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Physical constraints by different arc extension regimes. Intraoceanic arc-trench system: an approach with numerical modelling

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Since most of the modern intraoceanic collision zones have an extension, it is important to understand how and where the extensions are created and what the decisive factors are. Why is there no extension in certain subductions zones? Why can basins with a thin crust be observed, while in other places the crust spreads and a new magmatic arc is produced? What is the involvement of slab fluids and melt production in the mantle wedge for the extension process? In order to answer these questions we performed systematic numerical experiments with a 2D coupled petrological-thermo-mechanical numerical model of an intra-oceanic subduction process. Over time, part of our numerical models developed a spontaneous slab retreat associated with following flattening of the slab angle, and therefore an extension of the overriding plate and formation of a new spreading center. Our results indicate that weakening effects from subduction related melts play a major role in defining where the extension is localized: in the for-arc, the back-arc or within an arc. According to the general trend the stronger the weakening is, the more the extension shifts toward the back-arc direction. The intensity of the forearc weakening by slab derived fluids also plays a notable role: if such weakening is insufficient two plates are strongly coupled which results in a compressive subduction without the overriding plate extension.

If we compare the different extension types in our models with observations in nature, we observe a good agreement. For example in nature, intra-arc extension may split initially homogeneous arc in two distinct parts such as the active Mariana arc and the inactive West Mariana Ridge and create thin oceanic crust in the middle like the Mariana Trough, similar to our experiments. In this way observations based on seismic images of the Izu-Bonin-Mariana arc crust and mantle structure can be simulated with our model. For example, the first arc with no back-arc rifting (Kyushu-Paulau Ridge) in Izu-Bonin-Mariana system grew 10 Ma after subduction started (our model needs 5 to 7Ma). The extension within the Miocene Mariana arc divided 10 to 14 Ma later in two arcs, as we discribed above (our model produce after 12 to 14 Ma a back arc). Comparing the crustal growth in the IBM-system with our model, we assess the results to be close to what is described in literature. Arc crustal thickness in both cases (model and West Mariana Ridge, Mariana Arc) is about 15-20 km (Moho boundary).