Linking crustal and mantle events using *in situ* trace-element and isotope analysis

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Precise *in situ* analysis of trace-element compositions and isotope ratios has revolutionised geochronology and geochemistry over the past decade. This is primarily due to laser-ablation microprobe inductively coupled plasma mass spectrometry (ICP-MS) and the rapid development of the multi-collector (MC-) ICP-MS. The MC-ICP-MS has provided a wider range of isotopic systems (e.g., Li, Mg, Fe, Cu, Hf, and Tl) that can used to constrain the timing and nature of lithospheric processes. The *in situ* capabilities allow, for the first time, investigation of isotopic variation at the microscopic level and raise questions over the meaning of whole-rock measurements. *In situ* analysis also allows the isotopic data to be interpreted in a microstructural context and with integration of geochemical data from other microanalytical techniques. Integration of multiple data-sets both constrains the origin of a sample, and can unravel the processes that have subsequently modified it. The *in situ* isotopic techniques now available not only provide age information, but give new insights on magma genesis, ultimate source rocks and lithospheric tectonic history.

The *in situ* Re–Os isotope analysis of individual grains of sulfide in mantle-derived peridotite indicates that there are multiple generations of sulfides in most mantle peridotites and whole-rock Re–Os ages reflect a mix of these different sulfide populations. The mixtures reflect the end-product of multiple melting and metasomatic events in the lithospheric mantle. 'Age' spectra for these mantle events commonly mirror temporal signatures for thermal and tectonic events in the overlying crust. The combination of U–Pb dating of zircons (and characterisation of their trace-element patterns and Hf isotopes) is a powerful technique for understanding crustal evolution. The TerraneChron® methodology (www.es.mq.edu.au/GEMOC/) applies this approach to study detrital zircons from modern drainages or sedimentary rocks to construct records of crustal growth and reworking at scales ranging from local drainages to from terranes to continents. Integration of age information from the lithospheric mantle and overlying crust can be used to establish linkages between the two and further our understanding of large-scale geodynamic processes.