Geochronology of the Lithospheric Mantle underneath the Gibeon Kimberlite Field, Namibia

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Recent comparative work has shown that differences and similarities exist between the mantle underneath the Archean Kaapvaal craton and the attached Proterozoic terranes [1]. Differences are: higher average forsterite in olivines from the Kaapvaal craton, lower Al_2O_3 and CaO in their bulk rocks, Re depletion ages mostly older than 2.5 Ga and a thicker lithosphere. Similarities are: similar geothermal gradients, an overabundance of orthopyroxene in part of the mantle samples and the existence of garnets with sigmoidal REE patterns. Re depletion ages are all younger than 2.2 Ga [2].

The 70 Ma old Gibeon Kimberlite Province is located in Namibia within the mixed age Rehoboth Terrane (0.9-1.2 and 1.8-2.1 Ga). Three major localities with mantle xenoliths are known: Hanaus, Gibeon Townsland and Louwrensia. Luchs *et al* [3] distinguished for Hanaus and Gibeon Townsland two types of garnet peridotites by their REE patterns: i) peridotites with flat middle to heavy REE in their garnets and ii) a minor proportion with sinusoidal REE patterns as they are known from the Kaapvaal craton. Bulk rock isotope trace element and isotope compositions were calculated from the analysis of garnets and clinopyroxenes and their modal abundances. A Lu-Hf isochron for the peridotites with the sinusoidal REE patterns gave 1852 Ma as the age of enrichment of a previously strongly depleted mantle (εHf = 29). The garnet peridotites with the flat middle to heavy REE patterns yielded a Lu-Hf age of 810 Ma with εHf = 3.3. These ages overlap with crustal ages of the mixed age Rehoboth Terrane. We have extended our studies to samples from the Louwrensia kimberlite pipe and find a similar division as in Hanaus and Gibeon Townsland for the garnet peridotites. First results from isotope studies yield a Lu-Hf age of 1100 Ma which is within the age range of the adjoining Namaqua-Natal belt. Different mantle portions with ages reflecting different events seem to be hoisted to the Earth's surface by the Gibeon kimberlites. The grt-cpx Lu-Hf two-point isochron ages give an alignment of increasing age with decreasing temperatures between 1000 to 1200 °C. We interpret these ages as cooling ages. Since kimberlite eruption ages are obtained for some samples at 1200 °C we conclude that the closure temperature for the Lu-Hf system must lie around that temperature for peridotite systems.

[1] Bell *et al*, Lithos, 2003; [2] Pearson *et al*, Chem. Geol., 2004; [3] Luchs *et al*, Precambrian Research, 2013, in press

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Fe^{3+} determination in garnet: A crystal chemical test with the EPMA flank method

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We established the „flank method" for *in situ* determination of garnet iron oxidation state with the electron microprobe at micron-scale spatial resolution [1]. Besides the high spatial resolution, the great advantage of this method is the ability to analyse simultaneously the major element chemistry on the same spot.

The flank method has been calibrated with a large number of synthetic and natural garnets. We apply it here for the first time, to garnets with grain sizes of 10-15 μm. They were synthesized at various oxygen fugacities at high pressures. We determined $Fe^{3+}/\Sigma Fe$ together with the major element composition.

The test for the reliability of the $Fe^{3+}/\Sigma Fe$ determined with the flank method uses a crystal chemical approach i.e. is based on constraints from the structural formula. In garnet with general formula $A^{2+}{}_3B^{3+}{}_2Si_3O_{12}$, the number of trivalent cations on the octahedral B site is 2. A linear correlation of Fe^{3+} per formula unit and the sum of further trivalent cations plus Ti^{4+} must therefore exist. This is the case for the synthetic high-pressure garnets of this study (Fig. 1). The excellent correlation is independent proof of the high quality of garnet Fe^{3+} data determined using the flank method.

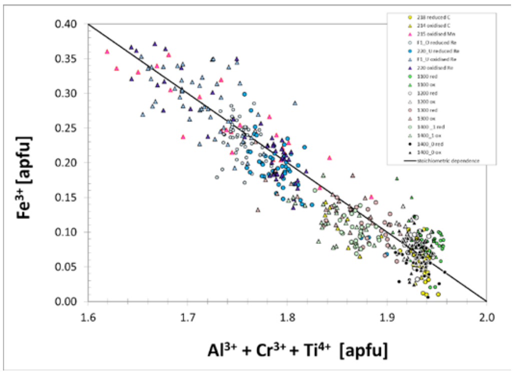

Figure 1: Fe^{3+} determined by the flank method versus the total of the remaining cations on the octahedral site.

[1] Hoefer & Brey (2007) *Am. Mineral.* **92**, 873-885.

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