

Cenozoic plate tectonic reconstructions of SE Asia

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Abstract: A new plate tectonic model for the Tertiary is proposed, based on the integration of new palaeomagnetic data from east Indonesia recording Philippine Sea plate motion, recent revisions of the history of the South China Sea, and previously available geological and palaeomagnetic data from SE Asia. Early Neogene counter-clockwise rotation of Borneo is interpreted to have closed a proto-South China Sea suggesting a strike-slip boundary in NW Borneo before the Neogene. This rotation suggests that the West Philippine Sea, Celebes Sea and Makassar Strait formed a single basin which opened in the late Paleogene, and widened eastwards. At ~25 Ma a major collision, that of Australia with a Philippine Sea plate arc, trapped Indian Ocean lithosphere which later became the Molucca Sea plate. The collision caused clockwise rotation of the Philippine Sea plate, initiated the Sorong Fault system, and then eliminated the Molucca Sea by subduction on its east and west sides. The effects of collision propagated westwards through the region resulting in the initiation of new plate boundaries marked by regional unconformities. The arrival of the Sulawesi ophiolite, which collided with west Sulawesi in the late Oligocene, was the earliest event in collision between Sulawesi and the Bird's Head microcontinent. Continental crust was thrust beneath Sulawesi in the early Miocene, and the Tukang Besi and Sula platforms were sliced in turn from the microcontinent, transferred to the west-moving Philippine Sea/Molucca Sea plate for a few million years, and finally accreted to Sulawesi. Reconstructing the Molucca Sea and Bird's Head microcontinent suggests that most of the Banda Sea has a late Neogene extensional origin. Collision between the Philippine arc and the Eurasian continental margin in Taiwan at ~5 Ma is the key to present regional tectonics.

Plate tectonic reconstructions of SE Asia may help in understanding the development of sedimentary basins, and the distribution of petroleum resources. Reconstructions of the region should also assist in identifying important controls on its tectonic development (e.g. the role of indentor tectonics), critical events (e.g. collisions or extensional events), and the timing and consequences of plate movements and reorganisations (e.g. their expression as unconformities and their regional correlation). Local, particularly two-dimensional, reconstructions often move problems outside the area of immediate interest, and neglect or fail to recognise both inadequacies and important features of models. Reconstructing a large region requires consideration of the implications of local reconstructions, and may indicate new solutions which can reconcile different data or show that commonly accepted views of regional development cannot be sustained.

During the Cenozoic the SE Asia region (Katili 1975; Hamilton 1979) was bounded to the north and west by a Eurasian plate, and to the south by the Indian–Australian plate. The motions of these plates are known, and their positions provide limits to the zone within which

the SE Asian collage of microplates and subplate fragments can be moved in reconstructions. However, the past position of the eastern boundary to the region has been much less certain. This boundary is, and has been, the western edge of the Philippine Sea plate but the motion of this plate has been difficult to link to the global plate circuit because it is surrounded by subduction zones.

New palaeomagnetic data from east Indonesia (Ali & Hall 1995; Hall *et al.* 1995*a, b*) permit reconstructions of the Philippine Sea plate and its motion since the early Tertiary. The east Indonesian islands of the North Moluccas include a relatively complete upper Mesozoic and Tertiary sequence of rocks which allow palaeomagnetic sampling over a wide stratigraphic range. The palaeomagnetic data from older sequences can be interpreted with confidence because there are results from younger rocks. The rocks are distributed over a large area so it is also possible to distinguish the effects of rotations caused by local deformation at the plate edge from those recording movement of the entire plate. These new palaeomagnetic data provide a clear indication of rotation of the whole Philippine Sea plate. They can also be

used to determine poles of rotation for the entire plate which can account for the new and earlier palaeomagnetic data, and other evidence of motion of the plate, for example, results of magnetic anomaly skewness studies. The calculated poles of rotation can thus be used to reconstruct the position and shape of the plate during the Cenozoic (Hall *et al.* 1995c). These reconstructions are linked to recent interpretations of the South China Sea area (Briais *et al.* 1993) to provide boundaries for the regional model of this paper.

During the development of the model an attempt was made to satisfy both geological and palaeomagnetic data. For reconstruction purposes, geological data are essential but often can be interpreted in different ways, and it is usually impossible to determine amounts of movement between different areas from geological arguments. On the other hand, much of the evidence for movement, and certainly for rotation about vertical axes, can only be acquired from palaeomagnetism and therefore *interpretation* of both geological and palaeo-magnetic data is essential. Van der Voo (1993) discusses the use and problems of palaeo-magnetic results, and provides a summary of data from SE Asia. Distinction between local and regional rotations is often far from clear, particularly because good palaeomagnetic data are sparsely scattered in time and space. In several areas, principally Sundaland–Borneo and the Philippines it is necessary to choose between alternative interpretations of palaeo-magnetic data. In such cases decisions were based on regional geological arguments, as discussed by Hall (1996), and account for differences between the models of Rangin *et al.* (1990), Daly *et al.* (1991), and Lee & Lawver (1994). Critical decisions, for example accepting the large counter-clockwise rotation of Borneo in this model, can be tested if reconstructions can be made that are consistent with geological data for the whole region. Thus, the reconstructions here should be seen as a way of distinguishing locally and regionally important data sets, identifying targets for future work, as well as providing a possible model of SE Asia with a new interpretation of its Cenozoic development.

An account of the reconstructions, with a more detailed account of the sources of information, is given by Hall (1996). An animation of the reconstructions, which can be run on either a Windows-based PC or a Mac with adequate hard disc space, is available free from the World Wide Web site at <http://gl.rhul.ac.uk/seasia/welcome.html>.

