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Deciphering sedimentary recycling via multiproxy *in situ* analyses

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Sedimentary rocks and modern sediments sample large volumes of the Earth's crust, and preserve units that vary greatly in age and composition. Determining the provenance of component minerals is complicated by the ability of some minerals to be recycled through multiple sedimentary cycles, so minerals from completely unrelated sources may end up in the same sedimentary basin. To untangle these multi-stage signals, two or more chemical signatures measured in minerals with different stabilities are required. For instance, labile minerals, such as feldspar, can break down rapidly during sedimentary transport, while more robust minerals, such as zircon, can survive multiple weathering cycles. Other minerals, including apatite, are especially sensitive to acidic weathering at source and during storage, transport and diagenesis, and may be indicative of environmental change [1]. Differences between the records preserved in each mineral will therefore provide insight into the secular evolution of sedimentary systems.

One sedimentary succession suitable for testing these hypotheses is the Upper Carboniferous Millstone Grit Group, a fluvio-deltaic, upward-coarsening sequence of mudstones, sandstones and conglomerates deposited in the Pennine Basin of northern England. New data from throughout this sequence clearly indicate two main feldspar populations, consistent with previous work [2], but also a minor third group which may represent an additional source. Since K-feldspar grains of similar ages typically describe overlapping domains on a $^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ plot, the addition of U–Pb and Hf measurements in refractory zircon and apatite from the same sediments may help to discriminate between possible source areas.

Previous zircon U–Pb analyses from two units within the sequence have identified three main zircon populations at c. 500, 1000–1800 and 2700 Ma, with the proportion of young to old ages increasing up section [3]. New data from the rest of the sequence indicate the 1000–1800 Ma population is the least persistent, and may indicate variations in the availability of this material in the source area, or dilution from alternate sources. New zircon Hf isotope measurements indicate ϵHf_i values between -19.2 and +4.5, with the most evolved material found only at the bottom and top of the sedimentary sequence. The combination of this zircon data with new U–Pb ages from apatite from the same units should fingerprint discrete source terrains within potential source areas, such as Greenland, north-west Scotland and the Southern Uplands of Scotland. As such, these data have significant implications for the transport distances and storage stability of both labile and refractory minerals.

[1] Morton (2012) in *Quantitative mineralogy of sediments and sedimentary rocks*, Sylvester (ed.), GAC-MAC **42**, 133-165. [2] Tyrrell *et al.* (2006) *Journal of Sedimentary Research* **76**, 324-345. [3] Hallsworth *et al.* (2000) *Sedimentary Geology* **137**, 147-185.