Solid Earth Discuss., 6, C1212–C1222, 2014
www.solid-earth-discuss.net/6/C1212/2014/

Solid Earth
Discussions
Open Access

Interactive comment on "Future accreted terranes: a compilation of island arcs, oceanic plateaus, submarine ridges, seamounts, and continental fragments" *by* J. L. Tetreault and S. J. H. Buiter

J. L. Tetreault and S. J. H. Buiter

joya.tetreault@ngu.no

Received and published: 30 October 2014

Response to Review C472: M. Pubellier

I thank M. Pubellier for his in-depth review; the suggestions are very constructive and have truly improved the manuscript. I will first reply to the review letter below, and then to points in the supplement that need further explanation/discussion. Otherwise, if the point is not addressed, it has simply been corrected.

In the review letter, the reviewer writes:

I agree with most of the results presented in this paper but I regret a bit that the empha-

sis was a bit too much on ancient examples (except the Solomon Islands and Taiwan that has been just mentioned). The authors could give more attention to the recent examples such as Southeast Asia. I have suggested some examples (which of course are those I know well) for reference; but there are others. I am sorry to have put some references of papers for which I participated but it is just for the sake of discussion. I think some examples of recent tectonics bring elements in this interesting discussion.

The reviewer comments that my paper is quite heavy on ancient examples of accreted terranes, and I admit, now looking back on my review, that it was done so, albeit subconsciously. My reasoning for mainly focusing on ancient examples was to tie the accreted "ancient" terranes to modern not-yet-terranes (FATs) and to keep them really temporally separate. And in doing so, I unintentionally ignored examples of accretionary orogenesis. But now that it is pointed out to me, I realize it is a big oversight in the paper! I now have included examples of present-day or recent terrane accretion. I also thank the reviewer for his numerous suggestions and references for modern accretionary systems in the southeast Pacific. I have tried to supplement them with examples from other modern accretionary zones.

The reviewer also writes:

Also, I think there is the need of precising if this paper discusses tectonic accretion of magmatic accretion. The link between is only the term "accretion". Both types are discussed in the paper and well separated for each units, but I keep wondering if they are not 2 different topics.

The second main concern of the reviewer is regarding magmatic versus tectonic accretion. In writing the review, I was aiming to only discuss tectonic accretion, as the paper is about terrane accretion. I discuss magmatic accretion when I discuss each FAT group and their formation, but that was not the primary type of crustal accretion that I want to focus on. I have now made some corrections and clarified terms in the paper that I hope will remove any ambiguity. Specifically, in the first paragraph of the

Introduction, I have added “tectonic” to clarify that type of accretion in sentences that discuss magmatism and terrane accretion. And, as discussed later with one of the points in the supplement, I have rewritten the geological settings for oceanic plateaus, submarine ridges, and seamounts to remove the overabundant discussion on magmatic accretion. I hope this streamlines the paper and removes any confusion over the type of accretion we are discussing.

Figures. The reviewer suggests:

Some figures (ex Figure 2) will display morphostructures which are too small. Better have a zoom on the interesting parts. On Figure 2 “Lu” seems to refer to the Huatung basin (aCretaceous old basin). Instead the Benham Plateau; a spectacular feature should be represented (just W of the P of PKR).

For Figure 2, as recommended, I have now included a zoom-in for southeast Asia. Hopefully the Luzon oceanic arc is easier to identify now on the figure. Also, inspired by the reviewer’s suggestions in the oceanic plateau section, I have expanded the oceanic LIP map (Figure 4) to include the Benham and Urdenata plateaus. And labels that were missing on a few oceanic plateaus/submarine ridges are now rectified. The revised Figure 2 and 4 are attached, but are unfortunately shrunk by the upload service. They will be bigger in the paper.

Comments in the supplement:

P 1454 line 15. *Actually also remant arcs (and leaky transforms ?)*

I did not include remnant arcs in this statement because they are never included in the crustal thickness and volume data of the referred studies. Ben Avraham et al. (1981) do include them in their definition of oceanic plateaus, but not in their review of seismic crustal structure. Leaky transforms fall under the term “thermal swell” but I nonetheless have added them to the list in the sentence.

