magmatism in Mergui (Burma) and Lhasa block (S Tibet) and absence of arc magmatism E of suture. To explain Carboniferous-E Permian and Permo-Triassic arcs in Cambodia, U Triassic magmatism in E Vietnam and L-M Permian arc volcanics in W Sumatra, we introduce Orang Laut terranes, which detached from Indochina and S China during back-arc opening due to W-ward subduction of Paleopacific. This also explains location of Cathaysian W Sumatra block W of Cimmerian Sibumasu block)

(Late Paleozoic ice age was series of 1-8 My duration discrete glacial events separated by periods of warmer climate. After smaller precursor events massive expansion of ice at Carboniferous-Permian boundary, and glaciation became bipolar. Ice sheets at maximum in Asselian- E Sakmarian, after which they decayed rapidly over much of Gondwana. Minor glaciations continued in Australia and Siberia through late E- M Permian)


(Discussion of SE Asia- W Pacific tectonics and plate kinematics. W Pacific back-arc basins opened in 3 main episodes of arc-trench rollback: (1) Eocene W Philippine Sea and Celebes Sea, (2) Oligocene-Miocene Japan, South China, Sulu and Makassar Seas, and (3) Late Miocene- Quaternary Okinawa, Mariana Troughs and Andaman Sea. Extrusion of Tethyan asthenosphere, contaminated by sub-Asian cratonic lithosphere, was major cause of W Pacific arc rollback and basin opening)


(On dispersed volcanic clusters over much of Asia and W Pacific following India-Asia and Australia-Indonesia collisions: (1) variably potassic tholeiites and alkali basalts in tension gashes, pull-apart basins, etc., and (2) shoshonite series (K-rich boninite) at extensional, near-collision shear zones and sundered arcs)


(Mixed Gondwanan, Euramerican and Cathaysian floral elements in ‘Mid’ Permian Gharif Fm of Oman)


(Extensive review of geology and paleontology of Permian of Thailand, Vietnam, Laos, Malaysia, Sumatra, etc. Followed by 7 appendices on Permian fauna-flora by Fontaine, Nguyen Tien, Vachard and Vozenin-Serra))


(Permian rocks widespread in SE Asia. Many limestones with fusulinaceans recognized as Permian, but ones without fusulinaceans and previously assigned to Permian, found to be Triassic. Widespread massive limestones represent extensive carbonate platforms. Local occurrences of thick-bedded cherts indicate deep marine environments. Pebbly mudstones in Myanmar, Thailand, NW Malaysia and Sumatra formed in glacial environment. Volcanic rocks absent in NW Peninsular Malaysia and Thailand, but widespread in N Vietnam, Sumatra, E Malay Peninsula and Timor. Faunal and floral assemblages used to establish climatic conditions, environments of deposition and to define crustal blocks and Permian paleogeography)


(Extensive review of Jurassic in SE Asia. Jurassic in Cambodia, Laos, Vietnam, E Thailand and Malay Peninsula mainly in continental facies, with occasional thin, shallow marine interbeds. Busuanga, Linapacan and Ili islands, NE of Palawan, Philippines, 200m thick Late Jurassic limestone with Cladocoropsis, Pseudocyclammina lituus, Salingoporella spp., Thaumatoporella, etc. (Fontaine et al. 1983, Bassoulet 1983). Late Jurassic- E Cretaceous limestones with Cladocoropsis- Pseudocyclammina at many localities across W Sumatra (NW Sumatra, Jambi, S Sumatra; all tied to ‘Woyla Terranes’?: JTvG), U Jurassic Bau Limestone in W Sarawak, etc.)
(M-U Permian-Triassic Ratburi Lst of Peninsular Thailand and Chuping Lst of NW Peninsular Malaysia with rel. low diversity corals and fusulinids (Pseudofusulina, Staffella, Monodiexodina), and with forams incl. Hemigordiopsis and Shanita. These characterize a well-defined biogeographic unit (Shan-Tai/ Sibumasu terrane; JTvG). Noted similarities of several fossil groups with Timor Permian faunas)

(Jurassic in W Philippines (Palawan Block), W Borneo, W Sumatra, Malay Peninsula, Thailand, Kampuchea and Vietnam. Marine Jurassic generally in limited areas only, and incomplete sections. Strong faunal affinities with Tethyan realm in E-M Jurassic, with Jurassic of Japan in Upper Jurassic)


44.7°) for Sibumasu. Sibumasu Terrane behaved as independent fragment when Indochina was undergoing CW rotation and S-ward displacement, as result of extrusion tectonics after India-Asia collision. CCW rotation of 15° estimated for Sibumasu Terrane, as result of continuous N-ward indentation of Australian Plate into S Sundaland Block

(Paleomag data for Borneo, Malay Peninsula, Philippines)

(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 after emplacement. Thermal gradient stabilized by E Miocene time, and Miocene cooling probably reflects renewed denudation pulse)

(online at: http://ac.els-cdn.com/)
(On SE Asia earthquake distributions and major plate movements)

(Main Range and E Province granite belts of SE Asia represent magmatic expression of closure of Paleo-Tethys in Late Paleozoic- E Mesozoic times. New U-Pb zircon age data from N Thailand and E Myanmar constrain closure in Myanmar to ~230 Ma. Age of 219-220 Ma from Kyaing Tong granite imply N extension of Main Range Province into E Myanmar (E Triassic). Tachileik granite in far E Myanmar 266 Ma, consistent with E Province ages. Hf data suggest Paleo-protorozoic crust underlies both Main Range and E Province granites)

(geodynamics of SE Asia closely connected with cyclic development of large oceanic basins: Paleotethys (M Paleozoic-E Mesozoic), Tethys (end Paleozoic- beginning Cenozoic), and Indian and Pacific Oceans (Late Mesozoic-Cenozoic). Opening of basins accompanied by simultaneous closing of earlier basins)

(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1986b10.pdf)
(Continental SE Asia dominated by Precambrian continental blocks overlain by Late Proterozoic-Paleozoic platform successions. Most blocks rifted and drifted from Australian Gondwanaland in Early Paleozoic and were in equatorial position by Permian time. Between blocks are intensely folded mobile belts. West Borneo block initial separation from Eurasia in Late Triassic-Jurassic (creation of Proto-South China Sea), then detached from Indosinia in Late Cretaceous-Paleogene and moved S along fault margin of Vietnam shelf)

(Majority of mineral occurrences of SE Asia in five metallogenic belts)

(Brief descriptions of characteristics of main fault zones in SE Asia)

(The Lithiotis limestones' in the Early Jurassic Tethys Realm'. Tethyan Early Jurassic reefal limestones commonly dominated by large thick-walled Lithiotis-type bivalves (also present in Fatu Limestones of Timor; Krumbeck 1923, Hayami 1984))

(online at: http://ses.library.usyd.edu.au/handle/2123/8580)
(New model of Indian Ocean plate tectonic history, suggesting smaller extent of Greater India and later collision than than previous models. Main driver is Jurassic rock sample dredged from Cretaceous Wharton basin off W Australia. Argoland accreted to equatorial intra-oceanic arc at ~126 Ma (E Cretaceous; obduction event recorded in zircons from ophiolites in Yarlung-Tsangpo suture zone between Indian and Eurasian blocks). E Argoland accreted to Sumatra at ~80 Ma, possibly re-attaching Woyla Terranes back to Sumatra margin. Greater India's indenter, Gascoyne block, reached W Burma and E edge of intra-oceanic arc at ~50 Ma, as India continued to migrate North. Final collision between Greater India (accreted to intra-oceanic arc) and Eurasia did not take place until ~35 Ma)


(Plate tectonic model for India-Eurasia collision. With plate reconstructions since Middle Jurassic (160 Ma) and including chapter on SE Asia and Woyla Arc of Sumatra)

(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1973010.pdf)
(Late Paleozoic rocks from Thailand, Malaysia, Myanmar, Vietnam, Laos, Cambodia, Sumatra, Borneo, etc.))

(Review of tectonic evolution and associated gold deposits of mainland Asia in past 800 Myrs. Nothing on Indonesia)

(Paleogeographic maps for Late Triassic (Carnian-Norian) and E Jurassic (Hettangian-Toarcian). Triassic continued N-ward drift of Cimmerian continent corresponed with closure and consumption of Paleotethys and opening of Neotethys. Most significant Late Triassic convergent event was Indosinian orogeny, result of
consolidation of S and N China blocks. Also, Indochina and 'Indonesia' sutured to S China. Triassic- Jurassic boundary important biotic extinction event.

(online at: http://journals.bg.agh.edu.pl/GEOLOGIA/2007-02/Geologia_2007_2_01.pdf)
(Global plate tectonic and paleogeographic maps for 8 E Devonian-Permian time intervals. Includes Australia-SE Asia blocks evolution. 'Indonesia' shown as part of Cimmerian Blocks that rifted off Gondwana in Permian and collide with mainland SE Asia in Triassic)

(Global plate tectonic and paleogeographic maps for 8 Mesozoic time intervals. Most significant Triassic convergent event was Indosinian orogeny (collision of Indochina and Indonesia with S China). N-ward drift of Cimmerian continents driven by closing of Paleotethys and opening of Neotethys Ocean. SE Asia not very well portrayed in this global map series)

(online at: http://journals.bg.agh.edu.pl/GEOLOGIA/2009-04/Geologia_2009_4_01.pdf)

(online at: http://journals.bg.agh.edu.pl/GEOLOGIA/2009-04/Geologia_2009_4_02.pdf)
(Global plate tectonic and paleogeographic maps for 8 Cambrian-Silurian time intervals. Australia and China blocks in low northern latitudes)

(Paleozoic global plate reconstructions, with focus on Gondwana region)

(Late Triassic global plate reconstruction, at time of Early Cimmerian and Indosinian orogenies that closed Paleotethys Ocean (earlier in Alpine-Carpathian-Mediterranean area, and latest in SE Asia). Pulling force of N-dipping subduction along N margin of Neotethys (= Mesotethys) caused drifting of new set of plates from passive Gondwana margin, dividing Neotethys Ocean (= opening of Cenotethys; Lhasa plate separation))

(Six global reconstructions for Pangaea from Late Carboniferous- M Jurassic. Most of Indonesia shown as part of 'Cimmerian Plates' that rifted from Gondwana in Permian and sutured with SE Asia in Late Triassic)

(online at: http://cdn.intechopen.com/pdfs/wm/37859.pdf)
(Trench-pulling effect of N-dipping subduction at S margin of Eurasia caused rifting as well as transfer of plates from Gondwana to Laurasia. This model applied here to S margin of Laurussia in Paleozoic times. With 12 plate tectonic maps for time slices from Early Cambrian- Late Carboniferous)

(online at: http://geolines.gli.cas.cz/fileadmin/volumes/volume20/G20-040.pdf)
(Brief summary of larger SE Asia project)

(online at: www.igcp.itu.edu.tr/Publications/Golonka_06.pdf)
(Peak of Paleozoic orogenesis in SE Asia and S China in Silurian-earliest Devonian. In N Vietnam deep water Ordovician and Silurian synorogenic deposits overlain by continental E Devonian red beds. With plate tectonic map for Early Ordovician)

(Major review of global plate tectonic evolution from Cambrian-Recent in 32 maps/time slices, with detailed maps for SE Asia (Vietnam focused). Differs from recent Hall and Metcalfe models in depicting the more 'traditional' view of SW Borneo as always having been part of Indochina-Sibumasu (which rifted off Indochina/S China by opening of Proto-South China Sea in Jurassic or Cretaceous))

(online at: www.odp.tamu.edu/publications/122_SR/VOLUME/CHAPTERS/sr122_05.pdf)
(Last major breakup from NW Australian continental margin (Exmouth, Wombat, Scott Plateaus) in Berriasian-Hauterivian. Major continental fragments in Asiat C Tethyside orogenic collage already collided with Asia by that time. Similarity of Mesozoic geological record suggests Sikuleh-Natal continental sliver in Sumatra, plus possible extensions in Java probably continental object that left NW Australia in Berriasian-Hauterivian. This sliver records E Cretaceous rapid subsidence and collision with Sumatra along Woyla suture in Late Cretaceous. NW Australian margin two older breakup events: (1) latest Carboniferous-earliest Permian: departure of Sibumasu block and E Cimmerian continent (Baoxan, W Thailand, E Burma), W Malaya and part of C Sumatra; (2) Late Triassic-Jurassic. Lhasa-C Burma block left Gondwanaland, which leads us to think breakup event was latest Triassic, probably Rhaetian)

(Review of Australian Jurassic fossils distribution)


(Review of exhumation of high and ultrahigh pressure metamorphic rocks and ophiolites. Three types of subduction zones: (1) Accretionary-type subduction zones exhume HP metasedimentary rocks by underplating; (2) Serpentinite-type subduction zones exhume HP to UHP in 1-10 km thick serpentinite subduction channel (incl. Bantimala, Sulawesi, Luk Ulo, C Java); (3) continental-type subductions exhume UHP rocks of continental origin. With examples from SE Asia)


(Two terrane groups in SW China: (1) with Permo-Carboniferous ice-rafted marine sediments and cold-water fauna of Gondwana facies (Gangmar Co, Lhasa, Sa' gya, Tengchong, Baoshan terranes), (2) with Yangtze-type U Paleozoic with Cathaysian flora and Pacific-type fusulinids (Changning-Menglian, Shuangjiang-Lancang, Qamdo and Bayan Har terranes). Longmu Co-Shuanghu-Denggen- N Lancang River- Kejie-Mengding suture zone between two groups is boundary between Gondwana and Pacifica in SW China. Baoshan and Nyainrong- Sog in Lhasa composite terrane first combined with Asian continent in early E Jurassic. N Tibet- W Yunnan microplate (with Gangmar Co, Lhasa, Tengchong terranes) collided with Asia at end of E Cretaceous)


(online at: http://library.dmr.go.th/library/Proceedings-Yearbooks/M_1/1997/7641.pdf)

(Same paper as Hada et al. 1999)


(Nan-Chanthaburi suture zone in SE part of C Thailand, between Shan-Thai (=Sibumasu) in W and Indochina/ E Malaya Blocks in E, regarded as main branch of Paleo-Tethys ocean. Two belts: in W imbricated bedded Chanthaburi chert-clastic sequence (former active margin of Shan-Thai terrane; cherts with M-L Triassic radiolaria), in E Thung Kabin serpentinite melange (incl. red cherts with E, M and L Permian radiolaria and blocks of E and M Permian fusulinid limestone). Both belts unconformably overlain by ?U Triassic greywacke-andesitic tuffaceous sequence, then Khorat Gp redbeds. Collision age believed to be latest Triassic)


(Kurosegawa Terrane in SW Japan, between two Mesozoic subduction complex terranes, is exotic terrane with Permian limestones with fusulinacean forams Cancellina, Colania and Lepidolina, suggesting terrane once situated within Colania- Lepidolina territory in E Tethys-Pantalasssa region at equatorial latitude, possibly close to E margin of S China or Indochina-E Malaya continental blocks. These blocks had rifted from Gondwana by Late Devonian. Amalgamated with proto-Asian continent (S China?) in Late Triassic (or later))


(Brief review of recent Royal Holloway sandstone provenance work (Gunawan, Sevastjanova, Zimmermann))


(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)

Hallam, A. (1986) - Evidence of displaced terranes from Permian to Jurassic faunas around the Pacific margins. J. Geol. Soc. London 143, p. 209-216. (Permian-Jurassic Tethyan marine invertebrate faunas from low latitude can be distinguished from less diverse higher latitude faunas. Displacement of these low-latitude faunas high latitudes around Pacific margins provides evidence for movement of displaced terranes. Fullest story worked out for W margin of N America, as far N as S Alaska. Also evidence for N-ward movement of continental segments along NE Asian margin. Torlesse Terrane of New Zealand appears to have moved considerable distance S-wards)

Halle, T.G. (1935) - On the distribution of the Late Palaeozoic floras in Asia. Geografiska Annaler 17, Suppl. (Sven Hedin volume), p. 106-111. (First paper to recognize three Permian floral provinces in Asia: Indian Gondwanan-Glossopteris in SW, Angara flora in N, Cathaysian/Sino-Malayan or Gigantopteris flora in SE. No figures)


Hasegawa, S. (1996) - Ridge subduction model- a mechanism for an earlier South China Sea opening and an alternative paleogeographic reconstruction of Southeast Asia. In: 11th Offshore SE Asia Conf. Exhib. (OSEA96), Singapore 1996, p. 155-167. (Late Mesozoic- Tertiary plate reconstruction, generally compatible with Tapponnier extrusion model. The now subducted Kula-Pacific Ridge beneath Eurasia Plate caused S China basins rifting and provides heat under S China continental crust)


(Unique E Jurassic (Pliensbachian?) heavy bivalve assemblage from Timor with Lithiotis, Pachymegalodon, Gervilleioperna, etc. described from Fatu Lst of Timor by Krumbeck (1923). Upper Jurassic bivalves in W Borneo part of East Asian Province with Philippines and Japan. Timor-Roti, Seram, Misool, etc., are part of Maorian Province with Malayomaorica and Retroceramus haasti)

(online at: https://www.nature.com/articles/srep02200.pdf)
(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)

(online at: www.earthbyte.org/people/christian/media/Heine_02_MScThesis_e-version.pdf)
(Argo and Gascoyne Abyssal Plains off NW Australia are the only preserved patches of Tethyan ocean floor; rest destroyed by subduction. W Burma Block identified as continental fragment breaking up from NW Shelf in Late Jurassic and accreted to SE Asian mainland in Santonian-Coniacian (85-80Ma) near W Thailand)

(Reconstruction of E Tethys (Mesotethys and Neotethys) ocean basin for last 160 Myr, with reconstructions in 20 Myr increments, constrained by magnetic anomalies in Argo and Gascoyne abyssal plains of Australia NW shelf, assuming symmetrical spreading, etc.)


(Discussion of geodynamic evolution of mainland SE Asia and China. Permo-Triassic ‘Paleotethys’ suture must be expected S of Tibet and in Burma. All sutures in Thailand, Vietnam and Yunnan already closed during Paleozoic)

(‘Late Variscan orogenesis and terranes in Southeast Asia’)

(Overview of Cretaceous macrofauna, microfauna, flora in Australia. Maximum paleobiogeographic gradients in Albian, Late Campanian and Maastrichtian)

**Bibliography of Indonesian Geology, Ed. 7.0**

*www.vangorselslist.com*  
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(SW Yunnan complex geological evolution of Paleo-Tethys and Eurasia-Gondwana collision at end of Paleozoic. S Lancangjiang zone at Laos border gabbros with U-Pb zircon age of 292 Ma, indicative of E Permian sea-floor spreading. Also arc-like andesites and granodiorite intrusions with zircon ages of 284-282 Ma. Point to Permian subduction of oceanic crust between Lincang Block and Lanping-Simao Block. M Triassic Lincang granite (239 Ma) batholith marks closure of Paleo-Tethys. Nd-model ages from 1.7-2.1 Ga point to Paleoproterozoic basement, probably fragment of Yangtze Block)

(Includes map of Albian-Cenomanian tropical-subtropical Elaterosporites microfloral province (peaking in subtropical arid climate?). Also known from PNG)

(online at: www.geosciences-journal.org/home/journal/...)

(Shan-Thai Terrane is remnant of 'poly-island' Paleo-Tethys oceanic system in SE Asia. It is composite terrane, with Cathaysian internal elements and transitional 'Sibumasu' central part. External 'Shan' elements left Gondwana last and have clear cold-water imprint. Final welding and Paleotethys closure in end Triassic-earliest Jurassic Late Indosinian event. Cenozoic Himalayan escape tectonics compressed Shan-Thai, opened Gulf of Thailand and disrupted original alignment of Gondwana-Tethys divide)

(Old review of SW Pacific mountain systems, including Sunda-Banda Arc)

(Significant fault movement in Tertiary in continental SE Asia. Three rotations: Indochina subplates wrench rotation, Sunda shear rotation, and rotation of Malay Peninsula and Sunda Platform by movements along Ranong and Semangko faults)


(New data in NW West Philippines basin Daito Ridge used to reconstruct Late Cretaceous- Tertiary plate tectonics of SE Asia. In model S Borneo rotates 90° CCW since Cretaceous)

(Major review of metallogeny of eastern Tethysides)

(Since beginning of continental collision between India and Asia ~2500 km of convergence. N-ward movement of India accommodated by major internal deformation of Asian lithosphere, incl. crustal thickening in and around Tibetan Plateau. Experimental modeling suggests crustal thickening dominant mode of indentation)
strain accommodation. Although common 10-30° paleomagnetic rotations, probably not accompanied by large E-ward 'extrusion')

(S China is composite of Precambrian-Mesozoic orogenic belts. Three continental blocks: Yangzi, Huunan, and Dongnanya. Yangzi separated from Gondwana in Late Precambrian. N margin of Huunan was N active Gondwana margin until Devonian. Huunan and Yangzi collided in Triassic. Huunan separated in Devonian, with continuous Devonian-Triassic sequence on S passive margin of Huunan. Dongnanya with Permian glacial marine deposits, separated from Gondwana in Late Permian and may be E continuation of Sibumasu)

(Permian fusulinids of Baoshan Block (= part of 'Sibumasu Group') lower generic diversity than coeval tropical assemblages. Dominant elements change from mainly eurytopic genera in E Permian/Sakmarian grainstones (>30°S; Pseudofusulina, Eoparafusulina) to warmer water algal-foram limestones in M Permian Murghabian (with Schwagerina, Eopolydiexodina) and Midian (with Sumatrina, Verbeekina))

(Late Cretaceous and Paleogene paleolatitudes of Tibetan Himalaya difficult to reconcile with current hypotheses of collision age (34, 52 or 65 Ma) and inferred Asian shortening (600-900km))

(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)

(Review of SE Asia tectonic framework)


(Based on evidence from Vietnam, age of gigantic Australasian Tektite Strewn Field here considered to be close to 10,000 years ago, much younger than commonly accepted age of 0.7 Ma, and may have triggered global climate changes and mass extinctions at Pleistocene/Holocene boundary)

(Well-illustrated series of Tethys reconstructions for Late Carboniferous- Late Permian, showing generally accepted model of Paleozoic ocean N of Cimmerian continents (Paleotethys), a Late Paleozoic- Mesozoic ocean S of this continent (Neotethys; = Mesotethys of other authors?;JTvG), and M Jurassic ocean (Alpine Tethys))

(Permian foraminifer Shanita of special paleobiogeographic importance. Occurs in Gondwana-derived blocks, in strip from Peninsular Thailand to Burma, S China, S Afghanistan, Oman, etc. to Turkey. Often associated with Hemigordius. Shanita-Hemigordius fauna considered as marker of marginal Gondwana environment (more specifically 'Cimmerian' strips that rifted off Gondwana in M-L Permian?; JTvG))


(Reconstructions of paleogeography and paleoceanography of Chihsian (E Permian), Wujiapingian, Anisian and Norian (Late Triassic) intervals in E Tethys. Paleogeographic change of the E Tethys and N-ward shift of Pangea during Permo-Triassic periods governed coeval paleocurrent pattern and evolution)


(Mainly on Carboniferous biostratigraphy of Australian region and Australian-derived SE Asia terranes)


(Two chert types used to map Paleotethys suture in N Thailand- Malaysia: (1) Devonian- M Triassic pelagic chert (common radiolarians, no terrigenous material) as blocks in sheared matrix, originated in Paleo-Tethys; (2) Triassic hemipelagic chert (scattered radiolarian tests and calcareous organisms such as foraminifera), accumulated on E margin of Sibumasu Block. Cherts in two N-trending zones: W zone hemipelagic cherts and glaciomarine successions on Precambrian basement (Sibumasu), E zone pelagic chert and limestone (Paleo-Tethys). Boundary between zones is N-trending, E-dipping, low-angle thrust, resulting from collision of Sibumasu and Indochina blocks)


(Audley-Charles et al. 1979: Permian Maubisse Fm of Timor close affinities with Asian facies and faunas)


(Using Permian fusulinid forams and paleomagnetic data to reconstruct low latitude origin of M Permian seamount, which accreted to S China (Japan) margin in Jurassic. Two or three coeval M Permian biogeographic territories in Tethys-Panthalassa realms: Neoschwagerina-Yabeina territory (>12 °S) and Colania-Lepidolina territory (<12°), and higher latitude Eopolydiexodina territory (>~25°S))


(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)


(Planktonic foraminifera distribution patterns suggest closure of Indonesian Seaway around 13-12 Ma)


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Kirillova, G.L. (1993)- Types of Cenozoic sedimentary basins of the East Asia and Pacific Ocean junction area. Palaeogeogr. Palaeoclim. Palaeoecology 105, p. 17-32. (Classification of marginal basins in W Pacific (incl. Philippine Sea, E China Sea, etc.): (1) oceanic and transitional crust basins: mainly deep water trenches, back-arc, inter-arc, forearc and intra-arc basins; (2) basins with continental crust: marginal-continental shelf and intracontinental basins, filled with alluvial deltaic and lacustrine sediments up to 11 km thick)


Kobayashi, F. (1997)- Middle Permian biogeography based on fusulinacean faunas In: C.A. Ross et al. (eds.) Late Paleozoic foraminifera, their biostratigraphy, evolution and paleoecology, and the Mid-Carboniferous boundary, Cushman Found. Foraminiferal Research, Spec. Publ. 36, p. 73-76. (Permian fusuline foram faunas three provinces: (A) Western Tethys, with Yabeina, Afghanella and Sumatrina and without Lepidolina; extends from Mediterranean to N Arabia; (B) Eastern Tethys, with diverse neoschwagerinids and verbeekinids, incl. Afghanella and Sumatrina, covering SE Asia, S China, Indochina, and limestone units in SW Japan Permian accretionary complex; (C) Panthalassan: without sumatrinids, dominant Yabeina and less Lepidolina, in exotic limestone blocks around Circum-Pacific (N America, Siberia, Japan))

(Latest Permian Palaeofusulina fauna serves as paleogeographic constraints on E and SE Asian terranes. Common in S China, Indochina and E Malaya shelf limestone facies. Also present on Early Permian rifted terranes, like N Thailand (Sibumasu terrane) and Tibet (Qiangtang Terrane). Absence of Palaeofusulina fauna and presence of late Midian Lepidolina multisepctata faunas in Lhasa Terrane (Tibet) and Woyla Terrane in Sumatra important for identifying rift-drift-collision process of Gondwana-affinity terranes)

(online at: https://www.jstage.jst.go.jp/article/pjab1912/20/4/4_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

(online at: www.gsm.org.my/products/702001-101351-PDF.pdf)
(Discussion of belt of Paleozoic (Ordovician-Permian) and Triassic rocks, extending from Shan Plateau (Myanmar) and W Yunnan (S China) in N through Thai-Malayan Peninsula in south and continuing into Borneo. No figures, maps)


(online at: www.journalarchive.jst.go.jp/...)
(On distribution of Early-Middle Cretaceous non-marine bivalve mollusc Trigonioides in SE Asia, including in continental facies of Rantaulajung Fm near Martapura, SE Kalimantan with Upper Cretaceous conchostracans)

(Short paper on provinciality in Triassic bivalves. Oriental Province of Tethys with species indigenous to E and SE Asia. Stretches from Kashmir, Burma, S China, Malay Peninsula, to E Indonesia. No maps)

(‘The Permian of the Indies and the Permian glacial period’)

(Russian review of SE Asian basins. Most sedimentary basins of SE Asia related to processes of rifting that activated in Paleo-Eocene after consolidation of continental crust of the Sunda (Malay) microplate, which ended in Late Cretaceous. Wide development of lacustrine basins, which accumulated main source rocks for oil and gas in region)

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Lacassin, R., P.H. Leloup & P. Tapponnier (1993)- Bounds on strain in large Tertiary shear zones of SE Asia from boudinage restoration. J. Structural Geol. 15, p. 677-692. (Restoration of stretched, boudinaged layers in mylonitic gneisses of Oligo-Miocene Red River-Ailao Shan (Yunnan) and Wang Chao (Thailand) shear zones suggests layer-parallel extension of 250-870%, implying minimum left-lateral strike-slip displacements of ~330 km (Red River-Ailao Shan) and ~35 km (Wang Chao))


Carboniferous flora of E Peninsular Malaysia ('Kuantan flora' of Asama) and NE Thailand typical Euramerican aspect, suggesting Indo-China Block was in terrestrial connection with N Paleotethyan landmass, probably S China Block since at least E Carboniferous. E Malaya Block also part of North Paleotethyan domain


Le Pichon, X., M. Fournier & L. Jolivet (1992)- Kinematics, topography, shortening, and extrusion in the India-Eurasia collision. Tectonics 11, p. 1085-1098. (Spatial distribution of topography in Greater India-Eurasia suggest transfer of lower crust to mantle by eclogitization and lateral extrusion account for minimum of one third/one half of total amount of shortening between India-Asia since 45 Ma)


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 serpentinization in mantle and volcanic seamounts and ridges. W Philippine Sea Basin anomalously small Curie depths. W Pacific marginal seas have lowest Moho 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)

(Analysis of paleolatitudes and latitudinal displacements for S China, Simao, Baoshan, Shan-Thai, Indochina, Qiangtang, Lhasa and Himalayan blocks: (1) Simao Block S China-derived; (2) Baoshan and Shan-Thai blocks rapid N drift from Late Carboniferous- Late Permian; (3) Baoshan Block collided with Simao Block in Late Permian and continued to drift N, together with S China and Shan-Thai blocks until Late Triassic; (4) Paleo-Tethys separating Baoshan and Simao blocks possibly opened in E Silurian; (5) Meso-Tethys ranged in age from E Permian- E Cretaceous, and reached greatest width of ~42° latitude in Late Triassic)


(Rule 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)


(Subduction prior to assembly of S China and N China blocks traditionally considered directed N-ward, but new tectonic model suggests SEward 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)


(Proto-Tethys paleo-ocean located between Tarim/N China and Sibamusu/Baoshan blocks opened from rifting of supercontinent Rodinia and mainly closed at end of E Paleozoic. Several continents/microcontinents in ocean. S suture marked by Longmu Co-Shuanghu-Changning-Menglian Suture. Tarim- Alax- N China Block to N of the Proto-Tethys Ocean no clear affinity with Gondwana, had S-ward subduction polarity and collided with Gondwana along N margin of Gondwana in E Devonian. Etc.)


(Mixed Gondwanan- Cathaysian floras from Turkey to Saudi Arabia, Kashmir to Western New Guinea)


(Overview of Permian macrofloras of SE Asia, with map of Permian phytogeographical provinces. Djambi flora of C Sumatra is southernmost Cathaysian flora. New Guinea Permian flora mixed Gondwanan and Cathaysian)


(Permian floras suggest boundary between E Gondwana and Laurasia runs along Bangonge-Dengqen suture of Qinghai-Xizang plateau, turns S near Qamdo in E Xizang, then possibly extends through Baoshan District of W. Yunnan to link up with Pham Sore and Bentong-Raub sutures of Thailand- Peninsular Malaysia, from where it continues further S across E Sumatra to Indian Ocean. Jambi flora of Sumatra, Jengka and Loei floras of Malaysia and Phetchabun and Loei floras of Thailand all contain elements of Cathaysian flora. W New Guinea Permian floras mixed Cathaysian-Gondwana flora.)

(Review of Devonian-Permian floral provinces of China. Cathaysian Floral province two major blocks: Sino-Korean-Tarim (N China) and S China Block, both vegetated by Euramerican floras until Late Carboniferous when Cathaysian elements first began to differentiate Two Cathaysian provinces established by Permian. Cathaysian flora developed in tropical, ever-wet climatic zone. Tropical conditions persisted in S China throughout Permian, but in N China, by early Late Permian alternating wet and dry climates, and by late Late Permian most of N Hemisphere in extreme arid conditions. Large leaved forms like Taeniopteris more common in N China and Gigantopteris almost completely restricted to S China. S China also with abundant Psaronius tree ferns and Gleicheniaceous ferns)

(Plate reconstructions of Australian region from 1000 Ma- recent)

(Three major E Asian crustal blocks (Tarim, N China and S China) have records of the Neoproterozoic rifting events that broke up supercontinent Rodinia. Tarim Block may have been adjacent to Kimberley region, S China Block between E Australia and Laurentia, and N China Block adjacent to NW corner of Laurentia and Siberia during E Neoproterozoic. All three blocks probably separated from larger cratons towards end of Neoproterozoic but stayed close to Australian margins of Gondwanaland from Cambrian-Devonian)

(Late Paleozoic detachment of E Cimmerian Sibumasu terrane from Australian Gondwanan margin may be initiated by mantle plume of Woniusi basaltic province in Yunnan, SW China (Baoshan Block= N Sibumasu terrane). Woniusi basalt province spread over ~12,000 km2 and ~300-500m thick. Zircon U-Pb ages Late Carboniferous- late E Permian (301-282 Ma), synchronous with basaltic rocks from Panjal Traps, Tethyan Himalaya, Lhasa, and S Qiangtang, forming large, fragmented igneous province, possibly sharing common mantle plume centered in N Greater India. Baoshan Block no thick Permian rift series (basalts mainly E Permian?: overlie glacial diamictite; faunal data suggest post-M Artinskian age (Ueno 2002)?JTvG))

(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)

(In E Asia tabulate and rugose corals present from E Ordovician- early Permian. Ordovician corals of N China related to Americo-Siberian region; S China close affinity to E Australia in Early Silurian, but more akin to Urals and C Asia in M-L Silurian. E-M Devonian 5 biogeographic provinces in E Asia: (1) Arctic; (2) Junggar-Hinggan; (3) Uralo-Tian Shan; (4) Paleoethytes and (5) S China. In E Permian N and S parts of Asia belong to cold-water Lytvolasma fauna, middle part warm-water Tethyan with Irannophyllum/ Ipcriphyllum fauna)

(Paleomagnetic results show S China block close to equator in Cambrian, probably adjacent to N Australia. This juxtaposes Cambrian marine basins in S China and Australia, explains stratigraphic similarity between late Precambrian Sinian System in S China and Adelaide System in Australia and continuing fossil affinities in Cambrium- Ordovician. Proposed geographic configuration lasted from late Precambrian (800 Ma)- E
Ordovician (470 Ma). Paleomag from Cambrian of N China block indicates it was in S Hemisphere, with paleontological evidence suggesting it was close to Tibet, Iran and N India during Paleozoic.

