Quantitative provenance analysis of heavy minerals through automated raman spectroscopy

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Quantitative provenance models (QPA), which relate vertical and/or lateral compositional trends within basin fills to the tectonic evolution of a source terrain, to (base-level induced) changes in sediment dispersal patterns and sedimentation rates, or to palaeoclimate fluctuations, are still in their infancy. Despite the efforts of many, traditional heavy mineral separation and point-count methods have always been qualitative to semi-quantitative techniques, the success of which was tied to the occurrence of particularly diagnostic grains (e.g. Cr-spinel, xenotime, monazite) and biased by counts from different operators.

Heavy mineral concentrations in sediments depends on chemistry and tectono-stratigraphic level of eroded rocks, but can also be modified by density-sorting during erosion, transport, deposition or post depositional dissolution that can be modelled using indices such as a) Heavy Mineral Concentration (HMC) index (used to estimate diagenetic dissolution in sandstones); b) the Transparent Heavy Mineral Concentration (tHMC) index allows contributions from single sediment source areas to total sediment budgets to be modelled and c) the Source Rock Density (SRD) index provides a proxy of the average density of source rocks, and thus of their crustal level.

Automated Heavy mineral analysis utilises a combination of Raman Spectroscopy and image analysis to automatically analyse and identify a large amount of heavy minerals from a sample. The approach allows to grains down to 10μm, expanding the capabilities of heavy mineral analysis to include silt. Using Raman, it is also possible to differentiate different types of Zircon based on the U-Th content and degree of radiation damage, and also different types of Garnets based on their major element chemistry. This data is produced during automated analysis and therefore requires minimal extra processing to extract this additional information. Furthermore, the use of Raman allows for a larger amount of grains and samples to be analysed with a rapid turnaround time. By integrating the heavy mineral indices with the high quality data provided by the Raman spectrometer, and analysing the data with the latest statistical techniques, it is possible to provide the highest-quality provenance interpretations.