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Subduction of water through the evolution of Earth

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The deep water cycle is crucial for the evolution of Earth and continental crust formation. A key question for the habitability of Earth is how the balance between subduction and output of H_2O in arcs, OIB and MORB has been maintained over 4 Gyr.

H_2O uptake in oceanic crust occurs through hydrothermal alteration. A further key process is the bending of subducted plates that facilitates hydration up to 20 km depth of the subducted lithospheric mantle. Water liberation is dictated by the stability of hydrous phases with respect to subduction geotherms. Despite a regime of cold subduction (7-9 °C/km) hydrous phases close to the top of the slab dehydrate mainly at depth ≤ 150 km, triggering wet melting of the mantle wedge and crust formation. Because of colder geotherms in the interior of the slab, serpentine in hydrated subducted lithospheric mantle can transfer H_2O to hydrous phase A that is stable to the deeper mantle. Cold and fast subduction zones like Tonga dominate slab budgets of H_2O transfer by hydrous phases, with the possibility that transport to the deep mantle is greater than outgassing at arcs. Water transport in nominally anhydrous minerals (NAMs) is less sensitive to top slab temperatures, increases with increasing pressure and temperature and dominates the water budget in hot slabs.

In the Archean, hotter conditions during subduction/underthrusting caused dehydration of hydrous phases at lower pressures, resulting in wet melting of mafic rocks leading to TTG formation. Water transport to the deep mantle is dominated by clinopyroxene in subducted mafic crust and olivine and orthopyroxene in ultramafic rocks. Estimates of integrated H_2O in NAM's to the deep mantle is similar to MORB output, indicating a long-term balance between ingassing and outgassing of the mantle.

For constraining the evolution of H_2O recycling through the evolution of Earth it is therefore critical to determine the onset of cold subduction. We will present a novel method how H_2O/Zr contents in detrital rutile can be used as a new proxy in the sedimentary record to track the onset of cold subduction on Earth and its impact on the deep water cycle.