P 1454 line 28. *Is size and geometry of the docking terrane a parameter. Seamount*

SED

6, C1212–C1222, 2014

Interactive Comment

seem to be able to subduct without any problem, same story with the small crustal fragments (ex: Sumba; Fleury et al., 2009)Fleury, J.M., Pubellier, M., Urreitztieta, M., 2009. Structural Expression of forearc crust uplift due to subducting asperity, Lithos 113, (2009), p318-330

I am not aware of any analytical study where the geometry is considered, but I definitely believe that it is important. The size of the terrane, of course, plays a part in the buoyancy analyses by Cloos (1993) and Molnar and Gray (1979), as I state in that sentence. While seamounts often do subduct, leading to earthquakes and accretionary prism uplift (well documented in Japan), it is possible for small seamounts to also accrete. I discuss the "decapitation" of small seamounts in Section 4.3. In the study by Cloos (1993), he ascertained that seamounts smaller than 3 km in volcanic core will most likely subduct or become incorporated in the accretionary prism, and in that case become an accreted terrane.

P 1456 line 20. *you may want to cite papers from Wakita and other (OPS- Ocean Plate Stratigraphy)*

New reference incorporated.

P 1457 line 5. *Beautiful example in Borneo wedge; Sapin et al. (2011) Sapin, F., Pubellier, M., Lahfid, A., Janots, D., Aubourg, C., Ringenbach, J.C., 2011, Onshore record of the subduction of a crustal salient: example of the NW Borneo Wedge., Terra Nova, 00, 1–9, 2011, Blackwell Publishing Ltd, doi: 10.1111/j.1365-3121.2011.01004.x*

Wonderful example, reference incorporated!

P 1457 line 28. *Is there really a difference? In geodynamic concepts, collision does not really exist; it is always a subduction affecting either sediments (over a shallow decollement) or layers within the crust (as you state correctly further)*

I think there was significant confusion over this statement from both reviewers, so I have amended the paragraph to state that docking commonly occurs with collision but can also occur during accretionary orogenesis (where subduction continues).

P 1458 line 7. *Yes in this specific case. In a more general way, it may depend on the vergence of the origina thrust; in the Molucca Sea , where 2 arcs are "colliding"; we observe the actually one of the arcs subducts beneath the other one. Since the shortening is diachronous, we see that part of the subducted arc (terrane) is actually back thrusted on the uuper plate. see if you wish: Pubellier et al., (1996) Pubellier M., Quebral R., Aurelio, M., Rangin, C., 1996. Docking and post-docking tectonics in the southern Philippines. R. Hall and Blundel, D., (eds). "Tectonic Evolution of SE Asia", Geological Society, Sp. Publication 106, 511-523*

Arc-arc accretion is probably best discussed in the composite FAT section, so I have incorporated the Philippine arc-arc collision as well as other modern examples of composite FATs there.

P 1463 line 3. *As mentionned above, this is the case for Taiwan and for Timor, but not the general case, which is a contnental sliver such as the Palawan/luconia sliver, the Sulu so-called arc, the Banda ridges, the North Arm of sulawesi in SE Asia, but also for Cuba or from the Bahama platform...*

These examples suggested by the reviewer, and my own example of the Luzon arc, would be best fit under arc-continental fragment collision. And as the reviewer points out, the frequency of this type of accretion is more than arc-continent collision. I have included these examples in the “Island arc: accreted examples” section and note their importance in the section “Composite terranes”.

P 1463 line 21. *See also the comparison between the CAOB and SE Asia by Wakita et al. 2013*

Included reference and new statement.

P 1465. *I think there is the need of precising if this paper discusses tectonic accretion of magmatic accretion. Both types are discussed in the paper. If the authors address*

SED
6, C1212–C1222, 2014

the tectonic accretion, the LIP such as the Otong Java Plateau or the Benham Plateau are also good examples since they have been involved in subduction/accretion context after they have been created.

This paper is about terrane accretion, and therefore tectonic accretion not magmatic accretion. In this section I perhaps expound too much on the historical journey of the oceanic plateau term and the debate over how oceanic plateaus are formed, and that has led to the confusion over tectonic versus magmatic accretion. Magmatic accretion is not crucial to the crux of the paper, so I have edited and severely refined this section so it has less tangential discussions. I hope by cutting and rewriting this section I have made it less confusing. I include the rewritten section in the supplement.

