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Electron microprobe petrochronology

Michael Williams (1), Michael Jercinovic (1), and Kevin Mahan (2)

(1) Department of Geosciences, University of Massachusetts (mlw@geo.umass.edu), (2) Department of Geosciences, University of Colorado (mahank@colorado.edu)

Petrochronology involves the incorporation of chronometer phases into the petrologic (and tectonic) evolution of their host rocks, such that direct age constraints can be placed on petrologic and structural processes. The electron microprobe has a central and critical role to play in establishing the linkage between chronometer phases and their host assemblage. In addition to characterizing the composition of the major silicate phases, the probe can be used to locate and map compositional zonation in accessory phases including chronometers such as monazite, xenotime, zircon, titanite, etc. One particularly effective technique for integrating petrology and geochronology is to combine high-resolution images of chronometer phases with large-scale images of polished sections. Chronometers can be evaluated in the context of their local compositional environment. This has proven to be useful for placing the chronometer domains within the reaction history of the host rock. Key chronometer domains, once selected, can be dated by the most appropriate tool, or by multiple techniques. For relatively old or small domains in monazite or xenotime, EPMA can provide precise age constraints. However, the analysis strategy must be designed as a trace element analysis from the beginning. Unlike major element analysis, background analysis is both critical and challenging, and new methodology is required, currently either wavelength scanning or multipoint analysis. Errors on the order of 2% are possible with standard instruments, and errors of 1% or better can be achieved with optimized instruments. Future improvements in electron microprobe hardware, software, and procedures will further enhance EPMA characterization of chronometer phases and petrochronological relationships. New thermodynamic modeling and experimental data will increasingly allow accessory chronometer phases to be integrated in petrological calculations and render petrochronology a routine part of petrologic analysis.