Liou, J.G., W.G. Ernst, R.Y. Zhang, T. Tsujimori, B.M. Jahn (2009)- Ultrahigh-pressure minerals and metamorphic terranes- the view from China. J. Asian Earth Sci. 35, p. 199-231. (Review of Ultra High-Pressure (UHP) metamorphic terranes in China and adjacent areas. These represent continental and oceanic crustal protoliths which experienced P-T conditions near coesite stability field (>~2.7 GPa and ~700°C). Typical products include eclogite, garnet peridotite, and UHP varieties of metapelite, quartzite, marble, paragneiss and orthogneiss. UHP metamorphic assemblages require relatively cold lithospheric subduction to mantle depths. Includes some data from Indonesia (Sulawesi, ))


Liu, S., Tao Qian, Wangpeng Li, Guoxing Dou, and Peng Wu (2015)- Oblique closure of the northeastern Paleo-Tethys in central China. Tectonics 34, 10.1002/2014TC003784, p. 1-22. (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; Mianlue suture to S in M-L Triassic (collisional sutures obscured by thrust faults in S Qinling-Dabieshan orogen))


(dinosaurs and associated vertebrate faunas known from Late Triassic- Cretaceous of Australia and mainland SE Asia. Most taxa are of Early Cretaceous age. No similarities between SE Asia and Gondwana, but clear affinities between SE Asia and northern hemisphere)


Marcoux, J. & A. Baud (1996)- Late Permian to Late Triassic Tethyan paleoenvironments. Three snapshots: Late Murgabian, Late Anisian, Late Norian. In: X. Nairn et al. (eds.) The Tethys Ocean, Plenum Press, New York, p. 153-190. (Three paleogeographic reconstructions of Tethys Ocean, from Europe to Australia (similar to maps of Tethys Atlas Project by Dercourt et al., 1993))


Maruyama, S., J.G. Liou & M. Terabayashi (1996)- Blueschists and eclogites of the world and their exhumation. Int. Geology Review 38, 6, p. 485-594. (Includes brief descriptions of Indonesian (Java, SE Kalimantan, Sulawesi, Timor, N New Guinea) and SW Pacific (E PNG, New Caledonia, etc.) blueschist occurrences)


Maruyama, S., S. Omori, H. Senshu, K. Kawai & B.F. Windley (2011)- Pacific-type orogens: new concepts and variations in space and time from present to past. J. Geography (Chigaku Zasshi) 120, p. 115-223. (online at: www.jstage.jst.go.jp/article/jgeography/120/1/115/_pdf) (In Japanese with English summary. Overview of Pacific-type active margins, with examples from Indonesia. Show Miocene forearc spreading in Banda outer arc, creating ophiolites that now rest on metamorphic belts from Timor, through Leti-Moa-Sermata to Dai islands, etc.)


(New plate tectonic interpretations for Greater S China Sea area since 35 Ma, partly constrained by amounts of extension computed from gravity models. Best-fit plate model assumes 250 km of left-lateral displacement along Red River Fault (calculated at Vietnamese coast of Gulf of Tonkin) from 35-20.5 Ma)

(Paleomagnetic studies from C Philippines, Sulawesi, Fiji-New Hebrides, etc., show differences in declination within same arc. Rotated segments of upper plate where buoyant feature on downgoing plate (seamount, continental fragment or island arc) locally deforms margin of upper plate. Stresses resulting from collision may result in (1) strike-slip faults causing sideward extrusion of portions of upper plate; (2) changes in subduction zone polarity; (3) strike-slip faults around margin of indenter; or (4) reorganization of entire plate margin)

(Sulu, Celebes and Banda Sea marginal basins all have E-W trending magnetic anomalies, progressively younging to North from Cretaceous to Paleogene, therefore believed to be parts of single marginal oceanic basin. (subsequent work suggests Banda Sea not Cretaceous but Neogene age: JTvG))


(Paleomag data from Philippines, Indo-China, Japan. Many published paleomagnetic studies on Mesozoic-Paleozoic rocks show magnetizations that are same as that of overlying Cenozoic volcanics, suggesting possible resetting, and making older rocks results suspect)

(Same paper as McCabe et al. 1993)

(Compilation of Permian paleomagnetic data. Asia is composite continent formed by accretion of crustal blocks. Malay Peninsula and Japan were situated near Equator in Permian and therefore separated from Asian continent. Permian of Sino-Korean and Yangtze blocks of China also near Equator)

(Reconnaissance paleomagnetic survey on Malay Peninsula suggests it lay at 15° N in Late Paleozoic, so could not have been part of Gondwanaland)

(From Carboniferous to Cretaceous S continents broadly similar floras but some species-level provincialism apparent at all times. Gondwanan floras radical turnovers near end Carboniferous, end Permian and end Triassic that appear unrelated to isolation or fragmentation of supercontinent. Throughout Late Paleozoic and Mesozoic high-latitude southern floras maintained different composition to paleoequatorial and boreal regions even though they remained in physical connection with Laurasia for much of this time)

(Tectonics of SE Asia, particularly Sulu- Celebes Seas. Some marginal seas originated by intraplate spreading, others by border spreading)

(Assembly of E part of Gondwana supercontinent (incl. E Africa, Arabia, India, E Antarctica and Australia) resulting from complex series of orogenic events from ~750- 530 Ma. Rel. little on Australia, which in ~800-700 Ma restores to N Hemisphere)

(Early Permian Gondwana Cool Water Province with Vjalovognathus in Canning, Carnarvon basins and W Timor. Permian conodont provincialism not distinct until Kungurian)

(Conodont faunas from SE Asia classified in new faunal provinces: Equatorial Warm Water (EWWP), peri-Gondwana Cool Water (GCWP) and N Cool Water (NCWP; N China). GCWP marked by Vjalovognathus, etc., EWWP by absence of Gondolelloides and Vjalovognathus in E-M Cisuralian, abundance of Sweetognathus and Pseudosweetognathus in Kungurian, etc. Mixed faunas between EWWP and GCWP include W Timor Artinskian, SE Pamirs Kungurian and Salt Range Guadalupian- Lopingian)

(On evolution of conodonts of E-M Permian Sweetognathus and Late Permian Iranognathus lineages)

(p. 112-113: Lower Jurassic ammonites described from Roti by Krumbeck (1922: Pliensbachian Ibex zone) have N Tethys affinities, suggesting these are from exotic blocks now on S Tethys/ Australian margin?)

(Extensive review of Carboniferous in W and E Malay Peninsula, W and NE Thailand, Vietnam, Laos, N and E Sumatra, W Sarawak, etc. Sumatra Alas Fm of Late Visean age)

(Older continental part of SE Asia four tectonic blocks (Sibumasu, Manabor (Malaya- Natuna- W Borneo), Indochina, S China), with independent pre-Triassic histories. Carboniferous mainly shallow marine with subordinate epicontinental and continental deposits. Carboniferous of Sibumasu continental margin deposits with glacial-marine diamictites. Manabor block shallow marine clastics with reefal limestones and abundant
volcanics interpreted as possible island arc. C part of Indochina Block emergent in Carboniferous and bordered by non-marine. Carboniferous faunas of SE Asia mainly of Eurasian aspect)

(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1986012.pdf)
(First of many Metcalfe papers on SE Asian tectonic blocks, their Gondwanan origins and histories of rifting, drift and collision with Asia. SE Asia 4 tectonic blocks, SIBUMASU, MANABOR, Indochina and South China. Indochina and S China rifted off Gondwana in Late Devonian- E Carboniferous and sutured to each other by M Carboniferous. SIBUMASU separated from Australian Gondwana in late Lower Permian. MANABOR accreted to Indochina/S China by Late Triassic, possibly earlier)

(Documentation of stratigraphic successions and paleobiogeographic affinities of Sibumasu, East Malaya, Indochina and SW Borneo blocks)


(online at: http://journals.royalsociety.org/content/d673155257474040/fulltext.pdf)


(Continental 'core' of SE Asia four main terranes: South China, Sibumasu, Indochina and East Malaya. Ordovician faunas of S China and Sibumasu strong affinities with N and NW Australia and Tasmania and include forms endemic to Australia and Gondwana. Affinities of E Palaeozoic faunas of Indochina and E Malaya not yetknown. N China placed near N Australia, Sibumasu adjacent to NW Australia and S China, Indochina, Tarim, Tsaidam, Lhasa and Changtang blocks formed part of North India-Iran margin of Gondwana.)

(Stratigraphical, sedimentological, paleobiogeographic and paleomagnetic data suggest that probably all SE Asian continental terranes derived from Gondwana. Terranes assembled between Late Palaeozoic and Cenozoic. Progressive CCW rotation of Borneo- Malay Peninsula region during Late Cretaceous- Cenozoic. Most Palaeozoic data from mainland Asia probably affected by Late Carboniferous and Cretaceous resets. Paleomagnetic data vital for constraining movements of crustal blocks)


(Evolution of E Pangea and Tethys in Late Paleozoic-Mesozoic involved rifting of continental slivers/fragments from NE Gondwanaland, N-wards drift and amalgamation/accretion to form proto East Asia. Three continental slivers rifted from NE Gondwanaland in Silurian-E Devonian (N China, S China, Indochina/E Malaya, Qamdo-Simao and Tarim terranes), E-M Permian (Cimmerian continent, incl. Sibumasu, Lhasa and Qiangtang terranes) and Late Jurassic (W Burma terrane, Woyla terranes). N-ward drift of terranes effected by opening and closing of three successive Tethys oceans, Paleo-Tethys, Meso-Tethys and Ceno-Tethys)


Metcalfe, I. (1999)- The ancient Tethys Oceans of Asia: how many? how old? how deep? how wide? UNEAC Asia papers, University of New England, Armidale, 1, p. 1-9. (online at: www.une.edu.au/asiacentre/PDF/Metcalfe.pdf) (Tethys in E Asia three successive ocean basins: Paleo-Tethys (late E Devonian- M Triassic), Meso-Tethys (late E Permian- Late Cretaceous) and Ceno-Tethys (Late Triassic (W)/Late Jurassic (E)- Cenozoic). Ocean basins water depths comparable to modern ocean basins and all three had widths of 2000-3000 km in E parts at maximum development)
(Same paper as above)


(Paleo-Tethys opened in Devonian when N China, S China, Tarim, Indochina separated from N Gondwanaland and closed in Permian-Triassic when Sibumasu-Qiangtang terrane amalgamated with Indochina/S China. Main suture zone in E Asia represented by Lancangjiang and Changning-Menglian zones of SW China, Nan-Uttaradit and Sra Kaeo zones of Thailand and Bentong-Raub suture zone of Peninsular Malaysia)

(All East Asian terranes derived from Gondwanaland. Rifted and separated as three continental strips in Devonian, late early Permian and Late Triassic-Late Jurassic, opening Paleo-Tethys, Meso-Tethys and Ceno-Tethys oceans. East Asia formed by assembling/closing of these oceans)

(Bentong-Raub Suture Zone of Malay Peninsula is closed segment of Devonian-M Triassic Paleo-Tethys ocean and boundary between Sibumasu and Indochina terranes. Suture zone result of Permian-N-ward subduction of Paleo-Tethys under Indochina and Triassic collision of Sibumasu terrane. Sibumasu separated from Gondwana in late Sakmarian (E Permian), then drifted N in Permian-Triassic, with E Malaya I-type volcano-plutonic arc on Indochina margin. Main structural discontinuity in Peninsular Malaysia between Paleozoic and Triassic. Orogenic deformation started in U Permian-Lower Triassic. E-M Triassic, A-Type subduction and crustal thickening generated Late Triassic-E Jurassic Main Range syn- to post-orogenic granites. Foredeep basin developed on margin of Sibumasu in front of accretionary complex with Semanggol Fm rocks. Suture zone covered by latest Triassic-Cretaceous red bed overlap sequence)

(Abbreviated version of above paper)


(On Gondwanan versus S China/Indochina-derived continental terranes in SE Asia. ’Cathaysian’ S China-Indochina and Simao terranes at equatorial paleolatitude in Permian, but derived from Gondwana in Devonian. Sibumasu attached to NW Australia Gondwana until Sakmarian, then evolved through Permian intermediate stage to Cathaysian, reflecting separation and N-ward drift. W Burma and smaller terranes (Paternoster, W Sulawesi, Mangkalihat) split off Gondwana in Late Triassic-Jurassic. SW Borneo, Luconia, Reed Bank, Palawan derived from S China/Indochina in Cretaceous. Various terranes in E Indonesia derived from New Guinea in Cenozoic)


(Re-evaluations suggest W Sumatra and W Burma blocks separated from Gondwana in Devonian, along with Indochina and E Malaya and together with S China formed 'Cathaysialand' in Permian. 'Argoland', which separated from NW Australia in Jurassic previously interpreted to be W Burma but may be SW Borneo)


(SE Asia collage of continental terranes derived from India-Australian margin of E Gondwana. Late Paleozoic-Mesozoic rifting and separation of three elongate continental slivers from E Gondwana and opening and closure of Paleo-Tethys, Meso-Tethys and Ceno-Tethys ocean basins. W Sumatra, W Burma, Indochina and East Malaya blocks separated from Gondwana in Devonian and with S China formed 'Cathaysialand' in Permian. They were translated W to positions outboard of Sibumasu Terrane by strike-slip tectonics in Late Permian-E Triassic at convergence between Meso-Tethys and Palaeo-Pacific plates. SW Borneo, previously considered of 'Cathaysian' origin, is possibly 'Argoland' that separated from NW Australia in Jurassic)


accreted to Sundaland core in Triassic. W Burma now considered Cathaysian, similar to W Sumatra, from which it separated by Andaman Sea opening. SW Borneo and E Java-W Sulawesi tentatively identified as 'Banda Block' and 'Argoland', which separated from NW Australia in Jurassic and accreted to SE Sundaland in Cretaceous (puzzling how these rifted off NW Australia at same time, switch relative E-W positions along way, then both accreted to Sundaland margin at similar time but with Meratus suture separating them?; JTvG))

(online at: https://www.academia.edu/13303900/Palaeozoic_Mesozoic_history_of_SE_Asia)
(One of later versions of Metcalfe SE Asia Cambrian- Eocene reconstructions of Gondwana-derived blocks and Tethyan oceans. Recent modification is identification of SW Borneo and/or E Java- W Sulawesi as missing 'Argoland' that separated from NW Australia in Jurassic and accreted to SE Sundaland in Cretaceous)

(online at: https://s3.amazonaws.com/academia.edu/documents/36381227/Metcalfe_2013_)
(Review paper on SE Asian plate tectonics. SW Borneo and E Java-W. Sulawesi now identified as missing 'Banda' and 'Argoland' blocks, separated from NW Australia in Late Triassic- Late Jurassic by opening of Ceno-Tethys and accreted to SE Sundaland by subduction of Meso-Tethys in Cretaceous)

(online at: www.gsm.org.my/products/702001-101709-PDF.pdf)
(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.)

(Final results of IGCP Project 321 'Gondwana dispersion and Asian accretion'. Collection of 19 papers on tectonics of SE Asia)

(Collection of 31 papers on biogeography and paleobiogeography of SE Asia- Australia, presented at Armidale 1999 conference)

(Radiolarian biostratigraphy in Thailand, S China, Malaysia, etc., constrains ages of Paleoetethys Ocean opening (Devonian) and closing (Triassic))

(Unorthodox, non-plate tectonic model for SE Asia)

(Review of global paleobiogeographic realms through time from 'anti-plate tectonics' perspective)


(Present-day animal distribution patterns linked to plate tectonics)


(Review of models of geological development of Indonesia and Philippines. Areas of present-day endemism within Wallacea identified. Tanimbar Islands biologically part of S Maluku. Timor (plus Savu, Roti, Wetar, Damar, Babar) and W Lesser Sunda islands form separate areas of endemism. Wallacea formed from complex of predominantly Australasian exotic fragments linked by geological processes within complex collision zone)

(Discussion of difficulty of carrying Paleotethys suture between Gondwanan 'Sibumasu' terranes and Paleoeurasia continent through Myanmar and into Yunnan, S China. Main point of contention is position of Boashan Block, which has both Gondwanan and Tethyan characteristics in Permian. Margin farther W than usually assumed)


(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1977026.pdf)
(Most tin-bearing granitic rocks in SE Asia in one of three main belts: (1) Late Carboniferous- E Triassic East Belt (tin-bearing, emplaced in continental crust of E Malaya- E Central Thailand above E-dipping Benioff zone); (2) Late Triassic Central Belt ('Indosinian orogeny' syn-collisional granites, emplaced during collision of 'Sibumasu' (W Malaya, etc.); and (3) Western belt with widespread Late Cretaceous-E Eocene plutons (emplaced in W zone above E-dipping Benioff zone))

(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1979003.pdf)
(General discussion of tin belts in different tectonic settings, incl. SE Asian province)

(Recognition of Phanerozoic subduction systems and two continental fragments of Gondwanaland through mainland SE Asia. Cambrian subduction system and 5 Mesozoic-early Cenozoic collision belts identified. Indochina, E Thailand and Cl Tibet accreted to China in E Triassic; western SE Asia and S Tibet separated from Gondwanaland in Permian or E Triassic and collided with Asia in Late Triassic. W Burma island arc system collided with Asia in Jurassic. U Triassic flysch and schist in E Indoburman Ranges accreted to W Burma in Jurassic- E Cretaceous)

(In fore-arc area of N Sunda Arc (W Burma-Andaman-Nicobar- W Thailand) emplacement of serpentinite melange diapirs and deposition of olistostromes were caused by Campanian collision with continental fragment since underthrust E-wards beneath arc. Age and position of E-directed thrusts and associated tin granites in continental back-arc area implies thrusting and generation of granites genetically related to collision)

(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1986b12.pdf)
(Main Mesozoic tectonic event in mainland SE Asia was Late Triassic Indosinian orogeny. Deformation and uplift in Malaysia Main Range and N Thailand, emplacement of syn- to late-tectonic two-mica granites of Central Tin Belt, and imbricate thrusting in Bangka Island best be explained by E Triassic collision of Shan-Thai block foreland with Indochina block to E. Continental fragment, exposed in Indoburman Ranges, collided with Burma in latest Jurassic, etc.)

(On belt of Jurassic accretionary complex along E Asian margin from Japan to S, composed of deformed sediments with U Permian limestone, Triassic bedded cherts and Lower Jurassic siliceous shales and younger clastic rocks)

(Nadanahada Jurassic disrupted terrane in NE China mainly composed of Permo- Carboniferous limestone and greenstone, Triassic bedded chert and M Jurassic siliceous shale enclosed in Late Jurassic- E Cretaceous clastics. Identical to Mino terrane of Japan, and representing parts of long E Asian Late Jurassic- Cretaceous accretionary belt along E Asia continental margin after Triassic amalgamation of Chinese continent. Also included Ryukyu arc, Palawan Blocks of Philippines and probably Borneo (Danau Fm))

(Classic paper linking major strike slip faults in Asia to India-Asia collision)

('Accretion mechanisms of oceanic fore-arc domains and geodynamics of SE Asia')

(Tertiary rift basins of Thailand and adjacent countries show considerable variability in timing of rifting and inversion episodes. Rift basins developed on blocks that were extruded SE-ward, possibly tied to Himalayan extrusion tectonics. In Thailand major sinistral strike-slip motion ceased at ~30 Ma, prior to formation of most rift basins. Alternative mechanism to open rift basins is subduction rollback of Indian plate W of Thailand)
(Two types of SE Asia Tertiary evolution models: (1) escape tectonics with no proto-S China Sea, (2) subduction of proto-S China Sea oceanic crust beneath Borneo. Proposed tectonic model with key points: (1) Ailao Shan-Red River shear zone mainly active in Eocene-Oligocene tied to extension in S China Sea; (2) three regions of metamorphic complex development affected Indochina from Oligocene-Miocene; (3) Subduction of proto-S China Sea in Eocene- E Miocene necessary to explain evolution of NW Borneo; (4) Eocene-Oligocene collision of NE India with Burma activated extrusion tectonics in mainland SE Asia and right lateral motion along Sumatran subduction zone)

(Late Cretaceous S-type granites from Malaysia-Thailand to Myanmar long used to infer episode of crustal thickening, supported by late Cretaceous-Eocene ophiolites in Myanmar, but no evidence for associated fold-thrust belt. Fission-track studies of Thailand indicate modest regional uplift from ~80-40 Ma. Left lateral motion on major NW-SE-trending strike-slip fault zones (Mae Ping and Three Pagodas faults) in Myanmar and Thailand attributed to Himalayan-Tibetan escape tectonics, but fault zones are network of branching faults with important N-S trends as well as NW-SE trends. This diffuse 1000 km long/up to 250 km wide, branching network of strike-slip faults may represent Late Cretaceous- Paleogene transpressional belt. Himalayan escape tectonics represent later deformation)

(From Yunnan to N Thailand, Late Cenozoic-Recent faults strike predominantly NNE-SSW, N-S to NNE-SSW and NE-SW to ENE-WSW. Associated sedimentary basins are aligned NE-SW to N-S. Fault patterns commonly interpreted as strike-slip dominated deformation, but N Thailand interpreted to have evolved mainly by oblique extension. Multiple episodes of basin inversion in N Thailand during Miocene require changes in stress pattern)

(N to NE subduction beneath SE Asia during Mesozoic-Cenozoic resulted in development of hot, thickened crust in Thailand-Myanmar region in back-arc mobile belt setting. Setting changed in Eocene-Recent to highly oblique collision when India coupled with W Burma block)

(Late Cretaceous-E Paleogene history of continental core of SE Asia (Sundaland), prior to India-Asia collision. In Myanmar and Sumatra subduction s interrupted in Aptian-Albian by phase of arc accretion (Woyla and Mawgyi arcs) and in Java, E Borneo and W Sulawesi by collision of continental fragments rifted from N Australia. Subsequent resumption of subduction in Myanmar-Thailand sector explains: (1) early creation of oceanic crust in Andaman Sea in supra-subduction zone setting at ~95 Ma; (2) belt of granite plutons of Late Cretaceous- E Paleogene age in W Thailand and C Myanmar; (3) amphibolite grade metamorphism at 70-80 Ma in W and C Thailand; and (4) accretionary prism development in W Belt of Myanmar, until glancing collision with NE corner of Greater India promoted ophiolite obduction and deformation in E Paleogene)

(On relationship between Cenozoic strike-slip faults of mainland SE Asia and adjacent sedimentary basins (Gulf of Thailand, Gulf of Martaban/Andaman Sea, Gulf of Tonkin. Most major onshore SE Asia strike-slip faults probably do not extend far offshore)
(Overview of deepwater fold-thrust systems. Two types: Type 1 mainly on passive margins, driven by sediment loading or local uplift, typically with high-quality continent-derived quartz sst reservoirs; Type 2 on active margins, in areas of continental convergence. Examples include NW Borneo, W Sulawesi- Makassar Straits, Banda Arc, Seram)

(SE Asia chapter describes Cenozoic vegetation response to plate tectonic evolution, as reflected in Indonesia palynology records. Middle Eocene arrival of palynomorphs known from older deposits in India is consequence of India-Asia collision. In M Eocene SW Sulawesi has Laurasian flora, and was attached to E Kalimantan. Makassar Straits became floral-faunal migration barrier in Late Eocene. First Australian- New Guinea floral elements (Casuarina, etc.) start appearing in W Java Sea around 22-21 Ma)

(Australia biogeographic realm comprises Western Australia, New Zealand, New Guinea and Sula Islands. Not much specific data/ interpretation)

('Global distribution of ammonite faunas in the Middle Jurassic (Upper Aalenian to Middle Bathonian): relations between biodiversity and paleogeography'. Tethyan, Pacific, Boreal domains and associated epicratonic platforms divided into 16 paleobiogeographical provinces. Provinces that show strong endemism are isolated (Boreal and SE Tethyan margins))

(Review of ocean basins, with global reconstructions for last 200 Myrs)

(Revised global plate motion model from Triassic at 230 Ma- present day. Plate velocities controlled or modified by increases in subduction processes and collisional events and ridge subduction events)


Nicoll, R.S. (2004)- New Permian cold water conodont faunas from the Tethyan Gondwanan margin of Australia. GSA Rocky Mountain and Cordilleran Joint Meeting, 20-11 (Abstract only)

(Small, low diversity conodont faunas from E-M Permian of S Carnarvon- Canning basins of W Australia (palaelatitude up to 60°S). Species of Hindeodus and Vjalovognathus cool-temperature tolerant forms were first conodonts to invade after Late Carboniferous-E Permian glaciation. Faunas of similar age from Timor (palaelatitude ~45°S) significantly greater faunal diversity)

Conodont faunas of allochthonous East Asian terranes show biogeographic affinities with Australasia during Cambrian-Permian, suggesting close proximity or Australian Gondwanaland from ~500-250 Ma


Overview of Permian terranes history, mainly of mainland Asia. Biogeographic provinces well developed in Late Palaeozoic due to steep equator-to-pole gradients. As continents rifted from S margin of Paleo-Tethys, they lost temperate Gondwanan affinities and acquired sub-tropical to tropical floras and faunas. A S belt of terranes, from Helmand block in Iran-Afghanistan, through W Qiangtang and Lhasa blocks of Tibet to Sibumasu block of Thailand-Malaya, all rifted off margins of Gondwana in Permian. Cathaysian floras existed in N parts of Gondwana (New Guinea), and since Cathaysian plants like Gigantopteris had to be dispersed by seeds this suggests land connections between Cathaysian microcontinents and Gondwana


Review of Mesozoic of Gondwana margins of E Tethys Ocean (Australian and Himalayan margins, Timor and ODP Legs 122-123). Region drifted N in Triassic, entering tropical paleolatitudes in Late Triassic- E Jurassic, then returned to mid-latitudes for M Jurassic- E Cretaceous. Episodes of deltaic sandstone progradation over shelves. Widespread hiatus between Callovian shelf deposits and Oxfordian deep-water sediments, coinciding with block faulting off NW Australia. Shallow depths of carbonate compensation during Late Jurassic- E Cretaceous over most of Argo basin off NW Australia caused deposition of radiolarian-rich claystone. Volcanism accompanied final stages of rifting between India and Australia in Late Berriasian-Valanginian. Late Barremian and Aptian rise in CCD, with warming and increased organic-rich claystone.


Mesozoic fossil floras of E Asia (China, Mongolia, Siberia, Korea, Japan) with (1) northern Tetori flora reflecting warm-temperate and moderately humid climate and (2) southern Ryoseki-type floras with features of hot and arid/semi-arid floras and Tetori-type plants being ‘typical of conditions’. (nothing on SE Asia)

(Collection of 15 papers on Cretaceous of Japan, Philippines, mainland E Asia; nothing on Indonesia/ New Guinea)


Page, K.N. (2008)- The evolution and geography of Jurassic ammonoids. Proc. Geologists Assoc. 119, 1, p. 35-57. (Jurassic ammonites 7 suborders, in ~20 distinguishable biogeographical provinces and subprovinces. S Pan-Tethyan Realm includes Mediterranean-Caucasian, E Pacific, Indo-Pacific and Austral realms/ subrealms. Indo-Malagach Province recognizable first in Callovian, with endemic Sphaeroceratidae (Macrocephalites, Subkossmatia) and Perisphinctidae (Indosphinctes, Choffatia, Kinkelineris, etc.). Persisted into Oxfordian times, with place of Macrocephalitinae taken by endemic Mayatinae. By Tithonian, several restricted Indo-Pacific/Austral genera and endemic species: Pachysphinctes, Virgatosphinctes, Aulacosphinctoides, Himalayitidae, Neocomitidae (incl. endemic Blanfordiceras), Uhligites, etc.)


Pitfield, P.E.J. (1987)- Report on the geochemistry of the Tin islands of Indonesia. British Geological Survey, Overseas Directorate, Report No. MP/87/9/R, p. (online at: https://gsmpubl.files.wordpress.com/2014/09/ngsm1987003.pdf) (In Thai-Malay Peninsula two separate granite provinces established, separated by Raub-Bentong line suture: (1) Main Range granitoids (associated with 'Sibumasu' Lower Paleozoic shallow marine sequences) and (2) Eastern Province (C and E Belts) granitoids (associated with Permo-Triassic deeper water volcano-sedimentary sequences). Tin Islands of Indonesia largely fall in Permo-Triassic volcano-sedimentary terrain, but characteristics of granites variable. Comparisons of granitoids suggest S-ward extrapolation of Raub-Bentong line between Karimun (E Province type) and Kundur (Main Range type) along chain of isles comprising Merak gabbro. Further S it may pass through C Singkep Island between Dabo (E Province type) and unnamed Main Range pluton in SW Belitung seems to comprise largely E Province plutons)

Thailand- Burma, S and I-types, Cretaceous 82-98 and 130 Ma). E and C Belts of Peninsular Malysia distinguished by Hutchison (1977), but are similar. Tin Islands of Indonesia part of E Province, Permo-Triassic. Widespread Cretaceous post-orogenic plutons, but not in Main Range and Tin Islands and not associated with mineralization)

(Textural evolution from coarse K-feldspar megacrystic granite, through heterogeneous granite porphyry to microgranite corresponds to sequence of geochemical evolution)


(Old paper on India collision and evolution of Sundaland)

(Paleomagnetic data from Indochina, Malaysia and Kalimantan show similar declination at similar times, suggesting much of older continental nuclei of SE Asia acted as single continental block ('Sundaland') at least since ~80 Ma. Plate motions derived from continental paleomagnetism and seafloor spreading show continental Sundaland moved W-ward across wake of the N-moving Greater India ~15 My ago (M Miocene) while at e same time Australia moved N-ward across Sundaland 's wake)

(E section of Paleotethys suture extends from Qinghai-Tibet to W Yunnan, S to Putong, Changning-Menglian, Uttarradit and Bentong-Raub, through Kalimantan (Kuching), Palawan, Luzon, Taiwan and Japan. Present ‘U’ shape of suture zone caused by N-moving Indian plate, S China Sea spreading and W-pushing Philippine Sea plate since 45 Ma. Restored Paleotethys suture oriented E-W from Late Cretaceous- Early Cenozoic)

(online at: https://www.sciencedirect.com/science/article/pii/S163107131500200X)
(Philippine Mobile Belt complex tectonic zone composed of rigid rotating crustal blocks. In Myanmar, N-most tip of Sumatra-Andaman subduction system also complex zone of various crustal blocks in-between convergent plates, but sustaining internal deformation with platelet buckling, indicative of non-rigid behavior)

(On relationship between modern faunal- floral distributions and Australia- SE Asia plate tectonic history)

(online at: www.geo.arizona.edu/rees/2202-4.pdf)
(Global 'icehouse-hothouse' climate transition began during Permian. Reconstructions for two stages, Sakmarian (285-280 Ma) and Wordian/ Kazanian (267-264 Ma), integrating floral with lithological data to determine climates globally)

Asia is composite continent consisting of three major cratons: Siberian, Indian and Arabian and three huge orogenic belts with minor cratons and microcontinents. Main body of Asian continent took its shape in Mesozoic. Main orogenic belts: Paleo-Asian, Tethyan and Pacific. Small cratons, like Sino-Korea, Yangtze, Tarim, and Sibumasu were on N margin of Gondwana before disappearance of Paleo-Asian Ocean. Ophiolites in Asia progressively younger from N to S, reflecting accretion of Asia by S-ward migration of orogenic belts. Large amounts of Mesozoic volcanic rocks in E Asian coastal areas mainly of Cretaceous age. Most Carboniferous-Permian volcanic rocks in C. Asia not arc volcanics, but product of extensional stage.


(On widespread Late Mesozoic and Cenozoic extension in E China and adjacent areas. First rift stage in Late Jurassic- E Cretaceous, second phase in NE Asia. Paleogene stage widespread continental rift systems and continental margin basins in E China (incl. S China Sea))


('The history of the Sunda Arc: a zoogeographic investigation’. Results of 1927 German biological expedition to the Lesser Sunda Islands (Lombok, Sumbawa, Flores))


('Reconstruction of the India-Asia collision zone- a study centered on Indochina')


(Reconstruction of India-Asia subduction-continent deformation history, using tomography, etc. Major breakoff between India and Tethys Ocean at ~45 Ma. In W vertical slab continuous to continent overrides deeper detached Tethys slab; in E no slab imaged. After Tethys slab broke off, subduction only resumed in C of margin. Second breakoff event detached C Indian slab from margin at ~15 Ma, which renewed Indian lithosphere underthrusting below Asia. Breakoff followed by large stresses in upper plate interiors, propagating at large distance from margin, along belt oriented at ~45° from trench. Successive strike-slip faulting across Asian continent, in agreement with models)


(Seismic tomography suggests existence of three Asian continental slabs. Asian continental subduction could accommodate up to 45% of Asian convergence; rest of convergence possibly accommodated by extrusion and shallow subduction/underthrusting processes. Continental subduction major lithospheric process in intraplate tectonics of supercontinent like Eurasia)


(Reconstructions of SE Asia block motions from India to Taiwan since ~50 Ma from tomography of subducted lithosphere)


(Tomographic anomalies at <1100 km under India/Asia collision zone interpreted as continental slabs subducted during collision, and used to constrain evolution of episodes of continental subduction. In W part two episodes of steep subduction of N margin of India: (1) starting at~40-30 Ma and ending by slab breakoff at ~15 Ma; (2) subduction beneath Hindu Kush mountains since ~8 Ma. E of collision zone, beneath Burma and Andaman Sea, two episodes of SE-ward extrusion followed by subduction. Extruded portions initially located along N margin of India)
(Reconstructions of SE Asia block motions from India to Taiwan since ~50 Ma. Extrusion absorbed ~30% of convergence between India and Siberia during entire collision span, but varied with time)

(Fluctuating affinities between aquatic faunas of China and Australia in Devonian. Within S China Block similar endemic freshwater fish faunas on Yangtze and Huanan terranes demonstrate juxtaposition in mid-Paleozoic. Triassic tetrapod faunas of Australia quite distinct from China and Thailand)

(Review of tectonic, magmatic and metallogenic history of Tethyan orogen from Carpathians to Indochina, with focus on formation of porphyry Cu±Mo±Au deposits, the most characteristic mineral deposit type formed during both subduction and collisional processes in region)

(Shan Hills of E Myanmar (Cretaceous Phuket-Mandalay foldbelt) and Khorat Plateau of Thailand rotated ~40° CW since Cretaceous)

(Evolution of the former Tethys ocean)

(On Tethyan pattern of transit plates between converging boundary in N and diverging boundary in S (repeatedly offset by S-ward shifts))

(Stratigraphic evidence in Thailand and Malaya suggest they were once joined with India (E Permian tilloids in Phuket Group of Thailand, etc., cratonic clastic source from W for Malay Peninsula and Thailand, detrital diamonds in Permian Phuket Gp of Thailand, etc.). India and SE Asia must have drifted N to collide with mainland Asia after break-up of Gondwanaland. 'Interesting' reconstruction)

(Paleozoic- E Mesozoic of Thai-Malay Peninsula provide evidence of subduction zone to E and, in Lower Paleozoic, cratonic sediment source to W. First paper to recognize separation of W Thai- Malay Peninsula from Gondwana in mid-Paleozoic and collision with mainland Asia in Late Triassic)

(E flank of Sibumasu block was passive continental margin, marked in NW Thailand by absence of M Permian-Triassic platform carbonates, widespread across Sibumasu further W. Instead, hemipelagic cherts, mudstones and sandstones including turbidites. Devonian-Triassic accretionary wedge in front of Sukhothai volcanic arc thrust W-wards across E flank of Sibumasu in M-L Triassic, then became source of terrigenous clastic rocks in
foredeep basin in W. Boundary with Sibumasu Permo-Triassic carbonate platform further W is Mae Ping-Nam Teng Fault system. N-wards in Myanmar and Yunnan Sibumasu Permo-Triassic carbonate shelf continues as Shan Plateau and Baoshan Block. E flank is represented by Changning-Menglian Belt, and Paleotethys ‘cryptic suture’ in Thailand possibly joins with Lancangjiang Suture)


(Luxi-Nujiang suture extends from Yunnan into Myanmar and continues into Thailand and Malacca Strait. It separates the Gondwana-derived Sibumasu Block’ into two terranes: (1) Irrawaddy Block in W, with thick Lower Permian, glacial diamicrite-bearing sediments (= ‘Phuket Slate Belt’ of Thailand/ Tengchong Block of Yunnan/ Lhasa Terrane in Tibet? and much of Bohorok facies of Sumatra); (2) Sibuma Block in E, with local, rel. thin, Lower Permian marine ice-rafted deposits (= Shan-Tai Plateau of E Myanmar/ Baoshan Block of Yunnan/ Qiantang Terrane of Tibet?). NE Sumatra diamicrite-bearing E Permian probably also part of Irrawaddy Block. Late Cretaceous-Paleogene dextral India-Australia oceanic transform propagated onshore as strike-slip fault, which disrupted Irrawaddy Block)


(online at: http://searg.rhul.ac.uk/searg_uploads/2016/01/Rigby.pdf)

(Minor Carboniferous flora in Thailand and W Malaysia (including ’Kuantan flora’), probably similar to S China floras. More extensive Permian floras known from Thailand, Laos, W. Malaysia, Sumatra and Irian Jaya. All are ’Cathaysian’ floras, but some floras from Thailand and Irian Jaya also contain Gondwanan Glossopteris)


(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))


(Early version of SE Asian plates history)


(online at: www.tandfonline.com/doi/pdf/10.1080/00188144.2014.915586)

(Review of tectonic blocks and continental growth of Asia and prediction of formation of future supercontinent ‘Amasia’ 200-250 Myrs from now)


(Most lineages of Indo-West Pacific marine fauna may have originated in western Indian Ocean, Australia, or SW Pacific, probably from lineages that remained isolated after breakup of Gondwanan supercontinent, or because of movement of island arcs)

(Cherts and associated shales of Thailand and Peninsular Malysia contain rich U Devonian- M Triassic radiolarian faunas, allowing subdivision in 13 zones (representing Paleo-Tethys Ocean sediments). Timing of collision of Shan-Thai with E Malaya is E Triassic and Shan-Tai with Indochina Late Triassic or later)


(Compilation of Jurassic fossils/ stratigraphy in SE Asia. Jurassic rel. rare. May be classified as (1) thick geosynclinal sequences in Sumatra, Java (?; JTvG), Timor and New Guinea; (2) marine calcareous facies with rich macrofaunas in E Sulawesi, Sula, Buru, Ceram and Misool; (3) marine clastic sediments with poor molluscs in W Thailand/ Burma, W Sarawak/NW Kalimantan, Laos, Cambodia, Vietnam, etc. and (4) Khorat Group continental red beds in NE Thailand- S Laos)


(Most of E Asia Cenozoic deformation not extrusion tectonics, but back-arc extension caused by E-ward rollback of subducting slab along E Asian active margin and collapse of overriding plate towards retreating hinge-line. Extension took place along ~7400 km long stretch of E Asian margin during most of Cenozoic)


(Numerous tectonic events globally in M-L Eocene at ~45 Ma and ~37 Ma, suggesting major reorganization in plate tectonic pattern. Not much specifically on SE Asia)


(Atlas of global plate and paleogeographic reconstructions for 20 time periods from 650 Ma- Recent. For SE Asia major source was Hutchison (1989))


(Reconstructions of Gondwana with interpreted paleoclimates from Late Ordovician-Cretaceous)


(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 arches complexes along Myanmar-Andaman segment; (3) Andean-type margins (Cu-Au-Mo porphyry; epithermal Au-Ag) in Jurassic-Eocen 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))


(First definition of the Cimmerian continent as thin and very long continental strip between Paleo- and Neo-Tethys (in SE Asia= Sibumasu; JTvG))

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www.vangorselslist.com

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(Major review of plate tectonic history of the Alpine- Himalayan system, which is product of obliteration of the Tethys Ocean. During E-M Mesozoic Tethyan domain consisted of two oceans, separated by string of continents called Cimmerian continent, which had begun separating from N margin of Gondwanaland in Triassic (although rifting in E-most parts had begun earlier). N of Cimmerian continents was Paleo-Tethys, S of it was Neo-Tethys. Closure of Paleo-Tethys formed Cimmerides (Carpathians- Caucasus-Tibet to E Sulawesi), closure of Neotethys formed the Alpides)

Sengor, A.M.C. (1985)- The story of Tethys: how many wives did Okeanos have? Episodes 8, 1, p. 3-12.

