Assesing iron and oxygen isotope homogeneity in garnets

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Garnet is a key mineral for (i) dating metamorphic processes in the crust, (ii) tracing P-T conditions in the upper mantle, and (iii) understanding porphyry, skarn and epithermal ore systems. All of these geotectonic settings and associated processes are related to mass transfer of elements in fluids or melts. Detailed knowledge of the redox state under which such processes occur (often referred to as fO_2) and/or the source of fluids is crucial for the study of mass transfer in rock forming processes in crust and mantle.

Here we assess three natural garnets for their major, trace and O-Fe isotope budget in search of suitable standards and constraints on processes controlling their isotope systematics. One garnet from Kakanui, New Zealand (KAK) and two from Erongo, Namibia (ERO-R and ERO-G) are analysed. KAK is a xenocryst pyrope-rich garnet ($Alm_{22-23}Prp_{62-63}Grss_{12}And_2 Spss_1$) from mantle-derived alkaline melt. ERO-R is an igneous almandine-rich garnet ($Alm_{64-65}Prp_{6-7}Grss_1And_{<1} Spss_{28-29}$) from a migmatitic vein with negligle proportion of Fe^{3+}. ERO-G is a hydrothermal highly zoned andradite-grossular-rich garnet ($Prp_{<1}Grss_{22-65}And_{32-77}Spss_{1-2}$) with all Fe as Fe^{3+}.

KAK is homogeneous in major and trace elements and in oxygen isotopes at the microscale with $\delta^{18}O$~5.3. Its $\delta^{57}Fe_{(IRMM-014)}$=+0.09±0.01 is slightly elevated compared to average depleted mantle. Oxygen and Fe isotopes are homogeneous in ERO-R with $\delta^{18}O$~8.5 and $\delta^{57}Fe$=+0.11±0.06, respectively. ERO-G garnet grains are zoned in oxygen composition with a variation form core to rim between ~13 and ~11 ‰, which coincides with the growth zoning pattern in Grss-Andr observed in BSE images. Accordingly, their heavy $\delta^{57}Fe$ vary from +0.6 to +0.9. Trace elements composition of ERO-G garnet is highly variable.

Based on our preliminary results KAK and ERO-R appear to be suitable standards for coupled Fe-O isotope analysis. Garnet O isotopes are in line with the source of the sample (mantle versus crust). Fe isotopes strongly correspond to Fe^{3+}/Fe^{2+} and may thus be a sensitive redox proxy in garnet.

Discovery of a Triassic magmatic arc source for the Permo-Triassic Karakaya subduction complex, NW Turkey

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The Permo-Triassic Karakaya Complex is well explained by northward subduction of Palaeotethys but until now no corresponding magmatic arc has been identified in the region. With the aim of determining the compositions and ages of the source units, ten sandstone samples were collected from the mappably distinct Ortaoba, Hodul, Kendirli and Orhanlar Units. Zircon grains were extracted from these sandstones and >1300 were dated by the U-Pb method and subsequently analysed for the Lu-Hf isotopic compositions by LA-MC-ICP-MS at Goethe University, Frankfurt. The U-Pb-Hf isotope systematics are indicative of two different sediment provenances. The first, represented by the Ortaoba, Hodul and Kendirli Units, is dominated by igneous rocks of Triassic (250-220 Ma), Early Carboniferous-Early Permian (290-340 Ma) and Early to Mid-Devonian (385-400 Ma) ages. The second provenance, represented by the Orhanlar Unit, is indicative of derivation from a peri-Gondwanan terrane. In case of the first provenance, the Devonian and Carboniferous source rocks exibit intermediate εHf(t) values (-11 to -3), consistent with the formation at a continental margin where juvenile mantle-derived magmas mixed with (recycled) old crust having Palaeoproterozoic Hf model ages. In contrast, the Triassic arc magma exhibits higher εHf(t) values (-6 to +6), consistent with the mixing of juvenile mantle-derived melts with (recycled) old crust perhaps somewhat rejuvanated during the Cadomian period. We have therefore identified a Triassic magmatic arc as predicted by the interpretation of the Karakaya Complex as an accretionary complex related to northward subduction (Carboniferous and Devonian granites are already well documented in NW Turkey). Possible explanations for the lack of any outcrop of the source magmatic arc are that it was later subducted or the Karakaya Complex was displaced laterally from its source arc (both post 220 Ma). Strike-slip displacement (driven by oblique subduction?) can also explain the presence of two different sandstone source areas as indicated by the combined U-Pb-Hf isotope and supporting petrographic data.

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