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Exploring new frontiers in fluids processes in subduction zones

Carbon mobilisation in the shallow Mariana subduction zone: insights from IODP Exp. 366

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Deep-rooted serpentinite mud volcanism in the Mariana forearc allows unique insight into dynamic processes and element cycles in the shallow portions of a subduction zone. IODP (International Ocean Discovery Program) Expedition 366 drilled and cored three of these mud volcanoes.

Recovered materials include mafic rock fragments enclosed in a serpentinite mud matrix. Titaniferous augite in these clasts is diagnostic of alkali basalt, implying an ocean island provenance. This result is in line with the composition of larger rock clasts that can be assigned to recycled Pacific Plate seamounts (Fryer et al., 2017, doi: 10.14379/iodp.pr.366.2017). The recovered samples are altered to prehnite–pumpellyite and blueschist facies mineral assemblages, indicating peak pressure/temperature conditions consistent with the estimated slab depth of $\sim$19 km.

Distinct veins generations crosscut the clasts and comprise i) silicate-only, ii) carbonate–silicate, or iii) carbonate–sulfate vein types. The most abundant vein minerals are pectolite, aragonite, calcite, and prehnite. Late nesquehonite veins are present in some samples. Carbonate 87Sr/86Sr values of $\sim$0.705 indicate precipitation from fluids released from the subducted slab rather than being of seawater origin. Carbon isotopes (δ13C = -0.6 to 3.3‰ VPDB) suggest an abiogenic source of carbon while O isotopes (δ18O = 20.1 to 23.5‰ VSMOW) indicate precipitation at $\sim$40–60°C, based on an estimated δ18Ofluid of -2‰˙

Mineral assemblages in the veins point to precipitation during water–rock interactions in rock-dominated systems. The lack of deformation suggests that they most likely formed away from the décollement, possibly within the mud volcano conduits. Fluids from which the vein phases precipitated contained C, Ca, Na, Sr, Ba, and S. Some of these elements (notably C and Sr) have most likely been derived from the subducted plate. The carbon may have been released during compaction of sediments, and subsequent release of pore waters and inorganic sedimentary compounds, or derived from decarbonation of carbonate in the ocean crust. Our data support the hypothesis that carbon mobilisation in the forearc of subduction zones is occurring and show that this process may happen shallow in the system at low metamorphic grades. Trapping of carbon in low-temperature vein mineralisations is a previously unidentified sink inside the forearc lithosphere, implying that only part of the carbon escapes to the seafloor.