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The Fate of Subducting Crust: Controlling Dynamics and the Emplacement of Magmatism

Nicholas Schliffke (1), Jeroen van Hunen (1), Valentina Mangi (2), and Mark Allen (1)

(1) Durham University, Earth Sciences, Durham, United Kingdom (nicholas.j.schliffke@durham.ac.uk), (2) Centre for Earth Evolution and Dynamics (CEED), University of Oslo, SemSaelandsvei 24, PO Box 1048, Blindern, NO-0316 Oslo, Norway.

Large scale continental collision ceases most subducting systems due to a vast number of interacting processes and forces, of which many remain ambiguous. However, the entrance of the continent with its highly buoyant crust is clearly one of the major components changing the subduction dynamics. Thus, the fate of the continental crust and its final emplacement will determine the lithosphere and mantle processes to a large extent. Magmatism is a possibility to provide unique insight into such underlying dynamical and chemical processes. Particularly in continental collision zones, where small amounts of magma with a diverse composition are produced, it is a valuable indicator of temporal and spatial processes, and hence, can help validate dynamical models.

Observed locations of the subducting continental crust, as well as magmatism, differ in present-day collision zones: the Indian continental crust has partially been placed below Eurasia during their recent collision, accompanied by northward migrating post-collisional magmatism. In contrast, the subducting crust in the Alps seems to have been emplaced close to the previous subduction channel. Thereby, only minor post-collisional magmatism scattered within the collision zone is observable at the surface.

In this study, we develop numerical models that can provide new insight into this topic, by combining previously developed 2D geodynamical models with thermodynamical databases and software. With this approach, we are able to trace both the location of subducting crust as well as the temporal and spatial evolution of various mantle and crustal magmas within arcs during subduction and the subsequent continental collision. We vary the continental buoyancy and the age of the subducting slab to study the effect on position of subducting crust and the degree of melting. The results suggest the angle of the subducting slab at the point of delamination controls whether the delaminated crust is emplaced within the subduction channel or underplates the overriding plate. The amount of crustal melts is larger in the latter case and the melts are laterally emplaced up to 300 km away from the trench position where the crust is exposed to increased heat. Small amounts of melts are also created in the scenario with relamination of continental crust into the subduction channel due to decompression melting.