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Tracing volatile recycling through the Mariana Forearc using halogens and noble gases

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Subduction zones act as a key constituent of Earth's volatile cycle, where oceanic lithosphere and sediments carry fluids and volatile elements from Earth's surface down into its interior. The cycling of volatiles at subduction zones imparts a fundamental control on arc volcanism, mantle redox conditions, mantle heterogeneities, and the long term stability of Earth's surface environment. As subducting oceanic plates dive deeper into the mantle, fluids are released from the slab due to sedimentary compaction and the breakdown of hydrous minerals. Rising waters interact with the mantle to generate arc magmatism, which returns volatiles to the surface. While the return of subducted volatiles via arc magmatism is generally well constrained, the transfer of volatiles from the slab to the forearc at shallow depths is not well understood. Here we investigate the noble gas and halogen composition of forearc fluids collected from serpentinite mud volcanoes in the Mariana forearc to better identify the source, and quantify the budget, of fluids released from the slab at forearc depths.

Fluids were collected from drilled boreholes (ODP 195 & IODP 366) at the summit of 4 serpentinite mud volcanoes: Yinazao (13 km depth to slab); Fantangisña (14 km), Asùt Tesoru (18 km), and South Chamorro (18 km). We find that the noble gas and halogen composition of the fluids sampled at the two shallowest depth-to-slab seamounts (Yinazao and Fantangisña) are dominated by seawater, indicating there is a limited flux of volatiles from the slab at these depths. In contrast, fluids from Asùt Tesoru and South Chamorro have large excesses in $^{4}He/^{20}Ne$ and $^{40}Ar/^{36}Ar$ relative to seawater suggesting a large contribution from a deep (mantle or slab) source. High precision measurements of Xe isotopes using dynamic mass spectrometry confirm that these fluids originate from the subducting slab, with a very limited contribution coming from the mantle. This is further substantiated by the similarity in I/Cl ratios between the serpentinite fluids and marine sediments and pore waters. These data provide new and unique insights into the shallow subduction regime and highlight the underconstrained flux of subducted volatiles to the forearc.