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An O and Li isotope study on fluid rock interaction on UHP rocks from Dabie Shan, China

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Low $\delta^{18}O$ (-5‰) and δD (-300‰) values for the Dabie mountains are explained by meteoric waters prior to UHP metamorphism [1]. Only fast subduction, short mantle residence followed by rapid uplift [2] and lack of intense water rock interaction such as pervasive fluid flow can preserve these early prints. Retrograde phases and oxygen isotope data however show heterogeneity in outcrop scale [2] and give evidence of later fluid events. In order to test fluid effects on microscale, in-situ analyses of O and Li isotopic compositions, as well as Li concentrations have been carried out on 2 localities: Bixiling in central Dabie is compared with Shuanghe, located close to the Tan Lu fault.

Garnets from the Shuanghe locality show negative $\delta^{18}O$ = -10 to -2 ‰ with variation up to 10‰ on cm scale. Garnet rims and garnet close to veins have higher $\delta^{18}O$ values. Whereas garnets from the Bixiling locality show minor variation in $\delta^{18}O$ within one sample; values scatter 0 to +8 ‰ depending on the sample. This provides evidence for the fluid source during and after peak metamorphism must have been of mantle or crustal origin and even affected the oxygen signature in garnets, which should be the most resistant to later isotopic exchange [1]. For Shuanghe fluid affected the rock on microscale, whereas for Bixilling the fluid-rock interaction was efficient on dm to m scale.

Li contents range from 10 to >100ppm in clinopyroxene and 2 to 30ppm in amphibole and are <2ppm in garnet. Li is incorporated in omphacite as a hp-phase and remains in the clinopyroxene during the subduction-exhumation cycle. In most of the samples, the Li contents increase towards the rim of the mineral and Li is present in secondary phases, indicating an association with retrograde metamorphic events. The large δ^7Li scatter (10-20‰) in the studied samples imply the presence of several Li sources and suggests a crustal signature. In the ultramafic sample the original peridotite signature (δ^7Li =5 ‰) is still preserved in part of the clinopyroxene, but the amphiboles display δ^7Li values up to 24.5 ‰.

References

[1] Rumble (1998),When continents collide…p 241-259.
[2] Zheng (2003) *Earth Science Reviews* **62**, p 105-161.

1.2.15

Oxygen isotope zoning in zircon

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Zircon records a robust record of magmatic evolution. Zoning is commonly imaged by cathodoluminscence (CL) and dated by ion probe. Complex histories involving growth, resorption, overgrowth, radiation damage and/or annealing can be inferred. Oxygen isotopes are an important monitor of closed system processes of fractional crystallization vs. open system contamination, however, small sample size has prevented widespread investigation of $\delta^{18}O$ zoning in zircons.

Zonation of $\delta^{18}O(Zc)$ can be inferred by bulk analysis of many grains if air abraded or sieved by size, but variability is generally underestimated. Ion microprobe analysis is required. Recently, spot to spot precision of 0.5-1.0‰ (1SD) has been attained *in situ* from 30 µm spots by single detector ion microprobe; and most recently, precision of 0.1-0.2‰ is attained in 10 µm spots by multi-collector (Cameca 1270). Spatial resolution is 0.1-1.0 µm in depth profiles.

Preliminary studies of zoning in single zircons have shown homogeneity of $\delta^{18}O$ in epigranites from Isle of Skye (analytical precision = ±1‰, 1SD, Monani + Valley 2001 EPSL), but variability in other settings, including intracrystalline differences of: 4‰ in low $\delta^{18}O$ rhyolites from Yellowstone (±1‰, Bindeman + Valley 2001 J Pet); 2.4‰ in a 4.4 Ga zircon from the Jack Hills, WA (±0.7‰, Peck et al. 2001 GCA); 0.7‰ in a mantle megacryst from Jwaneng kimberlite (±0.2‰, Valley + McKeegan, unpb); and 5.5‰ in a detrital igneous zircon from Grenville quartzite (±0.6‰, Peck et al. 2003 Am Min). In all cases, $\delta^{18}O(Zc)$ varies systematically from core to rim and/or correlates to CL.

Two magmatic processes are believed responsible for zoning in the above examples: contamination of an evolving magma by material of contrasting $\delta^{18}O$, or resorption and overgrowth on xenocrysts. Diffusional exchange is not indicated by these studies, but is possible at high temperature, water fugacity, or levels of radiation damage. More detailed *in situ* analysis will be necessary to fully assess post-magmatic changes.

The ability to measure profiles of $\delta^{18}O$ in zircons provides a new tool for understanding igneous and metamorphic evolution. Because sedimentary country rocks are often isotopically distinctive, $\delta^{18}O$ patterns within single crystals can be coupled to age, REEs, and other geochemistry to establish mass-balance for combined assimilation and fractional crystallization of magmas. In metamorphic zircons, zonation may provide a record of the timing and magnitude of fluid infiltration events; polymetamorphism; or heating/cooling rates.