HAWAIIAN LAVA TUBES -- A PRELIMINARY REPORT [1]

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The easternmost islands of the Hawaiian Archipelago are high volcanic islands built up primarily by relatively thin fluid flows of vesicular basalts. These flows occur either as smooth pahoehoe or rough aa depending on gas content and temperature. Lava tubes usually form in pahoehoe basalt and are a common feature in the Hawaiian Islands. Although sea caves and a limestone cave occur in the Hawaiian Islands, the purpose of this report is to briefly describe the significant lava tubes on each island and give their geological history.

BIOLOGY

The biota of Hawaiian lava tubes, especially the arthropods, are my primary research interest (Howarth, 1973). However, to understand lava tube ecosystems a detailed account of their geology and history is needed. In Hawaii there are troglobites (obligatory cave animals) living in lava tubes that have existed for a shorter period than is necessary for the evolution of the animals themselves. The vesicular and highly fractured nature of most basaltic lava, including pahoehoe, allows numerous avenues for subterranean dispersal by cave organisms. Thus, where vulcanism is nearly continuous over a prolonged period and the environmental conditions allow colonization of lava tubes by animals, then cave organisms can progressively move from remnants of older lava tubes into younger lava tubes as they become colonizable. The recognition of this dispersal mechanism is very significant for it now allows us to predict the existence of a specialized cave fauna in lava tubes elsewhere in the world. Significant faunas in lava tubes are also known from Japan (Ueno, 1971) and the Galapagos (Leleup, 1968).

LAVA TUBE REMNANTS

The oldest lava tubes in the Hawaiian Islands are exposed remnants on cliff faces and on the sides of river valleys. Some of these entrances are shelter caves formed by erosion, but many are the exposed termini of lava tube segments. Most of these are only shelter caves, the lava tube having been either partially or completely filled by subsequent lava flows, siltation, or collapse not far from the cliff face entrance. A few of these visited on the island of Oahu, however, have been true cave segments, with lengths of 50 m. These entrances are common in the drier cliff faces on all the main islands, but many are of difficult access and most remain unexplored. These caves were often used by the early Hawaiians for burials.

KAUAI

The primary vulcanism which built the shield volcano on the island of Kauai ceased 5-6 million years ago. However, there was extensive post-erosional volcanic activity on Kauai, known as the Koloa volcanic series, which now covers much of the eastern half of the island and lasted approximately 1.5 million years. The most recent dated flow is 600,000 years old (Macdonald and Abbott, 1970). Many of these post-erosional flows fill deeply eroded valleys and are very thick.

There are several lava tube sections extant on Kauai in the Koloa volcanic series which, judging from the degree of preservation, are most likely younger than 600,000 years. However, since sand dunes formed during the Waipio stand of the sea are found on the surface of the lava flow, the lava tubes must be at least 120,000 years old (Ku et al., 1974).

OAHU

Oahu has few lava tubes of much interest to the vulcanospeleologist. The latest substantial post-erosional flows on Oahu are the Tantalus and Sugarloaf flows which now underlie part of the city of Honolulu, smaller flows in Niu and other valleys on Southwestern Oahu, and a number of littoral tuff cones, the most famous being Diamond Head and Punchbowl. A number of large caves were accidently discovered in Honolulu during the past several decades by collapse from urban construction. These caves were water filled and have now been covered over by urbanization and are no longer accessible.

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Halliday (1958), described some of the caves on Oahu. Makua Cave is a large sea cave, as confirmed by the presence of dikes in the cliff above the entrance. Judd Street Cave is a remnant lava tube section in a steep slope at the entrance to Nuuanu Valley, Honolulu. The cave is a low braided stream passage typical of distributary systems near the edge or end of a flow.

MAUI

The island of Maui is actually two islands joined by a sandy isthmus. West Maui is much older and highly eroded. Only remnants of lava tubes in cliff faces are currently known from West Maui.

East Maui, or Haleakala Volcano, is much younger and a number of extensive lava tubes are known. The youngest lava on East Maui is Kalua-o-lapa flow on the south coast which occurred between 1785 and 1790 A.D. It has a small lava tube approximately 100 m long near the vent. Larger lava tubes have been known for some time in Haleakala Canyon near the summit of the mountain. These are Long Cave and Crystal Cave. A few large tubes are known above the town of Hana on the eastern slopes and a partially submerged lava tube nearby in Waianapanapa Caves State Park was well known in early Hawaiian legends.

HAWAII

The island of Hawaii holds the most interest for vulcanospeleologists, for it is here that one can watch lava tubes forming and study both young, well preserved lava tubes and older lava tubes in all stages of degradation. Lava tubes can be found here of all types and some have been described in the literature: Thurston Lava Tube by Powers in 1920 and Kaumana Cave by Von Seggern in 1968. Lava flows containing caves vary from short bursts of only small amounts of lava to the 1859 Mauna Loa flow which flowed 50 km to the sea and added nearly 0.7 km^3 of lava (Macdonald & Abbott, 1971).

The longest currently known lava tube in the State is Kazumura Lava Tube, located on the Southeast Rift of Kilauea Volcano at approximately 400 m elevation. The total mapped passage length (1972) is 3435 m. An additional 900 m of passage is known. The cave is young and well preserved. It is in an undated prehistoric flow which covers the 20,000 year old Pahala ash. The cave displays many of the phenomena found in lava tubes and is of great significance biologically. Several endemic cave arthropods are known from this cave (Howarth, 1972, 1973).

