Lu-Hf and Sm-Nd garnet geochronology: Closure revisited and new applications in lithosphere studies

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The link between ^{176}Lu-^{176}Hf and ^{147}Sm-^{143}Nd dates and *P-T* information from garnet is still subject to uncertainty because closure systematics are not well constrained. To progress in this field, we performed ^{176}Lu-^{176}Hf and ^{147}Sm-^{143}Nd geochronology on garnet crystals of different size (Ø = 0.90-6.2 mm) from a granulite from the Archean Pikwitonei Granulite Domain, Superior Province, Canada. Metamorphism in this region started at ~2716 ± 4 Ma and peak metamorphism (760 °C [1]) occurred at 2639 ± 2 Ma [2].

The ^{176}Lu-^{176}Hf dates for the larger size fractions (Ø > 2.5 mm) yielded 2714 ± 6 Ma, identical to the age of first garnet growth. Smaller grains exhibit slight younging to ~2680 Ma. In contrast, the ^{147}Sm-^{143}Nd dates are equal to or younger than the age of peak metamorphism. The age trends cannot be explained by inclusion effects or REE zoning, but instead relate to diffusive loss of radiogenic ^{176}Hf and ^{143}Nd.

The data enable the quantitative evaluation of the closure systematics of the ^{176}Lu-^{176}Hf and ^{147}Sm-^{143}Nd chronometers in garnet: ^{176}Lu-^{176}Hf dates for garnet of a typical grain size (Ø > 0.5 mm) represent (re-)crystallization of the phase. The same applies to ^{147}Sm-^{143}Nd, except for UH*T* rocks and cases where *dT*/*dt* is much lower than commonly observed in tectonic settings.

These constraints enable the use of garnet geochronology in unravelling prograde histories of deep-crustal rocks. We used this approach to assess the enigmatic history of the deep crust underlying the Pamir-Tibetan Plateau. We obtained a detailed record of near-isobaric heating between 37.0 and 26.5 Ma and relate this directly to high mantle heat flow induced by roll-back or breakoff of the Indian plate.

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[2] Heaman *et al.* (2011) *Can. J. Earth Sci.* **48**, 205-245.

Geomicrobiological activity in the Mesoarchean Witwatersrand-Mozaan Succession: Evidence from iron formations and shales

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The Mesoarchean (~2.96-2.92 Ga) Witwatersrand-Mozaan Succession of southern Africa is one of the oldest, well preserved supracratonic successions in the world. Numerous iron-rich units occur in this succession in the form of iron formations and iron-rich shales. Detailed studies of multiple deep level drill cores have led to the reconstruction of the lateral facies distribution of these iron-rich units. The iron formations are distal deposits, and change from hematite-magnetite, magnetite, mixed magnetite-carbonate to mixed carbonte-silicate facies towards proximal environments [1]. Proximal to the banded iron formations are iron-rich shales with manganese-rich carbonate concretions, grading into iron-poor shales and eventually sandstones [2]. This facies distribution illustrates that iron deposition only took place below wave base, likely below the photic zone. Distribution of iron was likely controlled by ferrous iron- and reduced manganese-rich hydrothermal plumes with a limited vertical extent due to neutral buoyancy [3]. Chemolithoautotrophic iron-oxidizing bacteria are inferred to have caused the precipitation of iron as ferric oxyhydroxides, with hematite preserved where the plume was not in contact with the sediment. Magnetite and isotopically light iron-rich carbonate, in contrast, formed diagenetically through interaction of the hydrothermal plume and organic carbon sourced from biological activity in the sediment [1]. The manganese-rich carbonate concretions in the more proximal iron-rich shale show evidence for dissimilatory manganese reduction of manganese originally precipitated by mangenese-oxidizing bacteria [2]. Microbial oxidation of iron below the photic zone in iron formations and of manganese in shales suggest that free molecular oxygen at micro-oxic conditions were developed at depth in the the Witwatersrand-Mozaan basin since known geomicrobial processes require micro-oxic contitions.

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