Mapping the Lava Deltas of the 2018 Eruption of Kīlauea Volcano

By Adam Soule, Erin Heffron, Lindsay Gee, Larry Mayer, Nicole A. Raineault, Christopher R. German, Darlene S.S. Lim, Michael Zoeller, and Carolyn Parcheta

Kīlauea on the Island of Hawai'i is one of the most active and well-monitored volcanoes in the world. Its most devastating eruption of the last 200 years occurred in 2018, destroying more than 700 homes and other structures and displacing thousands of residents (Hawaiian Volcano Observatory Staff, 2018). As is common for Hawaiian eruptions, the lava flows from the 2018 lower East Rift Zone reached the coastline, where they produced prodigious plumes of toxic, corrosive steam and several spectacular hydrovolcanic explosions. As activity progressed, a significant volume of lava entered the ocean and was deposited on Kīlauea's submarine slopes, where it formed a lava delta. Through funding provided by NOAA's Office of Ocean Exploration and Research and the National Science Foundation's Ocean Sciences Division, scientists aboard E/V *Nautilus* mapped the south flank of Kīlauea with the ship's EM 302 multibeam echosounder to characterize this and other recently formed lava deltas.

Three bathymetric surveys conducted between late August and early October 2018 captured the morphology of the volcano's submarine flanks from depths of 4,000 m to 50 m (Figure 1). By comparing the new bathymetric surveys to those collected in 2006, we were able to determine the location and volume of lava deposited subaqueously during the 2018 East Rift Zone eruption. Unsurprisingly, the areas of greatest deposition coincided with locations where the coastal plain expanded seaward, in places up to 1 km (Figure 2). As much as 2.5 km^2 of new land was added during the 2018 eruption. Surveys also captured lava deltas offshore from the Pu'u 'Ō'ō eruption, which was active

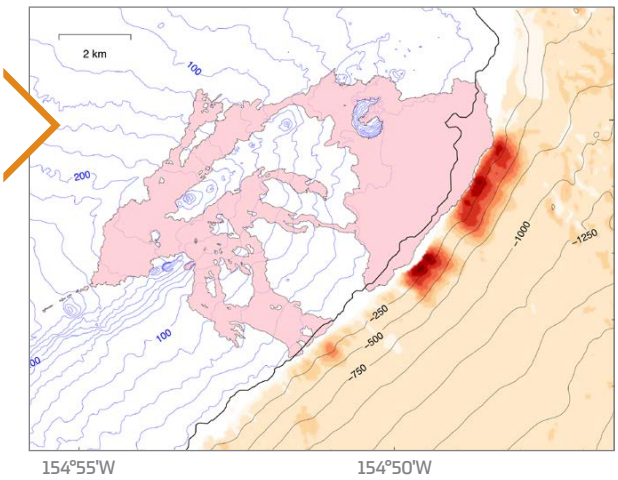


Figure 2. Bathymetric difference map between the E/V *Nautilus* 2018 surveys and 2006 surveys by R/V *Kilo Moana* shows the location of lava delta deposition offshore of the 2018 lower East Rift Zone lava flows (pink). Black contours indicate water depth in meters and blue contours indicate elevation in meters. The deltas coincide with the areas of greatest coastline addition, shown by the extension of the 2018 lava flows from the pre-eruption coastline (solid black line). Deltas extend ~1 km offshore from the new coastline to water depths greater than 750 m.

