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Subduction, serpentinization at deep-sea trenches and the Earth's water cycle

Ingo Grevemeyer (1), Lars Ruepke (1), and Cesar R. Ranero (2)

(1) GEOMAR Helmholtz Centre of Ocean Research, RD4 - Marine Geodynamics, Kiel, Germany (igrevemeyer@geomar.de), (2) Barcelona Center for Subsurface Imaging, Instituto de Ciencias del Mar, CSIC, and ICREA, Barcelona, Spain

The subducting ocean lithosphere may carry large amount of chemically bound-water into the deep Earth interior, returning water to the mantle, facilitating melting and hence keeping the mantle mobile, in turn, nurturing plate tectonics. Bending-related faulting in the trench-outer rise region prior to subduction has been recognized to be an important process, governing the return flux of water into the mantle. Thus, extensional faulting in the trench-outer rise is opening pathways into the lithosphere, promoting hydration of the lithosphere, including alteration of dry peridotite to water rich serpentine. In this paper, we review and summaries evidence for supporting that bending-related faulting is indeed a key process in the global water cycle. Two features are found in a world-wide compilation of tomographic velocity models derived from seismic refraction data, indicating that ocean lithosphere is modified when approaching a deep-sea trench: (i) seismic velocities in both the lower crust and upper mantle are significantly reduced compared to the structure found in the vicinity of mid-ocean ridges and in mature crust away from subduction zones; (ii) along profiles approaching a trench, both crustal and upper mantle velocities decrease systematically with decreasing distant to the trench, highlighting an evolutionary process as velocity reduction is related to alteration and hydration. P-wave velocity anomalies suggest that serpentinization at trenches is a global feature of subducting oceanic plates older than 10-15 Ma. However, the amount of water trapped within the uppermost mantle and carried into subduction zones depends on how serpentines are distributed in the upper mantle. Thus, estimates of bulk upper mantle hydration would be reduced from $\sim$3.5 wt% of water to as low as $\sim$0.3 wt% by assuming that reduction of seismic velocitiy results from serpentinized joints. In addition to observations on the state of hydration of the incoming plate, we will evaluate the fate of subducted water carried into subduction zones and its release in the "subduction factory".