Characterizing contributions to Aleutian lavas along the length of the arc: Evidence from Hf-Nd isotope systematics

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The Aleutian Arc provides an ideal tectonic setting to study Hf-Nd-Pb systematics due to its along-strike tectonic and geochemical variation. Sediment load and subduction rate decrease westward along the arc with an increasingly oblique subduction angle, causing a progressive decrease westward in the flux of sediment into the subduction zone.

A suite of lavas collected along the length of the arc and from front to back-arc have been analyzed for Hf, Nd and Pb isotopic composition. A systematic increase in Hf and Nd isotopic composition and a decrease in Pb is observed from east to west along the arc. Hf isotopic composition varies from ε_{Hf} +12.0 to +16.0. Nd (ε_{Nd} = +6.0 to +10.4) and Pb isotopes ($^{206}Pb/^{204}Pb$ = 19.0-18.0) show similar variation. This change in Hf, Nd and Pb isotopic composition along the arc is consistent with a decrease in sediment flux from east to west.

We modeled the effect of sediment input into the trench on the Hf and Nd isotopic composition of the arc lavas. For end-members we used DSDP Site 183 averge turbidite composition and Pacfic MORB. The upper, less voluminous portion of the Site 183 column is composed of pelagic sediment which has radiogenic Hf (ε_{Hf} = +10.6 to +11.5) and Nd (ε_{Nd} = +3.2); the lower portion of the column is composed of turbidite sequences with less radiogenic compositions (ε_{Hf} = +0.6 to +5.4 and ε_{Nd} = -1.9 to -1.3). Bulk mixing between the averge turbidite composition endmember with a Nd/Hf ratio of 6 and Pacific MORB creates a mixing line which encompasses the lower range of our data.

Aleutian arc Hf and Nd signatures are best modeled with average turbidite compositions that have experienced modest increases in Nd/Hf (to ~8). Our preferred interpretation is that this increase in Nd/Hf occurred during formation of a sediment melt. It is also possible that the small Nd/Hf increase could have occurred during formation of a sediment-derived fluid phase, but much higher fluid-generated Nd/Hf ratios (>10) are not required to explain the Aleutian Hf-Nd isotopic data.

Subduction modified Re-Os features of the mantle wedge

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The mechanisms leading to radiogenic Os isotopes in arc volcanic magmas are controversial, particularly over whether this is due to addition of subducted slab-released fluids or crust assimilation. Recent studies argued that mantle metasomatism (and therefore subduction released fluids) cannot explain the elevated radiogenic Os isotopic ratios of arc magmas [1]. Here we show that some mantle wedge xenoliths do have unique signatures of low Os contents and more radiogenic $^{187}Os/^{188}Os$ ratios compared with other mantle xenoliths and orogenic peridotites, indicating that the Re-Os isotopic system of these mantle wedge xenoliths has been signifcantly modified by subduction process. These features however, cannot be interpretated by simple binary mixing between mantle wedge peridotites and slab-released fluids. Moreover, the Os isotopes of mantle wedge xenoliths are not as radiogenic as some of the arc volcanic rocks [1].

In general, the low Os contents can be better exlained by Os loss, whereas the high $^{187}Os/^{188}Os$ ratios requires addition and/or *in-situ* growth of radiogenic ^{187}Os. This implies that the Re-Os isotopic systems of mantle wedge xenoliths have been modified through multi-stage processes. We propose that Re-Os fractionates during mantle metasomatism induced by subduction released fluids. Specifically, the metasomatised rocks have lower Os, but higher Re because of the high Re content in subduction release fluids [2,3], whereas the un-metasomatised rocks have higher Os and lower Re. The metasomatised mantle rocks are the main sources of arc magmas, because of their low melting point. Therefore, the primative arc magmas tend to have lower Os content, which makes them more sensitive to addition of radiogenic Os. In addition, the high Re/Os in the metasomatised rocks might also have contributed significantly to the radiogenic Os in arc rocks. The xenoliths are usually the residue of partial melting, which were less metasomatised, and therefore are less radiogenic than the arc magmas.

References

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