

**EXPLOSIVE DEEP SEA VOLCANISM PRODUCES COMPOSITE VOLCANOES (STRATOCONES) WITH PREDOMINANTLY DIFFUSE FLOW HYDROTHERMAL ECOSYSTEMS.** K. H. Rubin<sup>1</sup>, W. C. Chadwick<sup>2</sup>, R. W. Embley<sup>3</sup>, D. A. Butterfield<sup>4</sup>, <sup>1</sup>Univ. of Hawaii (Dept. of Geology and Geophysics, 1680 East-West Rd. Honolulu, HI 96822 USA), <sup>2</sup>NOAA/PMEL (HMSC, Newport, OR 97365 USA), <sup>3</sup>Oregon State Univ. (Newport OR, 97365), <sup>4</sup>Univ. Washington (JISAO, Box 354925, Seattle, WA 98195 USA).

**Introduction:** Submarine volcanism is a primary driver of water-rock interaction and a major geologic setting for water/silicate interactions and hydrothermal ecosystems on Earth. Explosive deep submarine volcanism produces volcanoes comprised dominantly of pyroclastic deposits. The structure, porosity, and hydraulic conductivity of subsurface marine aquifers driving hydrothermal activity, as well as chemical exchange rates during fluid flow, are largely determined by the physical character of geological strata that form the aquifer substrate. Explosive and effusive submarine eruption deposits produce distinctively different hydrologic substrates. The discovery of extensive deep sea explosive volcanism and angle-of-repose composite submarine volcano structures (stratocones) in the NE Lau Basin (Tonga) and Marianas arc with large diffuse flow vent fields provides the first definitive evidence that open-network, high-conductivity intergranular flow volcanic aquifers may be common in Earth's ocean, and on other planets where gas rich subaqueous pyroclastic volcanic eruptions occur.

**NE Lau Basin Volcanic/Hydrothermal activity:**

One of Earth's most active submarine volcanic provinces is in the rear arc and eastern backarc portion of Earth's fastest converging subduction zone and fastest opening backarc, along the northern Tofua arc in Tonga ([1] and references therein)]. This coupled with microplate extensional tectonics and a tear in the lithosphere promotes extensive regional volcanism distributed across many closely spaced volcanic centers. Some edifices are produced by primarily effusive volcanism, but another class are composite volcanoes (such as recently erupting West Mata volcano [2]), which have substantial portions (>50%) of pyroclastic and volcanoclastic sediment interlayered between lava flows erupted over 1 km to 3 km water depth [e.g., 2]. The latter volcanic edifices are structurally similar to composite volcanoes on land (e.g., slope analysis of multibeam bathymetric data from both ship-based and high resolution autonomous underwater vehicles indicate a wide range of uneven slopes on lava-dominated volcanoes, but a narrow range of slopes on pyroclastic and volcanoclastic dominated ones (e.g., [2,3]).

Observations on 3 ROV expeditions by our group in the area including a Nov-Dec 2017 expedition with Schmidt Ocean Institute on their vessel Falkor (plus 3 other expeditions with ship-based remote observational

tools in the past decade), provide information on the rate, composition, structures, and ages of rock units at many of these volcanoes, and their corresponding hydrothermal styles, and also the conditions of explosive, gas-driven volcanism at predominantly pyroclastic volcanoes [4]. The frequently active but small Mata volcanoes have a range of stratocone shapes and structures related to regional tectonics and their volumetric proportion of pyroclast and lava deposits, and support a diversity of hydrothermal venting styles, with diffuse flow fields dominating on mostly pyroclast edifices.

**Water-rock interactions:** By analogy to land-based volcanic systems, fluid flow in lava dominated aquifers is mostly along fractures and lava flow boundaries, whereas flow is more intergranular in clastic dominated aquifers. The latter might be expected to promote more diffuse flow regimes, larger and more distributed vent fields, higher water-rock ratios, and greater water-silicate rock exchange rates per unit of mass flow than lava-dominated volcanoes

In 2017 we observed and sampled several large (<500m) diffuse flow vent fields on recent, pyroclastic-dominated eruption deposits at West Mata volcano (formed within the last 1-10 years), as well as large focused flow (e.g., chimney dominated) vent fields ringed by extensive diffuse flow regions developed on older and sometimes coarser volcanoclastic aprons at nearby Mata volcanoes and spreading center volcanoes erupting gas rich magmas dominated by pyroclasts and highly vesicular lavas. Vent fields can occur pretty much anywhere on these volcanoes (not just at the summits). The fields were observed to support extensive microbial mats draped over the volcanoclastic-dominated seabed. The frequent wide-spread occurrence of diffuse flow venting and large aerial extent seem to be promoted by substrate structures dominated by thick pyroclastic units within the volcano structure, giving rise to a little discussed submarine "composite" volcano flow regime. Related recent work on magmatic gas rich vent fluids at active submarine stratocones are beyond the scope of this abstract but see [5].

**References:** [1] Embley R. W. and Rubin K. H. (2018) *Bull. Volc.* 80:36. [2] Embley R. W. et al. (2014) *G-cubed*, 15, 4093-4115. [3] Clague D. A.. (2011) *G-cubed* 12, QOAF03. [4] Rubin et al., (2012) *Oceanography* 25, 142-157. [5] Butterfield D. A. (2011) *Geology* 39; 803-806.