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The Role of Provenance Analysis in Quantifying Source-Sink relations

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Sediment routing systems (sensu P. Allen) are the major sites of mass transfer at the earth surface, starting with initial sediment production at the source and followed by transport (including temporal storage, modification, remobilisation) and final deposition at the sink. From a sedimentary geologists view the most intriguing questions are: how much sediment has been transferred from source to sink (volumes and rates per unit time, i.e. sediment budget), how is it characterized (i.e. sediment composition), and – having in mind not only modern systems – how does this change through time? In this talk, emphasis will be placed on bulk sediment composition and single detrital grain analysis, which are the major tools to assess relative contributions from contrasting sources and their variability through time.

Sediment composition is strongly controlled by a complex web of processes acting between source and sink. Sediments derived from similar sources thus may vary strongly due to the differential reaction of mineral species when exposed to chemical and/or mechanical forces. This variation can be used, for instance, to quantify the degree of chemical alteration of sediments and thus constrain climate conditions. In contrast, ultrastable minerals such as zircon or rutile generally do not alter during weathering and transport and can thus be used as inert mineral tracer in sedimentary systems that provide a direct (non-altered) link to the source rocks. This is of particular importance if detailed information can be extracted from single detrital grains capable to precisely identify source-rocks as well as timing and rates of cooling and exhumation. Less stable mineral phases such as feldspar, garnet, or apatite provide additional information for source-rock fingerprinting. Stable to unstable mineral ratios can be effectively used to constrain type and degree of alteration processes.

A major challenge in source rock characterisation/ discrimination and endmember unmixing based on single-grain analysis is that both modal abundance and grain-size distribution of the relevant minerals in their individual source rocks are mostly unknown and, thus, the proportional contribution of different source rocks to the bulk sediment is difficult to assess. Moreover, information from sediment composition is, by definition, relative, and needs to be related to the bulk mass transfer from source to sink. We will evaluate the currently most promising approaches in sedimentary provenance analysis with respect to their potential for quantitatively constraining sediment generation and dispersal.