Growth- and post-growth behavior of major and trace elements in garnets, a case study

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The distribution of major and trace elements in the mineral garnet plays an important role in the interpretation of ages deduced by e.g. Lu-Hf and Sm-Nd garnet geochronology. A common understanding is that Lu and other heavy rare earth elements (HREE) have high partition coefficients for garnet, hence will be enriched in early formed garnet cores, while on the other hand light rare earth elements (LREE), such as Sm, will be incorporated during late growth into garnet rims. Further, distribution patterns of HREE in garnet are important indicators for processes during metamorphism as they might point to episodic and multi-generation garnet growth, as well as to mineral reactions producing distint enrichment peaks during garnet growth (e.g. amphibole- & epidote-out reactions).

In this study we investigate these distribution patterns of major and trace elements in a variety of garnets from chemically different host rocks, and discuss the influence of e.g. diffusion on the preservation of growth zoning.

The first results show that nearly all single-generation garnets indeed preserve element distribution profiles with an enrichment of Lu and other HREE in garnet cores. Interestingly diffusion often seems to play a negligible role for the HREE compared to the major elements. Distinct Lu peaks in garnet cores do on the one hand correspond to wellpreserved Mn peaks, but also Lu enrichments together with flat Mn patterns are observed, which indicates that Lu (and presumably other HREE) are less prone to diffusional resetting compared to e.g. the major elements. One of the major aims of this study will be to constrain how explicitly diffusion can influence and alter major and trace element distribution profiles in garnets and how these are interrelated with each other. With this information it hopefully will be non-ambiguous to interpret geochronological data of garnets from the Lu-Hf and Sm-Nd isotope systems.

Role of fluid flow conditions on denitrification rates in sediments during managed groundwater recharge

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We measured in situ denitrification during infiltration through saturated sediments to develop a mechanistic understanding of controls on denitrification rates. Sampling and measurements were completed below a managed aquifer recharge pond, providing strong constraints on initial nitrate and carbon concentrations, flow rates, and other controlling parameters. Co-located thermal measurements were used to determine flow rates with time, and chemical and isotopic methods were used to assess denitrification progress. Zero order denitrification rates of 3 to 300 µmol L⁻¹ d⁻¹ were measured during infiltration. Denitrification was not detected at times and locations where the infiltration rate exceeded a threshold of approximately 0.9 m d⁻¹. Pore water profiles of oxygen and nitrate concentrations indicated a deepening of the redoxocline at higher flow rates, which reduced the thickness of the zone favorable for denitrification. Below the threshold infiltration rate, denitrification rates were positively correlated with infiltration rates, suggesting that for a given set of sediment characteristics an optimal range in infiltration rate exists for achieving maximum nitrate load reduction. This study has implications for managing water resources to achieve the greatest possible nitrate load reduction by denitrification in both natural and manipulated settings including recharge ponds, wetlands, and hyporheic zones in streams

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