***Interactive comment on* "The Cretaceous and Cenozoic tectonic evolution of Southeast Asia" *by* S. Zahirovic et al.**

C. Gaina (Editor)

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I. I am a bit concerned about some of your figure quality, they look a bit fuzzy, some- times too cluttered and inconsistent, and some figure captions need work.

> Figures have been improved – including their resolution and clarity, as well as the accompanying figure captions. Generally, larger font labels were incorporated and figures were reorganized, with some moved to the Supplement in order to provide a more succinct presentation of ideas.

Figure 1. General –the figure has a low resolution (for example in comparison to figure 2) , some labels are difficult to be read, please choose an appropriate font. Interpreted oceanic features: what is the criteria for showing isochrones in the Philippine Sea only, and fracture zones for the rest of oceanic area – please explain (and add a symbol in the legend for isochrones).

> Figure 1 has been improved with larger fonts for feature labels (by using abbreviations where necessary), legend labels and the graticule labels. The isochrons for the Philippine Sea Plate have been removed to reduce clutter. Thanks for the suggestions!

Figure 4 This can be replaced to a reference to previous papers that already used this methodology.

> Figure 4 and references to it have been deleted, as the Methodology already cites previous works including Seton et al. (2012) and Zahirovic et al. (2012) that followed a similar methodology.

Figure 5 Colour scales are too small; please add a white box behind them so one can read the values. The three figures on the right should have the same scale (if you want to make a point with this comparison).

> Figure 5 has been updated to plot the high-resolution Global Multi-Resolution Bathymetry and the World Gravity Map gravity anomalies. More profiles have been added to follow the Billiton Depression and Luk-Ulo/Meratus Suture through Sundaland, and even more have been added to an animation in the Supplementary Material. The gravity scale bar is common to all the profiles. However, the topography scale is different – but for a reason. The Billiton Depression does not portray the trademarks of a suture – neither in gravity or bathymetric anomalies, with a ~40 m difference to the surrounding Sunda Shelf. In contrast, the Luk-Ulo and Meratus sutures have very clear on-land geological signatures of a suture, manifest themselves as extreme topographic anomalies, and are easily traceable in the gravity anomalies of the Sunda Shelf. We hope that the accompanying figure captions clarifies this change.

Figure 6 The vertical gravity gradient doesn't show much – maybe you should try and enhance it somehow, the way it is now – the only lineaments are observed in the free air gravity (by the way, is it free air ?). You should say why you think a lithospheric scale feature is visible in the free air gravity; also please label the Billiton Depression.

> We have revamped this figure and we use the 1-min resolution gravity anomalies from the World Gravity Map (Balmino et al., 2012). We use the Bouguer gravity anomalies because we want to track the continuity of features between the emergent land and the submerged portion of the Sunda Shelf. We then band-pass the Bouguer gravity anomalies to remove small-scale features using a 150 to 10 km band (although the curvatures are observable in the free-air and unfiltered Bouguer grids), and then derive the vertical gravity gradients and gravity tilt angle derivatives using the Fast Fourier Transform tools bundled with GMT5. The message of this figure has slightly changed. Essentially, the Luk-Ulo and Meratus Suture can be traced using

the geology on Java/Borneo and followed through the Java Sea. However, the Billiton Depression does not exhibit any such traits – and seems to be largely a bathymetric feature with some relation to the “recent” Oligocene rifting in the East and West Natuna Basins, rather than being a Cretaceous-age suture.

Figure 7 I find this figure a bit misleading (as also pointed out by Rev. 1). Figure caption says: “Triassic and Jurassic fossil occurrences with coloured stars representing 24 fossil genra found on Borneo . . . Well-I can see only 2 genra on Borneo, and what is more interesting – none of the most pervasive genra that are documented on mainland (like Cladoplebis and (possible) Todites-hard to match the colours from the legend and the map. I am not sure you are making a point with this figure, I would suggest to remove it or modify it in such a way that it will be useful (and properly describes what is about).

