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Developments in Laser-Ablation Split-Stream Petrochronology

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One of the biggest challenges in assessing the timing and rates of petrogenesis and deformation is having the ability to match the age of a dated mineral to the conditions at which that mineral grew. This is especially challenging for high-temperature chonometers that can grow and remain stable over a wide range of pressures and temperatures. The development of the laser-ablation split-stream method has afforded the ability to rapidly aquire chemical and chronologic data that are directly linked; as such, timing and rates of processes are better constrained than before. Several examples are given within:

1) Zircon and monazite from a single, coesite-bearing sample from the Western Gneiss Region in western Norway record the entire 30+ Myr history of metamorphism during Caledonian orogenesis, from intial burial, through ultrahigh-pressure (UHP) conditions, and back to crustal levels. Early monazite (∼425 Ma) contains low concentrations of Sr and HREE, consistent with plagioclase and garnet stability during prograde metamorphism. 420–400 Ma ages from monazite (high Sr, increased Eu/Eu*, low HREE) and zircon (increased Eu/Eu*, low HREE) indicate the timing of HP conditions, and monazite with low Sr and high HREE indicates the breakdown of omphacite and garnet at 390 Ma.

2) Titanite is becoming more widely used as chronometer, primarily because laser ablation has made analysis more feasible. Nevertheless, dates produced from titanite can be difficult to interpret because titanite may alter more easily than zircon and monazite. LASS analyses of titanite, combined with X-ray maps and backscattered electron images provide insight into processes involved in growth, recrystallization and dissolution/reprecipitation, and allow us to better interpret ages and the geologic process that they represent. This study presents recrystallized titanite from metamorphic terranes as well as ocillatory-zoned titanite from igneous rocks, and suggests some possible processes that explain the TE/age trends.

3) Detrital zircons have long been used to investigate the location and geology of landforms in the past. By adding chemical information to the age data, a clearer history can be produced. Recent LASS data from Mesozoic sedimentary rocks indicate changes in chemistry of the Sierra Nevada–Peninsular Ranges batholith, as well and the exposure and erosion of distinct units (e.g., ophiolites) over discrete time periods.

4) Isotopic data retrieved in combination with age data across an orogeny or batholith can aid in the understanding of the areal and temporal evolution of both deformation and source rocks over time. This can be done with a number of petrochronometers: Hf in zircon, Nd in titanite and monazite, This study presents examples that show how significant advances can be made in understanding lithosphere evolution using this quick and efficient analytical technique.