

General Author Response

We thank both reviewers for their constructive feedback – we appreciate the significant amount of time required to review such a lengthy manuscript. We have revised our manuscript, figures and Supplementary Material (including animations and GPlates-files). Sections of text were restructured, streamlined and re-written in some cases to address reviewer feedback.

Although our work builds on many previous studies, we believe that our work reconciles some key controversies – including, 1) that the Southwest Borneo Core was autochthonous to Sunda since at least the mid Jurassic, 2) the Philippine Archipelago (including Halmahera, Obi and parts of Luzon) formed on intra-oceanic subduction since the latest Jurassic, 3) the Proto South China Sea opens as a back-arc along the east Asian margin, 4) that continental fragments are detached from east Asia and transported onto northern Borneo (Semitau) and Luzon (e.g. Mindoro), and 5) that the tectonic evolution of Sundaland is intricately linked to the convergence of the Indo-Australian, Eurasian and Pacific plates. Other key findings are presented in the main text.

We present our regional model, embedded in a self-consistent global plate motion model, in digital format so that it can be tested and expanded in future studies. In addition, we generate seafloor spreading histories, continuous plate boundary evolution and plate velocity fields in order to ensure that our model is consistent with relative plate motions and geodynamic driving mechanisms of plate kinematics. Below, indented and in blue text, we offer our responses to each point raised by the reviewers.

Reviewer #1 Manuel Pubellier

Review of the manuscript 'The Cretaceous and Cenozoic tectonic evolution of Southeast Asia'

by S. Zahirovic, M. Seton, and R. D. Müller

Evaluation the overall quality of the discussion paper ("general comments")

This paper is taking a multi-source approach to precise some aspects of the Geodynamics of SE Asia. This kind of paper is difficult and requires to have assimilated a lot of literature; particularly in this case where geology and tomographic data have to be integrated. The methodology is good and the paper is both regional and thematic. It is a very interesting paper although many of conclusions are widely accepted or have already been proposed. Among the new ones the Philippine Sea Plate originated on the periphery of Tethyan crust is a new one. These propositions have however to take into consideration the considerable amount of geological data collected in this wide region, and this might lead the authors to modify, precise or explain better some of the contradictions, mostly concerning the New Guinea margin during the Late Mesozoic and the age of the Proto South China Sea. I have tried to highlight some of them in order to help the authors. Most of all, the figures are far too complex and very difficult to read. Many of them have to be redrafted or simplified since the computer models may be good on the screen but not on the figures. Providing that these major points are discussed or checked on the basis of the following comments, and the figures simplified, I would be very happy to see this paper published.

Specific Comments

scientific questions/issues ("specific comments")

Docking of Argoland. : This issue has been discussed in several papers and together with the evolution of Meratus Mountains. The subduction was probably toward the north during Cretaceous times according to datings of foraminifers bearing reef limestone included in the Alino volcanic formation (see also Yuwono, 1988, cited). I agree with most of the options chosen for E. Borneo. The Pre-Late Cretaceous obduction ophiolite in Meratus is accompanied by HT Metamorphism. The discussion about the Argo/Burma triple junction would benefit from the remarkable work of Norwick on the reconstructions of NW shelf of Australia. This is consistent with the synthesis of ages presented in this paper; the age gap between 75/65 (end of subduction in Sumatra/proto Sunda subduction and 45 subduction jump in the Present Sunda trench.

We thank the reviewer for their feedback. We have studied the works of Norwick (1979) and Audley-Charles et al. (1979), and found them very stimulating. We have included these citations, and have expanded on the UHT metamorphism. However, we could not find any literature on this topic by Norwick (?).