Methods

Philippine Sea Plate Motion

Cooperative field investigations by the University of London and the Indonesian Geological Research and Development Centre carried out between 1984 and 1992 (e.g. Hall & Nichols 1990) provided the stratigraphic basis for a systematic palaeomagnetic programme in the north Molucca islands between Halmahera and Waigeo, and the Sula platform. The palaeomagnetic work was the basis for determination of the Philippine Sea Plate motion history (Hall *et al.* 1995c), which in turn provided the basis for tectonic reconstructions of SE Asia.

ATLAS Model

The reconstructions were made using the ATLAS computer program (Cambridge Paleomap Services 1993). In the ATLAS model the motions of the major plates are defined relative to Africa and its movement is defined relative to magnetic north. There has been little Cenozoic motion of Eurasia and it remains in a similar position in all the reconstructions, although there are small movements of Eurasia due to the plate circuit used in the ATLAS model, particularly for the last 5 Ma. Therefore there are minor differences compared to reconstructions which keep Eurasia fixed in its present position (Lee & Lawver 1994; Rangin *et al.* 1990).

Fragments and Tests

Reconstructions of SE Asia (Fig.1) for the region between 20°S–30°N, and 90°E–160°E, are presented at 5 Ma intervals for 50–5 Ma (Figs. 2 to 6). Approximately sixty fragments were used, and they retain their current size in order that they remain recognisable. However, in earlier reconstructions it is likely that fragments had different sizes and shapes or may not have existed, for example in areas of volcanism and extension in the Philippines, Sunda, and Banda arcs. In some cases, this has been incorporated by omitting the fragment before a certain time.

Most minor fragments can be linked to a major plate (Australia, Eurasia, Philippine Sea) and were moved as if attached, or partially coupled to, a plate with known motion. The model attempts to use the simplest possible motion histories. More complex movements were obtained by transferring fragments from one major plate to another. During the reconstruction process possible solutions were tested by asking (1) are palaeomagnetic data satisfied (2) are geological data satisfied, and (3) is there overlap of fragments during movements? Below, the main features of the reconstructions made for different time slices are summarised, with interpretations of the region's development.



Fig. 1. Simplified present-day tectonic configuration of SE Asia. Shallow marine parts of Eurasian, Sunda and Australian continental shelves are shaded in grey. Hatched areas represent mainly ophiolitic, arc and other accreted material added to Eurasian and Australian margins during the Cenozoic. Principal marine magnetic anomalies are shown schematically for the Indian Ocean, Pacific Ocean, South China Sea, Philippine Sea and Caroline Sea. Circled Z identifies Zamboanga peninsula of Mindanao. Double lines represent active spreading centres. Complexities in the Bismarck-Solomon Sea regions are not shown.