(online at: www.episodes.co.in/www/backissues/81/ARTICLES--3.pdf)

(Tethys ocean is ancestral sea out of which Alpine-Himalayan mountain ranges grew. The main Tethys had formed until Triassic, but older Tethys (Paleo-Tethys) existed, the closure of which formed Cimmeride orogenic system, which is distinct from, but largely overprinted by Alpide orogenic system, which is product of demise of 'classical Tethys' (Neo-Tethys))


(Similar to Sengor (1986) below. Repeated episodes of Tethyan Ocean closing: Paleotethys by accretion of Cimmerides terranes, Neotethys by accretion of Alpide terranes)


(Alpine-Himalayan system interpreted as places where two independent Tethyan ocean complexes (Palaeo- and Neo-Tethys) vanished during Permo-Carboniferous- E Cretaceous and late Cretaceous- Present respectively. Older orogen is called Cimmerides, younger Alpides. Cimmerides, together forming Tethysides)


(Review of plate tectonic history of the Alpine- Himalayan- Indonesian mountain ranges since Late Paleozoic)


(Paleo-Tethyan suture separates regions characterized by two different tectonic styles in Tethysides. N of suture (Iran, Turkmenistan, Afghanistan, Tadjikistan, Kirgizistan, Uzbekistan, Kazakhstan large parts of Russia and China), orogenic development characterized by large subduction-accretion complexes developed since Late Proterozoic. S of Paleo-Tethyan suture, orogeny characterized by Sumatra- or Andean-type continental margin arc that in places became island arc by back-arc basin rifting and later collided with Atlantic continental margin to create Alpine- or Himalayan-type orogenic belts. Paleo-Tethyan suture is line across which rate of continental enlargement by subduction-accretion changed dramatically. Rel. little on SE Asia)


(online at: www2.uibk.ac.at/downloads/oegg/Band_89_5_177.pdf)

('The Tethys: hundred years ago and today'. Extensive historic review of discovery and development of interpretations of Tethys Ocean(s). Includes chapter (p. 104-114) on contributions to tectonic understanding of mountain building by the Dutch 'heroes' geologists working in Indonesia between 1900-1940, particularly Molengraaff, Wing Easton who were early supporters of 'mobilism', i.e. Wegener's continental drift hypothesis)

(Major review of plate tectonic history of the Alpine- Himalayan- Indonesian mountain ranges since Late Paleozoic. Mainly on mainland S Asia)

(End-Permian faunal extinctions may be consequence of sealing off of Paleo-Tethys ocean from Panthalassa by land bridge formed from Cimmerian Continent, Cathaysian and Manchuride orogenic collages and Tuva-Mongol fragment of eastern Altaids. Limited Late Permian water exchange between Paleo-Tethys and Panthalassa and Neo-Tethyan rifts, starting anoxia in Paleo-Tethys)


(Five maps showing the spatial and temporal evolution of magmatic activity along Tethysides for: (1) late Carboniferous-Permian; (2) Triassic- E Jurassic; (3) M Jurassic-early Cretaceous; (4) late Cretaceous-early Cenozoic and (5) late Cenozoic-present)

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


(Series of reconstructions of now mostly vanished oceanic plates between Australia and Eurasia since 140 Ma)

(Major review of ocean basins evolution, incl. Indian Ocean and Tethys)

(New data from heavy minerals and detrital zircon ages of Late Triassic Halobia-bearing Pan Chaung Fm turbidite sandstones of Chin Hills in E Indo-Burman Ranges of W Myanmar. Intercalated with ultramafic rocks. Sandstones derived from mix of metamorphic, sedimentary and contemporaneous volcanic rocks. Pre-Devonian ages of Myanmar (W Burma) Triassic sands closely resemble Sibumasu and W Australia (incl. >2.6 Ga Archean zircons), but differ from Indochina. Significant Permian-Triassic zircon populations (peaks at ~240 and 260 Ma) in W Burma, but not present in NW Australia. This points to proximity of W Burma to SE Asia (tin granites, etc.) in Triassic, which is therefore not elusive Argo block, as suggested in some models)

(Major deformation event in Hong Kong between 164-161 Ma (M-L Jurassic) linked to collision of microcontinent along SE China continental margin. Accreted terrane zircon age spectra close affinities to sources along N Gondwana margin. Collision of exotic terrane and subduction rollback, hastened foundering of postulated flat slab beneath SE China, leading to widespread igneous event at 160 Ma)


(Similar tectonic histories in W Tethys and SE Asia of microcontinents rifting off Gondwana in Devonian-Permian and collisions with Eurasia in Late Triassic, etc.)


(Chimei igneous complex in Coastal Range of E Taiwan is N part of intra-oceanic Luzon arc that accreted onto Eurasian continental margin since ~5 Ma. Magmatic zircons with mean Pb/U age of ~9 Ma probably of emplacement age. Inherited older zircons with ages clustering at ~14 Ma, ~218 Ma (largest peak) and older ages of ~726, ~1863 and ~2522 Ma suggest Cathaysia-type sources, attributed to continental fragment that split off Eurasian margin by opening of S China Sea, then drifted and accreted to W Philippine Sea plate before Luzon subduction initiation. Shows importance of ribbon continents in Asian orogenesis)


(Extensive intracratonic rift system within intracratonic SE Asia, with >70 Tertiary basins from N Thailand across Gulf of Thailand, SE-wards to Natuna Ridge. It includes significant hydrocarbon provinces (Malay, W Natuna, Pattani, Phitsanulok) and represents transtension along major faults and suture zones. Most rift basins affected by subsequent Miocene and Pliocene transtensional deformation. Onset of rifting tied to Eocene start of India- Eurasia plates collision)


(Late Triassic- 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)


(Km-size late M Permian limestone blocks in Indus-Tsangbo suture, Tibet, may be from carbonate build-up or seamount on oceanic crust. Fauna transitional between warm-water Cathaysian and cold-temperate Gondwanan faunas. Timorites ammonoid present, largely cool bi-temperate genus, occurring in W Timor, Japan, Tibet, Iran and W Texas. W Timor assigned to transitional Cathaysian- Gondwanan Cimmerian realm in M Permian (Shi and Archbold, 1995))

(Late Permian brachiopods five marine biotic province: Cathaysian (tropical), W Tethyan (tropical), Himalayan (warm temperate), Austroazcean (cold temperate) and Greenland-Svalbard (cold temperate). Also Cimmerian biogeographical region from Middle East through Afghanistan and Himalayas SE to Shan-Thai terrane and Timor, typified by mix of genera of both Cathaysian and Gondwanan affinities)

(Six paleogeographic provinces based on M Permian brachiopods: (A) Greenland-Svalbard (Arctic region), (B) Grandian (W North America), (C) Cathaysian (Paleotethys and Mesotethys), (D) Austrazean (E Australia- New Zealand), and two transitional zones (C) Sino-Mongolian-Japanese (N temperate zone) and (E) Himalayan (S temperate zone) Province. West Timor Allen-Maubisse assemblages grouped with Lhasa, Chitichun and Zhongba assemblages of S Tibet and Salt Range (Pakistan) in 'Himalayan Province.')

(Late Permian (Wuchiapingian) brachiopod fauna from exotic reddish crinoidal limestone block in Indus-Tsangpo suture zone in S Tibet (= suture between Eurasian/Lhasa Block and Indian Plate). Comparable with faunas in Salt Range of Pakistan, Chitichun Lst in S Tibet and Basleo area of W Timor (incl. 'antitropical' peri-Gondwanan species Stenoscisma purdoni and S. timorense, etc.). Fauna mixed peri-Gondwanan and Cathaysian character, possibly seamount biota originally from S margin of Neotethys in Late Permian, displaced and sandwiched into younger marine deposits in Cenozoic India- Eurasia collision)

(Four Permian brachiopod assemblages from W Yunnan, SW China. Faunas from Baoshan Block dominated by species characteristic of Cathaysian Province with some links with Peri-Gondwanan faunas. Simao Block characterised exclusively by taxa of Cathaysian Province)

(Review of Permian successions and fossils in NE China. Dominated by brachiopods, fusulinids and land plants, with limited ammonoids, conodonts and bivalves. Guadalupian (M Permian) in Manchuride, Altaid and Yanbian Belts with bi-temperate Roadian- E Wordian Monodiexodina fauna and late Wordian- Capitanian Codonofusiella- Schwagerina or Neoschwagerina-Yabeina faunas)

(Three palaeolatitude-related brachiopod paleobiogeographic realms in E Permian. Six provinces distinguished in Asselian: Faunas from Gondwana not well differentiated at province level and form Indoralian province. From Sakmarian large transition zone (S Transitional Zone) between Paleoequatorial and Gondwanaland Realms formed, with Austrazean province(E Australia- New Zealand) in E margin of Gondwanaland, contemporaneous with peak of Late Paleozoic Ice (Sakmarian Eurydesma- Bandoproduc-tus-Cimmeriella assemblage, followed by Stereochia, Kasetia, Dychrestia and Spiriferella faunas). Large Cathaysian province stretching from S China, Iran in W Palaeotethys to Mongolian continent in N)


Shi, G.R. & N.W. Archbold (1995)- Permian brachiopod faunal sequences of the Shan-Thai terrane: biostratigraphy, palaeobiogeographical affinities and plate tectonic/palaeoclimatic implications. J. Southeast Asian Earth Sci. 11, p. 177-187. (Five Permian brachiopod assemblages known from Shan-Thai terrane: Late Asselian-Tastubian cool-water fauna, three 'transitional' faunas of Sterlitamakian, Baigendzhinian- E Kungurian and Kazanian-Midian ages, and Late Permian (Dorashamian) warm-water Cathaysian fauna. Shan-Thai belonged to Indoralian Province of Gondwan Realm in Asselian-Tastubian and was incorporated into Cathaysian Province in latest Permian)

Shi, G.R. & N.W. Archbold (1995)- A quantitative analysis on the distribution of Baigendzhinian- Early Kungurian (Early Permian) brachiopod faunas in the western Pacific region. J. Southeast Asian Earth Sci. 11, 3, p. 189-205. (Cluster analysis of distribution of 222 species of E Permian brachiopods from 25 localities across E Asia-Australia suggest 6 bioprovinces. In SE Asia two provinces (both sub-provinces of Cimmerian terranes): (1) Group B, Shan-Tai/ Sumatra/ W Papua Birds Head (warm temperate to S-subtropical; with Stereochia-Stictozoster) and (2) Group C, Himalayan/ Lhasa/ Timor (S-temperate; with Reedoconcha, Callytharella; also fusulinid Monodiexodina). Notable conclusions: Timor (Maubisse) was southern extension of Lhasa terrane, W Thailand most similar to Birds Head, Sumatra Jambi and Padang faunas similar and grouped with Shan Tai)

Shi, G.R., N.W. Archbold & L.P. Zhan (1995)- Distribution and characteristics of mixed (transitional) mid-Permian (Late Artinskian-Ufimian) marine faunas in Asia and their palaeogeographical implications. Palaeogeogr. Palaeoclim. Palaeoecology 114, p. 241-271. (Asia Permian marine biogeography 3 realms: Boreal, Tethyan and Gondwanan. In early E Permian sharp biogeographical boundaries, due to Gondwanan glaciation. In M Permian two transition zones with mixed faunas: (1) North (N China, Japan, etc.), with warm Cathaysian and temperate Boreal genera, (2) South (Arabia, Iran, Shan-Tai, Timor, W Irian Jaya, etc.) with both Gondwanan and Cathaysian elements. Both transition zones have anti-tropically distributed genera like Monodiexodina, Lytvolasma and Spiriferella and are succeeded by Late Permian tropical Tethyan faunas. Timor brachiopods from Sakmarian Maubisse Fm similar to W. Australia, Bitauni late E Permian assemblage mixed Gondwana-Tethyan elements, Late Permian Basleo fauna is 'Tethyan' subtropical-tropical)

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

Shi, G.R., Z.J. Fang & N.W. Archbold (1996)- An Early Permian brachiopod fauna of Gondwana affinity from the Baoshan block, western Yunnan, China. Alcheringa 20, 81-101. (E Permian brachiopod fauna from U Dingjiazhai Fm, 30km S of Baoshan, W Yunnan. Dominated by Stenoscisma and Elivina yunnanensis n.sp.. Strong links with faunas from Binain assemblage of Timor and Callytharra Fm of W Australia. Late Sakmarian age suggested)

Shi, G.R. & T.A. Grunt (2000)- Permian Gondwana-Boreal antitropicality with special reference to brachiopod faunas. Palaeogeogr. Palaeoclim. Palaeoecology 155, p. 239-263. (Permian marine antitropicality (genera from Boreal and Gondwanan Realms but absent in Paleoequatorial Realm) reported from most marine pelagic or benthic invertebrate groups, suggesting biotic interchanges between Gondwanan and Boreal Realms. Possible migration pathways and mechanisms reviewed: 'stepping-stone' migration via islands in E Paleotethys, migration along W coast of Paleotethys, etc.)

Shi, G.R. & S.Z. Shen (2001)- A biogeographically mixed, middle Permian brachiopod fauna from the Baoshan Block, Western Yunnan, China. Palaeontology 44, p. 237-258. (Baoshan Block (= part of Sibumasu complex; JTvG) M Permian brachiopod assemblage with Cryptospirifer in from lower Shazipo Fm. Associated with fusulinids Nankinella, Polydioxodina spp. and Schwagerina. Overlying U Shazipo Fm 500-700m carbonate contains Shanita- Hemigordius foram assemblage. Paleogeographical distribution of Cryptospirifer overlaps with slightly younger (Capitanian-Wuchiapingian) Shanita-Hemigordius (Hemigordiopsis) foram fauna, also endemic or largely confined to M Permian transitional faunas of Cimmerian region (Baoshan Block))


Shi, X., J. Kirby, C. Yu, A. Jimenez-Diaz & J. Zhao (2017)- Spatial variations in the effective elastic thickness of the lithosphere in Southeast Asia. Gondwana Research 42, p. 49-62. (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)

assemblages: (1) Pseudofusulina postkraffti and (2) Rugosorschwagerina sp. and Parafusulina, which occur in Cathaysian region, but also in Gondwana-derived blocks Baoshan, Tengchong, etc.)

(Late Permian- E Triassic collision of S China- Indosinian blocks along Song Ma-Menglian suture closed Paleo-Tethys Ocean, caused folding and thrusting and granitic magmatism in S China Block (SCB). E and C parts of SCB SW-dipping paleoslope in Late Palaeozoic-Early Mesozoic. Ophiolitic melanges of E SCB formed in Neoproterozoic, not Permain or Triassic (Neoproterozoic oceanic relics with Proterozoic acritarchs). M-U Triassic granitoids (235-205 Ma) belong to post-collision peraluminous S-type granites)

(On SE China Block two types of Mesozoic basins (1) Late Triassic- E Jurassic post-Indosinian orogenic basins and (2) M Jurassic- Cretaceous intracontinental extensional graben and half-graben basins. Modern basin and range framework was settled down in Cretaceous. In Late Triassic–Early Jurassic sediment source areas were to N and NE of outcrop region)

(Five biogeogeographic areas in Circum-Pacific region, based on Late Triassic thin-shelled bivalve Monotis. In SE Asia: Fauna C (Monotis subcircularis + Eomonotis + Entomonotis ochotica) in E Asia, Japan, W Borneo; Fauna E (Monotis salinaria) in Tethyan rocks of Alpine- Himalayan belt and Banda Sea region)

(Indo-Pacific region from Tonga Trench to E Indonesia proposed as analog with tectonic setting of North American Cordillera, which is also composed of numerous suspect terranes)

(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 Woyla terranes of W Sumatra may represent exposed remnant of this intra-oceanic system)

(Discussion of boundary between Oriental/Asian and Australian zoogeographic regions (Wallace Line, Weber Line, Lydekker Line, etc.))

(Biogeographic patterns of Carboniferous- Permian rugose corals of E Asia. In Carboniferous Cathaysian region one cohesive block (N and S China, Tarim, Kunlun, Qiangtang teranes), lying tropically or subtropically, biotically isolated from C Asia. S boundary of Cathaysian region does not coincide with single suture, nor sharply defined: gradual faunal impoverishment S-ward across Tibetan Plateau, implying faunal ranges controlled by prevailing climate, not by geographical barrier (‘Paleotethys‘). Region formed part of Gondwanaland craton, extending into tropical latitudes until separation in late Lower Permian)


(New GPS India-Eurasia motion slower than previous determinations and predict India-Sunda relative motion of 35 mm/yr oriented N10° at latitude of Myanmar. Sagaing Fault only accommodates 18 mm/yr of right-lateral strike slip. Two models of how and where remaining deformation may occur)


(online at: www.geo.sc.chula.ac.th/Geology/Thai/News/Technique/GREAT_2008/PDF/039.pdf)

(Short version of paper below)


(Two parallel tectonic sutures in Yunnan-Thailand region: (1) Changning-Menglian and Inthanon= M Triassic closure of M Devonian- M Triassic Paleo-Tethys Ocean (collision of Sibumasu) and (2) Jinghong- Nan-Sra Kao= Late Permian collapse of local Permian back-arc basin. Sukhothai Zone not part of Sibumasu Terrane, but part of Permian island-arc on W margin of Indochina Terrane)


(Permo-Triassic Sukhothai island arc system, situated between Indochina and Sibumasu continental terranes, extends S into East Malaya Terrane, with similar granitoids and Carboniferous- Triassic marine sediments. At W side Paleo-Tethys/ Raub-Bentong suture, at E side short-lived Permian back-arc basin. Late Permian marine shales with Cathaysian lyttonid brachiopods succeeded by latest Permian limestones)


(U Triassic Jiapila Fm volcanics 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. Con 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 S latitudes outboard of Gondwana margin)


(Carboniferous and Permian plant assemblages of N and S hemispheres distributed in four floral provinces. Mixed M and U Permian Cathaysian- Gondwanan floras from margins of Paleo-Tethys, i.e. New Guinea, Tibet, Oman, etc. No clear explanation)

(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)


(E Ordovician faunas of SE Asia Sibumasu plate similar to those of Canning Basin, NW Australia)


(Ordovician- Permian plate reconstructions of early Tethyan oceans (focused on W Tethys). Paleotethys opened in Ordovician-Silurian, with detachment of ribbon-like Hun Superterrane along Gondwana margin. Neotethys opened from Late Carboniferous- late E Permian from Australia- E Mediterranean, with drifting of Cimmerian superterrane and final closing of Paleotethys in M Triassic. N-ward subduction of Paleotethys triggered opening of back-arc oceans along Eurasian margin. Some closed during Eocimmerian collisional event, others stayed open and their delayed subduction induced opening of younger back-arc oceans (Black Sea, etc). Subduction of Neotethys mid-ocean ridge responsible for major change in Jurassic plate tectonics)


(Ordovician- Cretaceous reconstructions of greater Tethyan realm)


(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1973026.pdf)

(Review of early plate tectonic models of SE Asia)


(Most likely location of Pleistocene impact crater that created large tektite fields is under Mekong River Delta. On Malay Peninsula in Gambang tinfield tektites at base of lower tin-bearing 'Old Alluvium'))


(Many parts of SE Asia have Paleozoic or older continental crust. Ophiolite belts indicate mosaic of different blocks. If Permian pebbly mudstones are glacial deposits much of SE Asia was attached to Gondwana and rifting-separation took place after Permian)
(Continental crust under much of pre-Tertiary core of SE Asia. Late Paleozoic glacial marine deposits in W SE Asia indicate attachment to Gondwana in Permian)

Stauffer, P.H. & D.J. Gobbett (1972)- Southeast Asia a part of Gondwanaland? Nature 240, 102, p. 139-140.
(Brief discussion of Ridd (1971) and Tarling (1972) reconstructions)

(Carbo-Permian glacial-marine pebbly mudstones in S. Thailand, Langkawi islands (Singa Fm) and other areas form 2000 km long belt from Sumatra to C Burma. This suggests W side of Western SE Asia was attached to Gondwanaland in Carbo-Permian, while warm-climate Permian floras on other blocks suggest separate drift histories)

(Discussion of Altermann (1986) paper. Disputes Altermann's conclusions that Paleozoic pebbly mudstones are not glacial deposits)

(Brief review of Carboniferous- earliest Permian glacial deposits. Extend from southern Malay Peninsula through W Thailand (Phuket region), Myanmar, into SW China. Best known section is thick Singa Fm of Langkawi islands, NW Malaya. Most common clasts quartz sandstones, minor limestone, granite, trondhjemite. Generally overlain by late E- M Permian limestone (Chuping Lst in Malaya, Ratburi Lst in Thailand, Plateau Lst in E Myanmar))

(Maximum rate of deglaciation around time of Granulatisporites confluens Oppel-zone in late Asselian-early Sakmarian time)

(Biotic criteria for E Permian deglaciation sequences in Gondwana. Marine cold-water bivalves Eurydesma and Deltopecten and brachiopods Lyonia and Trigonotreta in earliest post-glacial marine transgressions, replaced by more diverse, temperate fauna. Palynomorph succession changes from monosaccate pollen assemblages, associated with fern spores, to more diverse assemblages with common bisaccate pollen. Organic matter shows decreasing 13C trend, believed to be due to post-glacial global warming. E Permian O isotopes show 18O decline in Asselian- Artinskian, likely due to melting of glaciers at high latitudes)


(Three faunal realms recognized for Jurassic and Cretaceous belemnites. Boreal and Tethyan realms for Jurassic ammonites, but no equivalent for Pacific. They apparently are divided, partly in the Boreal and partly in the Indo-Pacific. Boundary between Boreal and Tethyan realms was distinct and stable, boundary between Tethyan and Indo-Pacific realms varied considerably in Upper Jurassic and Lower Cretaceous)


(Review of faunal provinciality of SW Pacific (focus on New Zealand- New Caledonia). In late Middle- Late Jurassic region received repeated waves of benthic immigrants from Tethyan/Indo-Pacific region, etc.)


(Early interpretation of S part of Tethyan orogenic belt, from Mediterranean Sea to Indonesia)


(Mainly on China terranes; no mention of Timor. Glossopteris flora, bivalve Eurydesmas, rugose coral Lytvolasma, brachiopod Globiella and fusulinid Monodiexodina are cool climate flora/fauna, often occurring with tillites along N margin of Gondwanaland in E Permian. In late M Permian Gondwana Tethys became still warmer and warm tropical fauna of Neoschwagerina and Verbeekina replaced cool water one)


(In Permian most of Australia in cold Gondwana realm (Glossopteris flora), but N edge intruded into warm Tethyan realm (Bonaparte Gulf, Timor, New Guinea: temporary extension of Cathaysian Gigantopteris flora into W New Guinea. Late Triassic mollusc fauna of Jimi River/PNG no species in common with contemporaneous faunas from Misool, Seram, Timor, suggesting some paleobiogeographic boundary between these, although all are supposedly in warm-water Tethyan realm)


(Summaries of Devonian fossil groups in Australia. No maps)


(Correlating geological belts/ suture zones from N Thailand to S Peninsular Malaysia very difficult)


(Ductile shear in Ailao Shan/Diancang Shan metamorphic belt along Red River in Yunnan, S. China, with >500 km of mylonites with horizontal lineations on steep, NW-striking foliation planes, and left-lateral kinematic indicators. U-Pb radiometric ages of ~23 Myr imply strike-slip movement in earliestMiocene. Collision of India with Asia displaced Indochina at least 500km SE relative to S China)
(Interesting and popular, but disputed tectonic model explaining major strike slip zones and blocks rotations in SE Asia as results of India-Asia collision in Eocene)

(Extended and updated version of SE Asia extrusion model. Since Eocene large prograding zone of deformation migrated across Asia, concurrently with N-ward movement of India collision front. Several large left-lateral strike-slip faults activated. In first 20-30 Ma of collision process, India may have pushed sideways S part of Sundaland (incl. SW Borneo, Sumatra and Peninsular Malaysia) then all of Sundaland (incl. S Yunnan, Indochina, Thailand and Shan Plateau. Red River Fault may have taken up 800-1000 km of extrusion to SE. In Oligocene- E Miocene Sundaland would have rotated clockwise by ~20-25°)


(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.)

(W Australian Permian faunas more in common with Tethys than with E Australia. Timor faunas appear related, but significant differences. One record of fusulinid foraminifera in Desert Basin could not be relocated and is probably erroneous. Low diversity coral fauna, mainly indigenous with Australian species. Crinoid faunas related to Timor, but much impoverished)

(Widespread Paleozoic-Mesozoic marine rocks in W Australia, S Africa Antarctica, etc., inconsistent with hypothesis of Gondwanaland (?)

(Overview of new SE Asian Stress Map, with stress information from borehole breakouts, drilling-induced fractures, and focal mechanism solutions across 14 provinces in SE Asia. Intraplate stress field of SE Asia (Sundaland) is variable and not aligned with absolute plate motion)

(Variable stress pattern throughout SE Asia largely inconsistent with Sunda plate ESE motion direction. Present-day maximum horizontal stress in Thailand, Vietnam and Malay Basin predominately N-S, consistent with radiating stress patterns from E Himalayan syntaxis. Maximum horizontal stress in Borneo primarily NW-SE; may reflect plate-boundary forces or topographic stresses exerted by C Borneo highlands. S and C Sumatra basins maximum horizontal stress NE-SW, perpendicular to Indo-Australian subduction front. Plate-scale stress field in SE Asia controlled by combination of Himalayan-related deformation, subduction forces (trench suction, collision) and intraplate sources of stress such as topography and basin geometry)

(In W SE Asia pre-Middle Miocene mainly extensional regimes. Changes in plate dynamics towards end E Miocene terminated spreading of S China Sea and Philippines basins and allowed impact of W-directed Pacific convergence. After short transition in Langhian (16.3-14.2 Ma) start of compressional regimes)


(Review of Devonian stratigraphies and macrofaunas of S China, Indochina W Malaysia. Lower Devonian in most places marine clastics, M Devonian mainly carbonates. Devonian faunas of SE Asia greater similarities with Europe than with Australia, questioning common wisdom that this region was derived from Gondwana)

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.
(Yunnanolepiform antarch (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)


(Review of E Paleozoic of NE sector of Gondwanan and peri-Gondwanan margin from Turkey through Middle East, N Indian subcontinent, S China- SE Asia, to Australia and New Zealand. SE Australia enlarged through accretion of island arcs. Most of area represented passive margin. Paleotethys opened no earlier than Late Silurian. N China and others probably not attached to Gondwana in Lower Paleozoic. S China close to Gondwana, but not part of it, and Sibumasu probably part of Gondwana. New paleogeographical maps for Cambrian (500 Ma), Ordovician (480 Ma) and Silurian (425 Ma))

(Review of evolution of Gondwana supercontinent, from unification of several cratons in Late Neoproterozoic, combination with Laurussia in Carboniferous to form Pangea, to progressive fragmentation in Mesozoic. New paleogeographic reconstructions from E Cambrian (540 Ma) to 200 Ma. Sibumasu microcontinent stretches from Burma and Yunnan to Sumatra (unlike earlier Cocks-Fortey papers, now accepted to have been part of E Gondwana craton adjacent to NW Australia, until opening of Neotethys Ocean in Permian)

(Marine Triassic paleobiogeography. Norian ‘Tethyan/ low paleolatitude’ Monotis salinaria in Hallstatt facies of Timor, ‘Pacific/ mid-high paleolatitude’ Monotis ochotica in New Caledonia, New Zealand, etc.)


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


(Expanded version see Ueno (2003) below)


(Permian fusulinids in four levels in Baoshan and Sibumasu Blocks. East Cimmerian continent poor Tethyan neoschwagerinid and verbeekinid genera in M Permian. Increase in diversity from E to late M Permian (N-ward drift of Cimmerian continent) and from E to W (W Cimmerian closer to tropical Tethyan domain than E). M Permian Cimmerian two subregions: W= Tethyan Cimmerian and E= Gondwanan Cimmerian. Rare Tethyan fusulinids in Baoshan and Sibumasu blocks suggests E Cimmerian continent still far from Cathaysian domain and in warm temperate-subtropical zone until end-Permian. E Cimmerian block migrated into tropical zone by Late Triassic with Carnian sponge-coral buildups in Sibumasu Block)

(Review of 'subtropical', late E Permian fusulinid genus Monodiexodina from 33 areas, incl. several Timor occurrences, all in middle part of Maubisse Fm. Type species of Monodiexodina is Schwagerina wanneri Schubert 1915 first described from Timor. Monodiexodina-bearing areas can be restored to either N or S middle latitudes, suggesting genus is paleobiogeographically anti-tropical taxon. Generally found in monotypic, crowded manner in sandy sediments with uni-directionally aligned shells. Long-ranging 'mid-Permian', Artinskian- E Midian (=Capitanian))


(SW China Changning-Menglian Belt and N Thailand Inthanon Zone best-studied Palaeotethys collisional belts in Asia. Thick E Carboniferous- Late Permian carbonate build-ups with basalt at base formed on top of oceanic seamounts. Foraminiferal faunas record shallow-marine domain in Palaeotethys (Cathaysian Province) with high diversity fusulinids. Coeval Neotethyan domain also high diversity fusulinids. Lopingian Panthalassan mid-oceanic build-ups likely lower foraminiferal diversity than Paleo- and Neotethys)
(online at: www2.uibk.ac.at/downloads/oegg/GG_004_329_448.pdf)
('The marine realms of the Jurassic and the Lower Cretaceous'. Subdivision of Jurassic-Cretaceous into 5 main faunal provinces. Includes review of Indonesian Mesozoic macrofossils known at that time, all classified in 'Himalayan Province', which stretches from Tibet to Indonesia-New Guinea, possibly into New Zealand. Common deep-water faunas with Liassic dominated by Phylloceras, Dogger with Stephanoceras and, Macrocephalites)


(Paleomagnetic study shows latitudinal translation of allochthonous Kurosegawa ribbon continent of Japan along W margin of Pacific Ocean. Terrane was at 4°N paleolatitude in Late Triassic, 18°N in E Cretaceous, then translated ~1500km N to present position, associated with sinistral strike-slip along E Asian continental margin, in Mid-Late Cretaceous. Also show SW Borneo plate in Equatorial position since Jurassic)

(Paleomagnetic paleolatitude calculated for samples from around Loei, Thailand (17.6°N), suggest W Indochina Block was at 9°N or 9°S in E Permian and at 5°N or 5°S in Carboniferous. Two tectonic models conceivable. Most likely Indochina Block was near equator in Carboniferous and N-motion of block lasted through Permian)

(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) 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)


(Global mantle tomography model used to estimate longitude of past oceanic subduction zones. Identified 28 remnants of oceanic plates subducted into lower mantle and link these to mountain building zones from which they likely originated. Assuming remnants sank vertically through mantle, we reconstruct longitude at which they were subducted. No oceanic plate remnants from Carboniferous (~300-360 Ma))

(Vast Panthalassa Ocean once surrounded supercontinent Pangaea, but subduction since then consumed most of ocean floor. Extinct intra-oceanic volcanic arcs accreted to N American and Asian continental margins. To constrain paleoposition of extinct arcs, they were correlated with remnants of subducted slabs identified in mantle from-wave tomographic models)
(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/)

(Review of alluvial diamond occurrences with no obvious primary sources in Myanmar, Thailand and Sumatra ('Sibumasu diamonds'; spatially associated with Carboniferous-Permian glacial pebbly mudstones, stretching from Myanmar to Sumatra) and in 4 districts in Kalimantan ('Kalimantan diamonds'). Together they are referred herein as 'Sundaland diamonds'. Three possible scenarios for formation of Kalimantan diamonds)

(Overview of merits of the then still controversial theory of continental drift. On p. 57 points out that Dutch geologists working in 'East Indies' (Molengraaf, Brouwer, Wing Easton) all supportive of Wegener's hypothesis, because New Guinea obviously rapidly drifted to North, and very rapid active uplift and subsidence can be observed in E Indonesia)

(No sharp E-W boundary in modern plant distributions in SE Asia. Three areas on basis of floristic affinities/similarities (1) islands of Sunda Shelf, W Java (everwet Sundaland floristic group); (2) Wallacea, consisting of central islands and E Java, with two sub-areas: Java, the Philippines and Lesser Sunda Islands with more Oriental flora and Sulawesi and Moluccas with more Australian flora; (3) New Guinea/Sahul Shelf)

(Philippines, Borneo, and especially New Guinea comprise significantly more than average endemic plants. Three major distribution patterns in Malesia: Indian-Malesian, Circum-Pacific and Wallacea, the transition zone between Sunda and Sahul floras)


(SUPERCONTINENT PANGEA FORMED FROM OUACHITA-VARISCAN OBLIQUE COLLISION OF LAURUSIA AND GONDWANALAND IN LATE CARBONIFEROUS (~320-300 MA) (IN EUROPEAN REGION). SHORTENING IN C AUSTRALIA, MEGAKINKING IN LACHLAN OROGEN AND BINDING OF OROCLINES IN E. AUSTRALIA POSSIBLY TIED TO THIS EVENT (BUT 10,000 KM AWAY!). FOLLOWED BY
Extensions I (~300 Ma, Carboniferous-Permian boundary; E Australia cut into long magmatic rift) and II (235 Ma, Carnian), expressed as rifts and sags that accumulated second set of coal-bearing strata


Veevers, J.J. & R.C. Tewari (1995)- Gondwana master basin of Peninsular India between Tethys and the interior of the Gondwanaland Province of Pangea. Geol. Soc. America (GSA) Mem. 187, p. 1-73. (Deposition in Gondwana master basin of Peninsular India in latest Carboniferous- E Jurassic on Archean-Proterozoic basement. Gondwana deposition ceased with breakup of Greater India from rest of Gondwanaland in Late Jurassic- E Cretaceous, followed by rift-drift succession along its margins. Master basin 1000km inboard of passive margin of Tethyan Gondwanaland; filled initially with lobes of glaciogenic sediment)

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)


Von Koenigswald, G.H.R. (1960)- Tektite studies II: The distribution of the Indo-Australian tektites. Proc. Kon. Nederl. Akademie Wetenschappen, Amsterdam, B 63, p. 142-153. (Stauffer 1983: First paper to point out distribution of Australasian tektites in terms of size and shape from NW (Indochina) to SE (Australia), an observation crucial to later understanding of origin of these bodies)


After India-Asia collision in Eocene, Asia significantly enlarged its size and increased its altitude. W-tilting topography of E Asia reversed with uplift of Tibetan Plateau and opening of marginal seas, resulting in Asian fluvial system radiating from uplifted center of continent. Cenozoic deformation of Asia also responsible for initiation of Asian monsoon system in E Miocene and further strengthening at ~8 Ma and ~3 Ma.


