Slabitization: mechanisms controlling subduction development and viscous coupling

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This study investigates mechanisms controlling subduction development and stabilization over time (coined as 'slabitization'), from a nascent slab to a mature slab viscously coupled to mantle convection, from grain scale to plate tectonics scale. Beneath ophiolites, frozen-in portions of the subduction plate interface with both sides still preserved allow characterizing the evolution, shortly after subduction initiation, of mechanical coupling, slab penetration and mantle wedge metasomatism. Combining structural field work, mineralogical and crystallographic data, thermodynamic modelling and geochemistry from/on both sides of the plate interface, i.e. the base of the mantle wedge (basal peridotites) and crustal fragments from the slab (metamorphic soles), we track the evolution of the interface with progressive localization of strain and fluid transfer, from 1.2-0.9 GPa 900-750°C to 0.7-0.5 GPa 750-600°C. The neo-formed minerals, enrichment in FMEs and isotopic signatures show that the mantle base was infiltrated by slab-derived fluids migrating at ~1-10 m/a. Coeval deformation and reactions in slab metabasalts reveal the importance of mineral changes and deformation modes in controlling fluid delivery, detachment and accretion of successive slab slices to the mantle. This study documents how the interplay between metamorphic reactions, fluid/melt transfer and deformation mechanisms, particularly dissolution-precipitation creep (DPC), progressively stabilize the plate interface: (i) suppression of fluid transfer and DPC at depth triggers the onset of viscous coupling. This first occurs near ~ 30 km depth during subduction infancy and leads to sole formation; (ii) with increased cooling and fluid availability, strain localization develops downwards and unzips the subduction interface. The downward migration of viscous coupling triggers localized mantle wedge upwelling, leading to short-lived suprasubduction ophiolite or forearc lithosphere formation; (iii) the locus of viscous coupling stabilizes near ~80-100 km in mature (and cold) subduction zones, and sets mantle counterflow after ~10 Ma. This is where and when plates get reattached and slabs become part of the mantle convection system.

Mots-Clés : subduction initiation; rheology; viscous coupling; ophiolite; metamorphic sole