SPOTLIGHT 9 | South Chamorro Seamount

13°7.00'N, 146°00.00'E

By C. Geoffrey Wheat, Patricia Fryer, Ken Takai, and Samuel Hulme

Sixteen large, active serpentinite mud volcanoes exist in the Mariana forearc, the region of seafloor between the Mariana Trench and the volcanic island arc (Fryer et al., 2006). Up to 50 km in diameter and rising as much as 2.4 km above the surrounding seafloor, these seamounts form as a consequence of subduction processes, which generate deep-seated faults that penetrate the crust and mantle of the overriding Mariana microplate to the depth of the underlying and subducting Pacific Plate (Figure 1). Faults that are observed up to 100 km west of the Mariana trench provide a pathway for the ascent of fluid released from dehydration reactions within the subducting Pacific Plate and for the ascent of ground-up rock fragments. As this fluid upwells, it reacts with the overlying mantle, producing serpentine, hydrogen gas, and alkaline fluids (up to pH 12.5).

Deep-seated faults tap different pressure and temperature conditions in the subducting plate, conditions that regulate subseafloor reactions (Hulme et al., 2010). For example, the subducting slab under seamounts located close to the trench (55–70 km) is warm (< 100°C at 13–18 km) and contains low-alkalinity, high-calcium fluids. In contrast, the subducting slab under seamounts located farther from the trench (> 70 km) is hotter (200–350°C at 20–30 km) and contains high alkalinity, low-calcium fluids. These systematic differences in fluid composition coupled with distinct mineral assemblages in the ascending serpentinite muds provide a window to conditions along the décollement, the interface between the two plates and the locus of earthquake activity (Figure 1).

South Chamorro Seamount (Figure 2) is one of the furthest mud volcanoes from the trench (85 km) with a depth to the subducting slab of ~ 25 km (Oakley et al., 2008). Here, ascending fluids have a pH of 12.2 and are sulfate- and methane-rich. These fluids support subsurface microbial communities of Archaea and Bacteria that actively reduce sulfate, representing the most extreme pH conditions on Earth where life exists (Takai et al., 2005). Where these fluids vent at the seafloor, an assemblage of benthic megafauna exists, including mussels, gastropods,

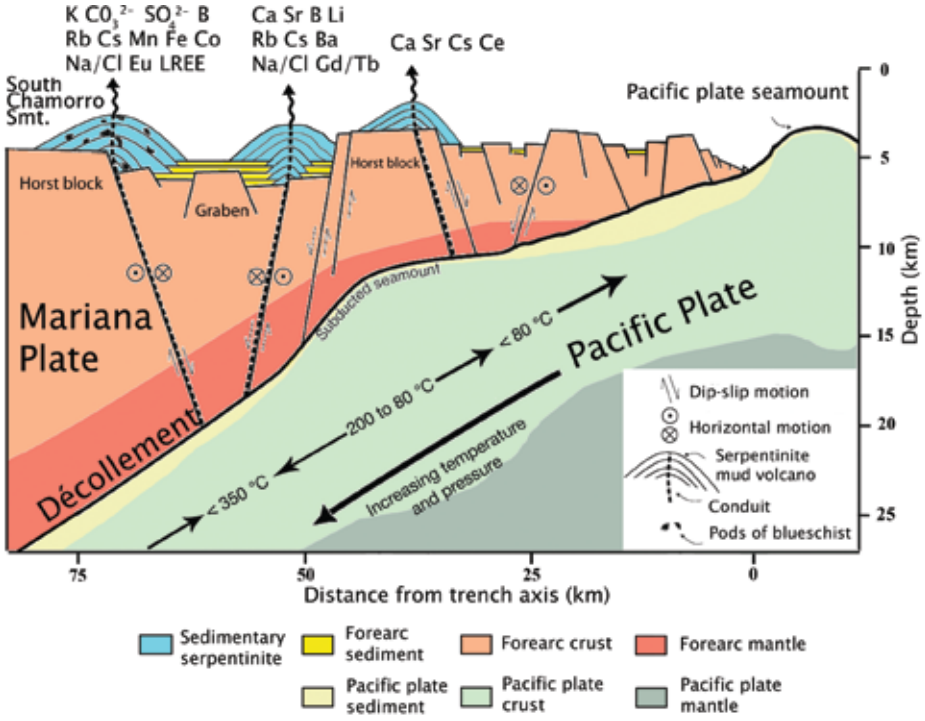

Figure 1. Cross section of serpentinite mud volcanism in the Mariana forearc. The increase in temperature and pressure spawns a series of reactions, resulting in altered fluids that ascend through faults and react with the overlying mantle. Reaction products (fluid and minerals) ascend to the seafloor. Elements and molar ratios are listed for values in excess of those in seawater. *Modified from Hulme et al., 2010*

C. Geoffrey Wheat *(wheat@mbari.org) is Research Professor, Global Undersea Research Unit, University of Alaska Fairbanks, based at Moss Landing, CA, USA.* **Patricia Fryer** *is Professor, School of Ocean and Earth Science and Technology (SOEST), University of Hawai`i, Honolulu, HI, USA.* **Ken Takai** *is Program Director, Subground Animalcule Retrieval (SUGAR) Project, Frontier Research System for Extremophiles, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan.* **Samuel Hulme** *is PhD Candidate, SOEST, University of Hawai`i, Honolulu, HI, USA.*

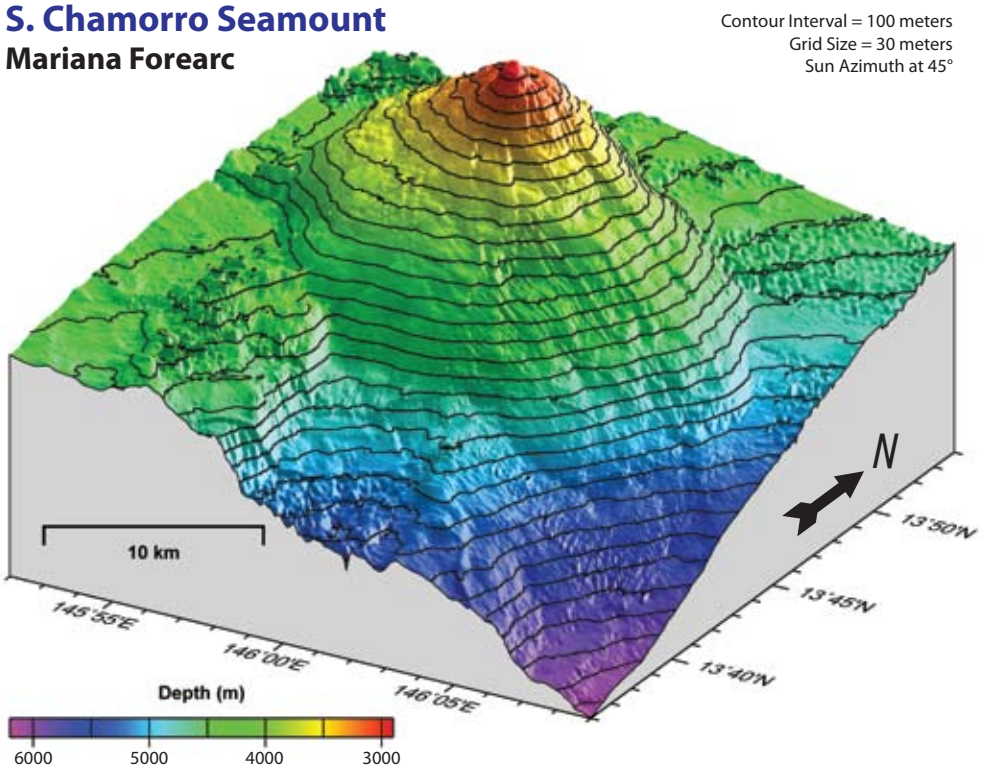

Figure 2. On the basis of US Navy Sonar Array Sounding System (SASS) data, South Chamorro Seamount was recognized as a forearc mud volcano in 1977 and was confirmed as such with the collection of serpentinized forearc mantle rock and slab-derived schist (1981). Sample collection includes submersible (*Shinkai 6500*, 1993 and 1997), coring (1997), drilling (Ocean Drilling Program Leg 195, 2001), and remotely operated vehicle operations (*Jason II*, 2003; *Hyper-Dolphin*, 2009). Data are from HMR-1 (1997) and EM300 (2003) side-scan sonar surveys.

Figure 3. Highly alkaline fluids (pH 12.2, 122 mmol alkalinity kg^{-1}, 0.2 mmol Mg kg^{-1}, and 503 mmol chlorinity kg^{-1}) vent from the CORK (borehole seal) opening at Ocean Drilling Program Hole 1200C on South Chamorro Seamount. These fluids react with seawater, rapidly forming brucite (the precipitate in the image). A PVC insert was deployed to foster in situ experiments and collect pristine fluid samples.

tubeworms, and galatheid crabs (Fryer and Mottl, 1997). To elucidate the underlying microbial and associated subsurface geochemical processes, a borehole observatory (CORK) was deployed during Ocean Drilling Program Leg 195 at the summit of the seamount to tap the hydrologic zone 149–202 m below the seafloor. This overpressured and permeable zone produces 20,000 liters of deep-sourced, microbially altered fluid per day, permitting in situ experiments in this extreme environment (Wheat et al., 2008; Figure 3). Although serpentinite mud volcanoes are currently limited to the Izu-Bonin-Mariana system, the geologic record indicates that such volcanism is a global phenomenon, occurring throughout Earth's tectonic history.

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