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Forward image registration for higher level interpretation of zircon provenance based on combined CL, U/Pb age and geochemical data

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Most detrital zircon studies generate cathodoluminescence (CL) images, U/Pb dates and variably extensive trace element concentration data. Yet the combined information contained in these data is rarely used for a higher-level interpretation of zircon provenance, which still mostly relies on comparison of sample-wide U/Pb age spectra. Here we propose a forward image registration software solution that allows the assembly of spatially registered data (CL texture/intensity/contrast/colour; Pb/U ratios/ages; trace element concentrations/ratios), enabling new clustering approaches to provenance study.

The solution is based on scripts that streamline bioinformatics and geospatial image analysis freeware and new algorithms. The workflow begins with automated rapid extraction of zircon grain images as unique objects from CL image mosaics. The objects are displayed in tidy grids of rotated, aligned and sorted grains, e.g. by CL intensity or aspect ratio. The customisable grids can be opened in software interface(s) where analytical spots of a chosen diameter auto-populate the centre of each grain. Operators can edit the spot location and add additional spots (e.g., on rims) and annotate the spots with further information at their desktop. Because the spot locations and parent objects are fully spatially registered on the grain mount, the analytical spot location table can be coordinated with a scanned image of the mount placed in the laser ablation sample holder and configured with the scan list. After U/Pb and trace element analysis and data reduction (e.g., Iolite), the element concentration, isotope ratio and age data are appended to the original CL and spatial information using the ablation spot names.

Equipped with this toolset, the analyst can now visualise the full range of zircon data from the registered dataset. The grid display of zircon objects can be sorted by variables such as U/Pb age, diagnostic trace element ratios, and CL attributes allowing intuitive visual discovery of interdependence. Using an example from a modern large river drainage system, we illustrate that new groupings and patterns can be discovered by interacting with all available criteria in one data space (dimensionally reduced and/or clustered). Such exploration could open the path to more unique sediment provenance solutions by cluster-density-grams.