P 1472 line 10. *Again most of the examples that have been discussed above are in fact in old systems. More atention should be given to Benham Plateau, Otong Java Plateau, Morotai Plateau and to the almost plateau regions such as the Roo Rise in front of Java... or complex structures such as the Ninetyeast ridge in Myanmar*

I added modern examples of accretion and subduction from the Roo Rise, Hikurangi Plateau, Ogasawara Plateau, and Benham Plateau.

P 1472 line 25. *The detachment is also located between the Sheeted dyke complex and the Gabbros, leaving the basalti units tectonised (Haiti) and the gabbros on the sea floor (Beata Ridge, if I remember correctly)*

The reviewer is referring to the Caribbean oceanic plateau. My original sentence is about the Colombian accreted plateau (sometimes called the Gorgona plateau), which might be a separate oceanic plateau from the Caribbean plateau (Kerr and Tarney, 2005), or just older magmatic additions of the Caribbean plateau so I am trying to leave it ambiguous. I added a statement about shallower detachments for the Caribbean plateau and other oceanic plateaus.

P 1473 line 11. *Also often exhumed Mantle between the continental fragment and the*

SED

6, C1212–C1222, 2014

continent (Peron Pindivic/Manatschal, Savva et al., 2012)

Yes, there is exhumed mantle in some of the basins between continental fragments and the mainland, good point! Unfortunately I could not find many published references, so I only added examples from the Porcupine basin, Santos, and the Phu Khanh basins.

P 1475 line 13. *These examples are taken in old orogens. See subduction jumps and reversals for example in Pubellier et al., 2003). Pubellier, M., Ego, F. Chamot-Rooke, N., Rangin, 2003. The building of pericratonic mountain ranges: structural and kinematic constraints applied to GIS-based reconstructions of SE Asia. . Bull Soc Geol France, 174, 6, pp561-584*

I added modern examples of continental fragment collision, accretion, and subduction in a paragraph at the end of this subsection.

P 1477 line 18. *In the accretion process; It may be that the post docking has a lot of effect. After the tectonic accretion or docking, there is often a slab detachement. This creates adiabatic decompression and tremendous uplift with post subducton magmatism (example in the Malay - Sibumasu Terrane, See Metcalfe's papers) and often with NEB or Adakites. Can these facts bring a change in the final composition of older orogens?*

Yes, I was definitely alluding to post accretion/collision magmatism. I added a sentence for post-collision adakite/granite emplacement. In addition, I added a paragraph about post-collision magmatic modification in the "From FAT to accreted terrane" section.

P 1478 line 20. *Again refer to the post-collision magmatism due to slab detachement (Borneo-Mt Kinabalu, or Subumasu Terrane).*

I have added a statement that slab detachment allows for exhumation of these UHP terranes.

P 1479 line 29. *See Pubellier and Meresse (2013) last figure for discussion. Pubellier, M., Meresse, F., 2013, Phanerozoic Growth of Asia; Geodynamic Pro-*

SED

6, C1212–C1222, 2014

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

cesses and Evolution. Journal of Asian Earth Sciences, 72, pp. 118-128, DOI-10.1016/j.jseaes.2012.06.01

Figure 12 of Pubellier et al., 2013 is a wonderful example of subduction zone "jumping" due to delamination at the Moho of the incoming FAT. I would also like to direct the reviewer to Tetreault and Buiter, 2012, "Geodynamic models of terrane accretion: Testing the fate of island arcs, oceanic plateaus, and continental fragments in subduction zones" JGR, 117, B8, where we use numerical experiments to show that detachments at the lower crustal level will lead to similar scenarios. Based on our previous geodynamic experiments, we are in agreement with the model of Pubellier et al., 2013.

Furthermore, I believe the reviewer is pointing out the possible influence of mantle flow as the FAT detaches from the lithospheric slab. This is a good point and I included it in this paragraph.

P 1479 line 25. *In Island arc, the weakness comes from the hot geotherms in the central part of the arc, on the apex of the magma chambers. This is where shear partitioning also takes place for the same reasons*

The heat flux of oceanic island arcs is variable when considering if they are active, extinct, or back- or fore-arcs. That said, I agree with the reviewer in that the elevated geotherms of island arcs are important variables when considering factors leading to accretion and should have included that in my discussion. I have now amended the paragraph to include it.