The South China Sea / Proto South China Sea issue P1363, Line 20 and below; the model of opening of the SCS of Schluter as a back-arc goes against all the geological and geophysical data (there is a tremendous amount of seismic lines, geological datings. . .) and no trace of the volcanic arc. Up to now the subduction of the PSCS is associated with the Southward subduction of the PSCS. Tonkul participated a lot, but the original ideas are much older (Holloway 1982. . .). P1354. The correlation of Semi-tau with S China is actually commonly admitted and come naturally when you restore the South China Sea and the PSCS openings. The block having docked against the rest of Borneo is probably not a real collision since it was already nearby. It is rather the shortening of crustal marginal blocks of the South margin of the SCS like the Palawan, Miri or Luconia; which are blocks individualized during the rifting.

We agree that the South China Sea did not open as a back-arc, but largely a result of pull-apart basin formation from south-dipping slab pull along Borneo, and potentially the effects of the extrusion tectonics acting on the east Asian margin. We find that the 'data', namely the seismic lines, presented in Schluter et al. (1996) are very useful, but we do not agree with the mechanism they suggest for the opening of the South China Sea. However, we propose that the predecessor, the Proto South China Sea, may have opened as a back-arc along the east Asian margin from the latest Cretaceous. This is supported by the accelerated tectonic subsidence on the east Asian margin from the latest Cretaceous, and the SSZ affinity of the ophiolites on Mindoro (~59 Ma age) and continental affinities to South China. This back-arc likely opened and rolled out, much like the Tyrrhenian Sea, and the arc (along with some detached continental fragments) collided with northern Borneo in the Eocene to result in the Sarawak Orogeny (Fyhn et al., 2010; Hutchison, 1996). An alternative scenario would be that the Proto South China Sea is just a piece of trapped Izanagi oceanic crust – which could be a future alternative scenario to test in numerical models. We have clarified the text to highlight that we disagree with the mechanism proposed by Schluter et al. (1996), and have included a reference to Holloway (1982, 1998). Thank you for the suggestion.

The New Guinea ophiolites. The proposition of the Jurassic basin connecting to Tethys raises several issues. The rifting along the former margin of New Guinea is indeed during

the Triassic (Tipuma formation) and the Sea floor spreading probably took place during the Callovo Oxfordian although it could be older south of the Bird's Head ; However the geochemical signature of the ophiolite of the Central Range of New Guinea (Irian Jaya) is a text-book example of Back-arc basin (see Monnier et al, 1999, and Pubellier, Ali and Monnier, Tectonophysics, 2003). This is true also for the Eocene coastal ophiolite.

Thank you for this very useful information. Our model for the Eocene is consistent with Cyclops Ophiolite generation in a back-arc setting. Although the paper by Monnier et al. (1999) interprets formation of this ophiolitic crust from south-dipping subduction along the Australian margin, we interpret it to result from generally north-dipping subduction and opening of the Caroline Plate. The age of the boninites (~43 Ma) is remarkably similar to the formation of Izu-Bonin-Mariana basins, as acknowledged in Monnier et al. (1999). We prefer north-dipping subduction of "Australian" (we refer to it as the Proto Molucca Plate) lithosphere to provide the northward slab-pull forces to drive seafloor spreading in the Australian Southern Ocean. However, our interpretation and that of Monnier et al. (1999) are both consistent with the surface geology – and further testing using numerical models may help resolve the subduction polarity controversies. We have updated our text to include an alternative scenario as outlined in Monnier et al. (1999).

In terms of the Central Ophiolite Belt, the oceanic crust is Jurassic in age with normal mid-oceanic ridge basalt affinities, however, the geochemical signature suggests a subduction component to imply back-arc basin affinities (Monnier et al., 2000). This is a very important contribution, and one which will require future work. We look forward to implementing an additional scenario in future work, that both addresses the SSZ character of these ophiolites, but also tries to resolve the remaining controversies we bring up in the discussion. For now, we will address this issue in text. The study by Monnier et al. (2000) shows that the 157 +/- 16 Ma is likely a minimum age, due to the K-Ar dating method. That places this ophiolite as old as 173 Ma, or older, and may represent a back-arc that preceded the ~155 Ma onset of seafloor spreading we interpret along northern Gondwana; a time-period we have not modeled in the reconstructions presented. However, it could also support the Alternative Scenario we propose in Fig 12B. In our revised text, both Scenario A and B are possible, and we acknowledge the SSZ character of the Central Ophiolite Belt. Thanks for the suggestion!

