

## **The Role of Electron Microprobe Accessory Phase Characterization and Dating in P-T-t-D Analysis**

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Accessory minerals continue to play a central role in dating tectonic histories (P-T paths), especially in multiply deformed and metamorphosed regions. Monazite and xenotime are particularly useful because distinct compositional and age domains can preserve a record of different stages in the P-T history. A critical step is to integrate the accessory phases with the silicate reactions and fabrics. Although a thermodynamic integration is the ultimate goal, establishing textural relationships is the necessary first step in building the P-T path. EPMA compositional mapping is a critical part of the analysis. Individual accessory grains must be mapped at high resolution to identify compositional domains, especially narrow rim domains. Simultaneous processing of high-resolution maps allows accessory phase compositions to be compared from grain to grain and from rock to rock and can help to define the true number and significance of accessory phase generations. Integrating high-resolution maps with full-section compositional maps is also invaluable for interpreting the significance of accessory generations. Both monazite and xenotime can undergo fluid-related alteration, which can dramatically modify the composition and reset the age of the altered domain. This can provide additional data about the timing of infiltration events, but if not recognized, it can compromise the geochronology, especially if analyzed domains mix altered and unaltered domains. Again, EPMA maps can be used to delineate and characterize the altered domains. Although the precision can be lower relative to complementary isotopic techniques, EPMA has an important role to play in dating the accessory phases. Typically, major constraints come from narrow rim domains, tiny remnant cores, or from small inclusions in silicate phases. For example, xenotime inclusions in garnet can constrain the growth of garnet on the elusive prograde path but inclusions tend to be very small ( $<5\mu\text{m}$ ). Similarly, matrix xenotime can constrain the timing of garnet breakdown events, but altered domains from late fluid infiltration must be avoided. Examples from the polymetamorphic Athabasca granulite terrane and for the Proterozoic of the southwestern USA show how EPMA characterization and geochronology, in combination with other geochronologic techniques, can enhance and clarify tectonic histories.