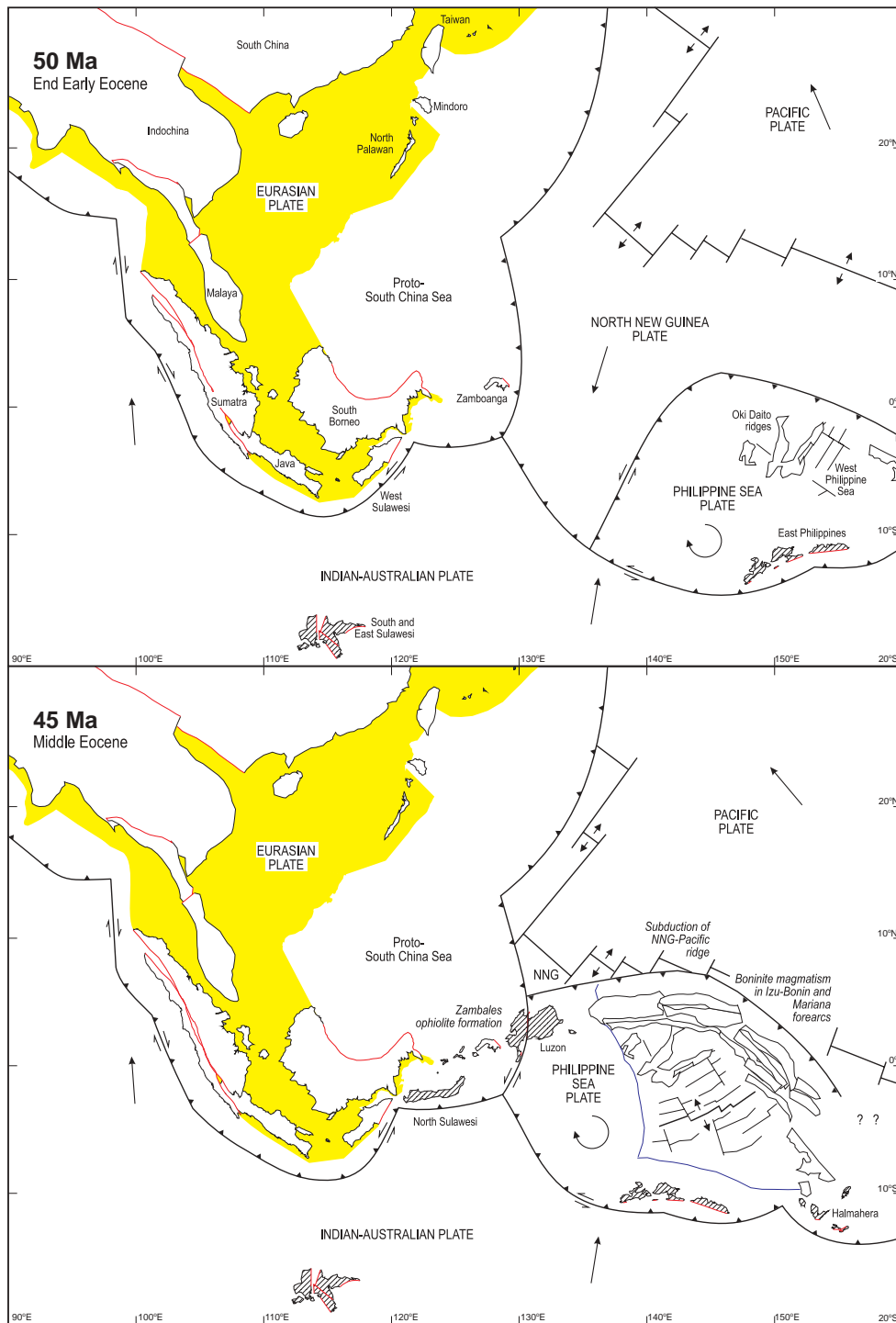


Fig. 2. Reconstructions of the region at 50 and 45 Ma when the Philippine Sea plate was rotating rapidly. Black lines with short paired arrows represent active spreading centres. Long arrows indicate motion directions of major plates. Circular arrows represent rotations.

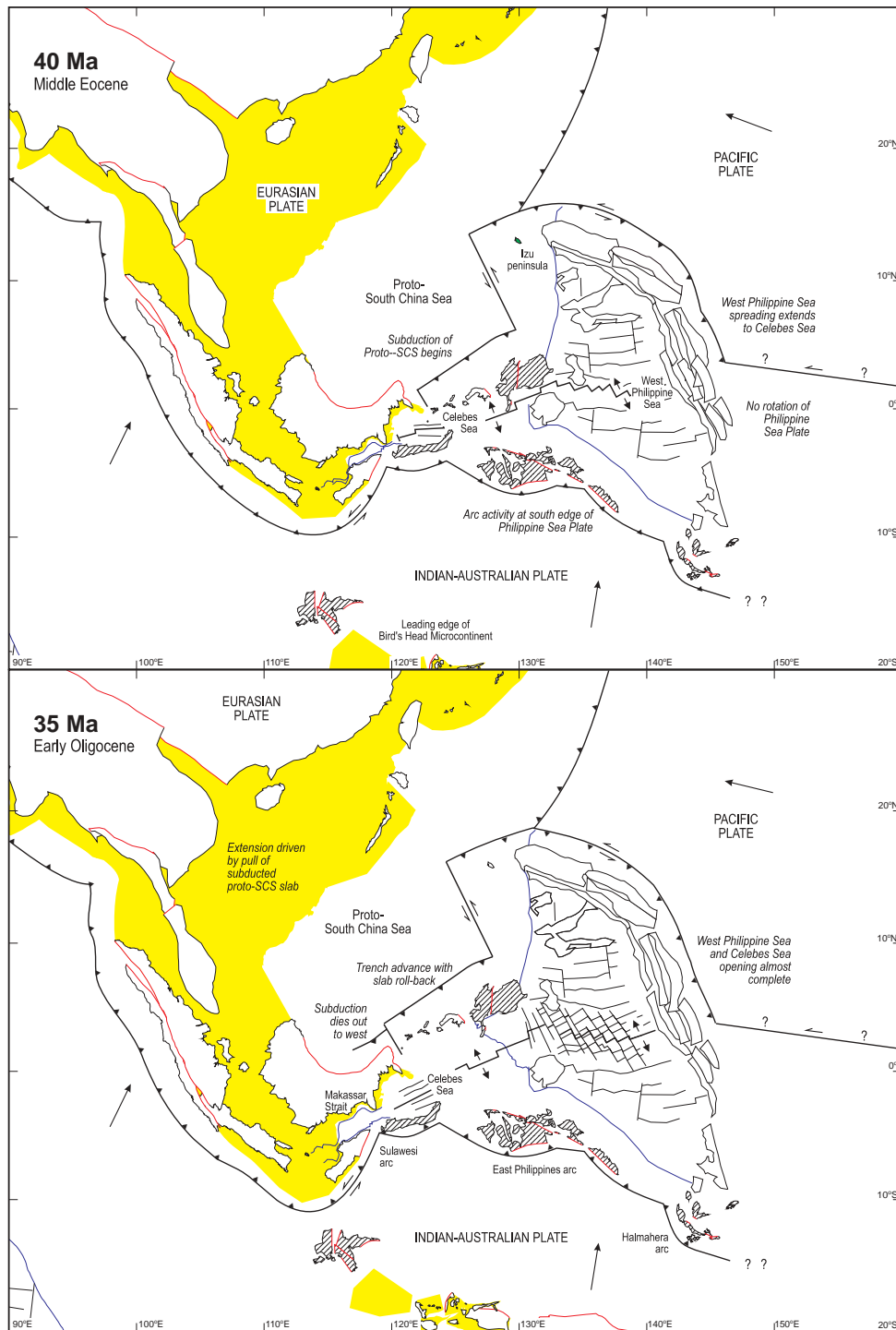


Fig. 3. Reconstructions of the region at 40 and 35 Ma. The Philippine Sea plate had ceased rotation and the West Philippine-Celebes Sea-Makassar Strait basin was opening, accommodated by subduction of the proto-South China Sea.

