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Oceanic sediment contribution to the chemistry of island arcs and mantle evolution

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Quantification of the composition of material injected into the mantle at subduction zones is of prime importance to understand the formation of island arc volcanism and to model the evolution of the mantle through geological times. Here we present Hf and Nd isotopic compositions of a representative section of old, altered oceanic crust and overlying sediments. This crust was drilled and sampled during ODP Leg 185 in the western Pacific in front of the Izu-Bonin-Mariana arc system.

Fourteen composite samples of altered basaltic crust drilled at Site 801C were analyzed. All samples have Hf and Nd isotopic compositions similar to present-day unaltered Pacific MORB ($^{176}Hf/^{177}Hf$ = 0.2832, $^{143}Nd/^{144}Nd$= 0.5131) showing that Hf and Nd isotopic systems were not disturbed by alteration and interaction with seawater.

The overlying sediments were sampled at Site 1149. The sedimentary column consists of biogenic (siliceous and calcareous ooze) and inorganic sediments (pelagic clay $\pm$ ash). While all sediments have rather uniform and unradiogenic Nd isotopes ($^{143}Nd/^{144}Nd \approx 0.51233$), their Hf isotopic compositions are distinct: biogenic deposits have low $^{176}Hf/^{177}Hf$ ratios (0.28268) whereas pelagic clays have high ratios (0.28295). The Hf isotopic compositions of these samples, which have low Nd isotopic ratios, plot above the OIB-MORB array, in the field of Fe-Mn nodules whose Hf-Nd compositions are interpreted to represent that of seawater. This composition is distinct from the “terrestrial array” and from GLOSS, perhaps because the Nd in these sediments comes from continental crust while the Hf comes from mantle-derived oceanic crust.

Since the Hf content of pelagic sediment is much greater than that of biogenic sedi-

ment, the composition of the former dominates the entire sediment pile. Subduction of this material, whose composition plots above the MORB-OIB array, explains the composition of lavas from the Izu-Bonin-Mariana arc, which are displaced to the left of the MORB field. Less than 0.3% sediment added to normal mantle accounts for the Hf-Nd isotopic composition of the arc lavas.

The basalts and sediments drilled during ODP Leg 185 represent typical oceanic crust and deep-sea sediments. Subduction in the past of similar materials would have influenced the composition of the mantle once recycled into the convecting mantle. Over Earth history such recycling would have had a marked effect on the average deep mantle and would have shifted its composition towards higher Hf isotopic compositions. This process may help explain why the MORB-OIB array lies above the bulk Earth composition.