Introduction and Plate Model Reconstructions: Although I do not like to push my papers, it would be good to have a look at the first GIS based reconstruction on the sphere (I can send this paper if not accessible). Pubellier, M., F. Ego, N. Chamot-Rooke & C. Rangin (2003), The building of pericratonic mountain ranges: structural and kinematic constraints applied to GIS-based reconstructions of SE Asia, Bull.Soc. géol. Fr., t. 174, n°6, pp. 561-584 See also papers from Scotese's group (Paleomap)

Interestingly, the Pubellier et al. (2003) paper did not appear in Google Scholar and our initial literature search, which is very unfortunate. We did find it after a careful search. As you point out, it is a very significant contribution to the field and a very novel application of technology to help visualize the evolution of the region. We have included this contribution to the region. Thanks for the suggestions!

However, the previous work in Seton et al. (2012), which our model is based on, cites the many contributions of the Paleomap project – which is mainly concerned with the global plate reconstructions, whereas here we focus on the regional plate reconstructions. If we are to cite the Paleomap contributions, then we should cite all

the other models and data used in Seton et al. (2012). Here we have chosen to refer readers to citations within Seton et al. (2012). We hope that this is acceptable.

The extension in the Gulf of California started around 11 Ma in Sonora and Baja if I remember correctly.

Yes this is correct, thanks for pointing it out. Further research indicates that rifting began after 12.5 Ma (Oskin and Stock, 2003; Mammerickx and Klitgord, 1982; Spencer and Normark, 1979; Karig and Jensky, 1972), when subduction ceased along this margin and the peninsula was transferred to the Pacific Plate. We have updated the text and citations. Thanks!

Discussion on the sutures The Billiton Depression is supposed to be a suture zone by some authors. It has to be specified if it is similar or reactivating the Lupar line; otherwise it is just the south side of the Natuna Arch; unless new data are presented. Similarly the Figure 3 shows the Boyan Suture (different from the classical Lupar Line?). In the same legend, please precise "It does not cross-cut the older Bentong Raub zone (Fig 3)". The Bentong Raub zone in this region is not known precisely particularly off-shore. There is some imprecision or confusion in this section and the legend of figure

The Billiton Depression is proposed by some authors to be a mid Cretaceous suture. However, no clear signal is evident in the gravity anomalies of the shelf, unlike the Luk-Ulo Suture. It may be a very old suture, but we show in our manuscript that it could not have been a Jurassic or younger suture, due to the continuity of the east Asian magmatic arc into the core of Borneo. It may instead be a basin related to Oligocene-Miocene rifting of the East Natuna Basin (Doust and Sumner, 2007). As a result, we interpret that the Billiton Depression is either a Paleozoic suture that is reactivated by Oligocene rifting, or simply a rift generated in a coherent Sunda Shelf during the Oligocene. Metcalfe (2011) implies that the Lupar Line splays out and extends both into Borneo and into the Billiton Depression. This does not entirely agree with the structural relationships synthesized by Cullen (2010), which includes structures presented in "Pubellier et al. (2006), Simmons et al. (2007), Fyhn et al. (2009) and Zhu et al. (2009)". We have clarified our text relating to the Billiton Depression.

We have removed the reference to the Bentong Raub Suture on Fig. 5 as it was confusing.

On Figure 5, there is a weird suture in the middle of the NW Borneo wedge, approximately where the MMU unconformity is known. This area has been documented quite a lot and I have never seen this suture, (although I live in Malaysia).

Figure 5 is the bathymetry and the gravity anomalies of the Sunda Shelf. We do not show any sutures on NW Borneo in this figure. Perhaps you are referring to Fig. 3 where we show the outline of the Semitau Block? We follow Metcalfe (2011) and invoke two discrete sutures – the Boyan Suture to the south of Semitau, and the Lupar Line to the north. The Boyan Suture was likely terminated with the Eocene collision of the Semitau continental fragment with northern Borneo. South-dipping subduction then consumed the Proto South China Sea along northern Borneo (and Semitau), and the Lupar Line marks the suture resulting from the collision of Dangerous Grounds-Reed Bank at ~17 Ma, which choked this subduction zone and created the Sabah Orogeny.

