LINKING CRUSTAL AND MANTLE EVENTS USING IN-SITU U-PB, LU-HF AND RE-OS ISOTOPE ANALYSIS

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Abstract
Over the past decade significant advances have been made in geochronology and geochemistry with the development of a variety of methods for precise in-situ analysis of trace element compositions and isotope ratios. These advances are primarily the product of coupling a laser ablation microprobe to the induced coupled plasma mass spectrometer (ICP-MS) and the rapid development of the multi-collector (MC-) ICP-MS. In-situ analysis also allows the isotopic data to be interpreted within a microstructural context and in the framework of geochemical data from other microanalytical techniques. The integration of multiple datasets is not only essential to constrain the origin of a sample, but also to unravel the processes that have subsequently modified it.

In-situ analysis of Re-Os isotopes in sulfides in mantle-derived peridotites provides a method for constraining the timing of events within the lithospheric mantle. The sulfides are 'time-capsules': like zircons in crustal rocks they record many events in the lithospheric mantle. Apart from dating the depletion events that formed the volume of lithosphere the sulfides provide constraints on a range of processes that might modify the mantle such as the addition of metasomatic fluids during lithosphere reworking. The analysis of individual grains of sulfide 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. In many samples the in-situ data yield older ages for original lithospheric mantle stabilization. The mixtures also reflect the end-product of multiple melting and metasomatic events in the lithospheric mantle. Age-relative probability diagrams can be produced using sulfides that are interpreted to be monosulfide solid solutions that represent residual phases from partial melting or that crystallized from sulfide melts. These 'age' spectra for the events in the sub-cratonic lithospheric mantle commonly mirror temporal signatures for thermal and tectonic events in the overlying crust. The correspondence of Re-Os model ages and crustal events in young terranes is heavily influenced by the large populations of sulfides with negative model ages.

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. The importance of zircon as a 'time-capsule' has been reinforced by the development of in-situ Hf isotope measurements using the MC-ICP-MS. The combination of U-Pb dating of zircons with their trace element patterns and Hf isotopes is a powerful technique for understanding crustal evolution. TerraneChron® applies this approach to study detrital zircons from modern drainages or sedimentary rocks to construct records of the addition of juvenile material and reworking from the terrane to continent scale. Integrated studies of zircons in lower-crustal xenoliths and of sulfides in mantle-derived xenoliths, in both cratonic and younger off-craton settings, provide new insights into processes of continental generation, tectonism and destruction.