In-situ Pb and Sr and Lu-Hf isotope systematics of mantle eclogites from the Diavik diamond mine, NWT, Canada

S.S. Schmidberger[1], L.M. Heaman[1], A. Simonetti[1] and S. Whiteford[2]

[1]Earth & Atmospheric Sciences, Univ. Alberta, Edmonton, AB, Canada (stefanie.schmidberger@ualberta.ca; lheaman@ualberta.ca; antonio.simonetti@ualberta.ca)
[2]Diavik Diamond Mines, Yellowknife, NWT, Canada (sean.whiteford@diavik.com)

The timing of eclogite formation and addition to the subcontinental lithosphere beneath Archean cratons in North America is currently little constrained. The highly diamondiferous A154S kimberlite was emplaced 55.4 Ma ago in the Slave Province (Lac de Gras area, NWT), Canada and hosts a suite of extremely well-preserved mantle eclogites. The eclogites consist of Cr-poor garnet and omphacitic clinopyroxene and exhibit a bimodal temperature distribution of last equilibration in the lithosphere (850-950°C and 1100-1250°C at 40kb). This study presents in-situ Pb and Sr isotopic data and Lu-Hf isotope compositions of constituent clinopyroxene and garnet obtained by MC-ICP-MS (laser ablation & solution mode) from non-diamond bearing eclogites collected at the Diavik diamond mine; on-going studies will also include diamond-bearing eclogites.

Epsilon Hf values for the Diavik eclogites exhibit a very large variation ranging from +4 to +135 for garnets and -35 to +5 for clinopyroxenes at the time of kimberlite emplacement (at ~55 Ma). One garnet-clinopyroxene pair is characterized by extremely radiogenic Hf isotopic compositions corresponding to epsilon Hf values of +1739 and +328, respectively. Internal mineral isochrons for six eclogites yield ages ranging from 460 Ma to 1.5 Ga. Initial Hf isotopic ratios obtained from these regressions intersect the temporal depleted mantle evolution line between 460 Ma and 2.0 Ga.

In-situ $^{87}Sr/^{86}Sr$ ratios obtained on individual Diavik clinopyroxene grains vary between 0.7029 and 0.7042, suggesting a derivation from depleted mantle compositions. In-situ $^{206}Pb/^{204}Pb$ (14.0-15.3) and $^{207}Pb/^{204}Pb$ (14.6-15.6) ratios for the clinopyroxenes yield Pb-Pb model ages of 2.5 to 2.0 Ga. The in-situ data are consistent with Paleoproterozoic formation for the majority of the eclogites and suggest that some of the samples could have formed in the late Archean.

Dating mantle melting using the Lu-Hf isotope system

D.G. Pearson, G.M. Nowell and C.J. Ottley

Department of Earth Sciences, University of Durham, UK. (d.g.pearson@durham.ac.uk, g.m.nowell@durham.ac.uk, c.j.ottley@durham.ac.uk)

In contrast to geochronological constraints available for the crustal portion of the lithosphere, comparably precise dating of differentiation events that create lithospheric mantle are lacking. Such data are required to understand the behaviour of lithospheric mantle during tectonic events. Here we show that Lu/Hf fractionation and Hf isotopic compositions in clinopyroxene are strongly coupled with whole rock major element indices of melt depletion (e.g., Al_2O_3) in a suite of peridotites from the Beni Bousera peridotite massif, N. Morocco. These variations are considerably more systematic than those evident for the Sm-Nd and Re-Os isotope systems. Despite evidence for significant late-stage disturbance of the Sm-Nd system in clinopyroxenes, they define a Lu-Hf isochron of 1427 ± 71 Myr (2s). Because significant Lu and Hf can partition into orthopyroxene, especially in spinel peridotites, a cpx isochron will not necessarily be an accurate reflection of the melting age. Whole rocks also define an isochron correlation with more scatter, indicating more disturbance at the whole rock scale. Nonetheless, the Lu-Hf isochron age is within error of the most reliable Re-Os model age for the Beni Bousera peridotites and similar to published estimates of the differentiation age for the Ronda peridotite. The age systematics suggest a major mantle differentiation event in the western Mediterranean area 1.4 Gyr ago. This precise age for a mantle melting event shows the potential of the Lu-Hf system in improving age constraints on the timing of lithospheric mantle differentiation. Highly radiogenic Hf isotope compositions in some Beni Bousera peridotite clinopyroxenes extend well above the mantle Nd-Hf isotope array, with epsilon Hf values of up to 209 but at surprisingly unradiogenic Nd (epsilon Nd 4 to 27). This illustrates the level of disturbance of the Sm-Nd system compared to the robustness of the Lu-Hf system. Highly radiogenic Hf isotope compositions, forming sub-vertical array above the mantle Nd-Hf isotope array are unique to continental lithospheric mantle and make Hf isotopes a potentially powerful tracer of lithospheric source regions in magmas and of the recycling of mantle lithosphere into the convecting mantle.