Once again, my coauthor and I would like to thank M. Pubellier for his thorough and thoughtful review! We agree that the addition of modern examples of terrane accretion was sorely missed in this review paper and now will improve the final version greatly.

Sincerely,

Joya Tetreault

Please also note the supplement to this comment:
http://www.solid-earth-discuss.net/6/C1212/2014/sed-6-C1212-2014-supplement.pdf

---

Interactive comment on Solid Earth Discuss., 6, 1451, 2014.

SED

6, C1212–C1222, 2014

Interactive Comment

TETREAULT: TERRANE ACCRETION 25

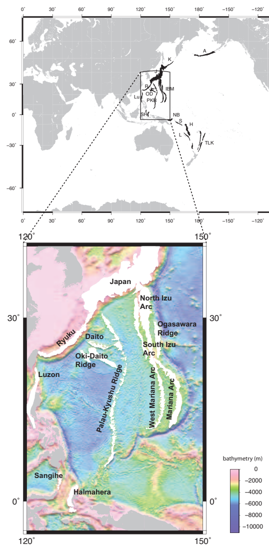

Fig. 2. Global location map of island arcs (shown in black) on the present day ocean floor. Arc systems labelled on the map are: A - Aleutians, H - New Hebrides, IBM - Izu-Bonin (Ogasawara)-Mariana arc system, J - Japan Arc, K - Kuril Arc, L - Loyalty Arc, LA - Lesser and Leeward Antilles, Lu - Luzon Arc, OD - Oki-Daito system, PKR - Palau-Kyushu Ridge, NB - New Britain Arc, R - Ryukyu Arc, S - Solomon Arc, SH - Sangihe-Halmahera arc system, SS - South Sandwich Arc, and TKL - Tonga-Lau-Kermadec arc system. Below is a zoom in of the numerous oceanic island arc systems (in white) in southeast Asia, with bathymetry from ETOPO 1 (Amante and Eakins, 2009)

Fig. 1. Figure 2

TETREAULT: TERRANE ACCRETION 27

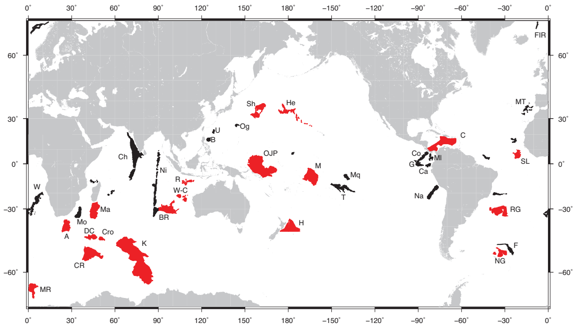

Fig. 4. Location map of oceanic plateaus (shown in red) and submarine ridges (shown in black). Updated from LIP list of Coffin and Eldholm (1994) based on the definition of Bryan and Ernst (2008). Oceanic plateaus and submarine ridges labelled in the figure are: A-Agulhas Plateau, B - Benham Rise, BR - Broken Ridge, C - Carribean Plateau, Ca - Carnegie Ridge, Ch - Chacos-Laccadive Ridge, Co - Cocos Ridge, CR - Conrad Rise, Cro - Crozet Bank, DC - Del Cano Rise, F - Faulkland Ridge, FIR - Faroe-Iceland Ridge, G - Galapagos Ridge, H - Hikurangi Plateau, He - Hess Rise, K - Kerguelen Plateau, M - Manihiki Plateau, Ma - Madagascar Ridge, Ml - Malpelo Ridge, Mo - Mozambique Ridge, Mq - Marquesas Ridge, MR - Maud Rise, MT - Madeira-Tore Rise, Na - Nazca Ridge, Ni - Ninetyeast Ridge, NG - Northeast Georgia Rise, Og - Ogasawara Plateau, OJP - Ontong Java Plateau, R - Roo Rise, RG - Rio Grande Rise, Sh - Shatsky Rise, SL - Sierra Leone Rise, U - Urdenata Rise, T - Tuamotu Plateau, W - Walvis Ridge, and W-C - Wallaby Plateau and Cuvier Plateau.

Fig. 2. Figure 4

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper