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Preliminary Geologic Report for the Alenaio Stream Flood Damage Reduction Study Area, Hilo, Hawaii

By

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INTRODUCTION

Flooding within the city of Hilo, Hawaii, has caused damage in excess of $1 million dollars in this century (U.S. Army Corps of Engineers, 1980). Much of this damage has occurred along the lower reaches of the Alenaio Stream, and the U.S. Army Corps of Engineers, Honolulu District (COE-HD), has undertaken a feasibility evaluation for mitigation of future flood damage in this area. The COE-HD suspected that the local geologic structure was contributing to the flooding problem and requested assistance from the U.S. Geological Survey (USGS) to provide needed geologic information. A cooperative program between the USGS and COE-HD was established to provide this information; this preliminary report summarizes our reconnaissance findings that are most pertinent to future engineering planning.

GENERALIZED GEOLOGY

The city of Hilo is built on historic and prehistoric lava flows that were erupted on the Northeast Rift Zone (NER) of Mauna Loa volcano, at vents located between 5,000 and 12,000 ft, 16-32 miles to the west-southwest of Hilo (fig. 1). The distribution and characteristic properties of these individual flows are the principal factors controlling the patterns of both surface and subsurface water runoff in the central Hilo area today, and an understanding of their distribution and effects is essential to any viable flood control system.

Surface water runoff within the area of present-day central Hilo has probably been channeled by ephemeral streams for tens of thousands of years, but these streams have been repeatedly shifted laterally, as major lava flows from the NER entered what is now the Hilo area. These flows often displaced the preexisting surface streams, by burying parts of the old streams, and by forcing the blocked streams to shift laterally, usually to the margins of the new flows.

The present Alenaio Stream flows in a channel dictated by the margins of three different pahoehoe flows--the flow of 1881, the "Kulaloa" flow and the "Punahoa" flow. On the Geologic Map (fig. 2), the Waipahoehoe Branch of Alenaio Stream is shown bounded by the Punahoa flow in its upper reaches, and by the 1881 flow in the area below Chong's Bridge. From the area northeast of Komohana Street, the Alenaio Stream is mostly bounded by the Kulaloa flow.

