

In-Situ Monitoring of an Active Submarine Volcano: Loihi Seamount, Hawaii

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Geophysical monitoring of the submarine volcano, Loihi (Hawaii), has been conducted for the past five years with self-recording robotic observatories placed on the summit of Loihi with the submersible *Pisces V*. The summit is located at a water depth of 960 meters, 34 kilometers south of the Island of Hawaii. Three separate instrument arrays, including hydrothermal vent temperature sensors, bottom pressure recording sensors to monitor inflation or deflation episodes and a time lapse video, and seismometer arrays were placed on the Pele's Vent Field. The data showed that hydrothermal activity is diffuse, with vent temperatures rising to 100° C and above. The long-term temperature and flow regimes differ from one vent to the next. Throughout the duration of the experiment, the summit of Loihi showed largely deflation, probably due to episodic magma withdrawal from the summit into the magma conduit. The seismic data shows that the Loihi earthquakes can be divided into three families. Namely, earthquakes generated by magmatic pumping, by tectonic events, and by hydrothermal fluid boiling or other circulation effects. The greatest concentration of earthquake foci occurs at 12 kilometers below the summit with other foci distributed below to the base of the lithosphere and above to the summit.

The growth phenomena of Loihi appears to follow closely, that of Kilauea. Loihi is a younger volcano than Kilauea. The internal magmatic plumbing of Loihi as interpreted from observational seismic data taken with

the Hawaii Volcano Observatory network appears to be similar to that of Kilauea. Therefore, in terms of a monitoring protocol, the set of events preceding a submarine volcanic eruption on Loihi should be edifice inflation as the magma migrates upwards, culminating in an episode of harmonic tremors and other volcanogenic seismic signals followed by a rapid deflation of the edifice accompanying a summit or more likely a flank eruption. Such a series of events was observed once on Loihi in 1991 with an array of ocean floor instruments located on the summit of Loihi.

An ocean bottom pressure recording gauge (NOAA-type deep ocean tsunami gauge) was deployed concurrently with the ocean bottom observatory (OBO). The bottom instruments have been deployed on a 12-month deployment schedule on the summit of Loihi since 1991. Between December 19 and December 23, 1991, the bottom pressure recorder recorded a 40-centimeter deflation event of the Loihi edifice. This deflation event was accompanied by intense earthquake activity. An average increase of 0.75° C in the vent waters with the sensors 0.5 m above vent field was observed to take place over a period of seven days, 45 days prior to the deflation event. The deflation event was followed 47 days later by a six-month long period of vent temperature instability with 0.5 ° C fluctuations of one to two weeks in duration. This data set suggests that during deflation and the possible accompanying deep water

flank eruptions, the geological structure of the summit of Loihi is disturbed and the hydrology altered. In a hot spot volcano, such as Loihi, the period of recovery to steady state hydrothermal activity is probably of the order of months after a deflation event.

During the month of July 1996, an unprecedented sequence of 3,000 earthquakes accompanied a severe tectonically-driven destruction of the summit of Loihi, including the disappearance of a 200-meter high volcanic cone into a newly

formed 200-meter deep pit crater. The Pele's Vent Field was destroyed. Subsequent mapping and sampling by submersible of the site showed that the seafloor had collapsed by 400 meters at the Pele's Vent site. This event marks the first time that the formation of an active volcanic pit crater was monitored and observed. The 1991 deflation event was probably a precursor to the 1996 summit collapse event. No significant tsunamis were observed.