(On Silurian-Devonian fish remains from Shan-Thai (=Sibumasu), Indochina and S China blocks and their biogeographic affinities. Vertebrate fossils suggest proximity between S China and Indochina terranes in M Paleozoic and close relationship between Shan-Thai and E Gondwana (Australia) in M Devonian)


(Simao (N Indochina) and Yangze (S China) continental blocks amalgamated in Late Paleozoic- Triassic by closure of Paleotethys branch (Ailaoshan ocean). Detrital and inherited zircons suggest Laowanzhai-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)


(Devonian- Permian fauna of Baoshan block in Yunnan, SW China, very similar to S Tibet, but not Yangtze region. Faunal and paleomagnetic data for Late Paleozoic show Yangtze region very close to Equator, but Baoshan and S Tibet in middle latitudes (~32-43°S; probably in Gondwana domain))


(On M Triassic age for Jinshajiang- Ailaoshan suture, formed by collision of Changdu-Simao Block with S China Block. Jinshajiang oceanic lithosphere formed (as oceanic marginal basin of S China Block) in latest Devonian- earliest Carboniferous)


(Jinshajiang suture zone in W Yunnan- W Sichuan is remnants of backarc basin in E part of Paleo-Tethys. Basin started in Late Devonian, closed in E-M Triassic)


(Sibumasu Terrane rifted from Gondwana in E Permian. Small solitary rugose Cyathaxonia coral faunas in Lower Permian of Sibumasu in SE Asia and Sydney Basin, SE Australia, suggesting cool shallow marine conditions, while Cathaysian corals reflect location near Paleo-equator. M Permian corals in Sibumasu dominated by solitary and compound Waagenophyllidae ('Cathaysian'), but, some endemic taxa in Sibumasu Terrane during this time suggest it was still independent paleobiogeographical entity. Eleven coral species including 5 new taxa described. No Late Carboniferous corals known from Gondwanan terranes in SE Asia)


(Permian stratigraphic successions in Changning-Menglian Belt range from passive margin, active margin to oceanic basin and seamounts. Permo-Carboniferous carbonate faunas typical Cathaysian (common fusulinids, compound rugose corals). Permian of Tenchong and Baoshan blocks different: Baoshan Block Lower Permian mainly siliciclastic with cool-water faunas and possibly glaciogene diamicrites, overlain by basalts and
volcaniclastics of probable rift origin, U Permian carbonates with mixed Cathaysian- Gondwanan faunas. Tengchong Block similar to Baoshan, but lacks volcanics)


(On coral faunal provincialism on Carboniferous- Permian of Tibet- W Yunnan and Cimmerian terranes. Sakmarian-Artinskian Cyathaxonia fauna. In late E Permian development of Himalayan (N margin of Gondwana) and Cimmerian provinces (Lhasa- Qiantang, Tengchong, Baoshan, W Yunnan), with Roadian solitary corals, Wordian-Capitanian Waagenophyllidae and endemic Cimmerian taxa such as Thomasiphyllum and Wentzellophyllum persicum. Thomasiphyllum has distinctive paleogeographical distribution in M Permian of Cimmerian continents, also in W Sumatra, etc. Late Permian Himalayan fauna with small solitary corals only (Lytvolasma fauna) and Cathaysian with Ipiciphyllum, Liangshanophyllum, etc.)


(Early Permian corals of E Cimmerian continent (= Sibumasu) of Peri-Gondwanan affinity with small solitary forms; different from Cathaysian area, where abundant large solitary and compound corals occur. In M Permian endemic Cimmerian- Cathaysian fauna of large solitary and massive Waagenophyllidae, with Cathaysian aspect. Late Permian corals all Cathaysian. Changes related to rifting of Cimmerian continent from Gondwanaland in late Early Permian and subsequent N-ward drift)


(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 palaeoequator, but further than W Cimmerian blocks (lack of Eopolydiexodina and Neoschwagerina fusulinids, corals Thomasiphyllum, Wentzellophyllum)


(Carboniferous-Permian of Baoshan Block of W Yunnan 3 main sequences: (1) Lower Carboniferous carbonate (diverse warm-water 'Eurasian-affinity' faunas, incl. Cyathaxonia coral fauna), (2) Lower Permian Asselian-Sakmarian 'peri-Gondwanan' cold water siliciclastics with diamictites overlain by E Artinskian carbonate with low diversity fusulinids Pseudofusulina- Eoparafusulina, also Cyathaxonia coral fauna, and Artinskian rift basalts; (3) M Permian 'marginal Cathaysian/Cimmerian' carbonates; warm water, but low diversity fusulinids incl. Eopolydiexodina, also Shanita and coral assemblage with Wentzellophyllum and of lower diversity than in Cathaysian regions. Upper Carboniferous absent)


(Cyathaxonia faunas of small solitary corals widely distributed in Carboniferous- Permian beds across China. 12 families and 40 genera recognized. Cyathaxonia faunas of Baoshan, W Yunnan and S Anhui, occur just below large disseminated solitary and compound corals in continuous sequence, implying occurrence not strictly related to Gondwana or peri-Gondwana cold water environment, but may reflect by deeper water, mud-rich, quieter sedimentary environments)

(SW Yunnan Shan-Tai terrane with E-M Ordovician granitoids with zircon ages of 492-460 Ma. S-type granites, representing S-ward continuation of E Paleozoic granitic belt of E Gondwana N margin)


(Review of geological features of Paleotethys suture zones, bounding continental fragments and magmatic, metamorphic and sedimentary records. Data from Changning-Menglian, Inthanon and Bentong-Raube suture zones argue for linkage with Longmu Co-Shanghu 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 backarc basin, Simao/W Indochina fragment, Luang Prabang-Loei backarc basin, S Indochina fragment, Wusu and Truong Son back-arc basins, N Indochina fragment, Jinshajiang-Ailaoshan-Song Ma branch/backarc basin and S China Block. Assembly of these fragments resulted in Triassic (Indosinian) metamorphism and related tectonothermal event. Switch from subduction of main E Paleotethyan Ocean to collision of Sibumasu with Simao/Indochina at ~ 237 Ma. Timing of collision events along Jinshajiang-Ailaoshan-Song Ma suture generally ~ 10 Ma older than along Changning-Menglian, Inthanon and Bentong-Raube suture zones)


(Metabasic rocks in NW Yunnan crystallized at 50-55 Ma and metamorphosed at ~39 Ma. Results suggest that E Eocene magmatism in NW Yunnan represents E-ward continuation of the Gangdese magmatic belt and that Neotethyan subduction continued until ~50 Ma, followed by India-Asia collision. At least two E-dipping subduction zones in Neotethyan suprasubduction system before 55 Ma. Sudden decrease in convergence rate in E Eocene (55-50 Ma) stimulated rollback of downgoing slab and induced melting of mantle sources)


(Late Paleozoic glaciation reported from many localities on Gondwana, including India, Pakistan, Australia, etc. Nothing known from SE Asia yet)


(Cyclolobidae of M Permian age. Waagenoceras- Timorites lineage inhabited paleotropical latitudes, and Timorites is found around rim of Pacific Ocean (both also found on Timor; JTvG))


(E Permian (Asselian) small brachiopod fauna from E Permian pebbly mudstones- sandstones of Phuket Gp at Ko Muk and Ko Phi Phi islands, Andaman Sea. With Komukia, Cancrinelloydites, Rhynchopora, Sulciplicia, etc. At one locality associated with solitary coral Euphyllium. Most genera found in temperate- high paleolatitudes, suggesting pebbly mudstones are cool water deposits, contemporaneous with Late Asselian Gondwana glacial deposits (=Phuket Gp is part of 'Sibumasu terrane'; JTvG))


(Permian blastoids widespread but most diverse in SE Asia and Australia. Timor faunas Sakmarian-Asselian and Kazanian, and most diverse and abundant. Paleoecology and stratigraphy poorly understood. Some common species between Timor and Australia, but others conspicuously absent: Angioblastus, Deltoblastus not in Australia; Auraloblastus not in Timor. Reasons for local endemism unclear. Kazanian Timor fauna is last successful blastoid community before going extinct)

(No Permian crinoid fauna in world as diverse and abundant as Timor. Five horizons between Sakmarian-Wuchiapingian. Australian faunas generally considered as cooler water faunas, >35°S. Timor warm-water shelf. In Artinskian greater similarity between W Australia and Timor than between W and E Australia)


(M Jurassic ammonites from Tibet Tethyan Himalaya (Spiti Shale) typical of SE margin of Tethys, with connections to W India, E Africa, NW Australasia. N Tibet (Qamdo) and S Tibet (Lhasa) consistent with Eurasian position in M Jurassic. Tithonian ammonoid affinities of Tethyan Himalaya very close to NW Australia, which Uhlig (1911) correctly included in Himalayan province)

(Collection of 27 papers on Jurassic geology, floras, faunas and biogeography of circumpacific region, incl. Sukamto & Westermann on Indonesia/PNG and Sato on SE Asia and Japan)


(Review of published Mesozoic marine realms subrealms and superrealms and problems in defining them. Most important superrealms: (1) Boreal/Euroboreal (Arctic and Boreal-Atlantic) and (2) Tethys-Panthalassa (Tethyan, Mediterran-Caucasian, Indo-Pacific (Jurassic-E Cretaceous) and Austral (M-Late Cretaceous))

(Collection of papers on relation between present-day faunal provinces and plate tectonic history of Indonesia, incl. Audley Charles paper on plate tectonics)


(online at: www.agu.org/books/gm/v050/GM050p0001/GM050p0001.pdf)
(Series of interesting M Triassic- E Cretaceous global plate reconstructions, largely driven by faunal records)

(On evolution of floristic provinces since Silurian. Three main phytogeographic units in earliest fossil floras (Angara, Euramerica, Gondwana). Fourth unit (Cathaysia) differentiated from Euramerica in latest Carboniferous. Includes mention of New Guinea Gondwanan flora. Nothing on Sumatra or other SE Asia)


(One of best defined Cretaceous phytogeographic realms is Albian-Cenomanian elaterate microfloral province, bracketing Cretaceous paleo-equator, in tropical-subtropical Africa- S America and outliers in China, Middle East and PNG. Typified by elater bearing pollen Elaterocolpites, Elateroplicites, Elateropollenites, etc. Parent plants inhabited paleotropical humid coastal plains of Proto-South Atlantic and Tethys oceans)


(Baoshan and Tengchong Blocks in W Yunnan, China, have Permo-Carboniferous glaciomarine deposits, cold-water faunas and Glossopitser, indicating Gondwana position at that time and part of Sibumasu tectono-stratigraphic unit. Glacial series of Baoshan Block rel. thin and over lain by thick basalts and red beds (volcanic rift setting?). Tengchong Block glacial marine beds >1000 m, followed by thick Lower Permian reefal limestones (passive margin?). Both terranes separated from Australian Gondwana in late E Permian. Docking started in Late Triassic, with closure of Changning-Menglian Belt)


(Late Paleozoic glacigene deposits form base of Gondwana megasequence along entire length of Tethyan margin of Gondwana. Examples of deglaciation sequences, including Tanzania, S Oman, Lesser Himalaya, NW Australia and SW China. All deglaciation sequences Late Asselian- E Sakmarian age. High content of organic matter in deglaciation deposits, like Late Asselian-E Sakmarian Treachery Shale of Australian NW Shelf with microflora of Pseudoreticulatisporas (= Granulatisporites) confluens. Peak sea level in Late Sakmarian- E Artinskians. Swift and synchronuous climatic amelioration reflect rapid and substantial global warming)


(Two groups of terranes with Late Carboniferous-E Permian glacial deposits that separated from Gondwana in Permian (together also referred to Sibumasu Blocks?; JTvG): (1) LBS (Lhasa Block, Tibet and Baoshan, W Yunnan) and Shan Thai (E Burma) which evolved in volcanic rift setting with margin of Greater India and NW Australia, and separated from Gondwana in Artinskian; (2) TMS (Tengchong Block, peninsular Thailand, W Malay Peninsula and N Sumatra), developed on peri-continental non-volcanic rift along N margin of Australia and pre-Permian New Guinea and separated slightly earlier than LBS)


(Late Carboniferous- M Triassic ‘Pangea stage’ similar trends across Gondwana. Late Carboniferous- E Permian glacial- periglacial deposits followed by deglaciation in E Sakmarian, with typical facies with coal measures and redbeds. In E Permian, large graben structures started to develop between Africa and India and between India and Australia. Rifting along Tethyan margin started in E Permian, associated with volcanism between Kashmir and Yunnan and in NW Australia. Spreading of Neo-Tethys lead to separation of Cimmerian Blocks from Gondwana in late E Permian- Triassic. Two facies realms (1) intracratonic rift (Cashmere, Lhasa, Baoshan blocks) and (2) detached more distal blocks (Tengchong, Malay, Sumatra))


(Collection of 10 papers describing Australasian floras-faunas and paleobiogeography from Cambrian-Quaternary (not including Triassic; JTvG))

Wu, H.R., C.A. Boulter, B.J. Ke, D.A.V. Stow & Z.C. Wang (1995)- The Changning-Menglian suture zone; a segment of the major Cathaysian-Gondwana divide in Southeast Asia. Tectonophysics 242, p. 267-280. (Changning-Menglian suture zone of W Yunnan, SW China, is major Cathaysia- Gondwana divide, representing closing of Paleo-Tethys Ocean. Narrow N-S zone of E Devonian- M Permian oceanic siliceous sediments and dismembered ophiolite complexes, including reef-capped oceanic islands. Simao terrane is E of suture, has Cathaysian affinities and not part of Sibumasu terrane as suggested by various authors. Subduction created active continental margin on W edge of Simao terrane throughout much of Triassic; until closure of this branch of Paleotethys in early Late Triassic)

(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))

(Subducted slabs under SE Asia mapped from seismic tomography and seismicity, when unfolded and restored, show incompatibilities with existing plate-tectonic models. Philippine Sea, Molucca Sea, and Celebes Sea plates are fragments of once much larger NE Indian-Australian Ocean, once continuous with Sunda slab and present Indian Ocean)

(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, Indian 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))

(manuscript online at: http://dro.dur.ac.uk/21242/1/21242.pdf)
(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 Nanhuan 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)

(Basins of Bohai Gulf, S China Sea, E China Sea, Japan Sea, Andaman Sea, Okhotsk Sea and Bering Sea typical geometry of dextral pull-apart. Java, Makassar, Celebes and Sulu Seas basins together with grabens in Borneo also dextral, transform-margin type basin system. Formation of gigantic linked dextral pull-apart basin system in NW Pacific due to NNE- to ENE-ward motion of E Eurasia, mainly response to Indo-Asia collision which started at ~50 Ma)

(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)

(Cambrian-Ordovician boundary unconformity in S part of S China Craton related to coeval orogenic activity along Indian margin of E Gondwana. Disconformity at base Ordovician part of regional break also documented in Himalaya, Qiangtang, Lhasa, Sibumasu and W Australia, with angular unconformity, metamorphism of older units and widespread magmatic activity. S China Craton also deformed and metamorphosed during mid-Paleozoic intra-continental Kwangian orogeny, with regional angular unconformity between Devonian cover and metamorphosed pre-Devonian along with granite intrusion between 460-400 Ma)

(Baoshan Terrane of SW China part of Cimmerian block in Late Paleozoic. Paleomagnetic studies on lower Permian Woniusi Fm basalts suggest Baoshan Terrane located at latitude 38°S ± 3.7° in late E Permian. Comparison with E Permian from Gondwanan blocks suggests Baoshan Terrane located near junction of N
India and NW Australia, and broke away from W Australia after E Permian. Basalts represent extensional setting and may represent start of separation between Baoshan and Gondwana)


(Paleomagnetic data of Jurassic- Cretaceous red sandstones from Peninsular Thailand suggests two opposite tectonic rotations in Trang area. As part of Thai-Malay Peninsula underwent CW rotation after Jurassic together with Shan-Thai and Indochina blocks. Between Late Cretaceous and M Miocene, as part of S Sundaland Block (incl. Peninsular Malaysia, Borneo and S Sulawesi), up to 24.5° ± 11° CW rotation relative to S China Block. N boundary of CCW rotated zone between Trang area and Khorat Basin)


(Paleoclimate indicators used to distinguish major Asian blocks. Early Permian cooler climate areas with diamicrites and Glossopteris flora, warm climates have fusulinid limestones, Gigantopteris florae, etc.. Suggest N-ward movement in Permian of blocks like Sibumasu from S Hemisphere Gondwana to N Hemisphere Asia)

Yan, J.X. & D. Zhao (2001)- Advancement of the Mesotethys along the northern margin of the South China Sea. Marine Geol. Quaternary Geology, Beijing, 21, 4, p. 49-54.

(In Chinese. Marine Mesozoic strata along N margin of S China Sea indicate marine basin. Basin was a large ocean in Mesozoic and can be traced W-ward to Mesotethys (Meratus suture of Kalimantan, and Woyla suture on Sumatra), E-ward ocean connected to extinct ocean in Sakawa zone of Japan through Taiwan Straits. Ocean closed around M Cretaceous, resulting from docking of N Palawan Terrane and Reed Bank terrane)


(Permian and Triassic (Chihsian, Wujiaopingian, Anisian and Norian) reconstructions and paleogeography of E Tethys area, mainly driven by paleoclimatic records)


(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 seafloor 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)


(U-Pb zircon analyses of gabbro from Garze ophiolite block from Garze-Litang melange mean age 292±4 Ma, suggesting earliest Permian age for sea floor spreading/ age of opening of Tethys at East Gondwanaland)


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


(E Tethyan orogenic belt in SW China includes S Tibet, N Tibet, Baoshan-Shan-Thai, Changdu-Simao-Indochina and Zhongza terranes between India and Yangtze continental plates, separated by sutures with dismembered ophiolites and arc volcanic belts, recording series of closed Carboniferous-Tertiary Tethyan ocean basins. Lancangjiang suture records Permo-Carboniferous Tethyan ocean, separating Gondwanaland and Eurasia. Two phases (1) Carboniferous-Triassic spreading of Lancangjiang, Jinshajiang and Garze-Li Jiang oceans and breakup of Changdu-Simao-Indochina and Zhongza terranes from S margin of Eurasia; (2) Triassic-Tertiary spreading of Nujiang and Yarlung Zangpo oceans associated with breakup of S Tibet, N Tibet and Baoshan-Shan-Thai terranes from N Gondwanaland)


(Paleomagnetic study of Jurassic-Cretaceous sediments on Khorat Plateau suggests 1500 ± 800 km of post-M Cretaceous left-lateral slip along Red River and Xian Shui He fault zones and 14 ± 7° CW rotation for Indochina block relative to S China block, in agreement with lateral extrusion model of Indochina during India-Asia collision. Additional data of Permain, U Triassic and Lw Jurassic suggest Indochina, Yunnan (S China), N China block and S China block probably in contact at least since Late Triassic)


(Paleomagnetic study of E-M Jurassic limestones and sandstones from Mae Sot area, W Thailand (part of Shan-Thai-Malay), Mae Sot paleolatitude show STM was close to or had already accreted with Simao or Khorat blocks in E-M Jurassic (in Late Triassic). Relative S-ward motion of 8 ± 4° of Indochina and CW rotations (14-75°) relative to China)


(Present-day fresh water fish distributions classified into 19 biogeographical zones/ main river systems Sundaic islands grouped into four pairs: Malay Peninsula- N Sumatra, C Sumatra-W Borneo, N Borneo-E Borneo-Sarawak and S Borneo-Java. Java is relatively small, but landbridge island connected it with large islands of Sumatra and Borneo during Pleistocene low sea level periods)


(Pre-glacial E Permain along S Tethys margin and produced lenticular-shaped Cimmeria continent. Mantle-plume model explained rift-related volcanism but Cimmerian rifts do not correlate well with pre-existing suture zones. Location and timing of Cimmerian rifting resulted from exploitation of structural heterogeneities within crust that formed due to repeated glacial-interglacial cycles in Late Paleozoic. Effects of
continental deglaciation helped to create shape of Cimmeria and Neotethys Ocean, suggesting climate change may influence location of rifting)

(Cenozoic tectonic evolution model of Asia, including lateral extrusion of SE Asia between 32- 17 Ma after India-Asia collision)

(Timor Triassic classified as ‘Gondwanan Tethys’ facies, similar to Lhasa- W. Birma?, different from ‘India-Gondwana’ and ‘Cathaysian-Tethys’. Misolia is element of subtropical ‘Gondwanan Tethys’. Gondwanan Tethys and Tropical Tethys merged in Late Triassic due to S-ward expansion of tropical-subtropical biota)

(Reviews of Permian-Triassic in mainland E Asia, New Zealand, etc., Little on Indonesia, New Guinea)

(Review of Triassic stratigraphy of China. Six regions, incl. NW Pacific (marine), tropical Cathaysian Tethys and warm-temperate Gondwanan Tethys (Himalayas and SE extension into Yunnan-Tengchong area)

(South China composed of several microplates in Late Palaeozoic, at time when Eastern Tethys was an ‘archipelagic Ocean’ with numerous microplates that amalgamated into Paleoasia during Late triassic Indosinian orogeny)

(Unlike typical oceans such as wide and ‘clean’ Atlantic, Tethys Ocean showed archipelagic pattern during all stages, especially E Tethys. Evolutionary history of Qinling-Qilian-Kunlun, S China and Xizang (Tibet) - Yunnan regions)

(Mid-Oxfordian ammonite fauna in Lanongla area, Tibetan Himalaya, characterized by endemic epimayaitids. Distribution of mayaitids around E Gondwana can be regarded as first signal establishment of Indo-Austral Subrealm in Late Jurassic-E Cretaceous)

(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).

(online at: http://ro.uow.edu.au/cgi/viewcontent.cgi?article=5216&context=smhpapers)
(On link between mantle flow and surface tectonics. SE Asia one of lowest lying continental regions in world, with half of continental area presently inundated by shallow sea. Widespread Late Cretaceous-Eocene regional unconformity in SE Asia likely driven by dynamic topography, i.e. several 100m of dynamic uplift and emergence of Sundaland between ~80-60 Ma due to slab breakoff after Late Cretaceous collision of Gondwana-derived terranes with Sundaland. Renewed subduction from ~60 Ma re-initiated dynamic subsidence of Sundaland, leading to submergence from ~40 Ma)

Zahirovic, S., K. Matthews, N. Flament, R. Muller, K. Hill, M. Seton & M. Gurnis (2016)- Tectonic evolution and deep mantle structure of the eastern Tethys since the latest Jurassic. Earth-Science Reviews 162, p. 293-337.

(Major review of plate tectonics of since 160 Ma. Rifting of ‘Argoland’ (E Java and W Sulawesi) in latest Jurassic from NW Australian shelf, likely colliding first with parts of Woyla intra-oceanic arc in mid-Cretaceous, and accreting to Borneo (Sundaland) core by ~80 Ma. Neo-Tethyan ridge likely consumed along intra-oceanic subduction zone S of Eurasia from ~105 Ma, leading to major change in motion of Indian Plate by ~100 Ma)


(online at: http://www.publish.csiro.au/ex/pdf/ASEG2018abM1_1C)

(Evolution of E Neo-Tethys since latest Jurassic rifting along N Gondwana. New Guinea N-ward motion over subducted slabs (related to Sepik back-arc basin and Maramuni subduction system), resulted in long-term flooding of margin since ~20 Ma. Sundaland continental promontory dynamic uplift in latest Cretaceous-Eocene due to accretion of Woyla Arc at ~80 Ma, leading to slab breakoff and temporary interruption of subduction. Renewed subduction along Sunda margin resulted in renewed dynamic subsidence from ~30 Ma, amplified by regional basin rifting events. Sinking Sunda slab likely triggered mantle slab avalanche, resulting in contemporaneous basin inversion and dynamic subsidence from ~15 Ma)


(online at: www.solid-earth.net/5/227/2014/se-5-227-2014.pdf)

(Major review and new model of tectonic evolution of SE Asia in last 155 My, with significant differences from Hall, Metcalfe, etc. models. SW Borneo already part of SE Asia in Late Jurassic, and did not originate from NW Australian shelf. SE Java and W Sulawesi blocks rifted off New Guinea margin in Late Jurassic, etc. With animation model in supplement)


(Incl. palaeogeographic reconstructions with Late Permian- earliest Triassic (260- 247 Ma) distributions of ammonites in Paleotethys)


(Brief review of mainland SE Asia mineral resources associated with complex tectonic history; see also Zaw (2014) paper below)


(Review of SE Asia mineral resources associated with complex tectonic history of Gondwana supercontinent break-up, arc magmatism, backarc basin development and collisions that created present-day mainland SE Asia. This paper summarizes historical and current SE Asian geological research and ore deposit studies. Incipient arc/backarc basin magmatism is key to formation of many important ore deposits in Truong Son and
Loi fold belts. Triassic to Cenozoic arc-continent and continent-continent collisions have led to the formation of sediment-hosted/orogenic gold deposits in Sukhothai and Sibumasu terranes. Oblique Cretaceous- Recent subduction along Andaman-Sunda trench responsible for gold and copper-gold-molybdenum porphyry and epithermal mineralization along arc in Myanmar and Sumatran volcanic arc.


(E Paleozoic structures, metamorphism and magmatic activity suggest Cathaysia (= SE part of S China block) collisional orogenic belt rather than intraplate type. Angular unconformity between Silurian- Devonian; transition from collision to post-collision at ~430Ma. Some E Paleozoic clastics probably of Gondwana origin.)


(Commentary of Wu et al. 1995 paper. Jinhaijiang-Ailaoshao suture is main Cathaysia- Gondwana divide in China, not Lancangjiang-Changning-Menglian suture)


(NE-SW-trending Hepu-Hetai shear zone extends for ~480 km along Guangdong-Guangxi provinces boundary in S China. Dextral ductile strike-slip deformation, with estimated displacement of >500 km. Inclusions in quartz within mylonite suggest that ductile shear deformation under medium T/P conditions of greenschist facies; 40Ar/39Ar muscovite ages of 213-195 Ma. Shear zone originated via penetration of Yunkai Promontory of South China into Indochina during Late Triassic)


(online at: www.terrapub.co.jp/onlinemonographs/meep/pdf/01/0101.pdf)


(Tomography of E Asia, the location of double-sided subduction zone where old Pacific plate subducts from E, and Indo-Australia plate subducts from S)


(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 (Triassocampe deweveri radiolarian assemblage), suggesting Paleo-Tethys ocean not yet closed in M Triassic)


(Paleomagnetic data show three main blocks of China (North China, South China, Tarim) were at or near equatorial latitudes in E and M Paleozoic. Late Paleozoic data suggest they were too far N to be attached to Gondwanaland and suggest they rifted from Gondwanaland in Late Devonian and Carboniferous. Etc.)


(Artinskian- Kungurian Metaperrinites and Kungurian Perrinites faunas in Rathuri Group in N Central and S Central Thailand, represent part of Tethyan perrinitid belt from Crimea in W to Timor in E)


(Collection of papers on evolution of W Yunnan- Sichuan, containing sector of Paleotethysides where it turns from E-W belts of Tibetan Plateau to N-S mountain belts of mainland SE Asia. Formed by closure of Paleotethys in Late Paleozoic by collision of Gondwan Tengchong and Baoshan Blocks with Eurasia (Yangtze, Simao blocks). Paleotethys was composed of main intercontinental ocean with several smaller intra-continental oceans and troughs)


(E Triassic continental collision (of Cimmerian Blocks) in SE China, marking beginning of E Mesozoic orogeny in region. In end-Jurassic, Borneo began rifting away from S China margin, creating Proto-South China Sea. Present S. China Sea has evolved after drifting away from S China margin of continental fragments such as N Palawan, Reed Bank, Xisha Islands, Zhongsha Islands and others)


(In Chinese with English summary.) (Adakite and adakite-like intermediate-acid magmatic rocks well developed in Cenozoic of Indonesia- New Guinea. Two types of origin: (1) oceanic type tholeiitic/calc-alkaline series with REE pattern of oceanic island arcs, seen at the oceanic islands; (2) continental type high-K calc-alkaline series with continental type REE patterns, often in continental margin orogenic zone and related to arc-continent collision zone or post-collision. Continental-type adakite similar distribution to large porphyry copper-gold deposits; oceanic island arc type adakite rocks related to epithermal gold zones and exhalation ore deposits)


(Permian- Jurassic reconstructions of terranes of N parts of Asia (Eurasia- China) based on paleomagnetic and flora data. Little or nothing on SE Asia)
I.3. Volcanism, Volcanic rocks geochemistry

(This listing is a limited selection of an extensive body of literature on Indonesia volcanic activity and its products. Additional titles on volcanism that are specific to one region may be included under these regions)


(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)


(No across-arc variation of K2O and Sr isotopic ratios in West Java Arc. Papandayan volcano medium-K series with high 87Sr/86Sr (0.7052-0.7059); Cikuray low-K, with low 87Sr/86Sr (0.70417-0.70426). Across arc variation of magma chemistry explained by crustal assimilation and involvement of subducted components)


(Ground-penetrating radar helps image and characterize fall and pyroclastic flow deposits from Tambora 1815 eruption. Reflection of interface between pre-eruption clay-rich soil and pyroclastics reaches maximum thickness of 4m. Soil surface terraced and used for agriculture and buildings)


('Contribution to the knowledge of Indonesian volcanism: the Merapi (C Java), structural setting, petrology, geochemistry and volcanicological implications')


('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)


(Volcanic rocks from Una-Una (<~100 Ka) and nearby Togian islands (~2 Ma) both alkaline or high-K calc-alkaline trachyte. Isotopic trends and geochemistry indicate ancient continental contribution to magma source, possibly Indian Ocean pelagic sediment. Probably related to young extension of Gorontalo Bay due to slab rollback)

Brouwer, H.A. (1916)- Het vulkaaneiland Roeang (Sangi eilanden) na de eruptie van 1914. Tijdschrift Kon. Nederlandsch Aardrijkskundig Gen. 33, p. 89-94. ('The volcanic island Ruang (Sangi Islands) after the eruption of 1914')

Brouwer, H.A. (1921)- Het vulkaaneiland Roeang. Jaarboek Mijnwezen Nederlandsch Oost-Indie 49 (1920), Verhandelingen 2, p. 6-30. ('The volcano island Raung. Active volcano in Sangi islands group')

(Batoe Tara or Komba ~50 km N of Lomblen, E of Flores, rises from deep sea to nearly 750m above sea-level. Active volcano with different types of leucite rocks: leucite basanite, biotite-leucite tephrites, etc.)

(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)

Buhring, C., M. Sarnthein & Leg 184 Shipboard Scientific Party (2000)- Toba ash layers in the South China Sea: evidence of contrasting wind directions during eruption ca. 74 ka. Geology 28, 3, p. 275-278. (Cores from southern S China Sea with up to 3.5cm thick ash layers with rhyolithic glass shards. Dated at ~74 ka (O-isotope Stage 4-5 boundary), the age of youngest Toba eruption in N Sumatra. Composition of glass similar to Toba ash. Youngest Toba ash layers in S China Sea expand previously known ash-fall zone over >1800 km to E and increased volume estimates of erupted Toba ash. See also comments by Chen et al. 2000)


(Interferometric Synthetic Aperture Radar data across Sumatra-Java-Bali arc provided evidence of inflation at six volcanoes (Sinabung, Kerinci in Sumatra; Slamat, Lawu, and Lamongan in Java; Agung in Bali), three of which erupted after observation period (Sinabung, Kerinci, Slamat). These volcanoes have shallow magma reservoirs. Globally, arc volcanoes in extensional and strike-slip settings (W Sunda) can develop shallow reservoirs, whereas volcanoes in compressional settings may lack them)


(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)


(Sulfur isotope compositions of basaltic and basaltic andesite lavas from 7 modern volcanoes of Java and Lesser Sunda islands range in d14S from +2.0 to +7.8, average +4.7. Magmas in Indonesian arc system originate from mantle sources enriched in 34S relative to MORB and OIB sources. Enrichment in 34S reflects addition of slab-derived material, presumably from sediments rather than altered oceanic crust)


(Predictive model for hydrogen-isotope shifts during degassing of basaltic-andesitic magma, from samples from 7 volcanoes along Sunda and Sangihe arcs (Batur, Rinjani, Guntur, Galunggung, Krakatau, Soputan, etc.))


(Historic account of Tambora 1815 eruption and its consequences. No geology)


(Al-rich spinels common in alpine peridotites and in certain metamorphic rocks, but rare in terrestrial volcanic rocks. Descriptions of occurrences of Al-rich spinel inclusions in olivine phenocrysts in island arc volcanics from five localities, including basaltic andesites of Bukit Mapas (S Sumatra) and high-K shoshonitic ankaramites of SE Bali)

Dosso, L., J.L. Joron, R.C. Maury & H. Bougault (1987)- Isotopic (Sr, Nd) and trace element study of back-arc basalts behind the Sunda arc. Terra Cognita 7, p. 398. (Abstract only?)


