Probing quartz for P-T-D paths

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TitaniQ (Ti-in-quartz) thermobarometery of chlorite–staurolite grade metapelites reveals that quartz grains in different fabric domains may record distinct stages of the P-T-D path and, in some cases, preserve detrital [Ti] signatures. Our findings are based on integrated microstructural and petrologic analyses, cathodoluminscence (CL) imaging, and secondary ion mass spectrometry (SIMS) of samples with known tectonic histories collected along an E–W transect across central Vermont, spanning rocks of the Rowe–Hawley Belt (RHB) and the Connecticut Valley–Gaspe Trough (CVG). Rocks of the RHB record crenulation cleavage development during both the Taconic and Acadian orogenies; CVG rocks record similar processes during the Acadian orogeny only. CL and SIMS analyses were conducted on quartz in different microstructural contexts such as in fold hinges, quartz-feldspar cleavage domains, inclusion suites defining internal foliations in garnet, and pressure shadows. Both suites of metapelites lack evidence for significant dynamic recrystallization of quartz; quartz grains predominately display polygonal textures. The dominant CL zoning pattern of quartz is darker rounded–anhedral cores and brighter polygonal rims, indicating an increase in [Ti] from core to rim. In some cases grains record bright cores with dark rims (RHB), or dark cores, bright mantles, and dark rims (CVG). RHB chlorite–garnet grade metapelites yield [Ti] from 0.4–157 ppm; a small fraction of analyses yield [Ti] greater than that predicted for peak metamorphic conditions. Analyses of garnet–staurolite grade CVG metapelites yielded [Ti] of 2.2–9.8 ppm. In both suites, dark cores with low [Ti] are interpreted as quartz growth during burial metamorphism and cleavage development via strain-induced solution transfer. Brighter mantles and rims with increasing [Ti] relative to cores result from quartz-producing metamorphic reactions and continued solution transfer to low strain and quartz-feldspar domains. [Ti]>50 ppm in RHB rocks are interpreted to be inherited detrital signatures and thus likely provide information on sedimentary provenance of the protoliths. These studies highlight the importance that both structural and metamorphic processes play in the cycling of quartz in metapelites and its ability to record P-T-D paths.

Micro-scale complexity in iron-sulfide phases in Precambrian sedimentary rocks determined by coupled spectroscopic, isotopic, and magnetic techniques

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The record of sedimentary pyrite forms the foundation for most isotope records working to define the coupled evolution and behavior of the ancient iron and sulfur cycles. In order to assess the strengths and limitations of records derived from pyrite-rich rocks (e.g. iron speciation, sulfur isotope ratios), we need to understand more about the processes that form and alter sedimentary pyrite.

From samples of the Archean/early Proterozoic Transvaal and middle Proterozoic Belt Supergroups, petrography reveals that what might operationally be called sedimentary pyrite has complex textures that hint at a rich process history of sulfur mineralization. A common limitation of virtually all proxy measurements employed to date is that they operate on ‘bulk’ samples, typically gram-sized or larger pieces. As such, they lose the ability to relate geochemistry to petrography at the scale of mineral grains. Many of the sedimentary pyrites in the Transvaal Supergroup exhibit complex redox and electronic structures of S and Fe, with crystals of pyrite, pyrrhotite, and sulfate-bearing minerals throughout.

Parallel application of multiple techniques on the same samples across micron bases spatial scales, provide an opportunity to diagnose issues resulting from post-depositional alteration of sedimentary rocks. We have integrated light and electron microscopy for petrography, electron microprobe and synchrotron XRF for elemental composition, synchrotron X-ray spectroscopy for redox and chemical state, SQUID microscopy for remnant magnetism, and secondary ion mass spectrometry (SIMS) for isotopic composition. The coupling of these tools allows in essence “images” of the proxy data at the micrometer scale, giving a wide array of textural and mineralogical information designed to inform and untangle the complicated histories of these early Precambrian rocks.

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