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Rutile geochemistry and its potential use as a petrogenetic tool

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The timing of onset of modern plate tectonics is currently in conflict. Some believe that it began in the Archaean and others the Neoproterozoic. At issue is the lack of reliable recorders of changing styles of subduction. Whilst high-pressure rocks are present from Archaean times, low-temperature, high-pressure rocks only appear in the Neoproterozoic. This latter association is the hallmark of steep subduction of cold oceanic crust and is central to the argument. Their disappearance from the rock record older than c.600 Ma may be a matter of preservation potential. We intend to investigate this question by the novel use of detrital rutile.

The intimate link between rutile formation and plate tectonics calls for a closer investigation of rutile geochemistry, including minor and trace element compositions and isotopic signatures. Research now focuses on relating geochemical signatures of rutile to the P-T-X conditions of its host rock and, hence, to the plate tectonic setting of its formation. Guided by the improved geochronologic constraints, rutile can than be used to recognise tectonic processes on the early Earth and to investigate secular changes in these processes. One category of typical protoliths that produce rutile includes basalts and gabbros in the oceanic crust, where rutile is formed during subduction. In modern subduction zones along a very low P/T gradient, rutile forms at $\sim$1.3 GPa and 400–500ºC in the blueschist facies. Modern continental subduction will produce medium to high-T eclogite with rutile equilibrated at 600–800ºC, while the collision of large continental blocks generates medium to high-P granulites formed at 800–1000ºC.

One of the other major causes of rutile growth in the crust is in hydrothermal settings and therefore we need to determine how to distinguish hydrothermal rutile from high-P metamorphic rutile. Our sample-set from Syros contains hydrothermal rutile in addition to high-P and our initial trace element studies demonstrate that mobile metals such as W, Sb and Sn are concentrated in hydrothermal rutile and, hence, are a potential first order discriminant. Oxygen isotope studies will further characterise such hydrothermal rutiles from Syros and other settings such as the Sesia Lanzo. Mantle rutiles, such as in the MARID association, are considered a minor input into the crust and are characterised by extremely high Cr contents and hence should be easily distinguished. We will then be in an ideal position to take detrital rutiles that sample unknown orogenic belts and reconstruct the tectonic evolution of the high-pressure setting of the rutiles.