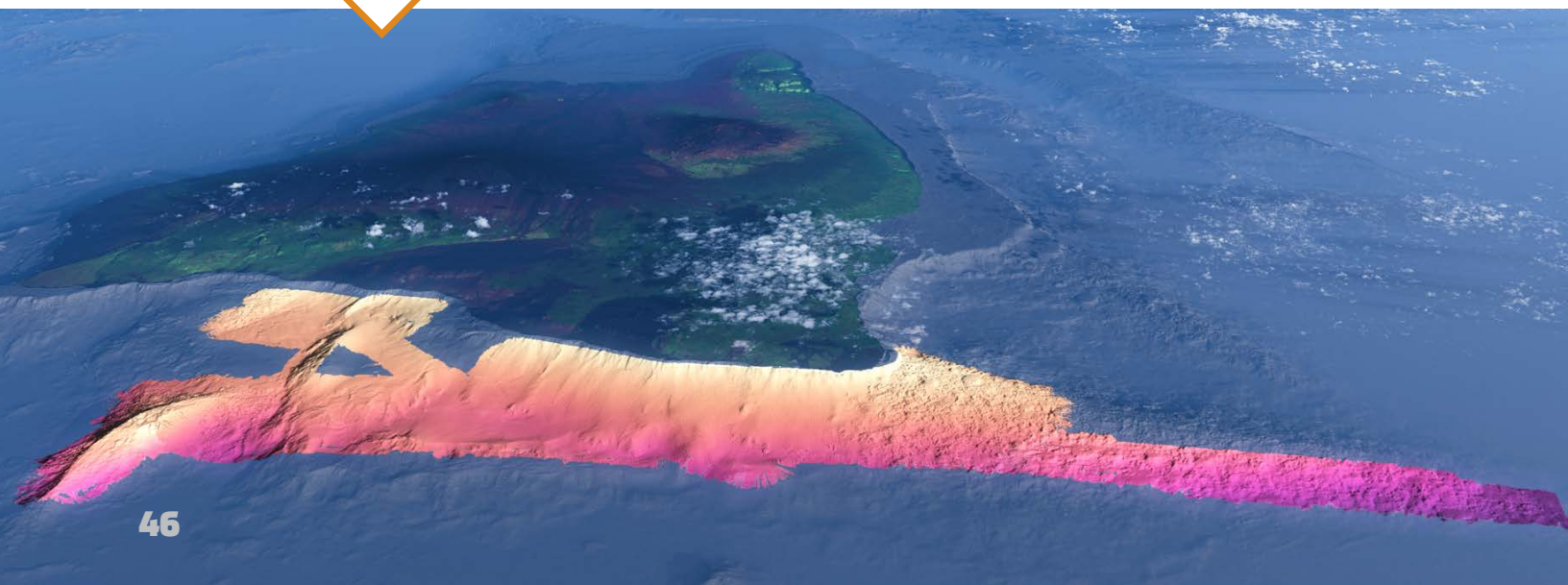
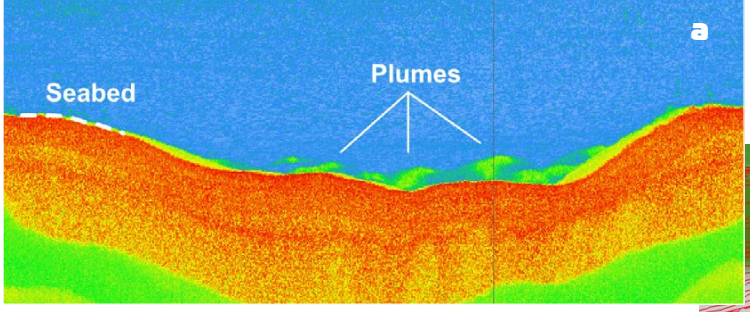


Figure 1. Three bathymetric surveys conducted by E/V *Nautilus* between late August and early October 2018 captured the morphology of Kīlauea's submarine flanks from depths of 4,000 m to 50 m.