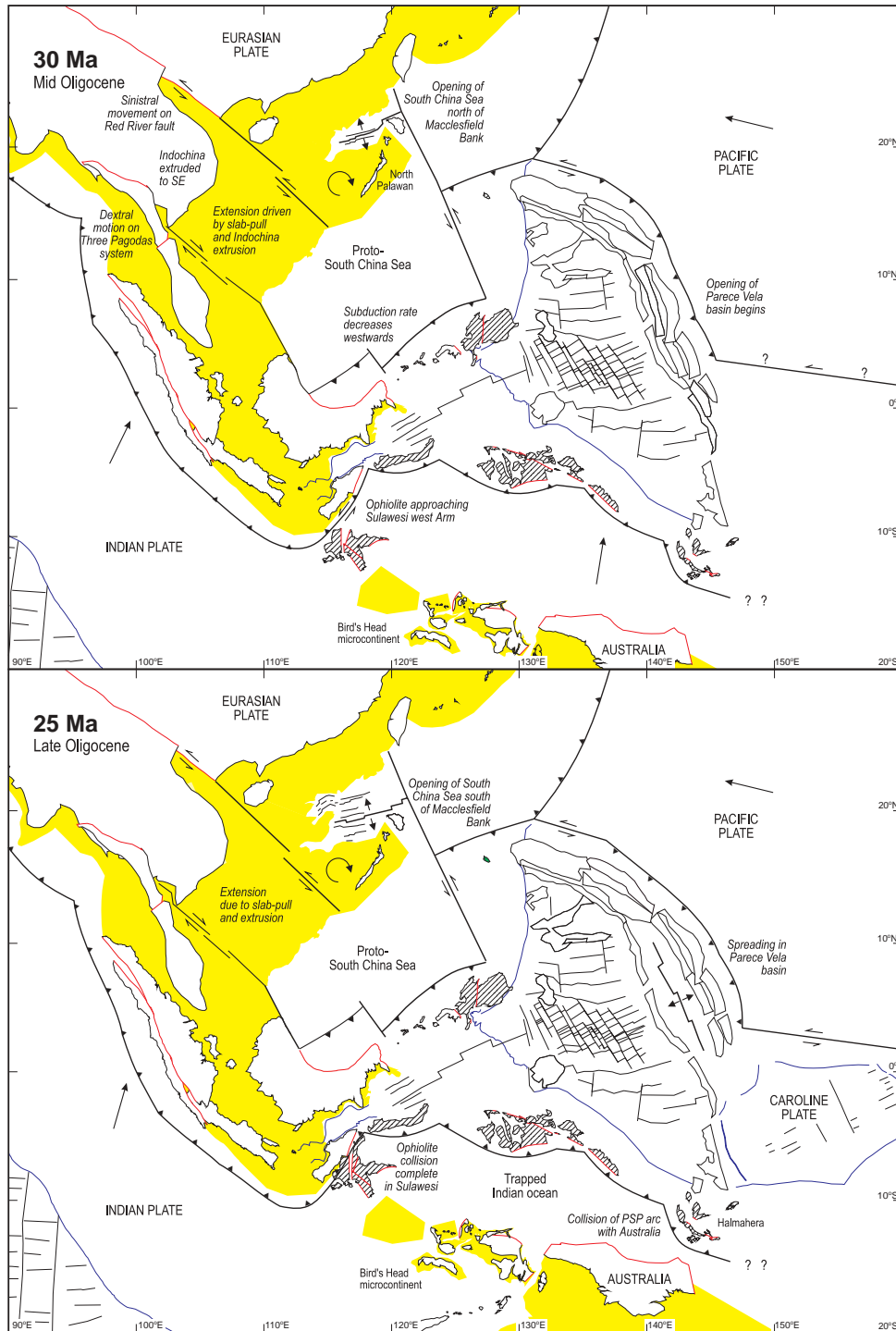


Fig. 4. Reconstructions of the region at 30 and 25 Ma. The South China Sea was opening. Northward movement of Australia trapped Indian oceanic crust in the future Molucca Sea after collisions in the Sulawesi and Halmahera regions.

