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Arc Evolution in Response to the Subduction of Buoyant Features

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The subduction of buoyant features such as aseismic ridges or oceanic plateaux has been invoked to explain arc deformation, flat subduction and increase in seismic coupling. Other studies have challenged these ideas, attributing a larger role to the overriding plate. However, many open questions remain about the dynamics of the relative simple case of a single freely subducting plate. How big does a plateau need to be to change the arc shape? What is the control of plate's strength on the impact of buoyant features? How do the velocities adapt to the subduction of less dense material? In the present study, we propose a systematic approach in order to tackle these questions. We use a new 3-D coupled fluid-solid subduction model where the interaction between the slab and the isoviscous mantle is only calculated on the slab surface, significantly increasing computational efficiency. The oceanic plate rheology is visco-elasto-plastic and its top surface is free.

We find that arc shape is significantly altered by the subduction of buoyant plateaux. Along the subduction plane through the plateau and depending on its size, the dip angle and the retreat velocity significantly decrease. Flat subduction is obtained in the case of large and strongly buoyant plateau/ridge. An interesting feature is that retreat velocity increases right after the plateau or ridge has finished subducting in order to catch up with the rest of the plate. The gradient in retreat velocity obtained along the trench may cause the slab to have a heterogeneous response to ridge push, eventually leading to slab advance where buoyant material is present. We apply our models to the Izu-Bonin-Marianas (IBM) trench and propose that subduction of the buoyant Caroline Island Ridge at the southern edge of the Mariana trench can explain both trench motion history and the current morphology of the IBM slab as imaged by seismic tomography.