Edwards, C.M.H., J.D. Morris, M.F. Thirlwall (1993) - Separating slab from mantle signatures in arc lavas using B/Be and radiogenic isotope systematics. Nature 362, 6420, p. 530-533. (Combining B/Be with Sr, Nd and Pb isotopes of alkaline, calc-alkaline and tholeiitic lavas of young volcanoes from Java (Guntur, Ringgit) and Flores (Kelimutu, Lewitobi, Mandiri). High B/Be and 10Be/9Be ratios in tholeiitic and calc-alkaline lavas are partial melts of mantle produced by fluxing by fluids from subducted slabs. Alkaline lavas always low B/Be and derived from mantle not modified by recent subduction)


Elburg, M.A. & V.S. Kamenetsky (2008) - Limited influence of subducted continental material on mineralogy and elemental geochemistry of primitive magmas from Indonesia-Australia collision zone. Lithos 105, p. 73-84. (Two basalt-andesite samples from Alor Island. Sr, Nd and Pb isotope data show influence of subducted continental material, but major and trace element compositions not very different from typical subduction-related magmas)


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

Foden, J.D. (1979) - The petrology of some young volcanic rocks from Lombok and the Lesser Sunda islands. Ph.D. Thesis University of Tasmania, Hobart, p. 1-306. (online at: http://eprints.utas.edu.au/17675/1/Foden_Thesis.pdf) (Study of 5 modern volcanoes in E Sunda arc: Rindjani (Lombok) and G. Sangenges, Tambora, Soromundi and Sangeang Api (Sumbawa) island. All occur 165-190 km above active, N dipping Benioff Zone. Volcanoes of this sector of arc erupted diverse range of lavas, ranging from ankaramite-high-Al basalt-andesite-dacite suite of Rindjani, through moderately potassic ne-trachybasalt- trachyandesite suites from Tambora and Sangeang Api, etc.)
to highly undersaturated, leucite-bearing types from G. Sangenges and Soromundi. The K20-content of these suites shows no correlation with depth to Benioff Zone)

(Rindjani large, active compound strato-volcano on Lombok, in W part of E Sunda Arc. Pleistocene-Recent calcalkaline suite composed of diverse lavas, including ankaramite, high-Al basalt, andesite, high-K andesite and dacite. Sr-isotopic and geochemical constraints suggest derivation from sub-arc mantle)

(Lavas of Tambora volcano on Sumbawa lavas of unusual, moderately undersaturated, K2O-rich types, ranging from ne-trachybasalt to ne-trachyandesite. Products of 1815 eruption are black, glassy, biotite-bearing, ne-trachyandesites with scoria, pumice and tuff of same composition. 1815 eruption followed lengthy period of inactivity)

(Bali–Lombok-Sumbawa sector of Sunda arc flanked in N and S by oceanic crust. Oldest rocks from Lombok and Sumbawa islands Lower Miocene- Pliocene sediments and volcanics beneath Quaternary volcanic centres. Three large active volcanoes in N parts of Lombok (Rindjani; basalt-andesite-dacite) and Sumbawa (Tambora and Sangeang Api; trachybasalt-trachyandesite), all ~150-190 km above N-dipping Benioff zone. Extinct Quaternary centres S of active volcanoes on Sumbawa (Soromundi, Sangenges). Volcanic composition-space-time relations in Lombok-Sumbawa sector not in accordance with general island-arc schemes)

(Rinjani lavas compositionally diverse, from ankaramites and high-Al basalts to andesites and dacites, representing typical calcalkaline association erupted by many Circum-Pacific volcanoes)

(Quaternary volcanoes of Lombok-Sumbawa sector of E Sunda Arc occur 165-190 km above N-dipping Benioff zone. Diverse range of lavas. No correlation between K2 and content and depth to Benioff zone. Between-volcano variations reflect mantle source heterogeneity)


(40Ar/39Ar dating of biotite, sanidine, hornblende, and plagioclase from youngest Toba Tuff of 75 ka suggests hornblende and some plagioclase are xenocrysts and came from at least 1.5 Ma old source)

(Helium He-3/He-4 isotope data from olivine and clinopyroxene from 13 volcanic centres between C Sumatra and Sumbawa in Sunda arc indicate crustal contamination unrelated to subduction in Sunda arc)

(Geochemical analyses of Quaternary-Cretaceous sediments from NE Indian Ocean used to estimate composition of sedimentary material subducted along Sunda Trench. Post-Miocene siliceous clastic sediments near Sunda arc largely derived from arc itself, largely accreted and not subducted. The least contaminated arc volcanics in W section of W Sunda arc, where sediment flux highest. Assimilation of crustal material by uprising melts from Indian Ocean-type mantle wedge better accounts for isotope changes of arc volcanics, and ties to variations in crustal thickness and composition along arc)


(online at: https://petrology.oxfordjournals.org/content/early/2011/12/15/petrology.egr062.full.pdf+html)

(Eruption of Tambora volcano (Sumbawa) in 1815 one of largest explosive eruptions in historical time. Extensive pyroclastic deposits from emptying of 30-33 km3 trachyandesite magma body. Parental trachybasalt magma can be produced by ∼2% partial melting of garnet-free, Indian-type mid-ocean ridge basalt-like mantle source contaminated with ∼3% fluids from altered oceanic crust and <1% sediment. Differentiation from primary trachybasalt to trachyandesite in two-stage polybaric differentiation)


(On U, Th, Po, Ra isotopes in volcanic arc rocks, incl. data from Sunda, Banda and Sangihe Arcs, Indonesia)


(‘The volcanoes of the Northern Moluccas’)


(Eruption of Samalas volcano on Lombok in 1257 with sulfur in ice cores twice volume of 1815 Tambora eruption. >40 km3 of dense magma expelled; eruption column up to 43 km altitude. Years 1258 and 1259 some of coldest N Hemisphere summers of past millennium. Eruption aggravated existing famine crises)

Gulyas, E. & P. Hederveri (1976)- Concentration of seismic energy within the two active domains beneath individual volcanoes and groups of volcanoes of Java, Indonesia. Tectonophysics 30, p. 129-140.

(Two seismically active domains under all individual active volcanoes of Java, separated by aseismic space)


(Small phreatic eruption of Sinabung Volcano, N Sumatra, in August 2010 marked first eruption in last ~1200 years. New eruption began on 15 September 2013 and continues to present. Ongoing eruption 5 major phases)


(Chemical and isotope (He-C-N) data of fumaroles and hydrothermal fluids from 19 volcanic centers along W Sunda arc suggest subducting slab is principal provider of volatiles. Increased contribution of CO2 in N
Sumatra suggest subducted sediment (particularly Nicobar Fan Himalayan-derived sediment) strong control on magmatic CO2 characteristics, suggesting significant part must enter trench

(Maximum emplacement temperature of pyroclastic flows based on charcoal reflectance is 487°C)

(The active volcanoes of Lomblen Island (Solor Archipelago). Lomblen E of Flores, with 3 active (Lewotolo, Labalekan, Ili Weroeng) and 2 recently active (Kedang, Mingar) volcanoes)

(The Batu Tara volcano. Active volcano, ~700m high, in Banda (Flores) Sea NE of Flores, 50km N of Lembata (Lomblen) island. Known for its potassic leucite-bearing basanitic and tephritic rocks (see also Stolz et al. 1988, Van Bergen et al. 1992, etc.))

(General discussion of genesis of island arc magmas. Three potential sources, mantle wedge above subducting slab, subducted slab of oceanic crust and possibly sediments and arc crust)

(Indonesia has 15 or more volcanic arcs with total length of ~9000 km. Eight arcs contain known mineral deposits, while rest may be prospective. Mainly general discussion on arc magmatism and mineral deposits No correlation between porphyry-Cu or epithermal mineralizations and single petrological/ geological factor)

(Review of subduction-related magmas. Most arc magmas derived from melting of upper mantle induced by released fluids and incompatible elements from subducted oceanic crust. Crustal-derived magmas, from melting of either subducted slab or lower crust, also present in some arcs)


(Rajabasa dormant Quaternary volcano at S tip of Sumatra. Volcanics mainly basaltic andesite, with K-Ar ages of volcanics 0.31-0.12 Ma (Pleistocene). 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)
(Early paper documenting increase in K-content with depth to seismic Benioff zone)


(online at: http://ijog.bgl.esdm.go.id/index.php/IJOG/article/view/159/159)  
(Volcano-tectonic earthquakes in September- November 2009 show epicentres aligning in NE- SW direction, coinciding with weak zone of Batur Volcano Complex, Bali. Focal zone depths ~1.5- 5.5 km beneath summit)

(Banda arc 3He/4He ratios significantly lower than common ratio in mid-ocean-ridge basalts (MORB). 80% of radiogenic He is from subducting continental material. Measurements along Sunda arc show MORB-like ratios from W Java to sharp transition zone at Lomblen Island (N/NW of Timor), where low ratios of Banda arc begin)

(He isotope analyses from 11 volcanoes from Flores (E Sunda arc) through inactive segment between arcs to Banda Island. Results consistent with involvement of crustal material in magma genesis throughout E Sunda/ Banda arcs, as far W as Iya in C Flores. Source of He in crustal component unlikely to be terrigenous sediments derived from Australian continent; rather, degassing of Australian continental crust)

(online at: http://dspace.library.uu.nl/handle/1874/272287)  
(Study of Sr, Nd, Pb, Ra, Th and U isotopes and major and trace elements from five active and >10 inactive volcanic centres in Adonara-Lomblen-Pantar Sector of E Sunda Arc (E of Flores and W of volcanically inactive Alor-Wetar sector). Both mantle components (depleted Indian Ocean mantle) and subduction-related components (subducted continental material, which changes in composition from E to W (Indian Ocean pelagic sediment and detrital Australian shelf sediment?, and crystalline Australian continental crust) contribute to magma generation. Active Adonara-Pantar Sector volcanoes display strongest sedimentary or even 'continental' signal of Sunda-Banda Arcs volcanoes. Volcanic activity in Alor-Wetar sector started at least 12 Ma ago as intra-oceanic arc, and ceased about 3 Ma ago)

(Isotopic and trace element data consistent with three-component mixing whereby slab-derived hydrous fluid and siliceous melt both added to sub-arc mantle source. Hydrous fluid largely controls input in shallow part of subduction zone, siliceous melt dominates flux at deeper levels. Sedimentary material primary source of both)


(online at: https://drive.google.com/file/d/0B7j8bPm9Cse0ak95aEQ5THJ5TWc/view)
(Indonesian arc >6000 km long from N Sumatra to Molucca Sea. Majority of products augite-hypersthene andesite or basalt. Leucite in volcanoes over deepest seismic contours. Overall increase in K and alkali % with Benioff zone depth, but rather high variability)

Hutchison, C.S. (1976)- Indonesian active volcanic arc: K, Sr, and Rb variation with depth to the Benioff zone. Geology 4, p. 407-408. (K, Sr, and Rb vary with depth to Benioff zone. K2O increase most useful for Benioff zone depth prediction)

Hutchison, C.S. (1977)- Banda Sea volcanic arc: some comments on the Rb, Sr and cordierite contents. Warta Geologi (Newsl. Geol. Soc. Malaysia) 3, 2, p. 27-35. (online at: https://gsmpub.files.wordpress.com/2014/09/ngsm1977002.pdf) (Unusually high Rb/Sr ratios in volcanic rocks and cordierite in rhyolite at Tanjong Illipoi (Wetar) indicate strong continental crustal influence in source of volcanic rocks. Romang also higher Rb/Sr ratios than active volcanic arc. Wetar very different from other islands of Banda Arc because of abundant light grey rhyolite and dacite. This extinct, eroded and uplifted portion of Banda volcanic arc N of Timor affected by subducted Australian continental Plate. Cordierite in rocks of Ambon also imply continental crustal basement in N part of Banda Arc)


(Arc magmas crustal contamination can take place in mantle source or as magma traverses upper crust. Source contamination generally considered dominant process, but Java segment of Sunda arc shows increase in 87Sr/86Sr and \( \delta^{18}O \) and decrease in 143Nd/144Nd values from Krakatau towards Merapi. Volcanoes E of Merapi, where upper crust is thinner, show less crustal input)


Kamenetsky, V.S., M. Elburg, R. Arculus & R. Thomas (2006)- Magmatic origin of low-Ca olivine in subduction-related magmas: co-existence of contrasting magmas. Chemical Geology 233, p. 346-357. (Comparison of olivines in mafic, high-Ca subduction-related magmas from Indonesia (S Sulawesi), Solomon Islands, Kamchatka and Lau Basin. Two populations: (1) high-Ca; crystallized from melt that dominantly contributed to whole rock composition. (2) low-Ca; generally interpreted as mantle or lithospheric xenocrysts)


Kandlbauer, J. & R.S.J. Sparks (2014)- New estimates of the 1815 Tambora eruption volume. J. Volcanology Geothermal Res. 286, p. 93-100. (Volume estimates of 1815 Tambora eruption, Sumbawa, re-analysed. Total volume ~41 ± 4 km3 Dense Rock Equivalent (23 ± 3 km3 ash fall and 18 ± 6 km3 pyroclastic flows))


Kemmerling, G.L.L. (1926)- LÔArchipel indien centre important de volcanisme. Bull. Volcanologique 3, 7-8, p. 87-98. (Early overview of volcanism in Indonesian Archipelago. 90 active volcanoes)


(Compilation of data and images for modern volcanoes of Indonesia)

(Most strato-volcanoes have concave slope, steep slopes of 20°-40° near crater edge, gradually slope decreasing towards foot in broad flat plain. In volcanic cones in which loose ejecta dominate over lava flows profile tends to be straight line, corresponding to natural angle of repose of materials. Variations in strength of eruption may cause convex slopes, but practically always tend to produce concave profiles. Concavity of most volcanoes attributed to secondary causes)

(online at: www.repository.naturalis.nl/document/549556)
(Brief descriptions and sketches of volcanoes on E Java, Gunung Api, Serua and Tidore, based on observations during 15-month Snellius Expedition (1929-1930) to Indonesia)

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.)

(Quaternary basalts in Circum-Pacific belt and in Indonesia change from more alkaline olivine lavas farther from trench (deeper source), to more tholeiitic closer to trench (ocean side, shallower source))

(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 solfataras 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)

(Soputan high-alumina basalt stratovolcano in N Sulawesi-Sangihe magmatic arc. Adjacent to Quaternary Tondono Caldera, but magmas distinct from caldera and other arc magmas. Soputan produces explosive eruptions with high ash plumes and pyroclastic flows. Open-vent-type volcano that taps basalt magma from greater depth, in arc-mantle wedge)
(In Indonesian. Includes chapter on biography of R.W. van Bemmelen)

('Basic data of Indonesian volcanoes'. Descriptions of 67 Indonesian 'A-type' volcanoes, with eruptions in historical time: 10 in Sumatra/ Sunda Strait, 17 on Java, 5 in Bali/ W Nusatenggara, 13 in E Nusatenggara, 7 in Banda Islands, 11 in Sulawesi/ Sangir islands and 4 in N Moluccas. Eight additional known A-type volcanoes not yet described)

(Holocene volcanoes in Philippines and Indonesia studied to determine relationship between regional maximum horizontal stress and opening direction of volcanic amphitheatre craters. Opening of craters occurs at acute angle relative to max. stress direction)

(online at: www.pnas.org/content/110/42/16742.full.pdf+html)
(Polar ice cores with evidence of colossal volcanic eruption in 1257 or 1258 A.D., most probably in tropics, which yielded largest volcanic sulfur release to stratosphere of the past 7000 yrs. Likely source is Samalas volcano, adjacent to Mt Rinjani on N Lombok Island, where >40 km³ of tephra were deposited. Three principal pumice fallout deposits in region and thick pyroclastic flow deposits at coast, 25 km from source. Pre-caldera topography of Mt Samalas calculated as ~4200m above sea level. Glass geochemistry of pumice matches shards in Arctic and Antarctic ice cores (see also Vidal et al. 2015))

(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)

('Petrology and geochemistry (trace elements and Sr isotopic ratios) of magmatism associated with subduction zones: examples from the Mediterranean Basin and the Sunda Islands (Merapi, Java)')

(Fluvially transported tephra in caves of Mulu, Sarawak, not Younger Toba Tephra, but older (before ~125 or before ~156 ka. Most likely location of source in Philippines)

('Study of 54 volcano craters that erupted with sector failures')

('The ignimbrite and the Batur caldera (Bali, Indonesia'). Batur caldera result of collapse of strato-volcano following outpouring of an ignimbritic unit (ash flow) covering N and S flanks of Batur ~22,000 years ago. Island of Bali tilted N-wards around its long axis. Outflow of ignimbrite followed long period of andesitic
activity, preceded and followed by flows of bandaite, a leucocratic lava with highly basic plagioclase (~80-90% An), probably generated, at shallow depths by assimilation of aluminous strata by basaltic magma)

McGeary, S., A. Nur & Z. Ben-Avraham (1985)- Spatial gaps in arc volcanism: the effect of collision or subduction of oceanic plateaus. Tectonophysics 119, 1, p. 195-221. (Many volcanic chains worldwide show gaps in the pattern of active volcanoes, which can often be related to collisions of oceanic plateaus. Examples from Indonesia include the Wetar gap of Banda Arc (due to Australia collision S of Timor region) and New Guinea)


Neumann van Padang, M. (1959)- Changes in the top of Mount Ruang (Indonesia). Geologie en Mijnbouw 21, 4, p. 113-118. (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)

Neumann van Padang, M. (1971)- Two catastrophic eruptions in Indonesia, comparable with the Plinian outburst of the volcano of Thera (Santorini) in Minoan time. Acta First Int. Scient. Congress on the volcano of There, p. 51-63. (Comparison of Plinian eruption with enormous volumes of pumice of Santorini with those of Tambora (Sumbawa, 1815) and Krakatoa (W of Java, 1883). Krakatoa and Tambora eruptions lasted only two days and led to collapse of tall volcanic edifices)


Nho, E.Y., M.F. Le Cloarec, B. Ardouin & W.S. Tjetjep (1996)- Source strength assessment of volcanic trace elements emitted from the Indonesian arc. J. Volcanology Geothermal Res. 74, p. 121-129. (Estimates of emission of volatile metals in volcanic sources of Indonesian Arc. SO2 emission 3.5 × 106 tons/ year, or ~20% of the annual worldwide volcanic flux of SO2. Trace metal (210Po, Pb, Bi, Cd, Zn and Cu) fluxes ~5-30% of global volcanic flux, i.e. low relatively low)
(Pleistocene- Recent lavas of W Sunda Arc dominated by basaltic andesite and andesite, with average 55% silica. Most lavas have Mg/Mg+Fe2 values too low to be unmodified products of partial melting of peridotitic mantle. Further differentiation to produce andesitic- dacitic magmas probably at rel. low pressure)

(Sunda volcanic arc good example of variation in geochemistry of lavas across island arc. In addition to correlation between K2O/SiO2 ratios and depths to Benioff Zone in Pleistocene-Recent lavas of Java, there are well-defined relationships for ‘incompatible’ elements (Rb, Cs, Ba) and light rare earth elements. Volcanic centres of Java indicate progressive change in conditions of primary basaltic magma production across arc)

(Quaternary lavas of normal island-arc basalt-andesite-dacite association in Java-Bali range from tholeiitic series over Benioff-zone depths of ~150 km to high-K calc-alkaline series over Benioff-zone depths of 250km. More abundant and diverse calc-alkaline lavas over intermediate Benioff-zone depths. Basaltic lavas become slightly more alkaline with increasing depth to the Benioff zone. Levels of incompatible minor and trace elements (K, Rh, Cs, Ba, Nb, U, Th, light REE) show increase of almost order of magnitude)

(Volcanic ash layers in deep-sea sediments of NE Indian Ocean, adjacent to W Indonesian range in age from Late Miocene- Recent. Three provinces: (1) large Late Miocene and younger rhyolitic tephra province off Sumatra; (2) restricted dacitic province off Sunda Strait and W Java; and (3) andesitic province off E Java and Lesser Sunda Islands. Chemical composition of tephra layers in each province remains constant with time. E-ward decrease in silica content in tephras coincides with similar decrease in Indonesian arc lavas. High silica content in Sumatra linked to thick pre-Cenozoic crust. E of Sumatra crust is Cenozoic and thin)

(Study of volcanogenic material in DSDP and other cores from E and SE Asia. Indonesia Cenozoic magmatic history two major phases: first extended into Ey Miocene, second began in Late Miocene and lasted until today. With map of Indian Ocean areas covered with rhyolitic and andesitic ash layers SW of Sumatra and S of Java)

(Study of history of Cenozoic explosive volcanism using DSDP and piston core data from Indian Ocean off Indonesia and W Pacific Ocean)

Oppenheimer, C. (2002)- Limited global change due to the largest known Quaternary eruption, Toba ~74kyr BP?. Quaternary Science Reviews 81, p. 1593-1609.
(≈74 kyr BP 'super-eruption' of Toba volcano in Sumatra is largest known Quaternary eruption. Possible 6 yr duration 'volcanic winter' following eruption has been proposed, but previous estimates of globally averaged surface cooling of 3-5°C after eruption probably too high; closer to 1°C)

(In Sunda Arc most volcanoes define four en echelon, linear segments, each of 500-700 km length. Volcanoes of Java that do not lie on these segments either formed at early stage in history of arc and erupted anomalous magma, or lie along other mapped structures)

(online at: https://d28rz98at9flks.cloudfront.net/15175/Rep_254.pdf)  
(Annotated bibliography of 750 references on volcanoes and volcanic activity in PNG before 1944)

(Many volcanoes in SE Asia potentially tsunamigenic and present hazard to rapidly developing coasts)

Pearce, N.J.G., J.A. Westgate, E. Gatti, J.N. Pattan, G. Parthiban & H. Achyuthan (2014)- Individual glass shard trace element analyses conïrm 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))

(Description of Tambora volcano on Sumbawa. Considered to be extinct until major 1815 eruption, which reduced it in height from ~4000- 2850m, produced ~150 km3 of ash, and directly and indirectly killed 92,000 people)

('History of volcanological investigations in Indonesia', in 'A century of natural sciences in Indonesia 1850-1950' book)

(New classification of Indonesian active volcanoes: Tambora (caldera formation), Merapi (lava dome), Agung (open crater), Papandayan (sector failure), Batur (post-caldera activities), Sangeangapi (lava flows) and Anak Krakatau types (volcano islands and submarine volcano))

('Volcanoes of West Nusa Tenggara')

(Decreases in surface temperatures after eruptions of Tambora, Krakatau and Agung were of similar magnitude, although amounts of dust and volatiles injected into stratosphere differed greatly. Large amounts of fine ash and volatiles dispersed into upper atmosphere by Krakatau and Tambora; Agung eruption in 1963 was smaller, but injected dust and volatiles into stratospheric aerosol layer more directly. Agung eruption relatively rich in SO2 and Cl. Relative amounts of fine ash produced by Tambora, Krakatau and Agung eruptions
estimated at 150: 20: 1, atmospheric sulfate aerosols ~7.5: 3: 1. Decreases in surface T after volcanic eruptions mainly result of sulfate aerosols, rather than silicate dust

(Island arcs commonly depicted as curved or sinuous, but most are composed of straight segments whose trend changes suddenly at hinge or boundary zones (multiple transverse faults). Fracture system may be related to structural, morphological, or movement of underthrusting slab, or movement in backdeep or overthrusting sheet. Transverse structural systems had effect on petroleum accumulations of island arc regions, both from stratigraphic and structural viewpoint. Examples of modern Indonesian arc system)

(Batur volcanic field in Bali two caldera-forming eruptions, at 29,300 and 20,150 years BP., resulting in deposition of dacitic ignimbrites. Ubud Ignimbrite covers most of S Bali and consists dominantly of pyroclastic flow with minor pumice fall deposits. Gunungkawi Ignimbrite more limited extent, occurs only in central S Bali)

(Batur volcanic field in Bali underwent complex evolution that comprised three periods of building and two major caldera-forming eruptions)

(online at: http://petrology.oxfordjournals.org/content/46/7/1367.full.pdf+html)
(Quaternary Batur volcanic field in Bali ~150 km above Benioff zone and adjacent to active Agung volcano and extinct or dormant Bratan caldera. Two caldera-forming eruptions and broad range of compositions from low-SiO2 andesite to high-SiO2 dacite. Earliest volcanism was building of Penulisan basaltic-dacitic stratovolcano starting at least at ~510 ka. Collapse of first caldera associated with eruption of dacitic Ubud ignimbrite at 29,300 yrs BP. After formation of Bunbulan lava-dome complex collapse of second caldera, with eruption of Gunungkawi Ignimbrite at 20,150 yrs BP. Followed by 1700 m high, basaltic andesite Batur stratovolcano)

(Review of chemical compositions of magmas of Indonesian active volcanoes. Volcanoes classified as (1) Calc-alkaline (= Pacific; 30/ 91%), (2) Alkaline (= Atlantic; 2; 6%) and Potassic (= Mediterranean; 1/ 3%). Calc-alkaline character of magmas of active volcanoes decreases regularly in direction from foredeep to hinterland, becoming alkaline in hinterland itself. Also, at single volcanoes calc-alkaline character decreases with time, 'confirming migration of axis of orogen towards foredeep')


(‘Arc and back-arc magmatic series of Sunda arc: nature of involved sources’. Three geochemical zones: arc, backarc and an intermediate zone. Focus on back-arc potassic basalts of Sumatra (Jambi, Sukadana) and Karimunjawa islands)


(Post-caldera lavas of Bratan volcano on Bali are basalts to andesites and typical of subduction-related tectonic setting. K-Ar ages ~14, 31, 55, 66, 94 and 125 ka)


(Ibu volcano on NW Halmahera one of most active volcanoes in Indonesia. Resumed activity in 1998. Lava dome of dacite composition is developing at rate of 3182 m³ per day)


(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 rhyolithic volcanic shards near marine isotope stage 5-4 boundary with chemical composition of 'Youngest Toba Tuff'. Toba event between two warm periods lasting 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)


(On largest volcanic eruption in Indonesia since Krakatoa in 1883. Early lava flow followed by two explosive phases. Two related but distinctly different magma types: porphyritic basaltic andesite and andesite)


(Deastors of April 1815 Tambora eruption sequence starting with four widespread ash fall layers, locally overlain by up to eight pyroclastic flow deposits. Wioth isopach maps of F1, F2, F3 and F4 Plinian tephra layers. F-5 deposit is co-ignimbrite ash fall, generated largely during entrance of pyroclastic flows into ocean. Large volume of F-5 ash requires eruption of 50 km³)


(Slake Toba ash event (75 ka; ~20 cm thick) and Australasian tektite layer (0.7 Ma; near Brunhes/Matuyama magnetic reversal) identified in Hole 758C, Indian Ocean W of N Sumatra)


(Lake Toba ash event (75,000 yrs ago) recovered in Hole 758C, had minor influences on foraminiferal populations. Australasian tektite event (just below Brunhes/Matuyama magnetic reversal at ~0.7 Ma) probably had some influence on foraminiferal ecology, because larger specimens become scarce just above microtektite layer. Cretaceous-Paleogene boundary of Hole 752B does not show obvious anomalous trace-element concentrations)


(Majority of gold-copper mineralization along Sunda- Banda arc low-sulphide- epithermal, related to Late Neogene eruptions of fine silicic/acidic pyroclastics of calc-alkaline affinity. Rel. wide distribution of Late Miocene- Pliocene acidic tuffs on Java, possibly related to caldera collapse or graben subsidence)


Soeria-Atmadja, R., S. Suparka, C. Abdullah, D. Noeradi & Sutanto (1998)- Magmatism in western Indonesia, the trapping of the Sumba Block and the gateways to the east of Sundaland. J. Asian Earth Sci. 16, 1, p. 1-12. (Similarities in Late Cretaceous-Paleogene stratigraphy and calc-alkaline magmatism between Sumba, S Sulawesi and SE Kalimantan suggest Sundaland origin for all these areas. S-ward migration of Sumba to present fore-arc position is after Late Cretaceous-Paleocene time)


Stothers, R.B. (1984)- The great Tambora eruption in 1815 and its aftermath. Science 224, 4654, p. 1191-1198. (Tambora 1815 eruption on Sanggar Peninsula of Sumbawa largest and deadliest volcanic eruption in recorded history. Combined volumes of ejecta 40-90 km3 (dense rock equivalent), most probably ejected in 3-24 hours. Sound range was 2600 km, ash range >1300 km, pitch darkness (up to 2 days) over 600 km, pyroclastic flows at least 20 km from summit and tsunami of 1-4m shore height over at least 1200km)

Stothers, R.B. (2004)- Density of fallen ash after the eruption of Tambora in 1815. J. Volcanology Geothermal Res. 134, 4, p. 343-345. (Tambora 1815 eruption produced largest known ashfall in historical times (~100 km3). Density of fallen ash measured at Makassar (~380 km N of Tambora) shortly after eruption: 636 kg/m3)

Sucipta, I.G.B.E., I. Takahashima & H. Muraoka (2006)- Morphometric age and petrological characteristics of volcanic rocks from the Bajawa Cinder Cone Complex, Flores, Indonesia. J. Mineralogical Petrological Sci. 101, 2, p. 48-68. (online at: https://www.jstage.jst.go.jp/article/jmps/101/2/101_2_48/_pdf) (Bajawa complex 78 cinder cones, grouped into five morphometric ages. Oldest group 0.53-0.73 Ma, Bajawa 02 (0.41- 0.51 Ma), 03 (0.32- 0.40 Ma) and 04 (0.22-0.31 Ma), youngest group 0- 0.20 Ma)


(online at: www.bgl.esdm.go.id/dmdocuments/jurnal20090304.pdf)
(Batur caldera, NE Bali, is 10 x 7.5 km collapse structure with two stages of collapse at 29.3 ka and 20.1 ka, interrupted by silicic andesite welded ignimbrite and domes)

(online at: www.bgl.esdm.go.id/publication/index.php/dir/article_detail/763)
(Erupted ash and volcanic aerosols from 1815 Tambora eruption caused global climate changes for 1-2 years. Aerosol cloud spread around Earth in ~3 weeks and caused surface cooling in N Hemisphere of 0.4-0.7 ° C)

(online at: www.bgl.esdm.go.id/publication/index.php/dir/article_detail/166)
(Eruption of Tambora on Sumbawa on 5-11 April 1815 generally considered as largest volcanic event in recorded history, leaving caldera 7 km in diameter and 1100m deep. Cataclysmic eruption initiated by Plinian eruption on 5 April, killing >90,000 people on Sumbawa and nearby Lombok, and depositing 40-150 cm of gray pumice and ash on slopes mainly over district W of volcano. On 11 April 8 pyroclastic surges and flows, burying ancient villages to N)

('Evolution of the Batur caldera, Bali')

(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/224/196)
(Large Batur caldera is source of two major ignimbrite eruptions of similar dacitic-rhyodacitic composition, with combined volumes of ~84 and 19 km3. Batur magma equilibrated at T of 1100-1300° C and P of 20 kbar)

(online at: www.jstage.jst.go.jp/article/geosoc/116/9/116_9_473/_pdf)
(Discussion of caldera-forming eruptions in Sunda Arc (Krakatau, Tambora, Rinjani, etc.))


('Alkali-lime index' decreases inward from outer zone of the arcuate zone in volcanic arcs of Kamchatka, Kurile Islands, Japan and Indonesia Islands)

('Volcanology in the Netherlands Indies')

Tjia, H.D. (1967)- Volcanic lineaments in the Indonesian island arcs. 11th Pacific Science Congress, Tokyo 1966, Bull. Volcanologique 31, 1, p. 85-96. (More than 400 linear arrangements of active volcanic centers of Indonesia. Subdivided into small (on the same volcano), medium (same volcanic range), and large (connections between volcanic loci on separate cones or ranges). >70% of lineaments classified as first and second order shear, tension, and extension directions. Most volcanic lineaments along narrow zones of weakness, related to regional structure)


Tjia, H.D. & R.F. Muhammad (2008)- Blasts from the past impacting on Peninsular Malaysia. Bull. Geol. Soc. Malaysia 54, p. 97-102. (online at: www.gsm.org.my/products/702001-100478-PDF.pdf) (At Plio-Pleistocene transition 3 large volcanic centres in Barisan Mts. (Sumatra) began producing large amounts of felsic tephra and pyroclastic flows. At Toba perhaps 4 paroxysmal events between 1.9 Ma-~30 ka. Centres marked by 100's of m of ignimbrite, pyroclastic tuffs and air-fall tephra. Air-fall tuff identified throughout Peninsular Malaysia, up to 1m thick and generally attributed to single 'Toba eruption' at 70-75 ka, but possibly multiple eruptions)


Umbgrove, J.H.F. (1945)- Different types of island-arcs in the Pacific. The Geographical J. 106, p. 198-209. (W Pacific- Indonesia island arcs associated with deep continent-ward dipping shear plane and deep trench along outer sides (came very close to characterizing a subduction zone, long before plate tectonic theory was
formulated; JTvG). Three types island arcs: double arcs (Indonesia), pseudo-single arcs (Kurile-Aleutian) and single (Marianas- Bonin) arcs

('The caldera problem'. Model for creation of calderas by volcano collapse after major explosive 'emptying-out' eruption, with reference to mainly Indonesian volcanoes (Toba, Tengger, Krakatau, etc.)

(Discussion on origin of Miocene and younger calc-alkaline or Pacific magmatism on S Sumatra (Barisan Mts.) and Java (Bantam intrusions and Merawan granite batholith))

(Inventory of 130 active volcanoes in Indonesia)

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

(Summary of activity of Indonesia's 130 active volcanoes from 1936-1948. Detailed records collected by Volcanological Survey until Japanese occupation in 1942; after that limited information, mainly from Java)

(Same title as Van Bemmelen 1963. On Java- Sumatra three Cenozoic pulses of uplift with intrusions and extrusions of acid magmas. Cenozoic deposits start with deposition of Eocene quartz sandstones and marine sediments without tuffaceous components. This was followed by Oligocene- E Miocene 'Old-Andesite' volcanoes, which are largely submarine and represent first cycle of andesitic, calc-alkaline Pacific volcanism. M Miocene second pulse of uplift with formation of proto-Semangko rift with acid magma on Sumatra (between E Miocene Telisa and M Miocene Lower Palembang beds. In Mio-Pliocene time subsidence again prevailed in Sumatra-Java belt. Andesitic volcanism resumed, forming 2nd Andesite Fm (M Palembang Beds of Sumatra, Bentang Beds, etc of Java). At end Tertiary a third pulse of orogenic uplift, creating present Sumatra-Java geanticline and again accompanied by rifting and voluminous outbursts of acid pumiceous tuffs on Sumatra)

(Same as Van Bemmelen 1961. Sumatra -Java arc of Indonesia three pulses of orogenic uplift after its Mesozoic geosynclinal subsidence. All three accompanied by rise and occasional ignimbritic eruptions of acid magma. 'Normal' igneous rocks of intermediate composition erupted during intervening periods)


(Active volcanoes of E Sunda Arc and Banda Arc 100-250 km above Benioff zone. Wide range of lavas, from are-tholeiitic (low-K) to leucite-bearing (alkaline) suites. Variations along and across arc. For volcanoes with
similar distance to Benioff zone potassium and other incompatible elements progressively increase towards collision area near Timor, and close to Timor also increasing with increasing distance to Benioff zone)


(Variations in isotope signatures along E Sunda Arc show maximum magma source contamination near extinct sector N of Timor. Increasing contribution of subducted continental material in direction of collision. Leading part of Australian continental margin reached magma generation zone in E Sunda- W Banda arc, implying subduction deeper than 100 km)


(Batu Tara is active potassic volcano in E Sunda arc. Leucite-bearing rock suite two groups, suggesting parental magmas with different mantle origins. Trace element and isotopic compositions consistent with involvement of subducted sedimentary/crustal component as well as MORB and OIB mantle)


(Incl. observation that Tin Islands granites are rel. rich in Rare Earth Elements)


(Four segments distinguished by Sr isotopes in Java-Sunda-Banda volcanic arc. Adonara-Pantar segment between Flores and Alor studied here, transition between W Banda Arc volcanics (in E) with clear 'continental' signature and Sunda Arc volcanics (in W) with little evidence of subduction of continental material)


(Mafic volcanics, ranging from calc-alkaline basalts through shoshonitic trachybasalts to leucitites, along E Sunda Arc arc from Bali (Agung) to Flores. With 3-fold enrichment in K, Rb, Sr, Ba, La and Nb, increasing toward collision zone, correlating with increasing 87Sr/86Sr and decreasing 143Nd/144Nd values. K-rich material derived from ancient subcontinental mantle. E Sunda K-rich mafic volcanism first appeared after collision began. Before collision, ancient NW Australian mantle erupted K-rich, diamond-bearing ultramafics with high Sr and low Nd ratios, part of ultrapotassic continental volcanic association)


Dutch and French editions; With two Atlas volumes

(Dutch text online at: https://books.google.com/books/about/Krakatau.html?id=j5Q0AQAAMAAJ)

(French text volume online at: https://archive.org/details/krakatau00verbgoog)

(Classic account of the 1883 cataclysmic eruption of Krakatoa volcano in Sunda Straits and its effects (incl. human casualties, tuffs and tsunami deposits, etc.))