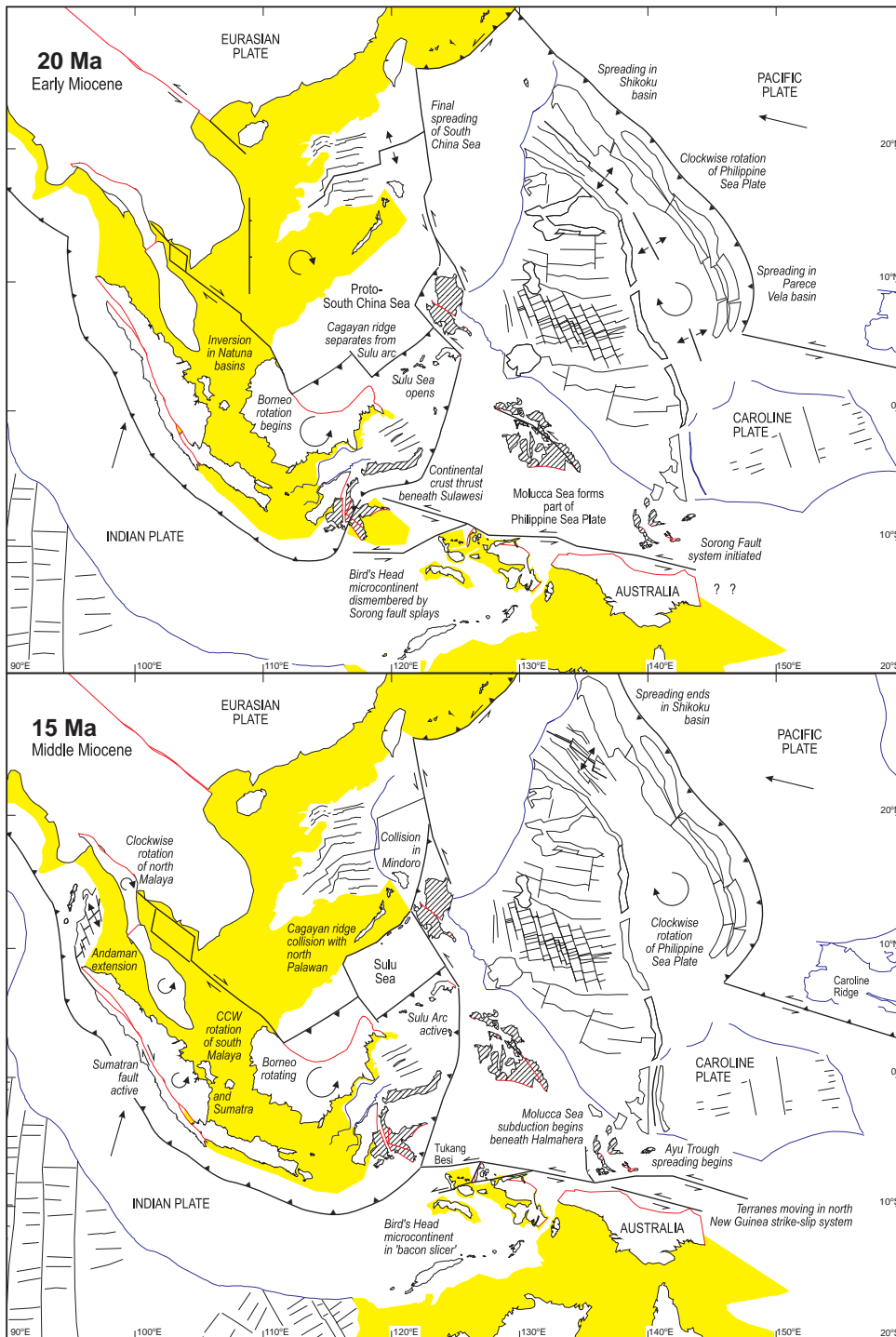


Fig. 5. Reconstructions of the region at 20 and 15 Ma. Borneo was rotating. Renewed rotation of the Philippine Sea plate was accommodated by strike-slip motion on the Sorong fault, with splays moving blocks of the Bird's Head microcontinent west towards Sulawesi.