The Luk-Ulo also known as Karasambung by the Indonesian colleagues is not a straight line between Java and Meratus but a curved line which passes near Bawean Island. This area is very well documented by the industry.

We have updated our figures to represent this. However, the suture in the Java Sea is represented by a dashed (i.e. uncertain) line, which should alert readers to this fact. Thanks for the additional information!

I am a bit surprised by the lack of affinity between Semitau and Indochina during Triassic and Jurassic. I see 2 stars; are there 2 samples?; Is this information reliable enough to consider its implication in the geodynamic context? The East Java/West Sulawesi is usually considered as the Argoland, or Argo, or Sumba block. It would be useful to specify the differences or homogenize the names. Besides I also agree that the core of Borneo was already in place in the Jurassic by similarities between the Malay Peninsula, part of Sumatra and the SW Borneo (Kutching) area.

Yes, it is interesting. As you mention, it may simply be a sampling bias, but the figure is derived from 24 samples, albeit collected only in two locations in northern Borneo. However, there are many more samples for comparison on Asia in the figure. We would not make the interpretation that a continental block from South China rifted and collided with Borneo purely based on this data alone, but we combine it with the other evidence of latest Cretaceous rifting on east Asia, and the Eocene Sarawak Orogeny. We interpret that a continental fragment (Semitau) is broken off South China from back-arc opening initiating in the latest Cretaceous, with the arc and continental fragment colliding/accreting to northern Borneo in the Eocene. We are encouraged that you are also inclined to believe that SW Borneo was near Sumatra/Malay Peninsula in the Jurassic-Cretaceous, but we hope further studies are undertaken to help resolve the remaining controversies.

Although Hall (2012) and Metcalfe (2011) argue that East Java and West Sulawesi are Argoland (derived from the Argo Abyssal Plain), we prefer to avoid giving them this name to 1) avoid confusion, and 2) because no definitive geological evidence exists that excludes East Java-West Sulawesi from originating on the Greater India or New Guinea margin. However, we do acknowledge that East Java and West Sulawesi may be the elusive Argoland in our discussion and Fig. 12, and encourage further debate and studies to help resolve this controversy.

The Fukien-Reinan Massif usually called by most authors Yenshanian Massif is much wider than represented on the Figure 7. Then the classical issue is do we correlate it also with the Cretaceous granites of Thailand and Peninsular Malaysia? The Massif can also be extended a bit further East as the basement of Schwanner continues under the Barito Basin.

We follow the outline of the Fukien-Reinan Massif proposed by Honza and Fujioka (2004), but realize it is likely much wider (Charvet et al., 1994). However, we could not locate any literature that explicitly outlines that Yanshanian Massif, and we are unable to accurately map it onto our Fig. 7. It also likely connects further east beyond the Schwanner Mountains, but we could not find an outline to follow – and prefer to keep this “conservative” outline. The main point is that the east Asian magmatic arc in the mid Jurassic onward can be linked to the SW Borneo core, which is one crucial piece of evidence to demonstrate that SW Borneo was already on the Asian margin at this time, and did not collide to Sundaland in the mid Cretaceous. As you mention, granites in the Malay Peninsula and possibly Thailand

may also be related, but we did not have an in-depth look at these, as the collision history of Thailand and the Malay Peninsula was beyond the scope of our work. However, we will take it into account in future work.

