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Single grain detrital rutile U-Pb chronology: a key provenance tracer

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Rutile is an accessory mineral commonly found in the heavy mineral suite of detrital rocks due to its stability during the sedimentary processes. This mineral originates mainly in medium- to high-grade metamorphic and some igneous rocks and similarly to zircon and other U-bearing minerals can be dated by the U-Pb method. Nevertheless, there are still very few applications of U-Pb dating of rutile to provenance studies, likely because it usually has a lower U content compared to zircon (which in turn leads to lower radiogenic Pb content limiting measurement quality) and it can contain a relatively large proportion of common (non radiogenic) Pb. In addition, there is a scarcity of widely available good quality natural rutile reference materials that can be used to assess reproducibility and accuracy of the dating technique.

We have addressed these issues and characterized two $\sim$ 1.8 Ga rutile reference materials (namely Sugluk-4 and PCA-S207 from granulite facies belts of the Canadian Shield) by SEM, trace elements, U-Pb ID-TIMS, and intra-grain and inter-grain U-Pb LA-MC-ICP-MS analysis. LA-U-Pb data (n $\sim$ 500 for each of the two reference materials, collected using a New Wave Research 193 nm wavelength laser ablation system coupled to a Nu Plasma HR mass spectrometer) have a reproducibility of ^{206}Pb/^{238}U and ^{207}Pb/^{206}Pb of $\sim$2–4% (at the 2σ level), which is only modestly worse than long-term data for multiple zircon standards, this being due to the real variation in measured values arising from limited Pb loss, age variation related to cooling, and common Pb variability. The analytical measurement of rutile U-Pb data is rapid, allows high spatial resolution (the laser sampling protocol employs a 50 or 35 μm static spot) and does not include common Pb correction [1].

We have applied our refined method to constrain provenance of rutile from modern drainages from British Columbia and the eastern Himalaya (with rutile ages as young as $<$1 Ma), and from the paleo-Brahmaputra deposits (Bengal Basin, Bangladesh; Bracciali et al., this meeting). Using a 35 μm static spot, our method successfully dates $>$75% of all rutile grains in a sediment; unsuccessful analyses are due to poor quality rutiles with massive common Pb and/or U contents $<$1ppm. Rutile has a $\sim$ 500^{o}C closure temperature for Pb diffusion and thus records mainly the time since the last significant metamorphism or cooling below $\sim$500^{o}C. In sedimentary provenance, rutile has therefore the potential to become a key provenance tracer as it adds an important lower temperature complement to zircon analysis or in general to other radiometric dating methods sensitive to different temperature ranges. Indeed, multiple dating methods applied to detrital mineral grains from the same sample comprise a much more unique isotopic fingerprint of the source region, and allow more confident identification of source areas or reconstruction of basin depositional histories.

[1] Bracciali L., Parrish R.R., Condon D., Horstwood M.S.A., Najman,Y., U-Pb LA-(MC)-ICP-MS dating of rutile: new reference materials and applications to sedimentary provenance, under review in Chemical Geology.