The reason for this is because the 24 fossil genera are found from two locations on Borneo. All those coloured stars sit on top of each other, which means that it looks like only two stars (genera) are represented. We have updated this figure and replaced the two sampling locations with a generic symbol attached to boxes containing the samples collected. In total, 30 samples are collected from the two sites on Borneo, with 24 unique genera. This figure is important because it shows that at least Semitau has very strong biogeographic affinity to South China in the Triassic and Jurassic. The continuity of the post mid-Jurassic volcanic arc and Fukien-Reinan massif along the east Asian margin and into Borneo suggests that the Southwest Borneo Core is autochthonous to Sundaland since at least the Mid Jurassic. Therefore it is unlikely that the Southwest Borneo Core was an allochthon derived from Gondwana in the latest Jurassic, as proposed by Hall (2012). The figure caption and main text has also been updated to refer to the figure with more clarity.

Figure 8 Again, I do agree with Rev. 1, and I have to ask for the figure caption of figure 8 to be clarified. Oroclinal bending does not involve only rotation, and one has to specify more clearly here that is the paleomagnetic data and the SSW-NNE curved lineations seen in the gravity south (and southwest) of Borneo that are used for deriving the paleo-position and trajectory of Borneo (because there are other lineations seen east of Borneo and if taken together with the lineations S and SW Borneo they may show indeed a pattern of oroclinal bending !). Again, the lineations on the vertical derivative of gravity cannot be distinguished on the grey palette you have chosen. In addition, one cannot see the Lee and Lawver (1995) reconstructed outline-please try with another colour.

This has been a very important comment from both Reviewer 1 and the Editor. We have gone beyond our original scope and derived a true oroclinal bending model for Sundaland. We “straighten” the curvatures we observe in the gravity anomalies using GPlates, and account for ~80° CCW rotation of Borneo relative to Sundaland since the Cretaceous, consistent with paleomagnetic estimates. Following the paleomagnetic study of Fuller et al. (1999), we partition 50° of the CCW rotation between 25 and 10 Ma, that is also consistent with the onset of basin inversions in the East Java Sea basins that may signify the cessation of oroclinal bending and associated crustal stretching. We have updated our colour scale for the vertical gravity gradients, and plotted the Lee and Lawver (1995) Borneo position using a thick green outline that should be much easier to see.

Figure 9 Please indicate a legend for present day coastline (I advise to choose another colour than black), tectonic block/terrane boundaries and plate boundaries.

This was a very good point. We chose to keep the coastlines as black so they can be seen easier, but made the MORs/transforms a light green colour that is both visible and does not clash with the colour scale of the seismic tomography or the other features plotted. The coastlines themselves are cookie-cut using the “terrane” static polygons (that we include), and the coastlines are partitioned along the terrane boundaries.

Figure 10 Again – the colour palette is not very relevant! The so-called “the interior surface of the slabs” is very confusing, and the smooth transition between light orange and yellow makes it very difficult to distinguish between different slabs (at least in the MIT-P model).

> This is an unavoidable result from using the 3D rendering functionality in GPlates. No alternative depth-based colour scale can be set. However, the blue colours are useful because they indicate that a volume has been slices open and intersected at that particular depth. The colour could be more useful, but the purpose of this figure is to show the general mantle structure, and indicate deep, intermediate and shallow slabs. This figure can be moved to the Supplement if it still causes confusion.

Figure 11 You have the location of profiles in this figure as well, why referring to Fig. 10 for that? Have you used the same colour scheme for both tomographic models?

> The same colour scale was applied, because both models are presented as % perturbations from the mean P- or S- wave velocities. We no longer refer to the other figure for the profile locations.

Figure 12 Labels on lower figure (cross-sections) are too small! Please add a legend explaining the colours.

> Labels have been made to be much larger. A legend has also been added to explain the colours. Thanks for the suggestion!

