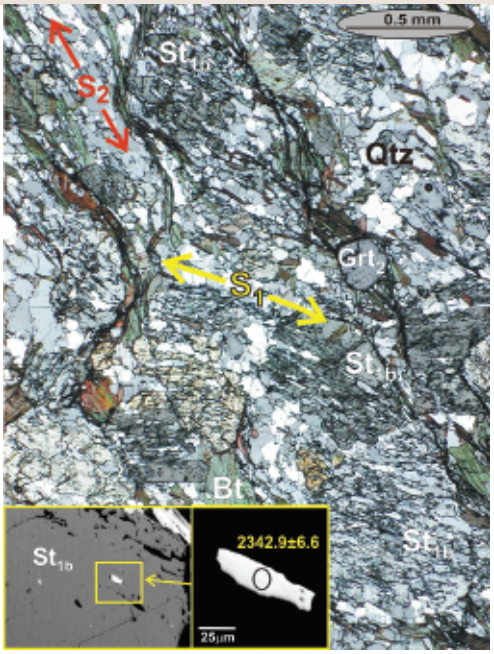
MONAZITE-(Ce) INCLUSIONS IN PORPHYROBLASTS DATE DEFORMATION AND METAMORPHISM, AND AID REGIONAL TECTONIC RECONSTRUCTIONS



Photomicrograph showing staurolite-rich domain with shallow-dipping S_1 fabric preserved mostly within late- to post-D_1 staurolite (St_{1b}) porphyroblasts. More steeply dipping S_2 cleavage is defined by partial re-alignment of biotite (Bt), and is overgrown by post-S_2 garnet (Grt2). A ca. 2.34 Ga age for S_1 is established by textural features of monazite inclusions in staurolite (see SEM image in lower left inset), particularly the elongation parallel to S_1 of monazite and its internal quartz inclusions.

Deciphering the history of rocks involved in multiple metamorphic events is a challenging endeavor facing metamorphic petrologists seeking to reconstruct the tectonic evolution of a region. Complex textures that may be recorded during prograde, peak, and retrograde metamorphism on a single *P-T-t* path are generally difficult to distinguish from textural relationships produced during multiple events. However, this problem has become more tractable with the development of new geochronological techniques that can determine the age of refractory metamorphic minerals (porphyroblasts), which have the potential to survive recrystallization during subsequent metamorphic events. In their recently published study of metasedimentary rocks in the Archean western Churchill Province (Canada), Berman et al. document detailed petrographic textures and variations in mineral compositions that establish sequences of porphyroblast growth with respect to two generations of strain fabrics preserved within, and external to, these minerals. Textural relationships reveal that some monazite crystallized at a late stage of porphyroblast growth (~520°C) during the first deformation event, whereas some crystallized during the second event. The Geological Survey of Canada sensitive high-resolution ion microprobe was then used for in situ dating of ~10–50 µm grains of monazite-(Ce), some of which were embedded within the early-formed porphyroblasts, and thus protected from isotopic re-equilibration during subsequent metamorphism.

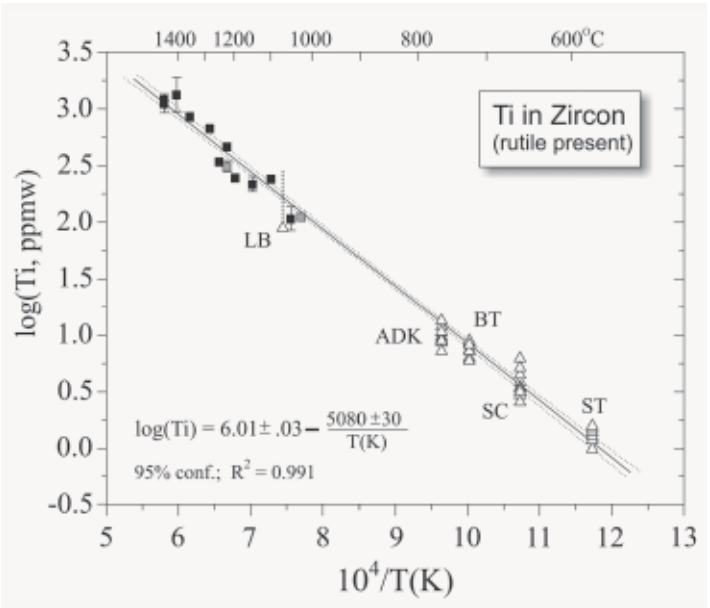
The micron-scale results not only provide the age of local deformation and metamorphic events, but also have significance for regional tectonic reconstructions. The two tectonometamorphic events dated at 2344 ± 6 and 1838 ± 5 Ma are believed to be associated with major collisional orogenies that occurred on the western and southeastern margins, respectively, of the western Churchill Province.

Berman RG, Sanborn-Barrie M, Stern RA, Carson CJ (2005) Tectonometamorphism at ca. 2.35 and 1.85 Ga in the Rae Domain, western Churchill Province, Nunavut, Canada: insights from structural, metamorphic and in situ geochronological analysis of the southwestern Committee Bay Belt. Canadian Mineralogist 43: 409-442

TITANIUM CONTENT OF ZIRCON – A THERMOMETER REVEALING MINIMUM MELTING CONDITIONS ON EARLIEST EARTH

Hadean zircons (>4.1 Ga) preserved in 3 billion-year-old metasediments at Jack Hills, Western Australia, provide insights into conditions that prevailed on Earth not long after its formation. Widely considered to have been a geodynamically violent period, the Hadean Eon (4.5–4.0 Ga) has recently been interpreted by some as benign – possibly even characterized by oceans. Determining the crystallization temperatures of these Hadean zircons is key to this debate. Based on a thermometer using titanium content in zircon, these zircons would have crystallized at about 700°C, which is close to minimum crystallization temperatures of granitoids. These results substantiate the existence of wet, minimum melting conditions within 200 million years of the formation of the solar system. They further suggest that Earth had settled into a pattern of crust formation, erosion, and sediment recycling as early as 4.35 Ga.

Watson EB, Harrison TM (2005) Zircon thermometer reveals minimum melting conditions on earliest Earth. Science 308: 841-844



The Ti-in-zircon thermometer was calibrated experimentally by Watson and Harrison between 1025 and 1450°C and by analysis of natural zircons known to have crystallized at 580 to 1070°C on the basis of independent geothermometers. Ti, a tetravalent ion under all relevant geological conditions, substitutes for Zr^{4+} or Si^{4+} in zircon. Incorporation of Ti into synthetic zircon is temperature dependent but is little influenced by pressure. The Ti-in-zircon thermometer provides minimum values unless cocrystallization with rutile can be established.