Modern-style plate tectonics controls the preservation of new crust during supercontinent assembly

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Much of what currently is known about the secular evolution of Earth's continental crust and its links to plate tectonics has been recovered from detrital minerals. This is profoundly related to the rather incomplete rock record; the detrital record allows access to information from eroded and unexposed terrains. Zircon has been the most studied mineral, as it is physically and chemically robust and contains a multi-isotopic toolkit. Notably, the distribution of detrital zircon ages has been linked to supercontinent cyclicity, and Hf and O isotopes have been used to estimate crustal growth rates. Despite the coincidence of peaks in the distribution of the U-Pb crystallisation ages of detrital zircon with the development of supercontinents, it is still unclear if this reflects episodic continental growth or bias due to selective preservation of new crust within collisional orogenic belts. To better understand this conundrum, another mechanically and chemically robust mineral that records collisional tectonometamorphic processes is required. Thus, we interrogate the detrital record of the mineral rutile, which can be used as a fingerprint for collisional orogenesis.

We collected U-Pb and trace element data from detrital rutile within two clastic sedimentary units, preserved at sub-greenschist facies conditions in NW Scotland. These are the Torridon and the Ardvreck groups, whose detrital zircon ages span a significant period between 3 and 1 Ga. We combine our new data with the global compilation of detrital rutile and zircon age distributions to explore linkages between these complementary records.

While zircon mostly records high temperature episodes during magma formation, rutile records metamorphic events by crustal thickening, in a range of P-T metamorphic conditions. Zircon and rutile age distributions show a significant correlation, both peaks and troughs, that can only be reconciled if, indeed, the detrital zircon record reflects a preservation bias that occurred during supercontinent assembly. Furthermore, by applying Zr-in-rutile thermometry to a subset of the detrital rutile data, we show that both low and high dT/dP conditions can be inferred since at least 1.7-2.0 Ga. This implies that one sided subduction, an hallmark of plate tectonics, has been operating since at least the Paleoproterozoic.