(Caldera-forming eruption of Samalas (Lombok) in 1257 AD associated with largest sulphate spike of last 2 ky recorded in polar ice cores. Four-phase continuous eruption produced 33-40 km3 dense rock equivalent of deposits, mainly pumiceous plinian fall products, pyroclastic density current deposits and ash that could be identified 660 km from source. Eruption dynamics consistent with efficient dispersal of sulphur-rich aerosols across globe)


Vroon, P.Z. (1992)- Subduction of continental margin material in the Banda Arc, Eastern Indonesia. Sr-Nd-Pb isotope and trace-element evidence from volcanics and sediments. Ph.D. Thesis University of Utrecht, Geologa Ultraictina 90, p. 1-205. (online at: http://dspace.library.uu.nl/handle/1874/316569) (Isotope and trace element geochemistry study of eastern part of Banda Arc, in area controlled by active arc-continent collision (Romang, Damar, Teon, Nila, Serua, Manuk, Banda). Composition of samples from 7 volcanoes suggests subducted continental sedimentary material in magma increases from <1% in NE to 5-10% in SW)

Vroon, P.Z., D. Lowry, M.J. van Bergen, A.J. Boyce & D.P. Mattey (2001)- Oxygen isotope systematics of the Banda Arc: low d18O despite involvement of subducted continental material in magma genesis. Geochimica Cosmochimica Acta 65, 4, p. 589-609. (Oxygen isotope data for 60 volcanic rocks and 15 sediments along entire Banda Arc. Generally low d18O values (excluding Serua, Ambon) compatible with 1-5% addition of subducted continental material to depleted MORB-type source in sub-arc mantle. Assimilation of up to 20% and 80% arc-crust material thought to be cause of high d18O values of Serua and Ambon)


Trace elements and Sr-Nd-Pb isotopes show 4 major provenance areas: N New Guinea + Seram, S New Guinea, Timor, North Australia.


(Isotope data for six active and one extinct volcano over Banda Arc. Rock types low-K tholeitic in NE, high-K calc-alkaline in SW. Volcanoes in NE 'normal' arc signatures, in SW extreme values. Evidence for contribution of subducted continent-derived material to magma sources. Addition of 0.1-2% local sediment in NE Banda arc, and 1-3% in SW Banda Arc to Indian Ocean MORB source explain isotope trends. Serua and Romang require >5% sediment)


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


(online at: http://geologic-risk.ft.ugm.ac.id/fresh/jsaag/vol-2/no-3/jsaag-v2n3p283.pdf)

(Two Quaternary caldera systems on Bali: Batur caldera and Buyan-Bratan caldera)


(online at: www.dwc.knaw.nl/DL/publications/PUB00010947.pdf)

(Four Mesozoic-Tertiary concentric belts of fold structures and plutonic rocks in Indonesia, connecting Burma with Philippines, each with own types of plutonic rocks and ore deposits: (1) Jurassic Malayan orogen of Malay Peninsula, Tin islands, possibly W, SW and C Kalimantan; (2) Late Cretaceous Sumatra orogen of Sumatra, C Java, Meratus; (3) M Miocene Soenda orogen (should be E Miocene; 'Old Andesites': JTvG) of SW Sumatra, Java S Mountains, volcanic Lesser Sunda islands and (4) the active Moluccan orogen. Late Quaternary volcanics two groups, 'Pacific' calc-alkaline and 'Mediterranean' potassic. Analyzed 157 samples for radioactivity and bulk chemical composition. Mesozoic granites from Tin islands very different petrochemistry from Kalimantan (Schwaner Mts, etc.) granites)


(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)


(Batur active stratovolcano on Bali, Indonesia, with large caldera correlated with eruption at ~23,700 years ago that formed thick ignimbrite sheet. Formation of caldera due to change in lava composition from basaltic-
andesitic to dacitic. Dacitic rocks characteristics consistent with origin by crystal-liquid fractionation from more mafic parent magmas in shallow chamber, possibly at 1.5 km depth and 1000-1070°C)


(Excluding Sumatra and Wetar (mainly dacitic and rhyolitic volcanics), four geochemical arc sectors in Sunda-Banda arc: W Java, Bali, Flores (each more K-rich eastwards, culminating in leucitite volcanoes Muriah, Soromundi, Sangenges and Batu Tara). Dominant source component common to all sectors probably peridotitic mantle. Second component, with high 87Sr/86Sr value, may be crustal material, most apparent in Banda sector, but also present to lesser extents in W Java and Flores sectors)


(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)


(Pleistocene-Recent lavas from Sunda arc range from island arc tholeiitic series, through calc-alkaline to high-K alkaline rocks. Calc-alkaline suite decrease in 87Sr/86Sr from W Java to Bali with some evidence for increasing 87Sr/86Sr with increasing depth to Benioff zone. 87Sr enrichment due to isotopic equilibration of oceanic crust with sea water and disequilibrium melting in slab. Calc-alkaline lavas with high ratios best explained by sialic contamination, or presence of alkali basalt as component of downgoing slab. Sr isotopic data for high-K alkaline lavas suggest mantle origin. High ratio in Lake Toba rhyolite implies crustal origin)


(Late Cenozoic basalts N of Timor from Solor to Serua primitive tholeiitic, but associated more silicic rocks suggest involvement of continental crust or sediment)


(Active arc located on what appears to be oceanic crust whereas associated subduction trench is underlain by continental crust. Recent lavas predominantly andesitic, tholeitic in N to calc-alkaline varieties in S islands. High 87Sr/86Sr ratios in calc-alkaline lavas interpreted to result from mixing of sialic component with mantle derived component. Likely cause is subduction and melting of sea-floor sediments or continental crust)


(In Banda Arc continental material (probably subducted sediments) appears to be subducting beneath volcanic arc that is underlain by oceanic crust)

Whitford, D.J. & I.A. Nicholls (1975)- Geochemistry of the volcanic rocks of the Sunda island arc of Indonesia. Exploration Geophysics 6, 2/3, p. 76-77. (Abstract only)

(Sunda volcanic arc from N of Sumatra, through Java, Bali, Lombok, Sumbawa, Flores, Lesser Sunda Islands, after which becomes Banda arc. Variety of tectonic environments. Sumatra crust ~40 km thick with Paleozoic granites. Benioff zone only to ~200 km. Beneath Java crust thinner and younger; oldest exposed rocks Mesozoic, and Benioff zone to ~600km beneath Java Sea to N. Further E, crust thinner (~15 km), oceanic in velocity structure and Benioff zone to great depths)

Sunda arc of Java-Bali relatively simple tectonic setting above N-dipping Benioff seismic zone. Quaternary lavas of ‘normal island arc association’ (tholeiites to high-K calc-alkaline lavas) over Benioff zone depths from 120-250 km. High-K alkaline lavas above Benioff zone depths >300 km. Magmas derived mainly from mantle wedge above Benioff zone, where modified by water and/or melt from the subducted oceanic crust.

(Island arc lavas range from tholeiites to high-K calc-alkaline lavas over Benioff zone depths 120 to 250 km. More abundant calc-alkaline lavas between these extremes. High-K alkaline lavas over Benioff zone depths over 300 km. Incompatible elements increase with depth to seismic zone. Java and Bali lavas geochemistry best explained by combination of mantle source melting and partial melting of that material at progressively greater depths. Primary tholeiitic magmas may form by 20-25% melting at 30-40 km, primary high-K calc-alkaline magmas by 5-15% melting at 40-60 km, and primary alkaline magmas by 5% melting at 80-90 km)

(143Nd/144Nd ratios in Quaternary lavas from Java and Banda arc exhibit inverse correlation with 87Sr/86Sr. Indonesian samples resemble Andean rather than island arc lavas)

(‘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 volcanoes of Tidore island (Molucass)’)

(online at: www.dwc.knaw.nl/DL/publications/PU00012167.pdf)
(English version of Wichmann (1918). Tidore Island composed of several andesitic volcanic centers, the tallest Matubu ~1730m high, others ~400-800m high)

(‘On the magmatic provinces in the Netherlands East Indies’. Not overly useful)

(Mainly listings of chemical analyses of 1220 volcanic rock samples)
(Popular, but thorough account of the 1883 eruption of Krakatoa volcano in Sunda Strait that killed nearly 40,000 people)

(Brief overview of volcano studies in Indonesia until 1929)


(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 60-80 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 Bengal, etc.)

(Review of 1815 eruption of Tambora volcano on Sumbawa island and its global impact)


Zaennudin, A. (2010)- The characteristic of eruption of Indonesian active volcanoes in the last four decades. J. Lingkungan Bencana Geol. 1, 2, p. 113-129.
(online at: www.bgl.esdm.go.id/publication/index.php/dir/article_detail/287)
(Indonesia has 129 active volcanoes (~13% of world). Three types: A (79) with recorded eruptions since 1600; B (29) with solfataric and or fumarolic activity and crater; C (21) in solfataric stage, but volcanic edifice not clear)

(Submarine volcano, rising >400m from sea floor in Sangihe Islands, Moluccas Sea. Erupted in 1918)


(Three types of hills around Indonesian volcanoes: (1) parasitic volcanic cinder cones (Slamet, Lamongan, etc.), (2) hillocks formed by lahar deposits (e.g. Galunggung, Raung, etc.), and (3) anticlinal structures resulting from
collapse of volcanic cones or squeezing of soft sediment by weight of volcano itself (N floor Ungaran, Gendol SW of Mt Merapi, N of Tangkuban Perahu, N of Arjuna, 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


(Oxygen and carbon isotopes of benthic (Uvigerina, Cibicidoides) and planktonic (Gs. ruber) foraminifera from Banda Sea deep-sea over last 180 kyr indicate increase in Banda surface and deep water salinity during glacial conditions. Planktonic data influenced by precession (23 kyr periodicity) while benthic values reflect intermediate Pacific water fluctuations. Banda Sea records indicate general good ventilation. Deepening of lysocline resulted in higher carbonate content during glacial periods, similar to N Pacific)

(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)

(Islands of Timor and New Guinea significant sources of sediment. Most material delivered into Arafura and Timor Seas comes from New Guinea. Island and continental materials overlap with volcanic input from Banda Arc. Discharge from New Guinea and Timor greater than from N Australia)

(Human-induced shifts from fringing reef-dominated to mangrove-dominated coastal habitats in S Sumatra and SW Sulawesi)

(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)

(Mainly low-saline N Pacific water fills upper part of Indonesian seas and downstream buoyant (surface) pool (DBP) that stretches over large part of N Australian Basin. Long-term mean steric sea level in Indonesian seas equal to neighboring Pacific Ocean sea level. Change of steric sea level from Pacific to Indian Ocean sea level at border between DBP and Indian Ocean. Darwin located inside DBP. Control of ITF set by baroclinic transport capacity of DBP relative to adjacent (Indian Ocean) water. Mean ITF, estimated as outflow from DBP to S Equatorial Current, is about 10 Sv. ITF imprint is fresh and cold. Atmospheric transfer of freshwater to N Pacific and vertical mixing in N Pacific provide driving of mean ITF and ITF is major branch of estuarine-type vertical circulation of N Pacific)

Andruleit, H. (2007)- Status of the Java upwelling area (Indian Ocean) during the oligotrophic northern hemisphere winter monsoon season as revealed by coccolithophores. Marine Micropaleontology 64, p. 36-51.
(Coccolithophores used as indicators for present-day functioning of Java upwelling)

(Coccolithophores help decipher Pleistocene paleoproductivity changes in E Indian Ocean in past 300-65.3 kyr. Core SO139-74KL at seaward limit of fore-arc basin of Indonesian continental shelf, beneath Java upwelling system. Dominated by Florisphaera profunda (41.5%), followed by Gephyrocapsa ericsonii, Emiliania huxleyi and G. oceanica. Warm tropical conditions prevailed throughout)

('Study of paleosalinity of Indonesian waters from the Last Glacial Maximum until Recent)

(Crater lake of Satonda, a small volcanic island 3 km NW of Sumbawa, with red-algal microbial reefs in marine-derived water of increased alkalinity. Potential analogue for ancient microbialites in open-marine facies)

(Crater lake of Satonda, a small volcanic island 3 km NW of Sumbawa, with high-alkaline water. With well-developed 'stromatolitic' red algal- microbialite reefs with demosponges in upper ~20m)


(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 thicket/ 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)


Barmawidjaja, D.M., E.J. Rohling, W.A. van der Kaars, C. Vergnaud Grazzini & W.J. Zachariasse (1993)- Glacial conditions in the northern Molucca Sea region (Indonesia). Palaeogeogr. Palaeoclim. Palaeoecology 101, p. 147-167. (Core K12 from 3510m water depth N of N Halmahera spans last 27,000 yrs. Palynology suggests glacial time climate drier than today. This and lower sea level resulted in expansion of Lower Montane oak forests on Halmahera. Surface water salinities probably higher. Also well-developed 'Deep Chlorophyll Maximum layer'. With elevated planktonic forams Neogloboquadrina dutertrei and presence of Ng. pachyderma in glacial times (similar to observed in Sulu Sea by Linsley et al. 1985))


Barmawidjaja, D.M., A.F.M de Jong, K. van der Borg, W.A. van der Kaars, W.J. Zachariasse (1989)- The timing of postglacial marine invasion of Kau Bay, Halmahera, Indonesia. Radiocarbon 31, 3, p. 948-956. (Kau Bay, Halmahera, E Indonesia is small 470m deep marine basin, separated from SW Pacific Ocean by 40m deep shallow sill. Bay water below depth of ~350m devoid of oxygen and high dissolved H2S. Radiocarbon dating on piston cores and study on microfossils demonstrate Kau Bay was freshwater lake in Weichselian times (freshwater diatoms). At 10,000 BP reconnected with open ocean. If sill depth did not change in intervening years, sea level at 10,000 BP stood 40m below present level)

Barrows, T.T. & S. Juggins (2004)- Sea-surface temperatures around the Australian margin and Indian Ocean during the Last Glacial Maximum. Quaternary Science Reviews 24, p. 1017-1047. (Sea-surface temperature maps for oceans around Australia based on planktonic foraminifera assemblages. During Last Glacial Maximum cooling in tropics of up to 4 °C in E Indian Ocean, mostly between 0- 3 °C elsewhere along equator. High latitudes cooled more, with maximum of 7-9 °C in SW Pacific Ocean)


(On composition and texture of aragonite in lacustrine stromatolites from alkaline crater lake of Satonda)


(online at: www.unu.edu/unupress/unupbooks/80197e/80197E00.htm)

(Overview of coastal progradation in various areas of Indonesia)


(Geomorphology, palynology, biogeography and vegetation/climate modelling suggests N-S 'savanna corridor' through Sundaland continent at Last Glacial Period at time of lowered sea-level. Minimal interpretation of 50-150 km wide zone of open savanna vegetation along divide between S China and Java Seas, forming land bridge between Malay Peninsula, Sumatra, Java and Borneo and served as barrier to dispersal of rainforest-dependent species between Sumatra and Borneo. Savanna corridor may have provided convenient route for rapid early dispersal of modern humans through region and on into Australasia)


(New Guinea mountains covered by glaciers at ~300 ka and at ~700 ka. Mean annual T was at least 6-7°C lower. Glaciers receded by 13 ka BP and New Guinea may have been ice free by 7 ka. Glaciers developed again at ~5 ka. At least four significant re-advances during last 5.5 ka. Little Ice Age ended 120-150 years ago and glaciers retreating to present day)


(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)


(online at: http://edoc.gfz-potsdam.de/gfz/get/14283/0/b800b700926b1f854f870c2e84b0c4a/14283.pdf)

(New bathymetric data show six large submarine slides at E Sunda margin between C Java and Sumba. Volumes between 1 km³ in Java fore-arc basin up to 20 km³ at trench off Sumba and Sumbawa)


(online at: https://www.gfdl.noaa.gov/bibliography/related_files/burnett0001.pdf)

(Model suggests pressure difference between Pacific and Indian Ocean does not significantly influence total transport of Indonesian throughflow)


(online at: https://gsmpubl.files.wordpress.com/2014/09/bgsm1992012.pdf)

Closure of Indonesian seaway 3-4 Myr ago may be responsible for global climate changes. N movement of New Guinea, ~5 Myr ago, switched source of flow through Indonesia from warm S Pacific to colder N Pacific waters, decreasing Indian Ocean sea surface temperatures and leading to aridification of E Africa. Changes in equatorial Pacific may have reduced atmospheric heat transport from tropics to higher latitudes, stimulating global cooling and growth of ice sheets.

(online at: www.pnas.org/content/early/2009/06/18/0809865106.full.pdf)
(Model reconstruction of forest types across exposed Sunda Shelf during Pleistocene Last Glacial Maximum, suggesting rainforests covered substantially larger area than today (see also Wurster et al. 2010 who argue for more savannah vegetation; JTvG))

(online at: http://macau.uni-kiel.de/...)

(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)

(Modern influx of fluvial sediment to Sunda shelf/ Strait of Malacca from Sumatra restricted by rain forest cover in equatorial ever-wet climate belt. Much of marine and estuarine environments erosional or non-depositional, except for localized deposition in slack water areas, such as down-stream end of islands. Thick (>13m), laterally extensive (>70000 km2) peat deposits forming on poorly drained coastal lowlands)

(Factors influencing fluvial sediment discharge include catchment-basin size, relief, gradient, tectonic setting, bedrock lithology, rainfall. Dominant variable affecting fluvial sediment discharge among islands of Indonesia appears to be seasonality in rainfall, regardless of tectonic setting, relief or catchment-basin size)


(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))

Rates of continental erosion reconstructed from volumes of clastic sediment, most of which offshore. Sediment flux from mainland Asia first peaked in E-M Miocene (24-11 Ma), well before initiation of glacial climate, indicating that rock uplift and precipitation are key controls on erosion over long periods of time. In E Asia faster erosion correlates with more humid, warm climates in E-M Miocene, changing to less erosive, drier climates after 14 Ma when Antarctic glaciation begins. Average sedimentation rates on most E Asian continental margins since 1.8 Ma 5-6 times less than modern fluvial flux.


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)


(Review of terrestrial ecology of East Asian tropics and subtropics, from S China to W Indonesia)


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


(Study of sedimentation processes in waters around Serawatu, Aru Islands, Moluccas')


(NE Java tsunami deposits)


(SE Asia (in particular Borneo and Indochina) major 'evolutionary hotspots' for diverse range of fauna-flora. Most region’s biodiversity result of accumulation of immigrants and in situ diversification. Colonization events comparatively rare from younger emergent islands like Java, which show increased immigration events)


De Deckker, P., N.J. Tapper & S. van der Kaars (2002)- The status of the Indo-Pacific Warm Pool and adjacent land at the Last Glacial Maximum. Global Planetary Change 35, p. 25-35. (During Last Glacial Maximum significant drop in precipitation in Warm Pool region that would explain increase in salinity while Sea surface T decreased by ~2°C, causing decrease of atmospheric convection over Indo-Pacific Warm Pool. Drier atmosphere and diminished level of cloud cover also reduced nocturnal temperatures at elevation, forcing tree line to drop and glaciers to much lower altitudes than today)


Dubois, N., D.W. Oppo, V.V. Galy, M. Mohtadi, S. van der Kaars, J.E. Tierney, Y. Rosenthal et al. (2014)- Indonesian vegetation response to changes in rainfall seasonality over the past 25,000 years. Nature Geoscience 7, p. 513-517. (online at: http://www.whoi.edu/fileserver.do?id=186164&pt=2&p=17766) (Climate 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)


Fieux, M., C. Andrie, P. Delecluse, A.G. Ilahude, A. Kartavtseff, F. Mantisi, R. Molcard & J.C. Swallow (1994)- Measurements within the Pacific-Indian oceans throughflow region. Deep Sea Research I, 41, 7, p. 1091-1130. (Two hydrographic sections between Australian shelf and Indonesia, where throughflow between Pacific Ocean and Indian Ocean emerges. Subtropical and Central waters separated from waters of Indonesian seas by sharp hydrological front, around 13°30 S, below thermocline down to 700 m. Off Sumba, Savu, Roti and Timor channels a core of low salinity and high oxygen near-surface water in axis of each channel, suggesting strong currents from Indonesian seas towards Indian Ocean. Deep water flowing in opposite direction, from Indian Ocean to Timor basin below 1400 m to sill depth)


Fontaine, H. (1971)- Depots coquilliers du delta du Mekong. Archives Geol. Vietnam 14, p. 135-141. ('Shell deposits of the Mekong Delta: During Flandrian large area of Mekong delta was covered by sea, which after withdrawal left traces of paleo-shorelines and shell deposits. C14 ages of shells 4150- 5680 BP)


Galey, M.L., A. van der Ent, M.C.M. Iqbal & N. Rajakaruna (2017)- Ultramafic geoecology of South and Southeast Asia. Botanical Studies 58,18, p. 1-28. (Globally, 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)

Gallagher, S.J., M.W. Wallace, C.L. Li, B. Kinna, J.T. Bye, K. Akimoto & M. Torii (2009)- Neogene history of the West Pacific Warm Pool, Kuroshio and Leeuwin currents. Paleocenography 24, PA1206, p. 1-27. (Presence of Indo-Pacific larger foraminifera and smaller taxa Asterorotalia and Pseudorotalia on Australia NW Shelf at ~4 Ma and from 1.6- 0.8 Ma suggest periods of increased Indonesian Throughflow (connecting W Pacific Warm Pool and Indian Ocean). From 10 to 4.4 Ma lack of biogeographic connectivity between Pacific and Indian Oceans suggests Indonesian Throughflow restriction, when collision of Australia and Asia trapped warmer waters in Pacific, creating WPWP biogeographic province from equator to 26°N)
(Late Quaternary paleoclimatology and oceanography deduced from two Banda Sea piston cores. Two-step
deglaciation seen in oxygen isotopes, but did not lead to higher surface water temperatures but to wetter
climate as recorded in palynofacies. Increasing monsoon regime around 10 ka. At ~10.5 ka climate got wetter.
Upwelling intensity increased around 9.2 ka and monsoonal intensity decreased again at ~2.7 ka)

in south-east Asia: using termites (Isoptera) as indicators. Biological J. Linnean Soc. 75, p. 453-466.
(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.)

Gingele, F.X., P. De Deckker, A. Girault & F. Guichard (2002)- History of the South Java Current over the past
(Sediment core below South Java Current (SJC) used to reconstruct paleoclimate/ paleoceanography of past 80
ka. Considerable contrasts from glacial to Holocene. Presently below low-salinity tongue from Java Sea via
Sunda Strait, with characteristic terrigenous matter. During last glacial stage sea level was lower, Sunda Strait
was closed and terrigenous supply from that source ceased. Circulation patterns alternatively dominated by N
Hemisphere E Asian Monsoon system and S Hemisphere Australian Monsoon system. Between 20-12 ka,
(Australian) SE Winter Monsoon reached maximum and intensified W flowing S Java Current)

Godfrey, J.S. (1996)- The effect of the Indonesian Throughflow on ocean circulation and heat exchange with

Godfrey, J.S., A.C. Hirst, and J. Wilkin (1993)- Why does the Indonesian throughflow appear to originate from

(Reviews of modern marine and terrestrial ecosystems of Indonesia (mainly biology))

to originate from the North Pacific. J. Physical Oceanography 25, p. 1560-1567.
(online at: http://journals.ametsoc.org/doi/pdf/10.1175/1520-0485%281995%2929%3C1560%3AWIARAC%3E2.0.CO%3B2)
(Transfer of water from Pacific to Indian Oceans in the Indonesian Seas comprised primarily of North Pacific
water masses)

(online at: www.tos.org/oceanography/issues/issue_archive/issue_pdf/18_4/18_4_gordon.pdf)
(Nice review of Indonesian Throughflow)

Research 99 (C9), p. 18235-18242.

(Indonesian Throughflow dominated by (1) low-salinity well ventilated N Pacific water through Makassar Strait
upper thermocline and (2) more saline S Pacific water through lower thermocline of E Indonesian Seas)

(Pacific water spills over deep topographic barriers into Sulawesi, Seram and Banda seas. W-most flow through Makassar Strait shallower barriers: 1350m deep Sangihe Ridge, providing access to Sulawesi Sea and 680m deep Dewakang Sill between S Makassar Strait- Flores Sea. Along E path, Pacific water must flow over 1940 m barrier of Lifamatola Passage before passing into deep Seram and Banda Seas. Deepest barrier encountered by W and E paths is 1300-1450 m Sunda Arc sill near Timor. Savu Sea connected to Banda Sea down to 2000 m, but closed to Indian Ocean at depth shallower than Timor Sill. Density-driven overflows force upwelling of resident waters within confines of basins)

(online at: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2012GL052021)
(Increased SCS throughflow during El Nino events increases S-ward flow of buoyant surface water through Sulu Sea into N Makassar Strait, inhibiting tropical Pacific surface water injection into Makassar Strait)

(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)

(Oceanographic models)

(online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/1999GL002340)
(Velocity measurements in constriction in Makassar Straits near 3°S suggest average throughflow is 9.3 Sv. Throughflow within Makassar Strait can account for all of Pacific to Indian interocean transport)

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

(online at: https://www.atmos.umd.edu/~dwi/papers/gordon_dwi_nature03.pdf)
(Within Makassar Strait (primary pathway of Indonesian throughflow), flow far cooler than estimated earlier. During boreal winter monsoon, wind drives buoyant, low-salinity Java Sea surface water into S Makassar Strait, creating N-ward pressure gradient in surface layer of strait. This surface 'freshwater plug' inhibits warm surface water from Pacific Ocean from flowing S into Indian Ocean, leading to cooler Indian Ocean sea surface, which may weaken Asian monsoon. Summer wind reversal eliminates obstructing pressure gradient, by transferring more-saline Banda Sea surface water into S Makassar Strait)

(Nd isotopic composition of Indian and Pacific Ocean cores for past 25 Ma reflect paleo-oceanography. Prior to 14 Ma broad passage between Indian and Pacific Oceans. Progressive closure of Indonesian gateway due to N movement of Australia and S-ward motion of Sunda block induced reorganization of paleoceanic circulation)
at ~14 Ma. Further reduced flux of Pacific water into Indian Ocean between 4- 2.5 Ma caused by final closure of Indonesian Gateway)

(Stalagmite record from Liang Luar Cave, Flores, suggests rapid increase in Indonesian monsoon rainfall at ~9.5 ka, synchronous with rapid expansion of rainforest in NE Australia, regional freshening of S Makassar Strait and ~1.5 °C cooling in upper thermocline of Timor Sea, indicative of reduced surface heat transport by Indonesian Throughflow when Java Sea opened during postglacial sea-level rise. Increase in monsoon rainfall tied to sudden increase in ocean surface area and/or temperature in monsoon source region as Sunda Shelf flooded during deglaciation)


(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)


(On Pacific to Indian Ocean water flow during last glacial maximum)

(Tidal currents dominate in transport of sandy sediments throughout Fly River Estuary, PNG)


(Paper discussing present-day plant distribution in SE Asia (mainly Erica, Rhododendron groups) and relation to plate tectonic history. Many terranes or groups of terranes have endemic species. Many distributions are hard to explain with present-day ecology, but can be understood through tectonic history)
(Tropical rain forest in SE Asia developed in extensive archipelago during past 65 My or more. Miocene rain forest extended further N (to S China and Japan). Pleistocene development of continental glaciers at high latitudes associated in SE Asia with lowered sea level, cooler temperatures, and modified rainfall patterns. SE Asian vegetation during last glacial maximum (ca. 18,000 BP) different from that of today, with increase in extent of montane vegetation and savannah and decline in rain forest)

('Sedimentation of the new Cimanuk delta’, NW Java)

(Unconsolidated deposit of iron ooids and pisoids off volcanic island Mahengetang, Sangihe Arc, in shallow-marine setting, in area of venting of hydrothermal fluids and expulsion of gas. Ooids composed of concentric accretionary layers of limonite admixed with amorphous silica, precipitated around andesitic rock fragments)

(Reconstruction of hydrological changes in Makassar Strait over last 14 kyr from Core SO217-18517 off Mahakam Delta (698 m water depth). Sea surface T based on Mg/Ca of Globigerinoides ruber, etc. provide evidence for increased precipitation during Bølling-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)

(online at: http://journals.ametsoc.org/doi/pdf/)
(Global Climate Modeling of effects of variations in Indonesian Throughflow. Throughflow generally warms Indina Ocean and cools the Pacific)


(Ranges of many tropical marine species overlap in centre of maximum marine biodiversity in Indo-Malayan region ('East Indies Triangle': Malaysia, Philippines, Indonesia and Papua New Guinea))

(On sediment discharge at Solo and Brantas/ Porong River deltas, E Java. Part of 1984-1985 Snellius II program)

(High input of sediment into coastal waters by Solo and Porong rivers resulted in rapid development of two-delta-systems. Solo delta mud-dominated, rapidly prograding elongate (single-finger) delta, while Porong delta is lobate, multidistributary delta)
(Review of delta of monsoonal Solo River. Late Quaternary mud-dominated, rapidly prograding, elongate 'single-finger' delta with well-developed natural levees)


(Study of river outflow, sediment transport, depositional facies and delta morphology of Solo and Porong river deltas, E Java. Very high denudation rates. Sediment transport mainly restricted to wet season. Solo delta single-finger delta. Porong delta half-circular, lobate delta with multidistributary network of channels)

(online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2004PA001094)
(Timor Sea, productivity fluctuations over last 460 kyr strongly influenced by monsoonal wind patterns off NW Australia (23 and 19 kyr). Also modulated by sea level-related variations in intensity of Indonesian Throughflow (100 kyr))

(Steeper thermocline T gradient in Timor Strait than in E Indian Ocean during glacials, implying decrease in Indonesian Throughflow cool thermocline outflow. Major freshening and cooling of thermocline waters at ~9.5 ka, when sea level rose above critical threshold, allowing establishment of shallow marine connection from S China Sea to Java Sea)

(online at: repository.tudelft.nl/assets/uuid.../ceg_hoogendoorn_20060131.pdf)
(With chapter of Late Holocene evolution of Mahakam Delta, E Kalimantan, based on Storms et al. (2005))


(On Pleistocene glaciation of Mt Kinabalu (4100m), Sabah, above ~3000m)


(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 10 m of peat. Peats record vegetation shifts at 28, 17-14 and 9 ka and variable history of human disturbance from 14 ka

Hope, G.S., A.P. Kershaw, S. van der Kaars, X. Sun, P.M. Liew, L.E. Heusser, H. Takahara et al. (2004)- History of vegetation and habitat change in the Austral-Asian region. Quaternary Int. 118, p. 103-126. (Climate reconstruction of last 200 kya from Russian Arctic to SE Asia and SW Pacific)

Horton, B.P., P.L. Gibbard, G.M. Milne, R. J. Morley, C. Purintavara & J.M. Stargardt (2005)- Holocene sea levels and palaeoenvironments of the Malay-Thai Peninsula, southeast Asia. The Holocene 15, 8, p. 1199-1213. (Sedimentology and palynology studies at Great Songkla Lakes and other areas of Malay-Thai Peninsula suggest Holocene relative sea level rise from ~22 m at ~9500 yr BP to mid-Holocene high stand of 4850-4450 yr BP, followed by sea-level fall at steady at ~1.1 mm/yr)

Huang, Y.S., T.Q. Lee & S.K. Hsu (2011)- Milankovitch scale environmental variation in the Banda Sea over the past 820 ka; fluctuation of the Indonesian through-flow intensity. J. Asian Earth Sci. 40, 6, p. 1180-p. 1188. (Environmental variation in Banda Sea over past 820 ka from core MD01-2380 data. Magnetic spectral data show Milankovitch periods, especially eccentricity period (400-ka and 100-ka) after 420 ka, but before 420 ka obliquity (41-ka) and precession (23-ka and 19-ka) cycles. In Banda Sea main factor controlling variation of magnetic minerals fluctuation of Indonesian Throughflow intensity due to sea-level change)

Hummel, K. (1931)- Sedimente indonesischer Susswasserseen. Archiv fur Hydrobiologie, Suppl.-Band 8, p. 615-676. ('Sediments of Indonesian fresh water lakes'. Analyses of sediment samples from lakes on Java and Sumatra)


Ilahude, A.G. & A.L. Gordon (1996)- Thermocline stratification within the Indonesian Seas. J. Geophysical Research 101, CS, p. 12401-12410. (Makassar Straits carries bulk of Pacific water throughflow, consisting of North Pacific water (upper thermocline Smax) and North Pacific Intermediate Water (lower thermocline Smin). Relatively salty water of South Pacific origin in lower thermocline in Seram and S Moluccu seas, particularly in NW monsoon)

*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: cooler water to warm-water 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)


(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)

(Reconstruction of changes in tropical Pacific oceanic circulation patterns across E-M Miocene boundary based on radiolarian assemblages at IODP Site U1335 in E tropical Pacific. Upwelling taxa increased during four intervals between 18.4-13.4 Ma. Sea surface T relatively high from 16.8-16.0 Ma and gradually decreased from 16.0-14.6 Ma and thereafter to 12.7 Ma. Starting around 17 Ma radiolarian assemblages dominated by different taxa in E and W tropical Pacific, indicating deeper thermocline in W. Increasing difference between E and W since latest E Miocene tied to closure of Indo-Pacific seaway and development of W Pacific warm pool along with development of strong Equatorial Undercurrent)

(Partial closing of Indonesian Gateway between 4-3 Ma supposedly triggered switch in source of waters feeding Indonesian Throughflow into Indian Ocean from warm- salty S Pacific water to cool and relatively fresh N Pacific Ocean waters. Planktonic foraminifera suggest surface conditions in E tropical Indian Ocean rel. stable from 5.5- 2 Ma, but subsurface waters freshened and cooled by about 4°C between 3.5- 2.95 Ma. Restriction of Indonesian Gateway led to cooling and shoaling of thermocline in tropical Indian Ocean)

(Planktonic foraminifera reflect Pliocene hydrography of W tropical Indian Ocean (Site 709C) and Leeuwin Current in E subtropical Indian Ocean (Site 763A) in response to Indonesian Gateway dynamics. Indonesian Throughflow and warm S-flowing Leeuwin Current off W Australia are essential for polar heat transport in Indian Ocean. During 3.5-3 Ma, sea surface T Leeuwin Current area 2-3°C cooler than rather unchanged sea surface T from tropical Indian Ocean, probably induced by tectonically reduced surface Throughflow)

(Climatic conditions in W Timor Sea and adjacent NW Australia reconstructed for last 460 ka from IMAGES Core MD01-2378. Reduced precipitation and elevated productivity characterize glacial stages. Long-term reduction in precipitation over last 320 ka in two steps at ~300 ka and 180 ka BP. Paleoproductivity and paleoclimate appear to be related to precession-controlled Australian monsoon system)
(Recent calcareous structures resembling stromatolites generated by cyanobacteria in alkaline crater lake of small Satonda island, N of Sumbawa)

(First discovery of Recent stromatolites, produced by coccoid cyanobacteria in crater Lake of Satonda Island near Sumbawa. Started to grow 4000 yrs ago. pH (8.45) and calcite saturation higher than in seawater, due to biogenic CO2 and weathering of volcanic silicates. May provide analogue to Precambrian stromatolite environments)

(Recent calcareous structures resembling stromatolites in crater lake of small Satonda island, N of Sumbawa)

(Pollen records from SE Asia suggest that during Lst 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)

(Kelantan River (NE Malay Peninsula) flows into S China Sea through two main channels. Mouth of river gradually shifted W under influence of beach drift generated by NE monsoon)

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

(Climate model to test response of climate to E-M-Pliocene tectonic changes, which constricted and uplifted passages between New Guinea and Sulawesi. Associated changes in Indonesian throughflow influenced amount of heat transported from Pacific to Indian Ocean and contributed to Pliocene climate change of Indo-Pacific)

Kuenen, P.H. (1942)- Bottom samples, Section I: Collecting of the samples and some general aspects. In: The Snellius Expedition in the eastern part of the Netherlands East Indies (1929-1930), 5. Geological Results, 3, 1, Brill, Leiden, p. 1-46.

