What can Zircon and Monazite tell us about Metamorphic Fluids?

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Zircon and monazite are potentially powerful tools for documenting episodes of fluid-rock interaction during contact and regional mid- to high-grade metamorphism. Both minerals have low solubilities in all but highly acidic or alkaline aqueous fluids. Monazite has a higher solubility than zircon at all pH values, consistent with field evidence that monazite is more susceptible to fluid alteration than zircon. For example, Th-Pb ages and oxygen isotope compositions of monazites in the contact metamorphic aureole of the Birch Creek pluton in the White Mountains of eastern California record magmatic fluid infiltration, which caused monazites near the contact to dissolve and reprecipitate. In contrast, zircons from the same rocks experienced only minor Pb loss. The hydrothermal monazites have patchy internal zoning, which makes it difficult to document trends in fluid composition.

If hydrothermal zircons grow in concentric zones like magmatic zircons, they could be used to not only date the episode of hydrothermal growth but also to reconstruct the elemental and isotopic evolution of hydrothermal fluids during growth. For example, ion microprobe studies of magmatic zircons show core to rim changes in composition reflecting growth temperature (from Ti in zircon thermometry), oxidation state (Ce/Ce*), and compositional evolution of the melt (Hf concentration)(Lowery et al., in press, Min Mag; Wooden et al., this conference). Unfortunately, zircons that are unambiguously hydrothermal have only been observed in settings where fluids were highly alkaline or F-rich. Furthermore, they usually have very irregular shapes or exist as irregular zones within otherwise unaltered grains.

In contrast, metamorphic zircons seem to grow in concentric layers. A similarity in Th/U between hydrothermal and high-grade metamorphic zircons and the low rate of zircon growth under anhydrous conditions suggest that metamorphic zircons grow from a fluid phase. Our experiments show that zircons grown from high-temperature, oxidizing aqueous fluids have negative Eu anomalies and low Th/U; these characteristics can potentially be used to identify zircons grown in the presence of fluid during high-grade metamorphism. Such zircons, if zoned continuously from core to rim, could be used to measure T-t paths and trends in coexisting fluid composition (from measured D values) and oxidation state.