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Carbonate–silicate–sulfate veins in metavolcanic clasts recovered from serpentinite mud volcanoes in the Mariana forearc (IODP Exp. 366)

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Deep-rooted serpentinite mud volcanism in the Mariana forearc allows unique insight into the 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 indicative 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 ∼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 ∼0.705 indicate precipitation from fluids released from the subducted slab rather than a seawater origin. Carbon isotopes (δ13C = -0.6–3.3‰ VPDB) suggest an abiogenic source of carbon while O isotopes (δ18O = 20.1–23.5‰ VSMOW) indicate precipitation at ∼40–60°C, based on an estimated δ18Ofluid of -2‰.
Mineral assemblages in the veins point to precipitation during water–rock interactions inside the clasts. Lack of deformation suggests that they most likely formed away from the décollement, possibly in the mud volcanoes' conduits. Fluids from which the vein phases precipitated were enriched in C, Ca, Na, Ba, and S. Some of these elements (notably C and Sr) have most likely been derived from the subducted plate. The carbon was probably derived from compaction of sediments and release of pore waters and inorganic sedimentary compounds or derived from decarbonation of carbonate in oceanic crust. Our data support the idea of carbon mobilisation in the shallow portions of subduction zones at low metamorphic grades. Trapping of carbon in low-temperature vein mineralisations inside the forearc lithosphere appears to be an important process; only part of the carbon hence escapes to the seafloor.