RADIOGENIC HF AND UNDARIOGENIC OS ISOTOPES IN THE HAWAIIAN LITHOSPHERE: EVIDENCE FOR AN ANCIENT RECYCLED LITHOSPHERE

M. Bizimis (FIU, Earth Sciences/NHMFL, Geochemistry), J. C. Lassiter (Max Plank In., Mainz), V. J.M. Salters (NHMFL, Geochemistry), G. Sen (FIU, Earth Sciences)

Introduction

The volcanic activity associated with the Emperor seamount-Hawaiian island chain is the longest lived on Earth (approximately 80 million years) and it is thought to represent the surface expression of a deep mantle plume. Understanding the physics and chemistry of this volcanism is fundamental in our understanding of the evolution of Earth and terrestrial planets. Here we report on the first combined Hf-Os isotope systematics of spinel peridotite xenoliths from the Salt Lake Crater (SLC), Pali and Kaau (PK) vents from the island of Oahu, Hawaii. These peridotites are thought to represent the Pacific oceanic lithosphere beneath Oahu, as residues of MORB-type melting at a paleo-ridge some 80-100Ma ago.

Results and Discussion

The Nd, Sr and Hf isotope compositions and trace element contents where determined at NHMFL/Geochemistry facility [1] and Os isotopes at MPI, Mainz or DTM, Carnegie Inst. Washington [2]. Clinopyroxene mineral separates in these peridotites have very similar Nd and Sr isotope compositions with the post erosional Honolulu Volcanics (HV) lavas that bring these xenoliths to the surface. This and their relatively elevated Na and LREE contents suggest that these peridotites are not simple residues of MORB-type melting but have experience some metasomatic enrichment by the host HV lavas. However, the SLC and PK xenoliths show an extreme range in Hf isotope compositions towards highly radiogenic values (εHf = 7-114), at nearly constant Nd isotope compositions (εNd = 7-10), unlike any OIB or MORB lavas. Furthermore, these Oahu peridotites show a bimodal distribution in their bulk rock 187Os/186Os ratios: the PK peridotites have similar ratios to the abyssal peridotites (0.130-0.1238), while the SLC peridotites have highly subchondritic ratios (0.1237-0.1134) that yield 500Ma to 2Ga Re-depletion ages. Hf-Os isotopes show a broad negative correlation whereby the samples with the most radiogenic 176Hf/177Hf have the most unradiogenic 187Os/186Os ratios. Based on their combined Hf-Os-Nd isotope and major element compositions, the PK peridotites can be interpreted as fragments of the Hawaiian lithosphere, residue of MORB melting 80-100Ma ago, that have been variably metasomatized by the host HV lavas. In contrast, the extreme Hf-Os isotope compositions of the SLC peridotites suggest that they cannot be the source nor residue of any kind of Hawaiian lavas, and that Hf and Os isotopes survived the metasomatism or melt-rock reaction that has overprinted the Nd and Sr isotope compositions of these peridotites. The ancient (>1Ga) melt depletion event recorded by both the low 187Os/186Os and high εHf ratios in the SLC peridotites can be explained with two different scenarios. First, the SLC peridotites may represent ancient depleted lithosphere that survived subduction, remained "rafting" in the upper mantle and is now sampled beneath Oahu. However, the lack of such undiagnostic Os isotopes in both MORBs and abyssal peridotites suggests that such peridotites are rare in the upper mantle and makes their exclusive presence under Oahu a rather fortuitous coincidence. Alternatively, the SLC peridotites may represent ancient depleted recycled lithosphere brought up by the Hawaiian plume. A recycled oceanic crust origin has been previously invoked for the Koolau shield lavas. It is then conceivable that fragments of the lithospheric portion of that subducted package have remained coupled with the oceanic crust and are being brought up by the plume from the deep, but because they were previously depleted, these peridotites contribute minimally, if at all, to Hawaiian volcanism.

Conclusions

The extreme Hf-Os isotope systematics of spinel peridotites from Salt Lake Crater, Hawaii suggest that they are residues of an ancient (>1Ga) depletion event, and possibly represent pieces of ancient depleted lithosphere brought up by the Hawaiian plume. Therefore, the SLC peridotites may represent the first-ever direct evidence that a mantle plume actually brings back on the surface recycled material, essentially closing the subduction cycle.

References