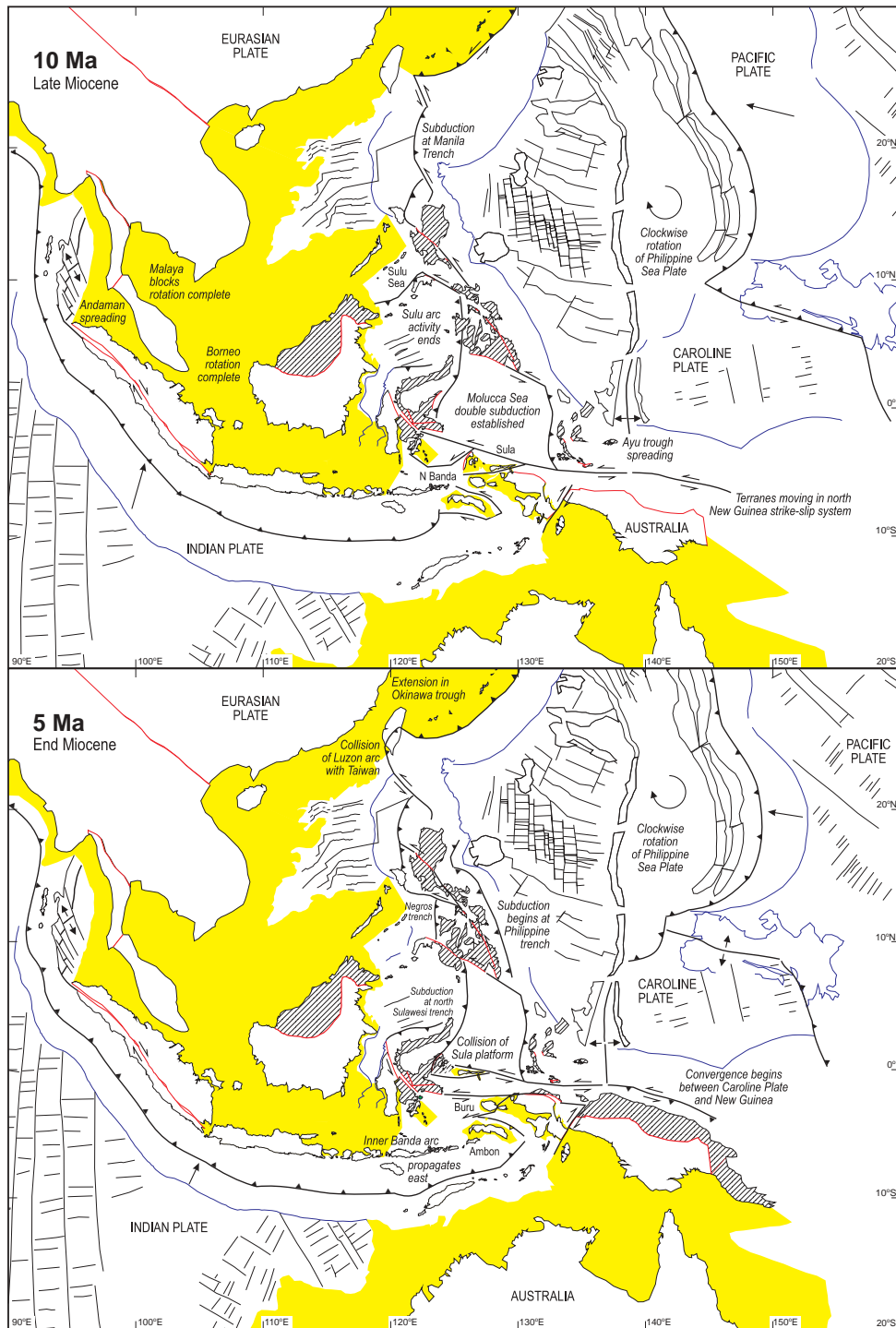


Fig. 6. Reconstructions of the region at 10 and 5 Ma. Borneo rotation was completed. The Molucca Sea was gradually eliminated by subduction on both sides. The Inner Banda arc propagated east, with extension in the North and South Banda Sea regions.

Reconstructions

50 Ma

Eurasia formed a stable continental area, with the Eurasian continental margin oriented broadly NE–SW. Taiwan, north Palawan and the continental shelf currently NW of Borneo were situated on the outer part of a stable passive margin, established during Cretaceous times. Sundaland was separated from Eurasia by a wide proto-South China Sea (SCS) probably floored by Mesozoic ocean crust. The southern edge of this ocean was a passive continental margin NW of a narrow continental promontory extending from Borneo to Zamboanga. North and south Malaya were much closer to Indochina and Sundaland was oriented NW–SE. The southern Sundaland margin had a NW–SE orientation along most of its length, implying a strike-slip and partly active margin resulting from oblique subduction of Indian ocean lithosphere. Because rotation of Borneo is accepted in this model the reconstruction thus differs from those of Rangin *et al.* (1990) and Daly *et al.* (1991) who infer a margin oriented closer to E–W.

Connecting plate boundaries to the Pacific is very speculative. The orientation of the Java trench is interpreted to have changed at its eastern end to NE–SW near west Sulawesi where there was a predominantly strike-slip margin, before linking to subduction zones further east. Alternatively, the Java trench could have continued broadly eastwards to a trench on the south side of the Philippine Sea plate (PSP) formed by the oldest parts of the east Philippines, the West Philippine basin, and Halmahera, which includes arc rocks dating back at least to the Cretaceous. North of the PSP there was a south-dipping subduction zone at the southern edge of a Northern New Guinea (NNG) plate. Spreading in the West Philippine Sea, situated in backarc setting, could have been driven by Indian ocean subduction, NNG plate subduction or both.

45 Ma

There was no significant change in the configuration of Eurasia and Sundaland. However, between 50 and 40 Ma rapid clockwise rotation of the PSP may have been linked to subduction of the NNG–Pacific ridge at its NE edge. The subduction of the ridge, orientated sub-parallel to the trench, caused massive extension in the Izu–Bonin–Mariana forearc associated with boninite magmatism. Ophiolitic rocks of Zambales complex, Luzon are speculated to be the

western end of this boninite arc. On the south side of the PSP Cretaceous arc rocks of Halmahera–east Philippines formed the basement of an arc situated above a north-dipping subduction zone. At 44 Ma a new spreading centre developed in the West Philippine Sea. The Sulawesi ophiolite was located on the Indian plate, although its position south of the bend in the Java trench suggests the possibility of a complex transform setting at this time.

40 Ma

Subduction of the NNG–Pacific ridge and consequent elimination of the NNG plate caused a major change in the length of the subducted slab in the west Pacific, resulting in a change in Pacific plate motion. This required changes in other plate boundaries and the 40 Ma reconstruction is therefore quite different from the older, and more confidently linked to the younger, reconstructions.

A subduction zone at the north edge of the Indian plate is inferred to have extended east from the Sunda–Java trench. Rotation of the PSP finished but the earlier rapid rotation had initiated a transform fault which now separated a formerly continuous arc between Luzon and the Izu–Bonin arc. The arc on the south side of the PSP was stationary. Spreading was well established and produced well-defined magnetic anomalies in the West Philippine Sea. This was situated in a backarc setting, and the width of the basin may be due to subduction beneath the PSP at both its south and NE edges, causing geochemical and tectonic complexity since both Pacific and Indian plates were being subducted.

The new palaeomagnetic data from east Indonesia give a greater confidence in reconstructing the position of the PSP, and suggest that the West Philippine Sea–Celebes Sea formed a single basin, narrowing west, as the spreading rate decreased. At its extreme western end, extension of the Makassar Strait (Situmorang 1982) probably never developed beyond the attenuation of continental crust as indicated by marine seismic studies (Dürbaum & Hinz 1982). The south-dipping subduction zone north of Luzon–Zamboanga, resulting from subduction of the proto-SCS, thus became less important westwards and there was no significant subduction beneath Borneo.

35 Ma

Indian ocean subduction continued at the Sunda–Java trenches, and also at the PSP arc

extending from north Sulawesi, south of the east Philippines, to Halmahera. The West Philippine–Celebes Sea basin continued opening until 34 Ma. The southern PSP arc remained stationary, so the whole of the northward motion of the north side of this basin was absorbed by subduction north of Luzon and at the NW edge of the PSP. This subduction system died out westwards so there was no closure of the west end of the proto-SCS. However, further east there was significant subduction and the pull forces of the subducting slab could therefore account for stretching of the Eurasian margin north of Palawan, in the region which was subsequently to become the South China Sea. The major differences between this and previous reconstructions (Rangin *et al.* 1990, Daly *et al.* 1991, Lee & Lawver 1994) are therefore the position of Borneo, the width of the proto-SCS and the link between the Celebes and Philippine Sea basins

30 Ma

Subduction on the south side of the proto-SCS continued, but spreading in the West Philippine–Celebes Sea basin had ceased. However, the transform link at the east end of the subduction zone now linked to the newly-established spreading centre of the SCS north of Macclesfield Bank. Movement of blocks driven by indentation of Eurasia by India (Tapponnier *et al.* 1982) contributed further to the closure of the proto-SCS, as Indochina was extruded SE on the sinistral Red River fault and the dextral Three Pagodas and Wang Chao faults (simplified as a single fault at the north end of north Malaya). Rifting of the Palau–Kyushu ridge began, leading to opening of the Parece Vela basin due to Pacific subduction beneath the eastern edge of the PSP.

