Chronologies of magmatic evolution from compositional zoning in allanite

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Allanite is a relatively common accessory mineral in metaluminous rhyolites and is particularly useful for unraveling the evolution of magma chambers because it may contain compositional zoning that is sensitive to changes in magmatic conditions and is amenable to geochronology. As part of an ongoing study to place the magmatic evolution of voluminous silicic magma chambers within an absolute timeframe, we have linked allanite composition to ^{238}U-^{230}Th crystallization age within single crystals using electron- and ion microprobe analyses. The compositions of allanites from rhyodacites and rhyolites erupted at Long Valley and Coso, USA, and Toba, Indonesia, follow a similar compositional trend of decreasing La, Ce, Ti, Mg and increasing Mn, Y, and Th, which mirrors the variability of compatible and incompatible elements, respectively, during fractionation of rhyolitic magma containing allanite (± chevkinite & monazite). Allanite-melt partition coefficients for individual elements are higher with increasing degree of rhyolite differentiation. Hence, the past melt compositions of an evolved magma are not easily calculated from the absolute concentrations of zoned allanite. As exemptions, Sm, Nd, and Fe are concentrated in allanites from the most evolved rhyolites, despite their modest compatibility in fractionating rhyolitic magmas, possibly because the increase in their partition coefficients during fractionation has a stronger effect than their decrease in melt during fractionation. Based on data from natural allanite-glass pairs from low-to high-silica rhyolites and predictions using the partitioning model of Blundy and Wood (1994), allanite-melt exchange coefficients for La/Nd and MnO/MgO are essentially constant for rhyolitic magmas, suggesting similarity in the relative partitioning of chemically similar elements that substitute into the same crystallographic sites in allanite. La/Nd and MnO/MgO best record the imprint of differentiation on rhyolitic magmas because they vary with fractionation even when eutectoid bulk compositions change little. Compositional zoning in Toba allanites records crystal growth from rhyolitic melts related by up to 45% fractionation, which when keyed to crystallization ages, dates the differentiation of a voluminous silicic magma over a ~150,000 year interval prior to eruption.

Basement nature of the Ordos terrane, North China Craton: Constraints from detrital zircon ages and Hf isotopes of khondalites from the Wulashan Complex

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A major advancement of Precambrian study in the North China Craton is tectonic subdivision of the craton into the Eastern and Western Blocks separated by the Trans-North China Orogen. However, data for the Western Block are limited to its northern part, namely the Yinshan Terrane. Understanding the history of the Western Block is hindered by the lack of data for the Ordos Terrane, wich is covered by basin sediments. The khondalites of the Wulashan Complex are high-grade metasedimentary rocks, which are considered to be derived from provenance(s) in the Ordos Terrane (Zhao et al., 2005). Therefore, U-Pb age and Hf isotope studies on detrital zircons of these khondalites will provide insights into the basement nature of the Ordos terrane.

Detrital zircons from four khondalite samples give U-Pb ages between 1.85 and 2.30 Ga, indicating Paleoproterozoic provenance(s) for the metasediments. These detrital zircons have concentric growth zoning, and possess $\varepsilon_{(Hf)}$ values between -8 and +9, suggesting that they crystallised from magmas derived from underlying old crust and/or juvenile materials from the mantle. The lowest $\varepsilon_{(Hf)}$ values at different ages define an evolution line that extrapolates to intersect the depleted mantle line at 2.6 Ga in a $\varepsilon_{(Hf)}$ vs. time diagram. This implies that the sedimentary procenance was underlain by a lower crust separated from the mantle at ~2.6 Ga. One sample has a population of detrital zircons with ~2.0 Ga ages and positive $\varepsilon_{(Hf)}$ from +1 to +9, clearly recording a significant crustal growth event at ~2.0 Ga in the region.

The above data may indicate that the Ordos Terrane of the Western Block has a ~2.6 Ga lower crust, with significant crustal growth at ~2.0 Ga. This is in strong contrast with the Eastern Block that has basement ranging from the early Archean (up to ~3.8 Ga), through middle Archean (2.9 to 3.4 Ga), to late Archean (2.5 to 2.9 Ga).

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References

Zhao G.C., Sun M., Wilde S.A., and Li S.Z. (2005) *Precambrian Res.* 136, 177-202.