Figure 13 A This is a paper that (mainly) discusses tectonic reconstructions, therefore please make an effort and be consistent! The plate IDs and colours should illustrate blocks that had an independent history at times described in the manuscript, it is a disadvantage (and distracting) to assign too many colours. I hope this can be fixed for this figure and the subsequent figures that are using the same scheme. Please reformulate the second sentence something like this: A three or four digit code (the so- called Plate ID) is assigned to each tectonic block (illustrated in this figure by different colours); these codes are used by GPlates. . .

> Figure 13 A and B have been modified to use a simplified colour-palette where the colour assignments are mostly based on tectonic affinities, rather than the semi-arbitrary/random Plate ID scheme used previously. Some distinctions did have to be made within a small region to help with visual identification – for example, distinguishing between Luzon, the East/West Philippine Arc and Halmahera.

Figure 13 B. Figure caption: Lines 12-14 –is this interpretation from this study? If not, please give reference. Line 27 – Please explain what “High resolution” means. Is this high-resolution based on data sampled at the same high-resolution?

> We removed the reference to the plate reorganization event in the Pacific as it is beyond the scope of our study, and seemed to add unnecessary confusion. Apologies regarding the “high-resolution” issue – it is just related to the quality of the supplied animation, which is clearer and larger than the reconstructions in this figure. We have changed the terminology to refer to “digital animations” instead.

Figure 15 –please make this figure Figure 1B

> We have followed your advice and made this Figure 1B, thanks for the suggestion! We moved Fig. 2 to the Supplementary Material as it does not add very much, and is largely repeating the other figures.

Figure 17A I am not sure what is the point of this figure since all these elements are already shown in Fig. 1. And I cannot see any legend for the age-coded tectonic regime.

> Figure 17A displays the regional basin names, which could not fit on Fig. 1. To remove clutter, we removed all the basin labels from Fig. 1 and refer the reader instead to Fig. 17A for the basin names.

Figure 17B. This figure should be presented before Fig. 13. The colour scheme of age-coded basins is not compatible with the ages of oceanic crust. The formation of P-IBM at 55 Ma was already postulated by Hall et al., 2003 – see comment from Figure

> Yes, you are right – the rainbow colour palette includes all the colours, including those used for colour-coding the basins. We have used an alternative age-grid colour palette to avoid this. However, we still present these close-up reconstructions after the larger-scale hemispherical-view reconstructions. We do this to allow the user to get familiar with the early history, and then introduce the more detailed regional reconstructions for a close-up. We have removed the discussion in the text related to the plate reorganization in the Pacific to reduce confusion.

Figure 18. The location of these wells (or the region shown in the inset figure) should be added on a map like the one in Figure 1 (or at least values for latitude and longitude should be visible).

> The latitude and longitude graticule labels have been made much larger. We would prefer not to provide the exact Lat/Lons because we georeferenced and digitized the well locations from Lin et al. (2003) and Yang et al. (2004), and although the georeferencing/digitization errors would be minimal, they are unlikely to represent the precise original GPS position used to create their original figures.

II. If the authors want to highlight the connection between the inception of westward subduction that led to the opening of the Philippine Sea (at 55 Ma) and the new age of Emperor-Hawaiian “bending” (that is 47.5 Ma according to Connor et al., 2013) by bringing other type of evidence to the table (not sure if Fig. 18 is also meant to help with this), then the whole argument started at page 26 has to be a bit more structured and go beyond the speculation that it has to be related to “increasing westward slab pull acting on Pacific crust 4 due to subduction at the Izu-Bonin-Mariana Trench from ~55 Ma”.

> Thanks for a very useful comment on this issue. Having consulted the co-authors, we decided to remove this discussion from the manuscript as it detracts from the main messages, and is largely beyond the scope of our work. Pure geodynamic models would need to be run in order to (at least partially) address the plate reorganization event in the Pacific. Consequently, we remove all reference to this issue from the text. Thanks for all the helpful suggestions!