25 Ma

In the SCS a ridge jump led to ocean floor spreading between Macclesfield Bank and Reed Bank, terminating spreading in the earlier-formed northern basin. Continued movement of Indochina on the Red River fault was also absorbed by extension within the Sunda Shelf. Dextral movement continued on the Three Pagodas and Wang Chao faults, probably partly absorbed in the Gulf of Thailand, Malay and Natuna basins.

PSP motion changed, linked to two important collisions. In the late Oligocene ophiolites, probably situated at the leading edge of the Bird's

Head microcontinent, were emplaced on the west Arm of Sulawesi. The area between the ophiolite and the Bird's Head is speculated to have been occupied by continental crust which in the early Miocene was thrust beneath Sulawesi (Coffield *et al.* 1993). The arc on the south side of the PSP collided with the Australian margin in New Guinea. These collisions trapped Indian ocean crust between Sulawesi and Halmahera which then became part of the PSP. Subduction ceased and between 25 Ma and 20 Ma (Fig. 5) the plate boundary became a strike-slip zone, the Sorong Fault system, which subsequently moved terranes of the PSP arc along the New Guinea margin.

Within the PSP, Parece Vela basin opening had propagated both north and south, forming the remnant arc of the Palau–Kyushu ridge. The Caroline plate is shown for the first time on the 25 Ma reconstruction, since although magnetic anomalies indicate Oligocene opening its position of formation and tectonic setting is uncertain. During the Neogene there has been little or no subduction at the Caroline–PSP boundary. Subduction of the Pacific plate beneath the PSP has been accommodated by sinistral motion at the Caroline–Pacific boundary with intervals of trans-tension and transpression in the region of the Caroline Ridge.

20 Ma

The clockwise rotation of the PSP necessitated changes in plate boundaries throughout SE Asia. These include the re-orientation of spreading in the South China Sea, and the development of new subduction zones at the eastern edge of Eurasia. Borneo started its counter-clockwise rotation, producing the Deep Regional Unconformity (Tan & Lamy 1990) of the north Borneo margin, with counter-clockwise motion of west Sulawesi, and smaller counter-clockwise rotations of most of the adjacent Sundaland blocks. An exception was north Malaya which began to rotate clockwise, thus remaining linked to both Indochina and south Malaya. Because the Borneo rotation pole was close to the NW corner of Borneo there was no major deformation of the Sunda shelf but there was inversion in basins such as West Natuna (Ginger *et al.* 1993). Rotation of Borneo was accommodated on the south side of the proto-SCS by southward subduction linked to the strike-slip boundary in west Borneo, but in the west, close to the Borneo rotation pole, the amount of subduction was small. Further east, the increased rate of subduction caused the Sulu Sea to open as a

back-arc basin at 20 Ma (Holloway 1982; Hinz *et al.* 1991; Silver & Rangin 1991) south of the Cagayan ridge, and between 20–15 Ma the Cagayan ridge moved northwards across the proto-SCS.

Collision in Sulawesi had almost eliminated the leading edge of the Bird's Head microcontinent. New subduction had begun at the west edge of the Philippine Sea plate below the north Sulawesi–Sangihe arc which extended north to south Luzon. The Philippine islands were carried passively with the PSP towards this subduction zone, as were the Halmahera islands, during a period of widespread carbonate deposition. North of Luzon, sinistral strike-slip movement linked the subducting SW margin of the PSP to subduction at the Ryukyu trench.

15 Ma

The reconstructions exaggerate the width of the western part of the proto-SCS because Borneo north of the Lupar Line is assigned to a single fragment, thus failing to show Neogene northward progradation of the Borneo margin by the addition of sediment. Most of this sediment is interpreted to have been derived from the north across the Sunda shelf, perhaps in part fed along the strike-slip margin from further northwest in Sundaland. As Borneo rotated, the remaining proto-SCS was eliminated.

The model predicts important changes in volcanic and tectonic history beginning at about 20 Ma for both Java and Sumatra. By 15 Ma North Sumatra had rotated counter-clockwise with south Malaya, and as the rotation proceeded the orientation of the Sumatran margin became less oblique to the Indian plate motion vector. This resulted in partitioning of convergence into an orthogonal subduction component and a parallel strike-slip component, leading to formation of the dextral Sumatran strike-slip system, and extension in the Andaman region. This model therefore predicts the development of a strike-slip system in Sumatra during the early–middle Miocene and this is consistent with the history of basins near to the present Sumatran fault, such as the Ombilin Basin. Sedimentation began in the Paleogene but there is no clear evidence for strike-slip control until the Neogene (C. G. Howells and A. J. McCarthy, pers. comm. 1996).

Collision of Luzon and the Cagayan ridge with the Eurasian continental margin in Mindoro and north Palawan resulted in a jump of subduction to the south side of the Sulu Sea. Southward subduction beneath the Sulu arc

continued until 10 Ma. The remainder of the Philippines continued to move with the PSP, possibly with intra-plate strike-slip motion and subduction resulting in local volcanic activity.