The oroclinal bending issue and the Figure 8 The lineaments of the Sunda Shelf visible on any gravity map were mentioned by Hutchison (2010) and follow Katili (1975) are interpreted in this paper as the result of a rotation and compared to an orocline (e.g. Central Asian Orocline?). This is only an assumption. It is difficult to drag and twist a continental plate. Although I spent a lot of time trying to figure out how it works, I do not understand the way the rotation is performed in this example; are the lineaments used as small circles for the rotation? Then I agree that the core of Borneo would be more distant to Sumatra but this is not reflected by the geological structures. The reference to the Java Sea (which does not have any oceanic crust except the extremity of the Damar/Flores basin) is not the best in the region; the Celebes and Makassar Basins are a better example that may illustrate the rotation of Borneo from Ipresian to Oligocene. Otherwise, the rotation of Borneo must be seen as a result of basins that opened to the north of the Present day NW Borneo. The South China Sea opened as a propagator with "V" pointed to the SW, implying a clockwise rotation of the SE margin of the South China Sea (NW Borneo). If all the convergence to accommodate the opening is taken in the closure of the Proto South China Sea, not much rotation is to be expected in the Java Sea. The rotation of this area would imply a large stretching in the Malay Basin and deformation in the Komodo to Penyu basins; which we do not observe. I think this part is to be explained better with simpler and more convincing figures.

The rotation of Borneo is an interesting phenomenon in the region, as the paleomagnetism and the structures on the Sunda Shelf seem to indicate the rotation, and possible oroclinal bending. Here we really only propose a hypothesis, that will require much more testing; using deformation models created in GPlates and testing them in numerical models of continental extension (similar to what has been done in the Atlantic and Australia-Antarctica margins, see Williams et al. (2011) and Heine et al. (2013)). We realize that the Java Sea is not underlain by oceanic crust, but we show that the lineations can be used to derive a rotation for Borneo. As you mention, we follow the lineations to derive Euler rotations to approximate the pole of the rigid body rotation. However, we also realize that this is no more than an approximation. It is however consistent with the model of Hall (2002) who also found that the pole of rotation for Borneo was likely close to NW Borneo, matching our derived rotations. As no rotation parameters exist for the Hall (2002) or subsequent models, we cannot compare it to our own. Instead, to improve the figure, we have added a comparison to the position proposed by the Lee and Lawver (1995) models.

Upon further literature review, the only study that notes the kinematic constraint in the Java Sea lineaments (albeit, indirectly in Fig. 2, 5 and 7) for the motion of Borneo relative to the Sunda Shelf is Rangin et al. (1990). We include this citation in a clarified text that explains our motivations.

So in a sense, we are using the paleomagnetic constraints everyone else is relying on, and we are trying to "tie down" Borneo to the rest of Sundaland using constraints from the lineations in the continental crust of the Java Sea. We recognize that the processes in continental and oceanic crust are fundamentally different, but we use this technique as an approximation to determine Borneo's pole of rotation relative to Sumatra. Interestingly, the palinspastic retro-deformation of the Australia-Antarctica margin identified similar lineaments in the continental crust

that highlight the direction of an ancient rifting episode (Williams et al., 2011). It is therefore likely that transforms and other structures are exploited during rifting – such as the Leeuwin Fracture Zone (on the Australian margin) and the conjugate Vincennes Fracture Zone (See Fig. 1 in Williams et al., 2011).

Most importantly, our rotations do not infer large strike-slip faults that are required to isolate Borneo from the rest of Sundaland, as are implied when rotating Borneo with an arbitrary location for the pole of rotation. We also include a table comparing our rotations to those of Lee and Lawver (1995) in the Supplementary Material, and we clarify the main text.

Similarly Figures 9 and 10 may be sexy on the screen but are extremely difficult to visualize and interpret as they are, even in colour. The authors need to find a clearer way to illustrate their points. For example Figure 10 is much better.

Figure 9 is problematic in its current form because it is too small – and is designed to take up an entire A4 portrait page. We will ask the copy editors to make it bigger. To make it clear, we made the seismic velocity anomalies from the seismic tomography model feint. This was designed to make the geometry easier to see.

Figure 10 is a 3D visualization of slab material from two seismic tomography models, with colour-coded slabs by depth. It is also designed to be bigger – and meant to be a more generalized figure to help locate the vertical profiles that are in Figure 11.

