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Rutile as a tracer of subduction zone conditions

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Rutile is a common accessory mineral in subducted oceanic crust and its trace element geochemistry is frequently used to investigate subduction zone processes. To understand the evolution of subduction on Earth, sedimentary equivalents of missing Precambrian low-T high-P metamorphic rocks can be investigated. This requires the estimation of pressure, temperature, time of formation, and source lithologies (P-T-t-X) on detrital single grains. As rutile is one of the most likely minerals from subduction zone rocks to survive sedimentation, and single grain T-t-X estimates are possible, it is a prime candidate for the investigation of subduction processes through time.

We present results from in-situ quantitative Fourier Transform Infrared (FTIR) spectroscopy of metamorphic rutile from various P-T conditions and bulk rock compositions that indicate a pressure dependence of H_2O in rutile.

H_2O contents in rutile vary between < 10 µg/g in granulite facies rutile up to ~2500 µg/g in blueschist- and low-T eclogite facies rutile. Rutile from low pressure samples have H_2O contents of < 400 µg/g, while rutile formed at higher pressures contain higher amounts of H_2O. At temperatures < 600 °C, a trend of higher H_2O contents in samples reaching higher peak pressures is identified. Samples with higher peak temperatures > 600 °C do not follow this trend, showing evidence of diffusive H^+ loss in FTIR maps of H_2O in rutile.

The substitution of H^+ and trivalent cations (e.g. Fe^{3+}, Al^{3+}) is linked, and as subducted oceanic crust is saturated in Fe and Al, the incorporation of H^+ into rutile in these lithologies should depend only on H_2O fugacity. As H_2O fugacity is pressure dependent, H_2O contents of rutile increase with increasing pressure. This pressure dependence of H^+ in rutile could aid in tracing modern-style cold subduction in the sedimentary record.

Rutile from mafic rocks, with Zr contents < 150–200 µg/g, and H_2O contents > 500 µg/g are interpreted to be derived from high pressure rocks related to modern-style cold subduction.

Evidence from fluvial, detrital rutile suggests that this signature can be retained during sedimentation processes, opening the possibility of finding high-P signatures in detrital rutile.