At the south end of the PSP, splays of the Sorong fault developed sequentially. The Tukang Besi platform separated from the Bird's Head microcontinent and was carried west on the PSP to collide with Sulawesi (Davidson 1991). Locking of splays of the Sorong fault caused subduction to initiate at the eastern margin of the Molucca Sea, followed by volcanic activity in Halmahera. This subduction zone later propagated north to link to a strike-slip zone connecting south Mindanao to the Sangihe trench. Thus the Molucca Sea became a separate plate and the double subduction system developed. At the east edge of the PSP spreading terminated in the Shikoku basin, formed as the PSP rotated accommodated by roll-back of the Izu–Bonin–Mariana trench.

10 Ma

Rotation of Borneo was complete. This, with collision in the central Philippines, the earlier collision in Mindoro, and continued northward movement of Australia, resulted in reorganisation of plate boundaries and intra-plate deformation in the Philippines. At the west end of Sundaland, partitioning of convergence in Sumatra into orthogonal subduction and strike-slip motion had effectively established a south Sumatra forearc sliver plate. Resultant extension led to development of ocean crust in the Andaman Sea (Curry *et al.* 1979).

At the east end of the Java trench the Eurasia–PSP–Australia triple junction decomposed into a zone of microplates, partly as a consequence of development of splays of the Sorong fault. The volcanic inner Banda arc propagated east into the area between Timor and the Bird's Head microcontinent which included trapped Indian ocean crust of probable Mesozoic age. This crust was now subducted and Seram began to move east as the arc propagated into the north Banda Sea, requiring subduction and strike-slip motion at the edges of this microplate. Further north, in the Sorong fault zone, Tukang Besi had been accreted to Sulawesi, locking one strand of the fault and initiating a new splay south of the Sula platform. The Sula platform moved with the Molucca Sea Plate, which was itself partly coupled to the PSP due to the low rate of convergence at the Halmahera trench. The Bird's Head moved north along a strike-slip fault at the Aru basin edge. North of the Bird's Head, and

further east in New Guinea, transpressional movements were marked by deformation of arc and ophiolite slivers separated by sedimentary basins. Opening of the Ayu trough separated the Caroline plate and PSP, although the rate of separation at this spreading centre was very low.

Subduction was now established in the whole Halmahera arc, and extended north to a sinistral strike-slip system through west Mindanao. This was one of several strike-slip systems active within the Philippines, probably linked to subduction zones at the western edge of the archipelago, such as the Manila trench. Links between the Sorong system and Sulawesi, with tightening of the knot at the triple junction and cessation of subduction at the Sulu trench, initiated southward subduction of the Celebes Sea beneath north Sulawesi.

5 Ma

The north end of the Philippine arc north of Luzon came into collision with the Eurasian margin in Taiwan. The PSP pole of rotation moved to a position north of the plate; clockwise rotation continued but the change in motion caused re-orientation of existing, and development of new, plate boundaries. Subduction continued at the Manila, Sangihe and Halmahera trenches, and new subduction began at the Negros and Philippine trenches.

In the Banda Sea the eastward movement of Seram relative to the Bird's Head changed to more convergent motion leading to significant subduction at the Seram trough. The Banda volcanic arc propagated east and its eastern end was at the longitude of Ambon, producing the famous ambonites. Since 5 Ma the southern Banda Sea has extended to its present dimensions (compare the 5 Ma reconstruction to Fig.1), probably by forearc and intra-arc extension, with continental crust now found in the Banda Sea ridges.

The Molucca Sea continued to close by subduction on both sides. At present the Sangihe forearc has overridden the northern end of the Halmahera arc, and is beginning to over-thrust west Halmahera. At the west end of the Sorong system the Sula platform collided with the east arm of Sulawesi, causing rotation of the east and north arms to their present position, and increasing the rate of subduction at the north Sulawesi trench. The northern New Guinea arc terranes have been omitted from the reconstructions before 5 Ma because there are insufficient data to reconstruct them adequately. However, the model suggests their Neogene history was

one of movement in a strike-slip zone, and only since 5 Ma has there been significant convergence between the Australian margin and Caroline plate.

Conclusions

A rigid plate model can explain in gross terms the evolution of the Indonesian and wider SE Asian region. Maintaining fragment dimensions fails to portray arc extension, addition of new crust in arc regions, much strike-slip faulting, accretionary growth of continental margins, and neglects the importance of regions of thinned continental crust. Adding new fragments to the model would improve modelling of local movements but dilute the model's simplicity in which driving forces are essentially Australia and PSP motion, and major regional events are linked to arc-continent collisions.

The model provides a coherent basic framework for understanding the evolution of the region. What is clear is that plate boundaries have at certain times changed character rapidly in response to the driving forces of the major plates of the region. Borneo counter-clockwise rotation is still unproven, but is feasible, and the model shows that there are alternative solutions to reconstructing the Philippines and answering other problems of the east Eurasian margin. The model currently has its greatest problems with timing and amounts of rotation of the west Sundaland blocks. Deformation recorded in the Sunda shelf basins suggests earlier rotations than those of the model, and the amount of extension predicted, particularly in the Gulf of Thailand, appears too great. It may be that these problems could be resolved through more complex solutions requiring non-rigid plate tectonics and/or local rotations of rigid blocks. The model shows the need for a major attack on the history of the region through integrated palaeomagnetic and geological studies, to differentiate regional and local movements, to determine their timing, and to correlate regional events

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