We hope that the final version of the figures will be bigger. In the meantime, you can download the full size figures ([download link here](#)).

Figure 11. Again refer to Norwick.

We are unsure how to incorporate the Norwick (1979) (??) reference here. We have incorporated it into the main text instead.

P1353 Philippines and also Figure 12. I agree with the comments on the accretion of blocks. Encarnacion was certainly not the first one to propose the Proto-Philippine Plate initiation and movement. It dates back from Karig for the mechanism, and later Jolivet et al. and the geology of the E Philippines is known from MGB books. The rotation was studied by Ali et al. and the origin as a supra-subduction zone (the scenario B of this paper) was proposed early by Pubellier et al. (2003), but in front of Australia (New guinea).

Pubellier, M., Monnier, C., Ali, J., 2003. Cenozoic Plate interaction of the Australia and Philippine Sea Plates: Hit-and-Run tectonics, *Tectonophysics*, 363, pp. 181-199,

The scenario is strongly supported by the nature of the ophiolite on the Central and the coastal ranges of New Guinea which have a back arc signature. The western side 5Mindoro. . .) is correct.

We have included references to the early works of Karig, and those of Jolivet. Thanks for the suggestions! We have included a reference to the work of Ali and Hall (1995) on the rotation history of the PSP.

We have updated our text to flag that the PNG margin in the Late Jurassic was rifted through back-arc processes. This is consistent with the scenario we propose

in Fig 12B, and we have strengthened the text to stress this. In terms of the Central Ophiolite Belt on New Guinea, we refer you to our comment above.

Along the same line, p1356. "The PSP cannot be linked with the other continental plates" is true from the Eocene but unknown before.

We have updated this sentence to highlight that it is a problem in the Eocene.
Thanks for the suggestion!

P1359 line 20; Proto Molocca Plate is not on Figure 13a as stated.

The reference to the Proto Molucca Plate (PMOL) on P1359 line 20 refers to Figure 13b, not 13a. The labels for the PMOL Plate can be seen on the 125 and 80 Ma snapshots. The problem is that this figure has been squashed and made too small. The two panels are meant to take up two full A4 portrait pages, and we will ask the copy editors for help in fixing this. In the meantime, you can download the figures the size we hoped they could be in the final version ([download link here](#)).

The Figure 13a is very confusing. It is indicated in the legend that they are blocks but the colour represent different things (emerged continent (Australia), foreland basin (New Guinea), sliver plate (S Sumatra, and Eastern Philippines), Fold-and-Thrust Belt (Simao, and Central Java. . .). Figure shows I think too many blocks, many of which are not crustal blocks ; e.g ; Sarawak is composed of the allochthonous accretionary wedge representing the former sediments deposited on the N margin of the proto South China Sea : N and W Sulawesi are the same S-Easternmost margin of Sundaland : eastern and western philippines are not separated by the Philippine fault which is a very recent feature (5my in the N and less than 1 My in the S). Why also separating Australia from the S. New Guinea /Arafura foreland ? Hainan also has the same geology than S. China block.

This is a good question. We decided to colour-code all the tectonic elements in our plate reconstruction by Plate ID, which is the ID that GPlates uses when reading the plate motion hierarchy and Euler rotations. We made a conscious decision to colour code the blocks this way so that one could track the tectonic elements easily through time – both in the figure, but also in the animation provided in the Supplementary Material. So in effect, the colours do not indicate anything about geology or tectonic affinity, but are just a visual aid in guiding the eye between timesteps and act as a legend for Figure 13b. We have updated the figure caption to explain this.

Figure 14 is too high and too small to be visible in the paper also. It should be simplified and more explicit.

We agree that Figure 14 has been made too small. It was meant to be placed on two A4 portrait pages, one page per panel (with the key going under the second smaller panel). However, the proofing process placed them on a landscape page, which made them too small and make them look cluttered. We will ask the copy editors to distribute this figure over two A4 portrait pages as originally planned. Please download the full size figures in the meantime ([download link here](#)).

