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Solid Earth Discussions

Interactive comment on "Three-dimensional thermal structure of subduction zones: effects of obliquity and curvature" *by* A. K. Bengtson and P. E. van Keken

A. K. Bengtson and P. E. van Keken

keken@umich.edu

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Dear anonymous,
Thank you for your comments and questions. We have improved the manuscript following your suggestions. For your last comment we have only a partial answer. We provide some detail about this below.
Peter van Keken and Amy Bengtson

The authors state in the introduction that 2-D models have generally been fairly successful at predicting slab surface temperatures inferred from geochemical observations, citing papers such as Plank et al., 2009, Skora and Blundy, 2010, and Cooper

et al. 2012. Given that their example model run matches the geometry of the Mariana subduction system fairly well, I wonder if they might be in a position to comment specifically on whether their 3D Mariana model yields an estimate for slab surface temperature(s) that is closer to what is inferred from geochemistry. I'm not sure whether any of the cited references have a slab temperature estimate for the Marianas, but at least one appears to be a global study, so perhaps. It would be interesting if the authors could specifically document whether their 3D model yields an estimate that is closer than previous 2D models (for example, the model of Syracuse et al. 2010 mentioned in the paper) for this region.

This is a wonderful question – it would be very nice if the prediction we make for the Marianas could be verified. We were only recently made aware of one set of data for the Northern Marianas, where we predict the temperature differences (due to 3D effects and oblique convergence) to be largest. Using Hf isotope data, Tollstrup and Gill suggested the temperature of the slab below the arc is higher than the wet sediment solidus (650C) but lower than 705-780C. Our 2D results are too hot for this (800C), but our 3D model provides temperatures below the arc that are in better agreement with these constraints (720-740C). We have added a paragraph discussing this constraint. The Mariana data in Cooper et al., G3, 2012, are limited to the central islands (Sarigan to Agrigan). At those the predicted differences between 2D and 3D are quite small, particularly for the oblique convergence case (Figure 7b). The 2D models predict a slab surface temperature that is approx. 50 degrees cooler than the best estimates from the H2O/Ce thermometer (Figure 9 in Cooper et al., G3, 2012) but this is somewhat uncertain due to the definition of depth to slab below the volcano (which gets more uncertain with steeper dipping slabs). Unpublished work comparing the details of the arc lavas with model predictions using the Arc Basalt Simulator (e.g., Kimura et al., G3, 11, Q10011, 2010) also suggest good agreement when the (updated) Syracuse et al. models are used, but these are again not diagnostic in determining the 2D vs. 3D results.

While it's not directly related to this question, we'd like to point out that the model results published in Syracuse et al. (2010) suffered from an error in the input boundary condition of the slab for old slabs (such as the Marianas). We have self-published correct profiles in http://www.earth.lsa.umich.edu/ keken/subduction/global_comparison/ .

Interactive comment on Solid Earth Discuss., 4, 919, 2012.