Kuenen, P.H. (1948)- Het gehalte aan kalk en organische stof van de Indische diepzeef-afzettingen. Handelingen 28e Nederlandsch Natuur- Geneeskundig Congres, Utrecht 1946, p. 258-259. ('The lime and organic content of Indies deep sea deposits')


Kuenen, P.H. (1950)- Marine Geology. John Wiley, New York, p. 1-568. (General textbook on marine geology, with many examples from Indonesian waters, incl. Chapter 3- 'The Indonesian deep-sea depressions' (p. 175-209), and discussions of formation of coral reefs, ancient river courses on Sunda Shelf (Fig. 203), etc. ('Pre-plate tectonics' discussions of origins of seas and continents; Kuenen skeptical of Wegener's continental drift theory; JTvG))


Lanuru, M. & R. Fitri (2008)- Sediment deposition in a South Sulawesi seagrass bed. Marine Res. Indonesia 33, 2, p. 221-224. (Deposition of suspended sediment in shallow coastal waters colonized by Thallasia-dominated seagrass in Pannikiang Island measured with sediment traps. Amounts of sediment deposition inside seagrass beds significantly higher than in adjacent unvegetated area)


Linsley, B.K. (1991)- Carbonate sedimentation in the Sulu Sea linked to the onset of Northern Hemisphere glaciation, 2.4 Ma. In: E.A. Silver at al. (eds.) Proc. Ocean Drilling Program (ODP), Scient. Results, 124, p. 375-378. (online at: www.odp.tamu.edu/publications/124_SR/VOLUME/CHAPTERS/sr124_28.pdf) (Sulu Sea ODP Sites 768 and 769 currently above carbonate compensation depth (4800 m), in deep marine silled basin. Pliocene- Pleistocene sediments with common pelagic material, but no pelagic carbonate before 2.4 Ma. Timing of increase in carbonate accumulation constrained by Gauss/Matuyama paleomagnetic reversal and coincides with onset of N Hemisphere glaciation at 2.4 Ma. Not clear if increase in carbonate accumulation at 2.4 Ma is due to productivity changes, preservation changes, or combination of two)

Linsley, B.K., Y. Rosenthal & D.W. Oppo (2010)- Holocene evolution of the Indonesian Throughflow and the western Pacific warm pool. Nature Geoscience 3, 8, p. 578-583. (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)

Linsley, B.K., R.C. Thunell, C. Morgan & D.F. Williams (1985)- Oxygen minimum expansion in the Sulu Sea, western equatorial Pacific, during the last glacial low stand of sea level. Marine Micropaleontology 9, p. 395-418. (Sulu Sea deep silled, dysaerobic basin, ventilated through single sill at 420m depth to China Sea. Increases in planktonic foraminifera Neogloboquadrina dutertrei and Ng. pachyderma and light d18 O values suggest reduced surface water salinities during last glacial maximum, with expansion of mid-water oxygen minimum layer and increased organic carbon preservation at mid-water depths at this time. Oridorsalis umbonatus dominant benthic foramin species between water depths of 2000-4200m. Bolivina robusta found only in oxygen minimum zone at 1700 m and in zone of oxygen depletion in deep part of basin. Below 4000 m, bottom waters maintained some degree of oxygenation during last glacial maximum. Radiolarians 3-8% of fauna at water depths <4000 m, gradually increasing in abundance to >50% below 4500 m)


(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)


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Indonesian Throughflow measured for 6 years. Mean relative throughflow-transport 5 million m3/s. Maximum net, relative transport to W between Australia and Indonesia is 12 Sv, in August/September. Amplitude and phase of annual signal vary considerably within Indonesian region


(Rivers on Sumatra, Java, Borneo, Sulawesi, Timor and New Guinea relatively high sediment discharge. These six islands only 2% of land area draining into global ocean, but responsible for 20-25% of sediment export)


(1992 Flores tsunami caused widespread deposition of coarse and well-sorted marine carbonate sand with molluscan shells sand on N and SSW shores of Babi Island)


(Study of planktonic foraminifera in surface sediment samples from fore-arc basins in W and SW Indonesian Archipelago. Present-day oceanography and marine productivity reflected in tropical to subtropical and upwelling assemblages of planktonic foraminifera in surface sediments. Opal in surface sediments corresponds to upwelling-driven increased marine productivity)


(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 Globigerinita 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 90-150m for G. menardii (lower thermocline depth))


(Overview of oceanographic work in Indonesia, deep sea basins bathymetry, Sunda shelf seas with drowned river systems and barrier reefs, etc.)


(Modeling of throughflow. Predominant throughflow pathway North Pacific (NP) water traveling through Celebes Sea, Makassar Strait, Flores Sea, and to Indian Ocean through Timor, Savu, and Lombok Straits. Halmahera prevents flow of South Pacific (SP) water into Celebes Sea and diverts some SP water S-ward through Seram and Banda Seas)

(Paleoceanographic evolution of E Indian Ocean At 60-35 kyr BP (ka) higher productivity than today at Banda Sea surface. Last Glacial Maximum reduction of deep-water circulation in E Indian Ocean, with more active circulation at intermediate depths. At 15-5 ka reduction in productivity over Banda Sea related to increased atmospheric precipitation with low-salinity water cap. From 5 ka- Present: W Australian coast increased influence of oxygen-depleted Indonesian Intermediate Water)

(Core in 2034m of water off S Sumatra. Micropaleontological proxies used to reconstruct conditions over last 35,000 years. Marine isotopic stage 3 sharper thermocline than today, shallower and absence of low-salinity ‘barrier layer’ from high monsoonal rains. Deglaciation marked by change in surface salinity and progressive alteration of thermocline with less productive deep chlorophyll maximum. Monsoonal activity commenced around 15 ky. Holocene marked by increase in river discharge to ocean, pulsed by delivery of organic matter to sea floor. No obvious and persistent upwelling conditions off Sumatra for last 35,000 years)


Nathan, S.A. & R.M. Leckie (2003)- The Western Pacific warm pool: a probe of global sea level change and Indonesian Seaway closure during the Middle to Late Miocene, AAPG Ann. Conv., Salt Lake City, 6p. (Online at: www.searchanddiscovery.com/documents/abstracts/annual2003/extend/77605.PDF) (Development of West Pacific Warm Pool linked with restriction of surface water flow through Indonesian Seaway. Preliminary results suggest Seaway narrowed during Middle to Late Miocene, ~11.5- 8.5 Ma)


Nathan, S.A. & R.M. Leckie (2013)- The South China Sea: proto-warm pool development and the East Asian monsoon. In: Geologic problem solving with microfossils III Conf., Houston 2013. (Extended Abstract) (Planktic foraminifera and stable isotopes from ODP Sites 806 (Ontong Java Plateau), 1146 (northern S China Sea), and 1143 (southern S China Sea) suggest M-L Miocene changes tied to constriction of Indonesian Seaway, etc. Eustatic changes of late M Miocene to early Late Miocene contributed to initiation of proto-warm pool from ~12.5 Ma- ~9.0 Ma)

Neeb, G.A.A. (1942)- Bottom samples, Section II: The composition and distribution of the samples. In: The Snellius Expedition in the eastern part of the Netherlands East Indies (1929-1930), 5. Geological Results, 3, 1, Brill, Leiden, p. 55-268. (With 1:4M scale map of East Indonesia seafloor sediment types)

Newton, A., R. Thunell & L. Stott (2011)- Changes in the Indonesian Throughflow during the past 2000 yr. Geology 39, 1, p. 63-66. (online at: http://earth.usc.edu/~stott/stott_papers/Newton%20Thunell%20Stott%20Geology%2020%202010.pdf) (Mg/Ca and O-isotope compositions of planktonic foram Globigerinoides ruberina corrs from N and S ends of Makassar Strait used to reconstruct surface-water temperature and salinity over past 2000 yr. Maximum T and salinity between 850-700 yr ago (Medieval Solar Maximum) and ~1000-700 yr ago (Medieval Warm Period)

(Mekong River Delta is tide-dominated delta, with mainly fine grained sediments. At 6000-5000 yr BP Holocene transgression created Late Pleistocene terrace in N parts of delta and marine erosion at 4.5 and 2.5m above present sea level. Over last 4550 yrs fast progradation produced delta plain of 62,520 km²)

(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)


(online at: https://tos.org/oceanography/assets/docs/18-4_pariwono.pdf)
(Brief history of oceanography research in Indonesia since colonial period)

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

(Most recent deglaciation resulted in global sea-level rise of ~120 m over 12 000 years. Numerical model is developed to predict response of rivers to this rise)

(Fluvial channel reservoirs most commonly meander pointbars or braided sheets. Deltaic distributary channel reservoirs typically elongate sandy channel sidebars attached to straight channel walls. Deltaic distributary channels usually thinner and shallower than fluvial channel belts, and not thicker than their depositional
mouthbars. Width-thickness ratios for fluvial distributary channel reservoirs average 50:1, meandering fluvial channel reservoirs have width-thickness ratios typically >100:1, braided river reservoirs 500:1 or higher.


(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)


(Overall flow of deep water from Pacific to Indian Ocean flushes deep E Indonesian basins)


(Data from Puncak Jaya show Last Glacial Maximum glaciation less extensive than previously thought)


(online at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.918.2627&rep=rep1&type=pdf)

(During the mid-Holocene when sea level was between ~2.5-4.5 m above present level, broad mangrove belts (Rhizophora pollen, Avicennia, Sonneratia, Bruguiera, etc.) along numerous coasts of Sunda and Sahul shelves. With subsequent seaward migrating shoreline gradually replacement by back-mangroves)


(Sedimentological and palynological study of sediment cores from N Mekong River Delta show delta development since M-Holocene sea level highstand. M Holocene Sub- to intertidal flat deposit followed by late Holocene regression and delta progradation)


(online at: https://tos.org/oceanography/assets/docs/18-4_qu.pdf)


('The Javanese mountain flora as proof of former connection of Java and the mainland of Asia'. Many of the present-day mountain flora species of Java also known from mainland Asia. This suggests areas were formerly connected, as also suggested by fresh water fish, etc.)

(Review of modern and fossil faunas associated with seagrass meadows in Late Cretaceous and Cenozoic warm, shallow marine deposits. Most examples from Recent and Miocene of Indonesia. Many foraminifera and other organisms generally associated with seagrasses not necessarily confined to seagrass substrates)

(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))

(organic matter δ13C data 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)

(Program of current measurements through five Indonesian Seas passages (Labani Channel in Makassar Straits, Lifamatola Passage, Lombok Strait, Ornbai Strait, and Timor Passage), over 3-years (2004-2006))

(online at: 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 ry B.P., when high-latitude ice sheets expanded and global temperatures cooled)

(Online at: www.iagi.or.id/fosi/files/2011/06/FOSI_BeritaSedimentologi_BS-21_June2011_Final.pdf)
(Mahakam Delta fluvial-dominated morphology not result of present-day processes, but reflects phase of fluvial-dominant progradation before present-day subsidence and transgression)
Salahuddin & J.J. Lambiase (2013)- Sediment dynamics and depositional systems of the Mahakam Delta, Indonesia: ongoing delta abandonment on a tide-dominated coast. J. Sedimentary Res. 83, p. 503-521. (Mahakam Delta presently subsiding and being transgressed and modified by marine processes. Most or all, fluvially-derived sand stored onshore in distributaries, whilst finer-grained sediment moves offshore. Marine benthic organisms inhabit distributaries up to 20 km landward from shoreline. Facies distribution is better indicator of modern depositional processes than delta morphology)

Sato, K., M. Oda, S. Chiyonobu, K. Kimoto, H. Domitsu & J.C. Ingle (2008)- Establishment of the western Pacific warm pool during the Pliocene: evidence from planktic foraminifera, oxygen isotopes and Mg/Ca ratios. Palaeogeogr. Palaeoclim. Palaeoecology 265, p. 140-147. (Planktonic foraminifera from sites DSDP 292 and ODP 806 in W Pacific Ocean. Site 292 is located at N margin, and site 806 near center of modern West Pacific Warm Pool. Between 8.5-4.4 Ma Site 806 overlain by warm surface water but not Site 292. N-ward expansion of WPWP from 4.4-3.6 Ma and establishment of modern WPWP by 3.6 Ma related to closure of Indonesian and Central American seaways)


Schiller, A., S.E. Wijffels, J. Sprintall, R. Molcard & P.R. Oke (2010)- Pathways of intraseasonal variability in the Indonesian Throughflow region. Dynamics Atmospheres Oceans 50, 2, p. 174-200. (Indonesian Throughflow provides low-latitude pathway for transfer of warm, low salinity Pacific waters into Indian Ocean. Primary ITF source is N Pacific thermocline water, flowing through Makassar Strait (sill depth of 650m at Dewakang Sill) and exiting into E Indian Ocean through passages along Lesser Sunda Island chain at Ombai Strait, Lombok Strait and Timor Passage. Recent flow measurements show variability patterns)

Schneider, N. (1998)- The Indonesian Throughflow and the global climate system. J. Climate 11, 4, p. 676-689. (Modeling role of Indonesian Throughflow on world climate)


Setiawan, R.Y., M. Mohtadi, J. Southon, J. Groeneveld, S. Steinke & D. Hebbeln (2015)- The consequences of opening the Sunda Strait on the hydrography of the eastern tropical Indian Ocean. Paleooceanography 30, 10, p. 1358-1372. (Advection of relatively fresh Java Sea water through Sunda Strait presently responsible for low-salinity tongue in E Indian Ocean with salinities as low as 32‰. During last glacial period Sunda shelf was exposed and advection via Sunda Strait was cut off. Sediment cores from E tropical Indian Ocean off Sunda Strait show lower T and higher δ18Osw during last glacial)

Sevastjanova, I., R. Hall & D. Alderton (2012)- A detrital heavy mineral viewpoint on sediment provenance and tropical weathering in SE Asia. Sedimentary Geology 280, p. 179-194. (Heavy mineral study of river sand samples from Malay Peninsula and Sumatra. Malay Peninsula granitic and contact metamorphic provenance (zircon, tourmaline, hornblende, andalusite, epidote, monazite, rutile and titanite, etc.). Sumatra two main sources: (1) modern volcanic arc (pyroxene, particularly hypersthene), and (2) basement. Zircon, apatite, hornblende, epidote, and olivine also common and likely of mixed provenance.)
Heavy mineral assemblages of Malay Peninsula and Sumatra modern rivers different from Cenozoic sediments, suggesting rapid source unroofing)


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


(online at: www.iagi.or.id/fosi/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)


(On role of tidal and wind-driven flows and buoyant river plumes in e development of Holocene clinoform in Gulf of Papua. Tidal flows on modern clinoform are strong and are landward and seaward directed.


(online at: https://journals.ametsoc.org/doi/pdf/10.1175/1520-0485%282004%290377%3C03ASOTITI%3E2.0.CO%3B2)

(In upper thermocline Indonesian Throughflow crosses Indian Ocean, from Makassar Strait to E coast of Africa, on time scale of ~10 yr and reaches Arabian Sea in >20 yr)


(online at: http://journals.ametsoc.org/doi/pdf/10.1175/JCLI4133.1)

(Oceanic circulation model to study response of closure of Indonesian Throughflow on climate)
(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 surface temperatures by ~0.5 °C. Throughflow slows and shoals during El Nino events)


(Indonesian Throughflow is only open pathway for interocean exchange between Pacific and Indian Ocean basins at tropical latitudes. ITF transport variability measured from remotely sensed altimeter data, with focus on outflow passages of Lombok, Ombai, and Timor. Strong interannual variability. Increased transport in the upper layer of Lombok Strait and all of Timor Passage likely related to enhanced Pacific trade winds. El Nino-Southern Oscillation variability strongest in Timor Passage)

(Velocity data from Ombai Strait N of Timor confirm E-ward flowing surface South Java Current and deeper Undercurrent cross Savu Sea to reach Ombai Strait, a main outflow portal of Indonesian Throughflow (ITF))

(Neogene planktic forams from NE Indian Ocean and Tropical Pacific deep sea cores generally similar until beginning Pliocene (5.2 Ma) when faunal record indicates divergence, suggesting Indonesian Seaway became biogeographic barrier to planktic foraminifera. However, still exchange of surface waters through this seaway. Earlier studies suggested M- Late Miocene occurrence for this biogeographic barrier).

(In SW Pacific marked differences in biogeographic distribution of the Menardella and Globoconella groups before and after 1.77 Ma, reflecting changes in surface water circulation. Spatial distribution of
Neogloboquadrina pachydermia changed little in last 3.3 My, but frequency increased around 2.58 Ma and again at 0.78 Ma. Distribution pattern of Globigerina bulides shows intense upwelling at 2.58 Ma


Sumner, E.J., M.I. Siti, C. McNeill, P.J. Talling, T.J. Henstock, R.B. Wynn, Y.S. Djajadihardja & H. Permana (2013)- Can turbidites be used to reconstruct a paleoearthquake record for the central Sumatran margin? Geology 41, 7, p. 763-766. (Sumatra has well-characterized earthquake record spanning past 200 yr, but sediment cores from Sumatran margin reveal few turbidites emplaced in past 100-150 yrs. No evidence of turbidites that correlate with large 2004 and 2005 earthquakes, suggesting not all large earthquakes generate widespread turbidites (Comment by Goldfinger et al. 2014 suggests absence of turbidites possibly because cores not in right locations))


Surachmat, A. (1999)- Salinity of the modern Mahakam Delta, East Kalimantan. Berita Sedimentologi 12, p. 14-16. (In Mahakam Delta upper delta plain (10-30 km from head-pass) only fresh water. Only last 10km of lower delta plain has brackish water within 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)

(Makassar Straits annual mean transport is S-ward at ~13.3 Sv (12.5-14.0 Sv), substantially higher than measurements from 1997 when El Nino suppressed transport (9.2 Sv))

(online at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.725.7432&rep=rep1&type=pdf
(S-ward transport in Makassar Strait confined mainly to upper 750m, above blocking topographic sill of Makassar Strait. Transport maximum occurs within thermocline (100-300m))


(online at: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2000GL011844
(Urpwelling along Java-Sumatra Indian Ocean coasts response to regional monsoon winds. Upwelling center with low sea surface T migrates W-ward and toward equator during SE monsoon (June-October), driven by alongshore winds and latitudinal changes in Coriolis parameter. Upwelling terminated due to reversal of winds at onset of NW monsoon. During El Nino episodes upwelling extends in time and space, when ITF carries colder water, shallowing thermocline depth (by 20-60m) and enhancing upwelling strength)

(online at: https://os.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 (4000-3000 yr BP)- delta plain.)


(Last 3000 yr of Mekong delta evolution characterized by progradation with increasing wave influence, SEward sediment dispersal, decreasing progradation rates, beach-ridge formation and delta front face steepening)


(Mekong Delta is mixed tide and wave energy delta with wide delta plain formed during last 6 ka and is one of largest deltas in world. Changed from tide-dominated to tide-wave-dominated during Late Holocene. Late Pleistocene Paleo-Mekong River incised valley >70 m deep and formed during last glacial period)


(Latest Quaternary paleoceanography based on calcareous nannofossils from deep-sea cores along N-S transect between 12-25° S off W Australia. Java upwelling system operates above N site and increases counts of small placoliths)


(Sediment core from Lake Towuti in E Sulawesi Ophiolite belt with three zones of varying magnetic properties, corresponding to levels of iron oxide dissolution and magnetite precipitation. Magnetically strongest zone weak iron oxide dissolution and intense magnetite precipitation, likely driven by lake conditions during dry conditions in Marine Isotope Stage 2)


(Mekong River delta characterized by several shore-perpendicular elongate delta plains, with sequences of beach ridges, reflecting progradation in last 3.5 ka)


(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)

(online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2004JC002826)


(Mekong Delta at SE tip of Indochina Peninsula with large delta plain ranked third largest in world. Present delta classified as tide-dominated/ wave-influenced. Delta evolved from tide-dominated from 6.5-2.5 ka to tide-wave mixed delta from 2.5 ka- Present. Wave energy will become more pronounced as delta continues to prograde towards shelf margins)


(Many rivers in volcanic areas of Java discharge huge quantities of sediment, forming actively growing deltas like Cimanuk, 170 km E of Jakarta)


(Indonesian Throughflow transports ~15 Sv (1 Sv = 1 million m3/sec) of relatively cool and low salinity water from tropical Pacific Ocean into Indian Ocean. 50-year time series of transport calculated)


(online at: www.statisticstutors.com/articles/debrat-indonesian-throughflow.pdf)

(Indonesian Throughflow transfers ~15 Sv (1 Sv = Mm3/second) of relatively cool, fresh water from tropical Pacific Ocean to Indian Ocean. Flow freshens the Indian Ocean and transports heat between basins. Etc.)


(online at: http://journals.ametsoc.org/doi/pdf/10.1175/2009JCLI2981.1)


(Extensive overview of Indonesian seas, with chapters on geology, oceanography and coral reefs)


(Continuation of overview of Indonesian seas, with additional chapters coral reefs, pelagic systems, mangroves and environmental issues)


(S China Sea throughput may play import ant role in climate variability of Indo-Pacific region)


(Submarine topography of Sunda Shelf in S China Sea, Java Sea and Straits of Malacca indicate Pleistocene rivers debouched near 100m isobath, suggesting about 100m of maximum sea level lowering)

(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)


(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)


(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 glacials wind belts with associated rainfall displaced 5-10° N -ward and equatorial pluvial zone was compressed)


(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)


(online at: https://pdfs.semanticscholar.org/91ea/86518ab13496ee4055c5af9d2477c02e2d2.pdf)

(Molluscan fauna of Jakarta Bay deteriorated between 1937 and 2005 due to increased sewage from Jakarta and sediment input from deforested W Java hinterland. Predatory gastropods and mollusc species associated with carbonate substrate vanished from Jakarta Bay, among which many edible species)


(online at: https://ia600404.us.archive.org/2/items/dezeenvanneder00koni/dezeenvanneder00koni.pdf)

(The seas of Netherlands East Indies’. With chapter on geology and coral reefs by Molengraaff, p. 272-357)


('On a recent drop in sea level in Netherlands East Indies'. Many coastlines in W Indonesia show evidence of recent sea level drop of 5-10m (raised coral reefs, etc.). With map of distribution)


(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)


(Throughflow oceanography models)


(On limestone karst development with examples from Java S Mountains, C. Sumatra, Halmahera)


(Climate changes in Quaternary lead to alternating humid and more arid periods, also in tropics. Chemical weathering dominates in interglacial equatorial rainforest conditions, like in Holocene. During glacial periods more pronounced seasonality and physical desintegration of rocks becomes more important. Pleistocene lowered sea level probably did not cause incision of valleys on shelf as rivers have very low gradient. Etc.)


(Lower rainfall and longer dry season characterised SE Asia during Quaternary Glacials. This had important effect on vegetation and landform development. Low Glacial sea levels thought not to have caused river incision; deposition of coarse-textured materials more characteristic. Incision mainly tied to Interglacial and Holocene humid tropical conditions when vegetation interfered with non-concentrated surface wash)


(Quaternary climatic changes in SE Asia four types of fluctuations: temperature, precipitation, wind patterns and sea-level)


(Review of geomorphology research in Indonesia, including geologic framework, climatic factors affecting landforms, volcanic landforms, karst terranes, lowlands, coastal geomorphology and coral reefs)


(Climate in W Pacific Warm Pool and other equatorial regions was colder by 3-4°C during glacial periods. Makassar Strait sediment core suggests vegetation on Borneo and surrounding islands did not change from tropical rainforest during last two Late Pleistocene glacial periods, supporting hypothesis that winter monsoon strengthened in glacial periods, allowing Indonesia to maintain high rainfall despite cooler conditions)
Visser, K., R. Thunell & L. Stott (2003)- Magnitude and timing of temperature change in the Indo-Pacific warm pool during deglaciation. Nature 421, 6919, p. 152-155. (Oxygen isotopes and Mg/Ca ratios of Globigerinoides ruber shells from Makassar strait in Indo-Pacific warm pool yield estimates of sea surface temperatures and ice volume. Sea surface T increased by 3.5-4.0 °C during last two glacial-interglacial transitions, synchronous with global increase in atmospheric CO2 and Antarctic warming, but T increase ~2000-3000 years before N Hemisphere ice sheets melted. Tropical Pacific region plays important role in driving glacial-interglacial cycles)


Walsh, J.P. & C.A. Nittrouer (2003)- Contrasting styles of off-shelf sediment accumulation in New Guinea. Marine Geology 196, 3-4, p. 105-125. (Study of modern ‘highstand’ off-shelf sedimentation in PNG Gulf of Papua and Sepik margin. Gulf of Papua receives >3x10^-8 tons of sediment annually from rivers. Most accumulates on shelf, <5% deposited in Pandora Trough. Sepik margin different: Sepik River discharges ~1x10^-8 tons of sediment annually, and submarine canyon extends to river mouth. 90% of river material regularly produces gravity-driven flows in canyon)

Walsh, J.P. & C.A. Nittrouer (2004)- Mangrove-bank sedimentation in a mesotidal environment with large sediment supply, Gulf of Papua. Marine Geology 208, p. 225-248. (Extensive mangrove forests are associated with major river systems. Indo-Pacific region numerous large rivers that discharge onto broad continental shelves, with common mangroves along these coastlines. Gulf of Papua >3350 km2 of mangrove forests, majority associated with Fly, Kikori and Purari River deltas. Sediment trapping in W Gulf of Papua mangroves estimated to be 2-14% of total sediment load)

Walsh, J.P., C.A. Nittrouer, C.M. Palinkas, A.S. Ogston, R.W. Sternberg & G.J. Brunskill (2004)- Clinoform mechanics in the Gulf of Papua, New Guinea. Continental Shelf Res. 24, 19, p. 2487-2510. (Largest islands of Indo-Pacific Archipelago account for 20-25% of global sediment discharge to oceans, >50% of this supplied to wide (>150 km) continental shelves. These conditions create large-scale clinoform-sigmoidal-shaped deposits on continental shelf. ~20% of sediment supplied to Gulf of Papua accumulates on clinoforms, <5% escapes to adjacent slope, 75% trapped on inner-topset region (<20 m depth) and within flood/ delta plains)


(Water from the W Pacific flows through Indonesian Seas following different pathways and is modified by various processes to form uniquely isohaline (34.6) Banda Sea Water)

(online at: www.aoml.noaa.gov/phod/docs/garzoli_jmr_2001.pdf)
(Throughflow in Makassar Strait requires at least 3-layer description: upper 200 m water mass characterized by the salinity maximum of North Pacific Subtropical Water; water in layer 2 is North Pacific Intermediate Water salinity minimum (~300m); bottom layer ~1600m)

(‘Introduction and description of the Siboga expedition 1899-1900’. First of many volumes on results of the zoological, botanical, oceanographic and geological studies in E Indonesia waters and islands by members of the Siboga Expedition. Geological results reported by Wichmann 1925)

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)

(On biogenic structures and depth zonation in 23 cores taken by RV Valdivia from 1000-5000m water depth, Sulu Sea. Slope- rise sediments down to 3800m almost totally bioturbated, with 8 types of traces: common Helminthopsis, Planolites, Thalassinoides, less common Chondrites, Scolicia, Skolithos, Trichichnus and Zoophycos. Abyssal plain deposits below 4400m less bioturbated (20% or less of sediment burrowed). Increase of trace diversity by small traces, dominated by Muensteria, 'mycellia' and Phycosiphon. Traces typical of many turbidite sequences (‘graphoglyptids' absent)

(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)

(Introduction and overview of special issue of Sedimentary Geology)

(Deltaic and estuarine environments of Sunda shelf receive large volumes of sediment and had diverse and productive vegetation before clearing. Three periods of change: long-term response of deltaic-estuarine plains to postglacial sea-level rise, Holocene patterns of coastal progradation and distributary migration under relatively stable sea level and impact of human modifications)

(Brief review of delta processes and Irrawaddy, Mekong, Mahakam, Rajang-Barang, etc. deltas of SE Asia)

(SE Asia geography today typical of only 2% of last million years; 90% of time land area was 1.5-2.0x larger as mean sea levels were 62m lower, climates were cooler, and extensive forests and savanna covered emerged Sunda plains. Land areas varied as sea levels fluctuated up to 50m with each of ~50 Pleistocene glacial cycles, and forests expanded and contracted with oscillations in land area and seasonality)

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

(online at: www.pnas.org/content/early/2010/07/22/1005507107.full.pdf) 
(Distribution of vegetation in SE Asia during Last Glacial Maximum (23-19 ka) still debated. Carbon isotopes of ancient cave guano profiles suggest substantial forest contraction during LGM on peninsular Malaysia and Palawan (and replaced by open savanna conditions), while rainforest was maintained in N Borneo)


(Classic review of oceanography of Indonesian waters. With maps of seasonal surface currents, salinity, oxygen, temperature, tidal types and amplitudes, etc.)

(online at: www.publish.csiro.au.ezproxy.lib.monash.edu.au/?act=view_file&file_id=M9620217.pdf) 
(During SE monsoon season main upwelling area along S coast of Java and Sumbawa, not along NW Australian shelf. Region characterized by high inorganic phosphate at bottom of euphotic layer and high plankton biomass. Transparency of water in upwelling area is low, indicating high suspended matter)

Flow of water from W Pacific to E Indian Ocean through Indonesian archipelago governed by strong pressure gradient. Average sea level difference 16 cm and most of pressure gradient contained in upper 200m. Annual maximum during SE monsoon in July-August and minimum in January-February)


(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)


(High-resolution seismic and coring revealed low gradient, subaqueous paleo-delta system, up to 20m thick, surrounding modern Mekong River Delta, formed around 3000 BP)


(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)

(Model used to simulate circulation through the Indonesian Gateways. Lowering of glacial sea level of 120 m not sufficient to severely block flow within Makassar Strait as main passage of Throughflow. Reduction in sill depth and absence of low buoyancy surface waters due to exposure of shelf area led to intensification of surface flow within Makassar Strait)
1.5. SE Asia Carbonates, Coral Reefs

Akbar, M., B. Vissapragada, A.H. Alghamdi, D. Allen, M. Herron et al. (2001)- A snapshot of carbonate reservoir evaluation. Oilfield Review, Schlumberger, Winter 2000/2001, p. 20-41. (online at: www.slb.com/~media/Files/resources/oilfield_review/or00/win00/p20_41.ashx) (Reservoir evaluation paper with example of M Miocene buildup in Sibolga basin, off NW Sumatra, with unsuccessful 1997 well due to lack of internal seals and late top seal preventing capture of early biogenic gas)


Azmy, K., E. Edinger, J. Lundberg & W. Diegor (2010)- Sea level and paleotemperature records from a mid-Holocene reef on the North coast of Java, Indonesia. Int. J. Earth Sciences (Geol. Rundschau) 99, p. 231-244. (Mid-Holocene fossil fringing reefs at Point Teluk Awur, near Jepara, N coast of C Java, contains two horizons of Porites lobata microatolls. Age of corals in lower horizon, 80 cm above sea level, ∼7000 yr BP, upper horizon at 1.5 m, 6960 ± 60 yr BP, matching transgressive phase of regional sea-level curves)


Bassi, D., J.H. Nebelsick, A. Checconi, J. Hohenegger & Y. Iryu (2009)- Present-day and fossil rhodolith pavements compared: their potential for analysing shallow-water carbonate deposits. Sedimentary Geology 214, p. 74-84. (Review of rhodoliths (algal nodules consisting predominantly of coralline algae) and sediments formed by these unattached coralline algae, called rhodolith pavements. Includes study of Recent 'rhodolith pavement' off Sesoko-jima (S Japan), at depths of 50-70 m on submarine terrace)

Beauvais, L., M.C. Bernet-Rollande & A. Maurin (1985)- Reinterpretation of Pretertiary classical reefs from Indo-Pacific Jurassic examples. In: C. Gabrie & M. Harmelin (eds.) Proc. Fifth Int. Coral Reef Congress, Tahiti 1985, 6, Misc. Paper (B), p. 581-586. (Jurassic carbonate mounds in W Thailand (M-U Jurassic, Mae Sot basin), C Sumatra (U Jurassic, Padang-Tembesi River) and Philippines (M Jurassic, Mindoro, U Jurassic Calamian Isl.) not 'reefs' like present day reefs. Corals typically float in lime mud matrix and are mainly digitate or lamellar, to cope with muddy conditions. Calcareous sponges also common. Main rock-building organisms are Bacinellid- Lithocodium-stromatolite assemblage, as encrusters over exotic grains or as single builder. Jurassic corals, sponges etc, have no major rock building potential)

Beauvais, L., H. Fontaine & A. Maurin (1987)- A review of recent data on mud-mounds discoveries in Asia. Oil and Gas Geol. 1987, 12, p. 373-376. (Many of Mesozoic carbonates in SE Asia are probably microbial mud mounds: Jurassic of Sumatra, Thailand, Burma, Philippines, Sarawak-Kalimantan)
*(Discussion of coral species richness patterns in Indo-Australian archipelago coral reef biodiversity 'hotspot')*

*(Ladinian and Carnian increasing expansion of reefs. Optimum reef diversity and frequency in Norian, as sponge and coral reefs associated with development of carbonate platforms. Not much on SE Asia)*

*(Miocene and Pliocene of ODP Leg 133 sites record biofacies evolution prior and during the partial drowning of Queensland Plateau carbonate platform. M Miocene depositional geometry is carbonate bank with a well-defined rim and flank. Late Miocene- E Pliocene carbonate ramps, rich in large benthic forams. Reconstruction of Tortonian- Messinian relative sea level curve shows rise punctuated by four falls. Lepidocyclina (N.) rutteni described from Australian faunal province for first time)*

*(Late Miocene- E Pliocene partial drowning of Queensland Plateau carbonate platform off NE Australia. Modern plateau mosaic of pinnacle reefs and larger reefs representing relicts of E-M Miocene buildups. Late Miocene rich in larger forams Lepidocyclina and Cycloclypeus show Pliocene partial drowning of platform preceded by 4 Myr of neritic carbonate deposition without any reefs. Low surface water temperatures (17°-19°C) major factor which suppressed reef growth during Late Miocene- E Pliocene)*

*(Leg 133 Queensland Plateau ODP site sites with Eocene (Nummulites, Discocyclina) and Late Oligocene- M Miocene larger foram facies)*

*(Snellius-II Expedition collections of Lower Pliocene corals near Salayer and Quaternary reefs on Ambon and Sumba and compared with Pliocene of Nias. Absence of Acropora and Montipora from Quaternary coral faunae (common in Pliocene and modern reefs) may reflect disturbance by Pleistocene sea level fluctuations)*

*(online at: www.reefbase.org/resource_center/publication/pub_14767.aspx)*
*(Oldest reefs of Bali developed on top of Neogene pillow lava flows, but barely preserved. Parts of early and late Pleistocene reefs on Bukit peninsula. Holocene post-glacial reefs developed along limestone cliffs and denuded volcanic hardnecks; on lava outflows; and on residual boulder coasts)*

*(350 species of living corals in E Indonesia)*

*(Eight types of carbonate platform recognized, based on basinal and tectonic setting: Fault-Block, Salt Diapir, Subsiding Margin, Offshore Bank, Volcanic Pedestal, Thrust-Top, Delta-Top and Foreland Margin platforms)*

('The high energy carbonate platforms with rhodoliths and the climatic crisis of the Mio-Pliocene transition in the Pacific area'. Large M and U Miocene carbonate platforms built on volcanic remains in W and SW Pacific. In rhodolith facies, without corals, probably related to colder climate interval. Warming around Mio-Pliocene boundary allowed resettlement of corals)


(Rhodolites over wide areas of tropical Pacific dated as M Miocene. They are preceded in E Miocene and succeeded in Late Miocone by hermatypic coral deposits. Possible causes of facies change: sea-level rise drowning reefs, drop of winter surface water temperature and increase in fertility of surface waters inhibiting compensatory growth of hermatypic corals until sea-level fall restored original conditions of deposition)


(Variety of carbonate cements identified in deep borehole through Ribbon Reef 5, off NE Australia)


(Study of 155 species of M Miocene- E Pleistocene reef coral communities from Indonesia (Salayar, S Sulawesi), PNG (New Britain) and Fiji. Coral communities vary with global sea level and time. 41.8% of species in M Miocene in New Britain now extinct. Study supports previously proposed models of E Pliocene turnover event in Scleractinia in Indo-Pacific)


(Neogene origination and extinction patterns from Indonesia (Salayar Island; 5.8-1.4 Ma), New Britain and Fiji. Two faunal turnover events(1) increase in Scleractinia diversity during M Miocene (17-14 Ma), coinciding with large-scale sea level fluctuations and M Miocene collision event, possibly facilitated by habitat fragmentation associated with tectonism and sea level fall (2) lowering of diversity throughout Late Miocene-Pliocene (7-3 Ma), followed by pulse of extinction at Pliocene-Pleistocene boundary (~2.6 Ma))


(Many islands in E Indonesia covered with Plio-Pleistocene fringing reefs, on some islands elevated recently up to 1300m above s.l. Highest reef caps are not necessarily oldest if uplift not uniform)


(Lower Miocene pinnacle reef complexes at Nido fields in S China Sea, NW of Palawan. Relief ~150-200 m)


(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)


(Diagenetic dolomite present in Paleozoic, Triassic, Paleogene and Neogene carbonates in SE Asia. Pre-Tertiary carbonates form part of economic basement; most not considered to form economic prospects. Manusela Lst of Seram viewed as E-M Jurassic (should be Late Triassic?; JTvG), Tampur Lst of N Sumatra viewed as Eocene (should be Permian?; JTvG))

(40 photomicrographs of carbonate microfacies, illustrating a model of Miocene reef sedimentation)

(online at: http://jgi.bgl.esdm.go.id/index.php/JGI/article/view/29/21)

(Halimeda important component of many reefal limestones (but probably more susceptible to diagenetic decay than Lithothamnion, corals or foraminifera))

(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)

(Description of reefs along W margin of Australia. Latitudinal and climatic gradient from macrotidal tropical in N to microtidal-temperate in S)

Scott Reef is a 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.

(online at: www-odp.tamu.edu/publications/194_SR/VOLUME/CHAPTERS/005.PDF)
(Facies study of 663m thick Miocene carbonate succession penetrated by two ODP wells on S Marion Plateau)

(Study of growth rates of Porites coral from growth bands at Kaledupa island, Tukang Besi, SE Sulawesi. Growth rates of Quaternary species from up to 400m thick uplifted reef terrace slightly lower, but comparable to modern coral (~10-15 mm/yr))


(Study of petrophysical properties of Miocene platform carbonates of Marion Plateau, off NE Australia)


(Holocene bioherms of accumulations of green alga Halimeda cover large areas of outer shelf in 30-50m depths in N Great Barrier Reef, behind shelf edge reefs (see also Marshall and Davies 1988))


(Carbonate platforms of NE Australia (Great Barrier Reef, Queensland, Marion and Eastern Plateaus S of PNG) contain record complex interactions over past 60 My. Size, shape, and location of carbonate platforms determined by continental rifting. N-ward plate movement controlled distribution of climate facies in Great Barrier Reef sequence. Rising and high sea-level periods favored increased carbonate deposition, falling low sea-levels restricted carbonate deposition. Oceanographic factors affected platform evolution, e.g., inhibition of reef development by high oceanic-phosphate levels during E-M Miocene. Development of foreland basin on N edge of NE Australian region initially caused dramatic expansion of carbonate facies, but ultimately terminated carbonate deposition as result of uplift and inundation by clastic detritus)


Droxler, A.W. & S.J. Jorry (2013)- Deglacial origin of barrier reefs along low-latitude mixed siliciclastic and carbonate continental shelf edges. Annual Review Marine Science 5, p. 165-190. (Modern coral barrier reefs extend along edges of some low-latitude siliciclastic shelves for 10's-1000's of km (Great Barrier Reef, NE Australia). Onset of rapid sea-level rise during early deglaciations was opportune time for coralgal communities establishment on top of maximum lowstand siliciclastic coastal deposits (beach ridges, lowstand shelf-edge deltas). Most modern barrier reefs relatively thin (~120m), late-Quaternary deposits, dating from mid Brunhes (~400 ky?): Recent, composed of 4-5 stacked coralgal units, separated by exposure horizons (reflecting 100,000-year glacial-interglacial cycles) and covering older nonreefal, often siliciclastic deposits. Includes examples from Gulf of Papua)

(N and S Marion Platforms off NE Australia studied by ODP 194 wells and seismic. Built by cool, subtropical faunal assemblages and asymmetric geometry. Four megasequences subdivided into 14 sequences. E-M Miocene sequences are prograding and aggrading sequences. From late M Miocene, mound geometries in basinal area where large drift deposits accumulated. Two most prominent sequences boundaries are drowning unconformities, at 11.1 Ma (N) and ~7 Ma (S Marion Platform). Timing of many Neogene sequence boundaries coincides with boundaries on Queensland Plateau (ODP Leg 133) and along Bahamas Transect (ODP Leg 166), suggesting global synchronicity of Neogene 3rd order sea-level changes)

(Pollution damage measured in surveys of 8 Java Sea reefs and 8 reefs in Ambon and Sulawesi. Reefs subject to land-based pollution 30-60% less diverse at 3-10m depth. Polluted reefs dominated by massive and submassive corals, and have almost no Acropora corals. Unpolluted reefs dominated by Acropora at 3m and by branching or foliose corals at 10m)

(Coral species diversity along transects from 14 reefs in Ambon S Sulawesi and Java Sea. Sites relatively unaffected by land-based pollution in E Indonesia 20% more diverse than Java Sea. Despite fact that Java Sea was exposed during Pleistocene lowstands, and was recolonized only within last 10 000 years, coral species diversity and assemblage composition on Java Sea reefs similar to open ocean reefs in E Indonesia)

(Analyses of porosity and permeability in two Miocene carbonate platforms cored by ODP Leg 194, seaward of Great Barrier Reef, at N Marion Platform mostly preserved as limestone) and S Marion Platform (mostly dolomitized)

(Porosity-permeability analyses of Early- Late Miocene platform and deep water carbonates cored on Marion Plateau. Platforms experienced widely varying calcite cementation, dolomitization and dissolution but little evidence of meteoric diagenesis, suggesting subaerial exposure played little role in porosity-permeability evolution. Permeability controlled by grain size and calcite cement content in grainstones and shelter pores and vugs in mud-rich samples. Dolomitization reduces permeability variation. ‘Windward’ (current-facing) settings overall higher permeability (less muddy depositional facies, greater cementation, and lesser grain dissolution)

(Sr-isotope stratigraphy used to determine timing of depositional events and dolomitization in two Miocene carbonate platforms cored by ODP Leg 194, seaward of Great Barrier Reef. Initial transgression of Marion Plateau volcanic basement E Oligocene (29-31 Ma). Main growth of carbonate platforms in Miocene (23-7 Ma), with five depositional sequences. Both platform-demise events (10.7 and 6.9 Ma) coincide with falls in global sea level combined with decreasing water temperature)

(online at: www.biodiversitylibrary.org/item/123958#page/545/mode/1up)
(‘Coral reefs and earth movements, with a letter from W.M. Davis’. On relations between patterns of coral reef growth and uplift- subsidence trends. Tested on Indonesia examples)
Escher, B.G. (1920)- Atollen in den Nederlandsch-Oost-Indischen Archipel. De riffen in de groep der Toekang Besi-eilanden. Mededelingen Encyclopedisch Bureau, Batavia, 22, 18p. ('Atolls in the Netherlands East Indies Archipelago: the reefs in the Tukang Besi Group', SE Sulawesi. Some of modern Tukang Besi reefs true atolls, up to 48km long, some small barrier reefs around islands up to 274m high. Reefs arranged in four NW-SE trending rows, possibly controlled by underlying structure)


Flamand, B., G. Cabioch, C. Payri & B. Pelletier (2008)- Nature and biological composition of the New Caledonian outer barrier reef slopes. Marine Geology 250, p. 157-179. (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, Sperolithon on deep reef slopes up to 90m. Below ~90m encrusting foraminifera acervulinids progressively replace coralline algal crusts)


Flugel, E. (1988)- Halimeda: paleontological record and palaeoenvironmental significance. Coral Reefs 6, p. 123-130. (Halimediform algae in carbonate rocks since U Triassic. Some 30 species described, in four 'genera'. Recent Halimeda in lagoonal and reefal environments. Reinvestigation of Boueina limestones from Norian-Rhaetian lagoonal carbonates of W Thailand indicates important role of alga (up to 60% Boueina marondei n. sp.) in sediment accumulation since Late Triassic)


Flugel, E. (2002)- Triassic reef patterns. In: W. Kiessling et al. (eds.) Phanerozoic reef patterns, Soc. Sedimentary Geology (SEPM) Spec. Publ. 72, p. 391-463. (Includes summaries of known Triassic reefal carbonates in Timor (various localities with Norian reef sponges and corals), Sulawesi, C-E Seram (up to 150m thick sponge-coral-hydrozoan limestone; Wilckens 1937), Papua New Guinea. (Triassic limestone development in Indonesia appears to follow trends across Tethys: first reef optimum in earliest Carnian (sponge-dominated), decrease in LateCarnian, second reef optimum in Late Norian- Rhaetian (sponge-coral and coral dominated); JTvG)

*(Evolution of Triassic reefs started with ~12 Myr global crisis of metazoan reef ecosystem after Permian-Triassic mass extinction), followed by recovery during M Triassic. Reef systems differentiated during U Triassic but were severely affected by global crisis at Triassic-Jurassic boundary)*


*(Most porosity in Tertiary reefal carbonates in Indonesia involves post-depositional diagenetic changes)*


*(Late Oligocene- early M Miocene widespread carbonates/reefs in SE Asia, related to rising eustatic sea level and expansion of coral-algal facies belt N to Japan and S to New Zealand. Examples mainly from Philippines)*


*(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)*


*(‘The significance of the Tertiary reef coral fauna of the Malay Archipelago (=Indonesia) for the development of the living reef fauna in the Indo-Pacific and Atlantic area’. On global distributions of Paleogene- Recent reef corals)*


*(Modern reef corals two distinct provinces, Indo-Pacific and Atlantic, with higher diversity in Indo-Pacific. Known genera, more than on modern reefs. In Paleogene-Miocene reef corals more widely distributed (up to ~50°N) than today (~32°N)))*


*(Modern textbook on Recent carbonate reefs and their organism. Modern reefs clear, warm, low-nutrient waters and are not found far outside 30° from Equator. With review of reef-building organism through time since Precambrian)*


(Global rhodalgal facies peak abundances in Burdigalian-E Tortonian (16-11 Ma). Dominance of red algae over coral reefs triggered by Burdigalian global increase in productivity (higher C- isotope values). Rhodalgal lithofacies expanded further in M Miocene when strengthened thermal gradients associated with establishment of E Antarctic Ice Sheet led to enhanced upwelling, while increased weathering rates introduced land-derived nutrients into oceans. Cooler temperatures following E-M Miocene climatic optimum contributed to sustain dominance of red algae)


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

(Well-rounded rhodoliths 1-8 cm consists of multiple species of nongeliculate coralline 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 Cycloclypeus- Operculina foramin assembly)

(Late Oligocene- Late Miocene carbonate in 433m deep borehole on Kita-daito-jima)

(Distribution of 8 non-articulated coralline algal species in upper 30m of slope of patch reef off Yonehara, Ishigaki-jima: Porolithon onkodes and Lithophyllum insipidum most abundant at depth of 1m, but absent below 20m. Spongites sp. A most common at 15m depth. Neogoniolithon conicum distributed throughout)

(Compositions of coral and coralline algal assemblages change with increasing depth. Hermatypic corals common down to 50m. Coralline algae Hydrolithon onkodes limited to upper 10m. Algal nodules with encrusting foram Acervulina inhaerens (rhodoliths) most abundant constituent on island shelf, commonly with Cycloclypeus carpenteri (50-150m). In Ryukus negligible Halimeda; probably two types of shelves in tropical-subtropical regions: nutrient-rich Halimeda-dominant and nutrient-poor rhodolith-dominant)

(Pleistocene carbonates of Ryuku Group with extensive rhodoliths in distal parts of reef complex. Four facies: (1) coral (reef- reef slope; 0-50m), (2) rhodolith (insular shelf 50-150m), (3) Cycloclypeus-Operculina (associated with rhodoliths; 50-150m) and (4) poorly sorted detrital limestones (insular shelf, >50m))

(online at: www-odp.tamu.edu/publications/133_SR/VOLUME/CHAPTERS/sr133_19.pdf)
(Oxygen isotopes from Holes 811A, 817A indicate extensive reef growth on Queensland Plateau in M Miocene before 12 Ma, signifying surface-water T of 20°C or more. Decrease in reefal detritus in Late Miocene (10.0-5.2 Ma) corresponds with isotopic data from planktonic foraminifera suggesting cooler surface waters (16°-19°C). This may have contributed to demise of reefs on Queensland Plateau. Surface waters remained cool until M Pleistocene (1.2-0.5 Ma), when surface-water T increased to 25 °C and Great Barrier Reef initiated)


Isern, A.R., F.S. Anselmetti & P. Blum (2004)- A Neogene carbonate platform, slope and shelf edifice shaped by sea level and ocean currents, Marion Plateau (Northeast Australia). In: G.P. Eberli et al. (eds.) Seismic imaging of carbonate reservoirs and systems, American Assoc. Petrol. Geol. (AAPG), Mem. 81, p. 291-307. (Marion Plateau off NE Australia large drowned carbonate platform, composed of cool, subtropical organisms, such as red algae, bryozoans, and larger foraminifera. Coralline algae notably absent. Onlapped by deep water prograding drift deposits)


Johnson, K.G., W. Renema, B.R. Rosen & N. Santodomingo (2015)- Old data for old questions: what can the historical collections really tell us about the Neogene origins of reef-coral diversity in the Coral Triangle? Palaios 30, 1, p. 94-108. (Updated stratigraphy and revised taxonomic determinations for important historical collections of Cenozoic fossil corals from Indonesia in Leiden museum reveal Pliocene and Paleogene sampling gaps. E Miocene increase in richness followed by plateau of relatively high richness. Observed patterns of taxonomic turnover highly correlated with sample size. Taxonomic revision reduced number of genera and species from 133 and 404 to 115 and 321)


Leinfelder, R.R., D.U. Schmid, M. Nose & W. Werner (2002)- Jurassic reef patterns- the expression of a changing globe. In: W. Kiessling et al. (eds.) Phanerozoic Reef Patterns, SEPM Spec. Publ. 72, p. 465-520. (Includes brief discussions of Jurassic carbonates of W Thailand, Sumatra and Philippines. Early- Middle Jurassic reefs absent in SE Asia, except small Lithiotis bivalve mounds on Timor, due to end-Triassic extinction event, etc. Minor Late Jurassic reefs in Sumatra and Bau Limestone of Sarawak- NW Kalimantan border area)


sea level. Some platforms may have started developing by Late Miocene. Tops of Sahul banks dominated by segments of green alga Halimeda, with some solitary corals (Fungia sp), larger foraminifera, coralline algae and bryozoans

(On tropical-subtropical to temperate carbonate environments along E coast of Australia. Subtropical shelf environments characterized by combination of shallow water hermatypic corals and deep-water rhodoliths. Halimeda more common towards the tropical boundary and bryozoans towards the temperate boundary)

(M Miocene carbonates of Marion Plateau consist of floatstones and rudstones dominated by rhodoliths. Corals occur only as fragments. Growth types and algal associations characteristic of rhodoliths that formed at depths of some 10's of m and below normal wave base)

(On seismic imaging of carbonate buildup reservoirs, with examples from Luconia (N Borneo) and Malampaya (Philippines))

(Carbonate depositional model for Pleistocene Ryuku Group, Irabu Island, SW of Japan)

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


(Variety of M. Miocene- Lower Pliocene carbonate accumulations off Vietnam. Best reservoirs in large, fault-controlled, buildups which have undergone extensive leaching during emergence. Moderate reservoir quality in platform facies which extend over large areas and in small buildups usually developed on footwall crests)

(online at: www.odp.tamu.edu/publications/133_SR/VOLUME/CHAPTERS/sr133_52.pdf)
(ODP wells off Great Barrier Reef and Queensland and Marion Plateaux. Carbonate sedimentation on Queensland Plateau began in M Eocene, when temperate waters transgressed across platform depositing bryozoan-rich sediments on drowned metasedimentary basement. Late Miocene platform demise)

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)

(Dutch version of Molengraaff 1917 paper below)

(online at: www.dwc.knaw.nl/DL/publications/PU00012388.pdf)
(Discussion of reef growth theories of Darwin, Daly, etc., requiring sealevel rise or seafloor subsidence for significant reef development, and the possible causes of subsidence)

(Early descriptions and distribution maps of coral reefs in Indonesia)


(online at: http://repository.naturalis.nl/document/149624)

(Overview of development of coral reefs in Indo-Pacific during last 23 ka. Seven framework and three detrital facies identified. Degree of reef development linked to coral community structure. Four reefal anatomy types, based on dominant depositional patterns: balanced aggrading/onlapping, unbalanced aggrading/downlapping, prograding and backstepping)

(Review of carbonate deposition and diagenesis, including case history of Malampaya gas field, NW of Palawan, Philippines)

(online at: www.ipa.or.id/download/news/IPA_Newsletter_07_2005_9.pdf)
Widespread Miocene carbonates are important oil-gas reservoirs. Most economic carbonates of E-M Miocene age, below regional M Miocene shales section. All economic carbonate production in SE Asia is from secondary porosity.


Niermeyer, J.F. (1911)- Barriere-riffen en atollen in de Oost-Indische Archipel. Tijdschrift Kon. Nederlands Aardrijkskundig Genootschap, Ser. 2, 28, p. 877-894. ('Barrier reefs and atolls in the East Indies Archipelago. Recent reefs common in Indonesia. Barrier reefs and atolls were believed to be rare rare, but prove to be more common on latest maritime maps')


(Unpublished, major review study)

(Extensive areas of Halimeda bioherms on Kalukalukuang Bank (K-Bank), 50 km E of Sunda Shelf margin in E Java Sea. K-Bank isolated limestone platform, with top sloping from ~20 m water depth in N to ~100 m in S. K-Bank relatively flat top with marginal banks of suspected Pleistocene origin as interpreted from seismic)

(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)

(Studies of three Recent isolated carbonate platforms in Celebes Sea, E of Sabah, illustrate complexity of facies distribution. May be analogs for Luconia Miocene carbonate platforms)

(online at: https://openresearch-repository.anu.edu.au/handle/1885/109304)  
(Marion Plateau is most southerly of marginal plateaus offshore NE Australia, in area beyond Great Barrier Reef and is extension of Queensland continental shelf in water depths 100-500m. Plateau summit remained exposed through Paleogene, during which it was planated to form gently dipping 200 km wide plateau. Capped by Late Oligocene- Miocene carbonate buildups)

(online at: www.odp.tamu.edu/Publications/133 SR/VOLUME/CHAPTERS/sr133_34.pdf)  
(Marion Plateau off NE Australia has several shallow marine carbonate platforms, most of which drowned and now in >400 m of water. Oldest drowned platform of E-M Miocene age with initial shallow-marine phreatic phase of cementation, followed by meteoric diagenesis, followed by dolomitization and/or a deep marine cementation. Demise of platform caused by exposure for ~7-10 My sea level drop in M-L Miocene (N10-N17))


Purdy, E.G. & D. Waltham (1999)- Reservoir implications of modern karst topography. American Assoc. Petrol. Geol. (AAPG) Bull. 83, 11, p. 1774-1794. (Tropical karst landscapes exhibit mainly positive relief features, temperate karst areas more negative relief features (i.e., sink holes, dolines, etc.), but not observed in subsurface on seismic sections. Topographic profiles over karst relief features of China, Java (Gunung Sewu) used to construct synthetic seismic sections)


Santoso, W.D., Y. Zaim & Y. Rizal (2017)- Carbonate biofacies and paleoecology analysis based on Acropora coral in Ujunggenteng area, West Java Province, Indonesia. J. Riset Geologi Pertambangan (LIPI) 27, 2, p. 179-188. (Limestone at Ujung Genteng, SW Java, with three Acropora coral associations, tied to 0-13m paleobathymetry. (Age?))


Distribution of buildups impacted by fault activity, starting in latest Miocene- E Pliocene (initial collision of Australian Plate with Banda Arc, increasing and peaking in E Pleistocene), causing flexural reactivation of structural highs and lows along shelf-margin. Seismic evidence of moat channels and drift deposits suggest contour current activity intensified in late E Pleistocene (~1 Ma). Despite good conditions, buildups did not form until M Pleistocene (~0.58-0.8 Ma), corresponding to onset of major sea level fluctuations.

(Atlas of photomicrographs of Cambrian- Pliocene carbonate thin sections, mainly from Mediterranean region)


(Three stages in Late Paleocene- E Eocene Tethys carbonate platforms: (1) late Paleocene: coralgal-dominated at low-mid paleolatitudes; (2) latest Paleocene: coralgal reefs dominant at middle paleolatitudes and larger foraminifera-dominated (Miscellanea, Ranikothalia, Assilina) at low paleolatitudes; (3) E Eocene larger foraminifera-dominated (Alveolina, Orbitolites, Nummulites) platforms at low-middle paleolatitudes. Onset of larger foraminifera-dominated platform correlates with Paleocene/Eocene Thermal Maximum. Decline of coralgal reefs in low latitudes related to warming, with sea-surface temperatures in tropics beyond maximum temperature range of corals)

(Larger-foraminifera turnover (LFT) at Paleocene-Eocene transition involves rapid increase in species and shell size. LFT coincides with Paleocene-Eocene Thermal Maximum (PETM). Because of vulnerability of corals to high surface-water temperatures, global warming may have favored larger foraminifera at expense of corals as main carbonate-producing component on carbonate platforms at lower latitudes)


(Overview of reefs and bottom sediments composition of Pulau Seribu, Java Sea, NW of Jakarta)

(Study of carbonate sediment composition of Pulau Seribu group of coral reefs, Java Sea)

Sluiter, C.P. (1890)- Uber die Entstehung der Korallenriffe in der Java See und Branntweinsbai, und uber neue Korallenbildung bei Krakatau,. Biologisches Centralblatt 9, 24, p. 737-753. 
(‘On the origin of the coral reefs in the Java Sea and Brandewijns Bay (near Padang, W Sumatra) and on new coral growth near Krakatoa’. On initiation of new coral growth in Bay of Jakarta (away from muddy bottoms and usually first by solitary corals Madrepora, Porites, etc., followed by massive corals Astraea, etc.) and growth of modern reefs. Same as Sluiter (1890) below)

(online at: http://62.41.28.253/cgi-bin/... )
(‘On the origin of the coral reefs in the Java Sea and Brandewijns Bay (near Padang, W Sumatra) and on new coral growth near Krakatoa’)

Bibliography of Indonesian Geology, Ed. 7.0 308 www.vangorselslist.com July, 2018
(online at: https://ijog.geologi.esdm.go.id/index.php/IJOG/article/view/386/247)

(Indonesia with its 17,500 islands contains 32% of world’s shallow coral reefs)

(Genetic diversity has largely recovered on reefs decimated by eruption of Krakatau in 1883. Recolonization occurred mainly from Pulau Seribu, but also larval input from other regions. Recovery of genetic diversity in coral reef animals can occur on order of decades and centuries rather than millennia)

(Reservoir quality of Miocene carbonates primarily controlled by prevailing paleoclimate. Two end members: (1) humid, oceanic tropical-subtropical settings (e.g. Miocene of SE Asia). Warming trend and rising sea level allowed thick coral reefs and skeletal banks to develop. Typically several 3rd-order cycles, separated by discontinuities in platform growth with subaerial exposure, with porosity development associated with meteoric leaching and karstification. Basal transgressive carbonates mostly tight; (2) arid, land-locked temperate-subtropical settings with elevated salinities and relatively low temperature restricting growth of buildups. Mainly thin, narrow fringing coral reefs with small lagoons in rhodalgal ramps, with minimal meteoric dissolution during subaerial exposure. Evaporitic lagoons cause of pervasive dolomitization, leaching and generation of moldic, vuggy, and intercrystalline porosity. Often with anhydrite cement)


(Extended Abstract. Mega-Platform 1.2-km- thick Miocene carbonate platform in N part of Luconia province. Study of isotopic composition of diagenetic cement. Meteoric calcite cement relatively low oxygen isotopic ratios due to addition of lighter meteoric-derived 16O. Carbonate precipitated directly from seawater exhibits 87Sr/86Sr ratio of sea water at time of precipitation. Later diagenetic carbonates incorporate 87Sr released during dissolution and recrystallization, inheriting 87Sr/86Sr ratios of formation waters from which they crystallised, typically with Sr ratios greater than contemporaneous seawater)


(Five years after the 1988 eruption of Gunung Api volcano, Banda Islands, lava flows supported diverse coral community (124 species) with high coral cover and with some colonies measuring over 90 cm in diameter)


Umbgrove, J.H.F. (1929) - De koraalriffen der Duizend Eilanden. Dienst Mijnbouw Nederlandsch-Indie, Wetenschappelijke Mededelingen 12, p. 3-47. ('The coral reefs of the Thousand Island's (Pulau Seribu, W Java Sea))

Umbgrove, J.H.F. (1930) - The end of Sluiter's coral reef at Krakatoa. Leidsche Geol. Mededelingen 3, p. 261-264. (online at: www.repository.naturalis.nl/document/549489) (Rapid re-colonization of Krakatoa remnants (NW Rakata) by corals (mainly branching types) after 1883 eruption, as observed by Sluiter (1890). Forty years later covered by pumice deposits eroded from exposed Rakata walls)


Umbgrove, J.H.F. (1939) - De atollen en barriere-riffen der Togian eilanden. Leidsche Geol. Mededelingen 11, 1, p. 139-187. (online at: www.repository.naturalis.nl/document/549574) ('The atolls and barrier reefs of the Togian Islands'. Study of modern atolls and reefs in Tomini Gulf, N Sulawesi, with reconnaissance geology observations on Togian Islands. Oldest rocks are sediments, intruded by young volcanics (but no recent activity). Raised reef terraces younger than Tj/Miocene)

Umbgrove, J.H.F. (1939) - Madreporaria from the Bay of Batavia. Zoologische Mededelingen 22, 1, p. 1-64. (online at: www.repository.naturalis.nl/document/149596)

Umbgrove, J.H.F. (1939) - Madrepora from the Togian reefs (Gulf of Tomini, North Celebes). Zoologische Mededelingen 22, 10, p. 265-308. (online at: www.repository.naturalis.nl/document/149424) (Descriptions of modern corals from steep barrier reefs, atolls and fringing reefs of Togian Islands. In setting rel. sheltered from monsoons, therefore lacking shingle ramparts and sand cays)

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limit of reef corals controlled by depth of light penetration (corals depend on zooxanthellid algae for food). This is usually around 40m, but may be reduced in areas of clay-silt sediment supply, like Bay of Jakarta.

(online at: http://e-journal.biologi.lipi.go.id/index.php/treubia/article/view/1894/1780)
(Mainly zoological studies of Indonesian coral reefs)

(online at: http://e-journal.biologi.lipi.go.id/index.php/treubia/article/view/1933/1816)
(Observations on Onrust island coral reef in W Bay of Batavia. Close correlation between amount of suspended silt (light penetration) and lower depth limit of growth of reef corals)

(online at: e-journal.biologi.lipi.go.id/index.php/treubia/article/download/1934/1817)
(Observation on coral islands Dapur, Damar Besar (edam) and Pulau Ayer (Hoorn) in Bay of Jakarta, after initial work of Umbgrove. Not much coral growth below ~10-15m, due to silt content of bay water)

(Includes mention of Timor Permian (Sakmarian) Tubiphytes (= Shamovella) grainstones)

(On distribution pattern of Acropora coral species in Indonesia)

(Acropora coral fauna of Togian Islands, N Sulawesi, high diversity and includes relict Tethys Sea elements (conclusion re-assessed in Wallace 2001: more likely remnant Pacific fauna))

(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)


(Alor in Banda Sea is in core of Indo-Pacific warm Pool. 18O isotopes of coral growth stages used to monitor inter-annual climate changes. El Nino events in last 30 years clearly reflected by increased 18O)

(Series of submerged coral reefs in Huon Gulf (PNG) and around Hawaii. Rapid subsidence (2-6 m/ka over last 500 ka), combined with eustatic sea-level changes, responsible for repeated drowning and backstepping of
coral reefs. Reef drowning characterized by distinct biological and sedimentary sequence. In short term, rate and amplitude of eustatic sea-level changes control initiation, growth, drowning or sub-aerial exposure, subsequent reinitiation, and final drowning. Over longer time scales (>100-500 ka) tectonic subsidence and basement substrate morphology influence reef morphology and backstepping geometries.

(W Huon Gulf actively subsiding foreland basin with 14 drowned carbonate platforms and many pinnacles/banks, increasing in age (~20-450 kyr) and depth (0.1-2.5 km) NE to Ramu-Markham Trench. Superimposed on downward flexing of platforms toward trench is tilting of deep platforms to NW and shallow platforms to SE. This may reflect encroaching thrust load from NW (Finisterre Range). Over shorter time scales (~100 kyr) eustatic sea level changes critical in controlling initiation, growth, drowning of platforms. Tectonic subsidence and basement morphology influence backstepping geometry and tilting of platforms over longer timescales)

(Coral, algae, larger forams facies models and development of Pleistocene carbonate platforms, Huon Gulf. Facies from shallow to deep: 1. coral reef lst (reef flat-upper reef slope <20m; with Calcarina), 2. coralline algal-foraminiferal nodule limestone, 3. Halimeda limestone (deep fore-reef slope ~20-60m; with Amphistegina, Heterostegina, Operculina), 4. Coralline algal- foraminiferal crust limestone (deeper fore-reef slope ~60-90m; with Amphistegina, Cycloclypeus, Heterostegina operculinoides, Operculina) and 5. Planktonic foraminifera limestone (with Amphistegina, Cycloclypeus, Heterostegina))


(online at: www.dwc.knaw.nl/DL/publications/PU00013229.pdf)
(Review of distribution of modern coral reefs in Indonesia. Most are fringing reefs and patch reefs. True atolls or barrier reefs are virtually absent)

(Facies and biota description of Pee Shoal in Timor Sea. Steep and flat-topped knoll. Facies zonation: (A) scarce sponges, hydrozoans and crinoids (320-210m water depth); (B) hardground outcrops (step-like banks, vertical cliffs) colonized by octocorals and sponges (210-75m); (C) summit region (75-21m) slopes merge gently into flat-topped summit, colonized by massive and encrusting corals and octocoral Heliopora. Sediments from summit dominated by Halimeda)


(Comprehensive review of Tertiary carbonates in SE Asia)
(On ongoing research on modern carbonates of Wakatobi area, Tukang Besi Islands, SE of Buton/Sulawesi. Archipelago includes large atolls, smaller buildups and 4 main islands with modern rimmed shelves or fringing reefs. On islands >10 Pliocene-Quaternary coral reef terraces, uplifted to ~300m)

(online at: http://searg.rhul.ac.uk/pubs/wilson_2008%20Equatorial%20shallow%20marine%20carbonates.pdf)
(Marked change from larger foram to coral-dominated carbonate producers around Oligo-Miocene boundary. Early Miocene acme of coral development in SE Asia)

(online at: http://searg.rhul.ac.uk/pubs/wilson_2011%20SE%20Asian%20carbonates.pdf)
(Review of shallow water carbonate environmental and climatic changes through last 50 My in SE Asia)


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

(online at: http://searg.rhul.ac.uk/pubs/wilson_hall_2010%20Australasian%20carbonates.pdf)
(Tectonics control location of SE Asian Cenozoic carbonate deposits. 70% of 250 shallow marine carbonate formations in SE Asia initiated as attached features, 90% of economic hydrocarbon discoveries developed over antecedent topography, of which >75% isolated platforms. Economic reservoirs mainly in backarc and rift-margin settings (40% each). Demise of many platforms influenced by tectonic subsidence, often in combination with eustatic sea-level rise and environmental perturbations. Fractures enhance reservoir quality or may cause compartmentalization of reservoirs through formation of fault gouge or fault leakage)

(Despite significant clastic influence, Neogene carbonates developed adjacent to major deltas or volcanic arcs, and are comparable with modern mixed carbonate-clastic deposits in region. Regional carbonate development in areas of high clastic input influenced by antecedent highs, changes in amounts or rates of clastic input, delta lobe switching or variations in volcanic activity, energy regimes and relative sea-level change. With examples from patch reef complexes in Miocene deposits of proto-Mahakam and Wonosari Platform, Java S Mountains)

(Corals generally rare in SE Asian Eocene-Oligocene carbonates; instead dominated by larger forams and coralline algae)

(Locally common larger foram-rich carbonates at tropical latitudes)

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Yamano, H., T. Miyajima & I. Koike (2000) - Importance of foraminifera for the formation and maintenance of a coral sand cay: Green Island, Australia. *Coral Reefs* 19, p. 51-58. *(Green Island Reef (Great Barrier Reef, Australia) sand cay major constituents benthic foraminifera (mainly *Amphistegina lessonii*, *Baculogypsina sphaerulata* and *Calcarina hispida*), calcareous algae (*Halimeda* and coralline algae), hermatypic corals, and molluscs. Benthic foraminifera ~30% of total sediment)*

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