The Hawaiian Islands

by Robert I. Tilling

Because of their prolific activity, the Hawaiian volcanoes have been the focus of many scientific studies, especially following the establishment of the Hawaiian Volcano Observatory (HVO) in 1912 by Thomas A. Jaggar, Jr. This brief article to accompany the cover photo on this issue surveys the current volcanic activity in Hawaii and reviews ideas about the origin of these islands.

In January 1987, in commemoration of the 75th Anniversary of HVO's founding, the U.S. Geological Survey published two special works. The first by Decker and others, (1987) is a two-volume work that represents the most comprehensive geoscience study of Hawaii to date. The second (Tilling et al., 1987) is a general-interest booklet highlighting selected aspects of the eruptive behavior of two of Hawaii's active volcanoes, Kilauea and Mauna Loa.

The eruptive processes observed during the current eruption in Kilauea's east rift zone, which began in January 1983, are representative of those that have occurred repeatedly in the geological past to create the Hawaiian Islands. The first three and a half years of this eruption, still continuing as of this writing (August 1987), were characterized by spectacular, but brief episodes of high lava fountaining (cover photograph), interspersed with longer periods of much weaker activity within the throat of the vent (Wolfe and others, in Decker, Wright and Stauffer, 1987, p. 471-508; Heliker et al., 1987).

In July 1986, the eruptive vent shifted about 3 km downrift (to the ENE), and the episodic high-fountaining bursts ceased. Since then, the eruptive activity has consisted exclusively of phenomena associated with an active lava lake (Ulrich et al., 1987). Numerous short-lived overflows from the lake have built a new 40 m-high volcanic shield, and periods of sustained overflows have led to the formation of lava-tube systems, through which lava can flow underground a distance of more than 10 km to enter the Pacific Ocean. The flows that entered the sea have formed lava deltas composed of hyaloclastites, pillow lava, and pahoehoe or aa, whose subaerial parts accrete new land to the island.

The geology of Hawaii is best considered within the context of the Pacific basin as a whole. The Hawaiian Islands are the exposed tops of a gigantic, mostly submarine, volcanic mountain range (the Hawaiian Ridge-Emperor Seamounts Chain), which stretches 6,000 km from Hawaii (the "Big Island") generally northwestward to the Aleutian Trench (see Fig. 2 of Stone and Wallace, this issue). This prominent linear volcanic feature developed during a span of about 75 million years by countless outpourings of fluid basaltic lava.

The Polynesians who first settled the Hawaiian Islands believed that the islands become progressively younger from the northwest to southeast. Geological and geochronometric data clearly show that this general age progression holds for the entire Hawaiian Ridge-Emperor Seamounts system, with the still-active Hawaiian volcanoes at the southeast end and Late Cretaceous (80-75 Ma) volcanoes at the northwest end (Clague and Dalrymple, in Decker, Wright and Stauffer, 1987, p. 5-54).

Intraplate volcanism dominates the geological history of Hawaii. As first suggested by Wilson (1963), the age progression and distinctive linearity of this intraplate volcanic chain reflect the combined processes of magma generation, eruption, and continuous movement of the

Pacific Plate over a stationary "hot spot" (or "melting anomaly") in the asthenosphere. The sharp bend in the chain, about 3,500 km northwest of Hawaii, is interpreted as indicating a major change in plate motion - from north to northwest, that occurred about 43 Ma (Clague and Dalrymple, *ibid.*). According to the now widely accepted "hot-spot" hypothesis, part of the Big Island is presently situated over the hot spot, thereby tapping the magma source to sustain Hawaii's historically active volcanoes on Maui, Hawaii and, southeast of Hawaii, the submarine volcano Loihi. The other, and older, Hawaiian islands have drifted in a northwest direction beyond the hot spot, were successively severed from the feeding magma source, and are no longer volcanically active.

For the Big Island itself, the relative ages of its five volcanoes are also in accord with the hot-spot hypothesis. The oldest volcano, Kohala, forms the northwestern corner of the island and last erupted about 60 Ka. The second oldest is Mauna Kea, most recently active 3 Ka; and next is Hualalai, for which there is only one recorded historic eruption in 1800-1801. The youngest volcanoes, Mauna Loa and Kilauea, form the southeastern half of the Big Island and are still very active. Mauna Loa erupted in July 1975 and in March-April 1984, and the current eruption at Kilauea, which began in 1983, shows no signs of stopping (as of August 1987).

If the hot-spot hypothesis is correct, the next volcano in the Hawaiian chain should form east or southeast of the Big Island. Indeed, geological and seismic data indicate that Hawaii's newest active volcano already exists at Loihi, a seamount located about 35 km off the south coast of the Big Island (Malahoff, in Decker, Wright and Stauffer, 1987, p. 133-144). However, given that Loihi's summit is still more than 950 m below the ocean surface, it may take tens of thousands of years before the still-growing submarine volcano emerges above sea level, if eruptive activity persists in the same location during that span of time.

Dr. R.I. Tilling (USGS National Center, MS-910, Menlo Park, CA 94025, U.S.A.) conducts active research on volcanic phenomena. He has served as Chief of the Office of Geochemistry and Geophysics, responsible for the USGS Volcano Hazards Program.

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