Conclusions I agree with most of the main options taken in this exhaustive compilation. However, the results are not new, although the discussion is done in depth. The rift- ing of W Sulawesi/East Java/Mangkalihat is known (Mangkalihat uncertain since it is devoid of basement outcrop: only Miocene and Pliocene carbonates) and has been discussed by

many authors but under the name of Argo or Sumba Block and the rifting of the core of Borneo has generally been considered as part of S China before the opening of the SCS and PSCS. The discussions had been however on the correlation between the Java and the Argo block, and to the west with the Woyla and Burma block.

Thank you for all the very useful feedback. We have updated our conclusions to highlight the new contributions we have made, in light of the many recent models published for the region. Although some of the ideas have been presented before, but often only in passing, while some recent models have not addressed these constraints. Here we demonstrate that the SW Borneo core was on the Asian margin by mid Jurassic, that the Proto South China Sea likely formed as a back-arc from the latest Cretaceous, that Mindoro and South Palawan likely detached with the back-arc opening, that Luzon is a composite terrane of Asia derived fragments and ophiolitic basement derived from the allochthonous Philippine Archipelago. We also clarify the history of continental fragment collisions on Sundaland, and model the continuous intra-oceanic subduction in the Tethys. We also show that subduction was active along Sumatra (and Java-Sunda) from the Late Cretaceous, except for the 75-65 Ma magmatic gap. As a result, we use our novel approach in making evolving plate boundaries that remain consistent with the plate motions – something which is often missing from published plate reconstructions. This allows us to apply plate kinematic constraints on the motion of plates, such as tracking the plate velocities that are required, and we remain consistent with the rules of plate tectonics (i.e. we do not require the problematic intra-oceanic subduction between the Australian and Indian plates along the “I-A” transform of Hall (2012)). We make seafloor age-grids and extract velocity fields for all plates, and embed our regional model into a global one that will form the framework of testing alternative scenarios using geodynamic numerical models. In addition, we provide our model in digital format that can be loaded, tested and modified by anyone using our open-source GPlates software. As a result, we believe that our contribution is a novel one, thanks to decades of research from many research groups that allowed us to make this synthesis. By making the model available to the public, it encourages others to improve the model, and establishes a community framework for improving our understanding of a very complex tectonic area. We do not claim to have solved all the problems, and we clearly flag when our interpretations can be improved. We hope that our work will prevent others from having to re-invent the wheel when making finer-scale revisions to our model, while we also encourage others to make drastic changes if they like as well – as the software and model is designed to be modular and easily changed. We hope to have stimulated debate and further work to better understand the evolution of ocean basins, the link between the Tethys and Panthalassa, and the complex interaction between the Gondwana-derived blocks with the Eurasian and Pacific active margins.

P1377. There has never been subduction at the Palawan Trench. This is an old idea from before the studies in SCS and Borneo. This concept was due to the wedge-like deformation which is mostly gravitational collapse. The subduction existed but slightly to the SE in the Present Sulu sea (Cagayan Ridge and the Borneo wedge). I believe the author know this but the phrasing of L10 (p1377) should be changed to avoid confusion.

This is an excellent point – apologies for the omission and confusion. What we meant here is that the Proto South China Sea was consumed completely along a subduction zone that followed north Borneo (presumably the proto Palawan Trench). We have corrected the text. Thanks for picking this up!

