

Oxygen Isotope Thermometry of Quartz Inclusions in Garnet

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Oxygen isotope ratios of quartz inclusions (20-800 μ m dia) within garnets (1-20mm dia) from the Adirondack Mountains, NY, were analyzed by ion microprobe (SIMS) to develop an *in situ* method of oxygen isotope thermometry. Pristine quartz inclusions (PQI) for 8 of 12 samples have $\delta^{18}\text{O}$ values significantly different than matrix quartz (MQ) at 95% confidence. This indicates PQI are armored from isotopic exchange processes during slow cooling that can cause disequilibrium between MQ and garnet.

Criteria for PQI are based on several comparative tests of all quartz inclusions (QI) from a sample. Values for $\delta^{18}\text{O}$ (QI) are homogeneous within each inclusion and show no relation to inclusion size indicating garnet was closed to diffusion at the observation scale. Average $\delta^{18}\text{O}$ for QIs with a specific texture (cracks in QI, healed cracks in QI, mineralized cracks in garnet, or mineralization along QI grain boundaries) were compared to $\delta^{18}\text{O}$ averages for QIs where the texture was absent. If there was a measurable difference, QIs with that texture were not used for thermometry. Generally, QIs that are in contact with mineralized garnet cracks are closer to $\delta^{18}\text{O}$ (MQ). This suggests that early-formed garnet cracks can behave as fast pathways for retrograde oxygen isotope exchange.

Analysis of $\delta^{18}\text{O}$ (Grt) by SIMS and laser fluorination mass spectrometry (LF) in tandem provides the best accuracy and precision (average $\Delta^{18}\text{O}$ (LF-SIMS) = 0.22‰). Profiles across single garnets by ion microprobe show no zonation in $\delta^{18}\text{O}$ (Grt). If garnet is homogeneous and inclusions are removed, laser fluorination $\delta^{18}\text{O}$ values of bulk garnet are best for QI-Grt thermometry. Prior to laser fluorination, bulk garnet aliquots were crushed to 10-100 μ m and treated with HF to remove inclusions that could affect the measured $\delta^{18}\text{O}$ (Grt) value. Treatment of standard garnet UWG-2 with HF has no effect on the measured $\delta^{18}\text{O}$ value.

Calculations of $\Delta^{18}\text{O}$ (Qtz-Grt) based on PQI's (SIMS) and $\delta^{18}\text{O}$ (Grt) (LF) data range from 2.65-3.24‰. These fractionations yield temperatures of 640-740 \pm 50°C (if $A=2.71$), which are consistent with petrologic and carbon isotope peak temperature estimates from 625 to 800°C for upper amphibolite and granulite facies metamorphism. This method of inclusion thermometry retrieves accurate temperatures and is best suited for retrogressed samples.