Monazite thermochronology applied to the Challenger Mine, S. Australia

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Monazite from aluminous metapelitic granulites hosting the Challenger Au mine, South Australia, was studied in an effort to reconstruct the high-grade Archaean thermal history of the deposit.

Large-volume partial melting in ore zones resulted in coarse-grained diatexites that contain large (typically >300 µm) comlpexly zoned monazite grains. Neighbouring waste rocks (sugary granoblastic gneisses) formed via high-*T* dehydration reactions. Monazite in waste rocks is small (~50 µm) and evenly distributed. The contrasting high-*T* evolution of these two rocks types allows us to reconstruct both the sub-solidus (waste rocks) and supra-solidus (ore zones) evolution of accessory monazite.

Small monazite grains in waste rocks contain high-Y and –U cores reflecting prograde monazite growth at the expense of xenotime. High-Y cores also yield the oldest $^{207}Pb/^{206}Pb$ SHRIMP dates of ~2460 Ma. These are typically surrounded by low-Y and low-Th/U overgrowths that formed between 2455 to 2450 Ma.

Large monazite grains in diatexites locally contain high-Y cores with X_{Y+HREE} compositions and $^{207}Pb/^{206}Pb$ dates similar to those in waste rocks. These are surrounded by two generations of monazite inferred to have crystallized from two different partial melting events: one at ~2447 Ma and the other shortly thereafter between 2434-2430 Ma. Final crystallization and back-reaction of partial melts gave rise to discontinuous high-Y overgrowths between 2420-2415 Ma. A single grain may, therefore, record periodic growth and resorption over a period of ~40 My.

These data imply rapid prograde heating from garnet-grade conditions (550ºC) at 2460 Ma to biotite-dehydration melting (>850ºC) by 2449 Ma (>30ºC/My). The timescale and low-*P*-high-*T* *P-T* trajectory of this heating path are consistent with magmatic advection of heat into the upper crust. Relict Au-Qtz veins at Challenger are reminiscent of Archaean lode-gold deposits typical of collisional settings. These observations imply a close coincidence between Au deposition, high heat flow, and the onset of horizontal accretion culminating in ductile deformation of anomalously hot upper crust.

Biogenic and metamorphic monazite in a Neoproterozoic turbidite sequence, Windermere Supergroup, southern B.C.

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Understanding the precursor mineralogy of monazite in metamorphic rocks is an important factor in formulating appropriate monazite-forming reactions during low-grade metamorphism. Shales and sandstones of the Neoproterozoic Windermere Supergroup, southern Canadian Cordillera, contain both very early diagenetic and metamorphic monazite. Early monazite is distinguished by its association with pyrite which is considered to have formed by bacterial sulfate reduction (BSR) soon after initial sediment deposition based on $\delta^{34}S$-depleted isotopic compositions. Monazite occurs as small (≤ 10µm) subhedral, unzoned inclusions in and along the rims of pyrite and chalcopyrite. P and REEs may be adsorbed onto Fe oxide particles which are the primary source of Fe during diagenetic sulfide forming reactions. An additional source of P is organic matter which is consumed during BSR. These reactions liberate both P and the REEs which may then form a number of REE phosphate minerals, including monazite. In contrast, metamorphic monazite is distinguished by its pseudomorphous texture, forming elongate poikilitic clusters (up to 100µm long) of numerous small (10-20µm) monazite grains.

The petrographic association of monazite and pyrite formed by BSR suggests that chemical ages (work-in-progress) of early formed monazite may constrain the age of sedimentation. Chemical dating of the metamorphic grains yields an age around 180 Ma and possibly formed during Jurassic metamorphism, at temperatures around 200ºC, based on xenotime-monazite thermometry. The circa 180 Ma age is consistent with regional U-Pb geochronology which indicates that Jurassic metamorphism occurred between 196-164 Ma and demonstrates the potential of monazite for geochronology in low-grade metasedimentary rocks.