References

- Audley-Charles, M., Carter, D. J., Barber, A., Norvick, M., and Tjokrosapoetro, S.: Reinterpretation of the geology of Seram: implications for the Banda Arcs and northern Australia, *Journal of the Geological Society*, 136, 5, 547-566 [10.1144/gsjgs.136.5.0547](https://doi.org/10.1144/gsjgs.136.5.0547), 1979.
- Charvet, J., Lapierre, H., and Yu, Y.: Geodynamic significance of the Mesozoic volcanism of southeastern China, *Journal of Southeast Asian Earth Sciences*, 9, 4, 387-396, 1994.
- Cullen, A. B.: Transverse segmentation of the Baram-Balabac Basin, NW Borneo: refining the model of Borneo's tectonic evolution, *Petroleum Geoscience*, 16, 1, 3-29 [10.1144/1354-079309-828](https://doi.org/10.1144/1354-079309-828) 2010.
- Doust, H., and Sumner, H. S.: Petroleum systems in rift basins—a collective approach in Southeast Asian basins, *Petroleum Geoscience*, 13, 2, 127-144, 2007.
- Fyhn, M. B., Pedersen, S. A., Boldreel, L. O., Nielsen, L. H., Green, P. F., Dien, P. T., Huyen, L. T., and Frei, D.: Palaeocene–early Eocene inversion of the Phuquoc–Kampot Som Basin: SE Asian deformation associated with the suturing of Luconia, *Journal of the Geological Society*, 167, 2, 281-295, 2010.
- Heine, C., Zoethout, J., and Müller, R. D.: Kinematics of the South Atlantic rift, *Solid Earth*, 4, 2, 215-253 [10.5194/se-4-215-2013](https://doi.org/10.5194/se-4-215-2013), 2013.
- Honza, E., and Fujioka, K.: Formation of arcs and backarc basins inferred from the tectonic evolution of Southeast Asia since the Late Cretaceous, *Tectonophysics*, 384, 1, 23-53, 2004.
- Hutchison, C. S.: The 'Rajang accretionary prism' and 'Lupar Line' problem of Borneo, *Geological Society, London, Special Publications*, 106, 1, 247-261, 1996.
- Karig, D. E., and Jansky, W.: The proto-gulf of California, *Earth and Planetary Science Letters*, 17, 1, 169-174, 1972.
- Mammerickx, J., and Klitgord, K. D.: Northern East Pacific Rise: Evolution from 25 my BP to the present, *Journal of Geophysical Research: Solid Earth* (1978–2012), 87, B8, 6751-6759 [10.1029/JB087iB08p06751](https://doi.org/10.1029/JB087iB08p06751), 1982.
- Monnier, C., Girardeau, J., Pubellier, M., and Permana, H.: The central ophiolite belt of Irian Jaya (Indonesia): petrological and geochemical evidence for a back-arc basin origin, *Comptes Rendus de l'Academie des Sciences Series IIA Earth and Planetary Science*, 331, 11, 691-699 [10.1016/S1251-8050\(00\)01479-8](https://doi.org/10.1016/S1251-8050(00)01479-8), 2000.
- Norvick, M.: The tectonic history of the Banda Arcs, eastern Indonesia: a review, *Journal of the Geological Society*, 136, 5, 519-526 [10.1144/gsjgs.136.5.0519](https://doi.org/10.1144/gsjgs.136.5.0519), 1979.
- Oskin, M., and Stock, J.: Pacific–North America plate motion and opening of the Upper Delfin basin, northern Gulf of California, Mexico, *Geological Society of America Bulletin*, 115, 10, 1173-1190 [10.1130/B25154.1](https://doi.org/10.1130/B25154.1), 2003.
- Rangin, C., Jolivet, L., and Pubellier, M.: A simple model for the tectonic evolution of southeast Asia and Indonesia region for the past 43 my, *Bulletin de la Société géologique de France*, 6, 6, 889-905, 1990.
- Spencer, J. E., and Normark, W. R.: Tosco-Abreojos fault zone: A Neogene transform plate boundary within the Pacific margin of southern Baja California, Mexico, *Geology*, 7, 11, 554-557 [10.1130/0091-7613\(1979\)7<554:TFZANT>2.0.CO;2](https://doi.org/10.1130/0091-7613(1979)7<554:TFZANT>2.0.CO;2), 1979.
- Williams, S., Whittaker, J., and Müller, R.: Full-fit, palinspastic reconstruction of the conjugate Australian–Antarctic margins, *Tectonics*, 30, 6, 21, [TC6012, 10.1029/2011TC002912](https://doi.org/10.1029/2011TC002912), 2011.