The development of the subduction channel and "turning on" of slab-to-mantle material exchanges at the start of subduction: insights from eruptive serpentinites (IODP Exp 366) from the forearc of the Mariana subduction system

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Recent IODP Expeditions of the forearc regions of the Izu-Bonin-Mariana subduction system provide new insights into the phenomena of slab-mantle material exchanges in the initial stages of subduction. IODP Expedition 366 explored the unique serpentinite mud volcano system of the Mariana forearc, drilling and sampling active serpentinite volcanoes sited at 13, 15, and 18 km depth-to-slab. Combined with results from ODP Legs 125 (Conical Seamount: >19 km depth to slab) and 195 (South Chamorro Seamount: ≥18 km), these seamounts provide a window onto the development of the "subduction channel", and initiation of slab-to-mantle fluid and material exchanges.

Between 13 and 20 km depth-to-slab, marked changes occur in the compositions of both the unique high pH (10.6-12.6) porefluids upwelling through these seamounts, and though the serpentinite materials in equilibrium with these fluids. The absence of dissolved inorganic carbon in porefluids from the seamounts nearest the trench (13-15 km depth-to-slab) is associated with Ca and Sr contents 6-7x richer than seawater. The fluids derived from seamounts over deeper sections of the slab (>18 km) are Ca and Sr depleted, but rich in Na, K, and B.

Many of the typical fluid-mobile species associated with volcanic arcs (B, K, Cs, As) are strongly depleted in the shallowest Mariana serpentinite solids as well as the porefluids. These species show variably increasing concentrations in samples from the deeper seamounts, consistent with the onset of prograde metamorphic reactions in slab sediments and altered basalt, and with increases in inferred slab temperatures from 70°C to 250°C (e.g., Hulme et al 2010).

The bulk compositions of serpentinite matrix materials from the Mariana seamounts thus far examined are distinct from those of their entrained serpentinized ultramafic clasts, showing enrichments in less-mobile species (Ti, Zr, REE) suggestive of a contribution from slab-derived basalts, as well as inputs of Na, Ca, and Sr from their associated porefluids. Entrained blueschist-facies metabasaltic clasts from 1-50 cm in size show elevated Ti and Zr concentrations consistent with their origins in seamounts from the down-going Pacific plate. These and associated clasts of coralline calcite point to the ongoing disaggregation of Pacific Plate materials during subduction, and their exhumation via ongoing serpentinite mud eruptions.

References

Hulme S.M., C.G. Wheat, P. Fryer and M.J. Mottl, 2010, Pore water chemistry of the Mariana serpentinite mud volcanoes: a windo to the seismogenic zone. Geochemistry Geophysics Geosystems 11:1, doi:10.1029/2009GC002674