Ancient lower mantle heterogeneities revealed by modern OIB – a story told by W and He isotopes

A. MUNDL-PETERMEIER[1], R.J. WALKER[2], R.A. FISCHER[3], M.G. JACKSON[4]

[1]Dept. Lithospheric Research, Univ. Vienna, Austria
[2]Dept. Geology, Univ. Maryland, College Park, MD, USA
[3]Dept. Earth & Planetary Sciences, Harvard University, Cambridge, MA, USA
[4]Dept. Earth Science, UC Santa Barbara, Santa Barbara, CA USA

The negative correlation between $\mu^{182}W$ (ppm difference in $^{182}W/^{184}W$ between sample and standards) and high $^{3}He/^{4}He$ ratios in Hawaiian and Samoan lavas indicates the long-term preservation of one or more mantle source domains that formed during the lifetime of ^{182}Hf (within the first 60 Ma of solar system history). Here we report a global study of $\mu^{182}W$ in OIB from 15 different ocean island basalt (OIB) archipelagos that are characterized by $^{3}He/^{4}He$ ratios ranging from MORB-like (8 R/R_A) to 41 R/R_A (the measured $^{3}He/^{4}He$ normalized to the atmospheric ratio). Data from some of the OIB systems follow the negative He-W trend previously defined by the Samoan and Hawaiian rocks. However, other OIB systems are characterized by shallower (e.g., Iceland) or steeper (e.g., Heard) trends. Distinctly different slopes for different OIB trends could result from the mixing of multiple mantle components, where different mantle plumes tap several, isotopically distinct source domains.

Negative $\mu^{182}W$ values as low as -20 in some OIB most likely result from contributions from one or more lower mantle domains that interacted with the outer core ($\mu^{182}W$ = -220). Consistent with this, thermodynamic models suggest that core-mantle equilibration may result in a core-like $\mu^{182}W$ in a molten silicate layer at the core-mantle boundary. Assuming distinctly elevated W concentrations in this layer, incorporation of only minor amounts (< 0.3%) of such material into a rising plume are required to account for the negative ^{182}W signatures observed in some OIB. Very high $^{3}He/^{4}He$ in combination with small negative $\mu^{182}W$ values in some samples suggest the presence of a further un-degassed mantle plume component that formed in the earliest stages of Earth's history and survived mantle mixing processes to the present.

The characterization and processes leading to the formation of early-formed mantle reservoirs, as well as the compositional consequences for plume-derived rocks will be discussed.