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Constraining sediment routing and recycling using the Pb isotopic composition of detrital K-feldspar: Examples from NW Europe

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Many provenance studies aim to constrain palaeogeography, ancient sediment routing and drainage evolution over geological timescales. Geochemical and isotopic signals in individual mineral grains are becoming increasingly important in providing detailed insights. However, given the potential for sedimentary recycling, mixing and grain modification (e.g. during transport or diagenesis), it is often unclear how intermediate and ultimate sources of sand grains can be distinguished. More robust palaeodrainage reconstructions can be constrained through the careful integration of several provenance approaches. In applying more than one technique, it is critical to consider the nature and likely persistence of the mineral being interrogated. For example, zircon is an extremely useful and commonly utilised provenance proxy, as it is both robust and almost ubiquitous in sandstones. However, its inherent stability also implies that recycled zircon populations can remain unidentified, resulting in potentially misleading paleodrainage models.

In-situ analysis of Pb isotopes in detrital K-feldspar provides an effective means of constraining provenance. As basement Pb isotopic domains with distinctive compositions vary on a broad (>100 km) scale, the technique is particularly suited to determining the scale of ancient drainage systems. It has been shown that detrital K-feldspar grains in sandstones can retain the Pb signature of their original basement source despite weathering, transport and diagenesis. Furthermore, as K-feldspar is less likely to be recycled, determining its source can complement provenance methods which utilise signals in robust (= potentially recycled) grains.

The Pb-in-K-feldspar technique has been applied to Late Palaeozoic to Mesozoic sandstone intervals in a number of sedimentary basins on the NW European margin. Data from Permo-Triassic to Middle Jurassic arkosic sandstones from the margins of the Rockall Basin, offshore western Ireland, show that the K-feldspar was supplied by three isotopically-distinct basement sources, the availability of which varies with stratigraphy. Though suggesting consistent derivation from a northern source, the results also imply changes in the drainage pattern over time. These could be driven by variations in hinterland uplift, by cryptic climatic factors or by a combination of both. In Upper Carboniferous sandstones of the Pennine Basin, onshore northern England, the integration of Pb-in-K-feldspar data with detrital U-Pb zircon geochronological constraints has allowed the identification of likely recycled grain populations. The integrated dataset suggests that a specific zircon age population, though ultimately derived from a far-northern source, was recycled from Lower Palaeozoic sedimentary rocks to the immediate north of the basin.