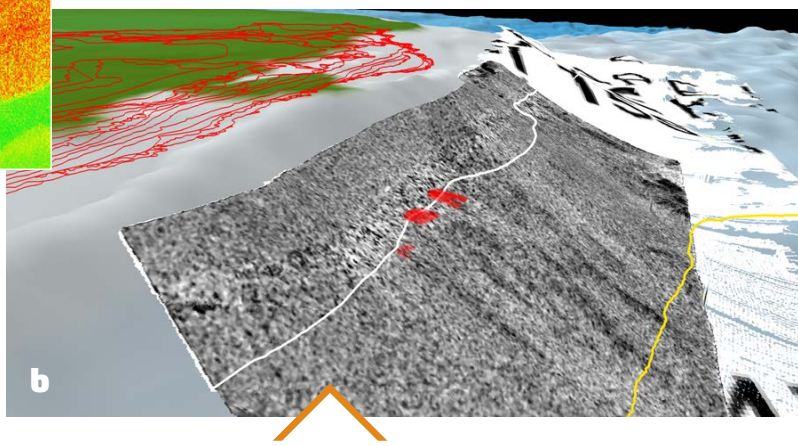


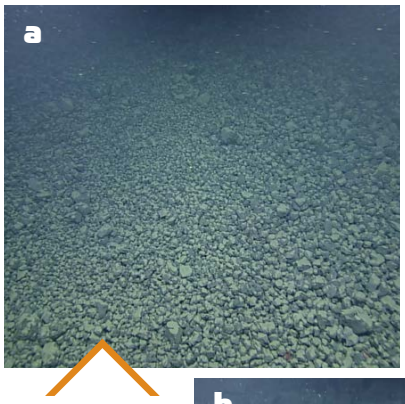
Figure 3. (a) Green plumes ascending a few meters above the seabed reflect low-lying water column anomalies imaged by the EM 302 multibeam echosounder. (b) Three water column targets (red dots) located along the 300 m depth contour (white line) superimposed on seafloor backscatter data from the EM 302 multibeam echosounder (the yellow line is 700 m contour, and red lines represent coastline growth as determined by US Geological Survey unmanned aircraft system flights).

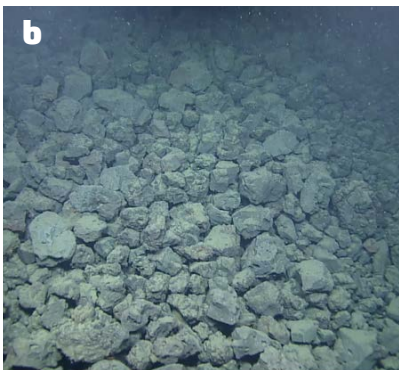
from 1983 to 2018, revealing areas of both deposition and removal due to delta collapses over the last 12 years.

Echosounder recordings during surveys over the lava deltas formed in 2018 also revealed water column anomalies that might reflect active fluid circulation, steam generation, or particle entrainment (Figure 3). These anomalies were ephemeral, appearing and disappearing from the same area as the ship traversed the coastline.

The SUBSEA program aboard *Nautilus* that followed the initial lava delta mapping (pages 48–49) diverted from its activities at Lōʻihi Seamount to investigate the water column anomalies. An ROV *Hercules* dive transect at ~300 m depth across a portion of one of the lava deltas observed a diverse array of fragmental lava. The clastic material ranged in size from a few centimeters in diameter to more than a meter and was well sorted within lobes, indicative of downslope transport (Figure 4). A second transit conducted at ~1,500 m depth across the delta encountered a series of intact lava flows. Following one of these flows upslope, diffuse hydrothermal venting, 1°–2°C above ambient, was discovered to have already been colonized by yellow-orange microbes. Rock, fluid, and microbiological samples were collected on the dive for onshore analysis.

Concurrent analysis of the bathymetric data, ROV imagery, and samples will allow us to address fundamental questions regarding the processes of deposition and remobilization as subaerial lava flows cross the coastline. Evaluating the volume of lava deposited on the submarine flanks will provide key data for understanding the integrated effects of this eruption as recorded by subaerial geophysical monitoring and observations. Further, ocean entries of active Hawaiian eruptions are known to be among the most hazardous locations on the volcanoes. In addition to persistent corrosive plumes and hydrovolcanic explosions, large collapses can occur that enhance explosivity and cause local tsunamis. Such collapses are difficult to predict without greater knowledge of the physical characteristics of the material deposited in the submarine environment and the manner in which deposition alters seafloor slopes. The ability of *Nautilus* and ROV *Hercules* to quickly respond to the volcanic crises at Kīlauea has provided critical data and observations to help address key questions at ocean entries, one of the most frequently visited, yet potentially dangerous, regions on ocean island volcanoes.





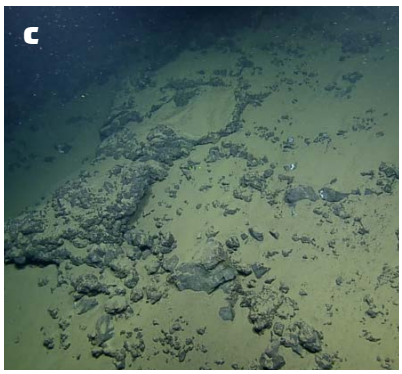


Figure 4. Photos showing materials that comprise the new lava delta, including (a) fine-grained clastic material (295 m depth), (b) coarse-grained blocks (303 m depth), and (c) intact lava flows (692 m depth). The black bar indicates ~1 m scale for each image derived from 10 cm spaced lasers mounted on ROV *Hercules*.