Passage shapes in the cave vary from high narrow meandering "canyons" to large elongate rooms which are nearly circular or key-hole shaped in cross-section. There also are sections of the cave with up to 4 well defined levels. These different passage types alternate with one another and each must have a common origin. The multi-level passages most commonly indicate the existence of a skylight in the upper-most level. Such correlation suggests that secondary roofs form over the molten lava under skylights. Other passage shapes may be formed or influenced by the slope and landforms before the flow, the amount of erosion and levee building by the flowing lava, the thickness of the roof, spalling during and after the flow, and also the amount of draining of the molten lava at the cessation of the eruption. Since not all the lava drains from such cave passages and there is currently no way of measuring the thickness of the floor, these caves may display less than 10% or more than 90% of the size of the active flow channel. Below lava falls in the cave well preserved plunge pool surfaces in the form of sine waves are "frozen" in the floor. Such kinetic energy, especially at a lava fall, most likely erodes the substrate.

In most of Kazumura Lava Tube the walls and ceiling are glazed. The floor here and there has a smooth, typical pahoehoe surface, commonly also with a "stepping stone" pattern of plate-like crusts frozen in the surface. In places it has a clinkery pahoehoe surface. Occasionally the passage is nearly filled by large treacherous spalling block mountains. There are a few areas well decorated with speleothems, mainly lavacicles and driblet spires.

The cave passage has 7 known skylights in the 4335 m of passage. All of these skylights appear to have been formed while the lava was flowing in the tube. In most cases a secondary roof had time to form beneath the skylight. At the other skylights most of the spalling blocks from the skylight fell into molten lava and were carried away by the flow.

The upslope cave begins at an entrance from a sinkhole 15 m long, 7 m wide, by 4 m deep. An unexplored cave passage continues on the upper end of the sinkhole. Four of the skylights are small holes in the ceiling at high narrow canyon passages and since the diameter of the largest is less than 1/4 of the width and 1/4 - 1/16 of the height of the cave passage, they are not considered to interrupt the continuity of the cave. The other 2 entrances are offset on upper levels. These entrances also do not interrupt the continuity of the cave passage.

POSTSCRIPT

Since this lecture was given the final terminus breakdown in Kazumura Lava Tube has been bypassed. The present (1974) surveyed main passage length is 8.1 km with an additional 2 km of main passge and side passages known.

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LITERATURE CITED

Halliday, W.R. 1968. An initial survey of the caves of the Hawaiian Islands. Bull. Natl. Speleol. Soc. 20: 58-60.

Howarth, F.G. 1972. Cavernicoles in lava tubes on the island of Hawaii. Science 175: 325-326.

_____. 1973. The cavernicolous fauna of Hawaiian lava tubes, 1. Introduction. Pac. Ins. 15(1): 139-151.

Ku, Teh-Lung, M.A. Kimmel, W.H. Easton, & T.J. O'Neil. 1974. Eustatic sea level 120,000 years ago on Oahu, Hawaii. Science 183: 959-962.

Leleup, N. 1968. Introduction. Mission zoologique belge aux iles Galapagos et en Ecuador (N. et J. Leleup, 1964-65) Resultats scientifiques. Koninklijk Museum voor Midden-Africa-Musee Royal de L'Afrique Centrale. Premiere Partie: 9-34.

Macdonald, G.A. and A.T. Abbott. 1970. Volcanoes in the Sea, The Geology of Hawaii. University of Hawaii Press, Honolulu. 441 pp.

Powers, S. 1920. A lava tube at Kilauea. Hawaiian Volc. Obs. Bull. 8:46-49.

Ueno, S.I. 1971. The fauna of the lava caves around Mt. Fuji-san. I. Introductory and historical notes. Bull. Natl. Sci. Mus. Tokyo 14: 201-218, pls. 1-4.

von Seggern, D.H. 1967. Electromagnetic mapping of Hawaiian lava tubes. Master of Science Thesis, Univ. of Hawaii. 41 pp.

FORMATION AND GROWTH OF LAVA TUBES DURING 1970-71 AT KILAUEA VOLCANO, HAWAII

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READ IN ABSTRACT

An expansion of this paper with additional content by Donald W. Peterson has been published in Studies in Speleology (Vol. 2, part 6, 1974, for 1973, pp. 209-222), under the title: Observed Formation of Lava Tubes during 1970-71 at Kilauea Volcano, Hawaii.

A complex braided and distributary system of lava tubes developed by roofing of lava rivers and coalescence of pahoehoe toes during 1970-71 at Kilauea. Lava was eventually transported as far as 12 km underground through these tubes, at average rates of 2-3 km/hour. Skylights formed at various times during development of the tube system, allowing observations into the active tubes. Initially the tubes were small--generally only 1-3 m deep--but they enlarged to at least as deep as 15 m, probably by erosion while lava continued to flow through them. The tubes were excellent heat insulators, so that lava cooled very little during its flowage in the system. Underground lava falls, multi-storied tubes, lava stalactites, and many other features common in prehistoric lava tubes were observed in various stages of formation.