Overview of IODP Exp. 376: hydrothermal systems and submarine eruption processes of Brothers volcano, Kermadec Arc

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The recent International Ocean Discovery Program (IODP) Expedition 376 to Brothers volcano in the Kermadec Arc in May-July 2018 is an example of the ambitious science that can be achieved through scientific drilling. Brothers volcano is a submarine caldera volcano that hosts two distinct, active hydrothermal systems –one dominated by seawater-rock interactions, and the other dominated by magmatic fluids and gases. As such, it is an exciting target for research related to geohazards (what are the eruption processes and related hazards of submarine caldera volcanoes?), hydrothermal mineralisation (what controls these processes and how do they relate to ore deposits now exposed on land?) and geobiology (what life may exist in this extreme range of temperature and pH conditions?). Despite challenging drilling conditions (including temperatures as high as 236 ˚C and pH as low as 1.8), with D/V JOIDES Resolution we recovered 222.4 m of core from five sites across the volcano as well as three borehole fluid samples. Here we present an overview of the drilling operations, the preliminary findings of the Expedition, and future plans to investigate its submarine eruption dynamics.

Recovered core material consists primarily of dacitic volcaniclastics (breccia) and lavas, affected by pervasive and complex alteration. We show that the extent of alteration reflects primary lithological porosity and the contrasting spatial and temporal contributions of seawater, hydrothermal fluid and magmatic fluid. Our findings suggest a two-step model for the origins of metal-rich volcanogenic massive sulphide deposits that is linked to caldera formation (de Ronde et al, 2019). In this model, initial hydrothermal activity of the pre-caldera volcano is dominated by magmatic gases and hypersaline brines. The gases mix with seawater as they ascend to the seafloor, while the dense hypersaline brines remain in the subsurface. Following caldera collapse, seawater is able to infiltrate the volcano through fault-controlled permeability, where it interacts with wall rock and the sequestered hypersaline brines before finally transporting their associated metals back to the seafloor where it forms Cu-Zn-Au-rich chimneys at the caldera rim. This two-step process may be common at submarine arc volcanoes that host volcanogenic massive sulphide deposits, and provides a mechanism for efficiently concentrating mineralisation at or near the seafloor. Future work will focus on identifying the volcanic eruption processes that are able to produce a submarine caldera at water depths of more than 1300 m, where hydrostatic pressure may modify eruption styles by limiting the amount of degassing and bubble growth that is possible during magma ascent.

de Ronde, Humphris, Höfig, Reyes, and the IODP Expedition 376 Scientists (2019) Critical role of caldera collapse in the formation of seafloor mineralization: The case of Brothers volcano. Geology, v.47, p.762-766

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