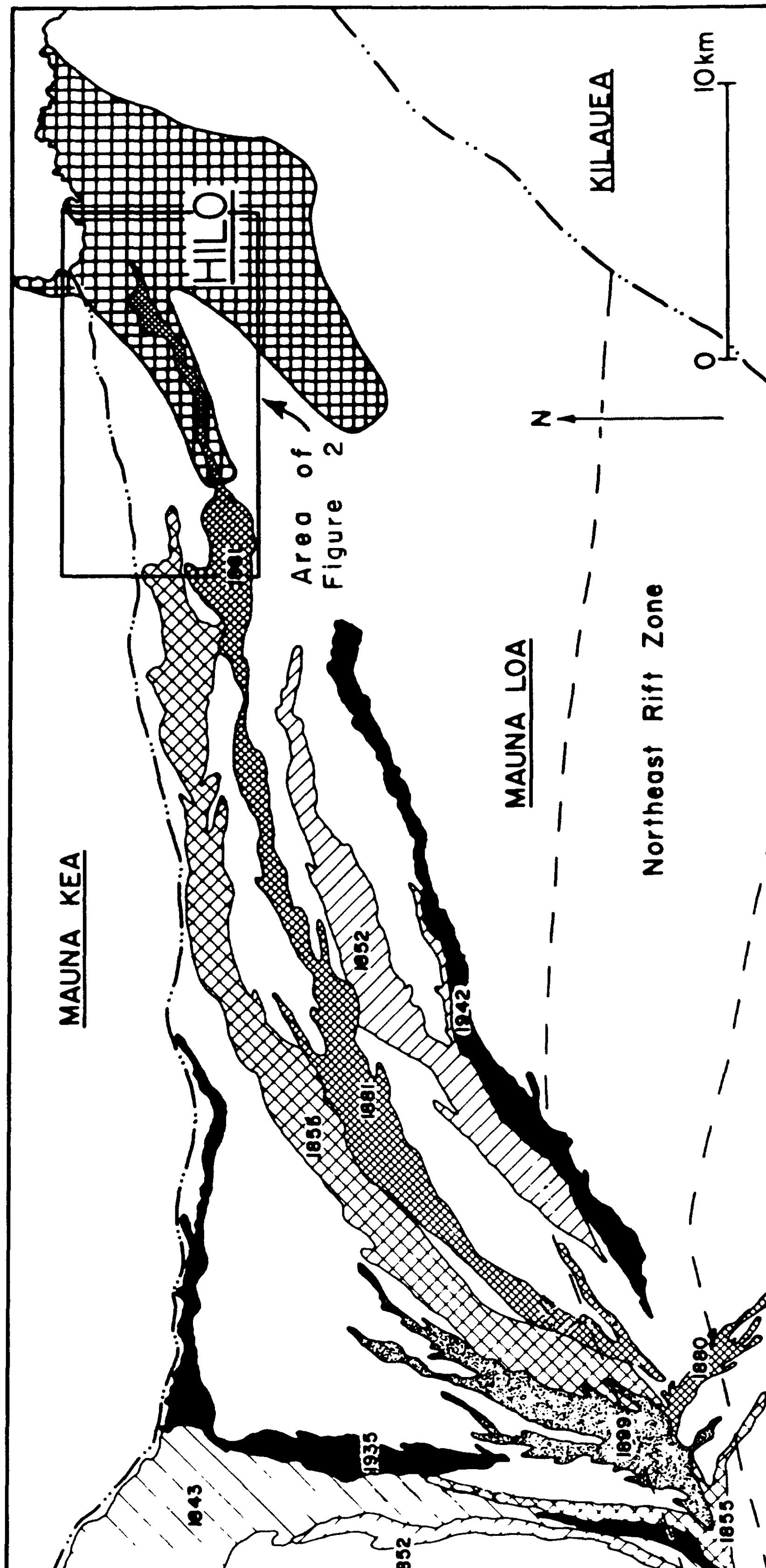

Figure 1. Generalized geologic map, showing relation of Mauna Loa's Northeast Rift Zone to Hilo, and distribution of historic lava flows.

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BRIEF DESCRIPTION OF INDIVIDUAL GEOLOGIC MAP UNITS

The units are described in order of age, from the youngest to the oldest. Unit names are highly informal, and subject to change.

<u>1881 flow</u> Tube-fed pahoehoe. Typically contains 2-3 percent plagioclase and 3-4 percent olivine phenocrysts (crystals visible by unaided eye) set in a microcrystalline matrix. The abundant vesicles (small gas bubble cavities) are typically spherical and of uniform size. This flow can be recognized by the presence of fresh black volcanic glass on all undisturbed surfaces.

<u>1856 flow</u> Tube-fed pahoehoe similar to the 1881 flow, but with less common olivine, slightly more weathered surface glass, and more mature covering vegetation.

<u>Kulaloa flow</u> Tube-fed pahoehoe. Contains abundant fine plagioclase laths and may contain up to 2 percent olivine. The abundant vesicles are typically spherical and of uniform size. Deeply weathered glass is present on many fresh, undisturbed surfaces. ^{14}C age: 1,100 to 1,400 years. Named after Kulaloa Road in Waiakea-Uka.

<u>Punahoa flow</u> Tube-fed pahoehoe. Contains abundant fine plagioclase, but rarely contains olivine. Surface is usually deeply weathered and surface glass is found at only a few localities. The vesicles are normally subrounded in shape and variable in size. ^{14}C age: 3,000-4,000 years. Named after Punahoa Ahupua'a (Punahoa = associated with springs; ahupua'a = a unit of the Hawaiian land division system). This flow covers a large surface area in the Humu'ulu Saddle region and in the lower rain forest and forms outcrops to at least 6,200 ft above Hilo. This flow is characterized by numerous tubes which transport a great volume of ground water to Hilo. Over 90 percent of Hilo's spring-derived drinking water is obtained from lava tubes in this unit (Hawaii County Board of Water Supply, 1971).

Kino'ole flow — Dense a'a. Contains 5-8 percent sugary olivine and 5-7 percent plagioclase, mostly intergrown with olivine. The flow has a rubbly surface, but a dense interior. Estimated age 5,000-7,000 years. Named after poor exposures on Kino'ole Street.

Wailuku flow — Very dense a'a. Typically contains 8-12 percent clear, angular olivine and minor, very fine plagioclase. This flow is tough, flinty "bluestone" throughout, except in a few outcrops of undisturbed surfaces near flow margins. ^{14}C age: 10,500 years. It flowed down the Wailuku River channel, and forms much of the present-day Wailuku riverbed.

Homelani ash — Deep yellow and orange-brown volcanic ash. Loose and friable in top 3-4 ft, but lower portions are well indurated and fairly impervious to water. The thickness is variable, but averages about 10 ft. Its age is generally in excess of 10,000 years, although younger ash units, similiar to that which overlies the Punahoa flow in places, undoubtedly form the upper few inches of the Homelani ash. Named after the Homelani Cemetery.

Halai Hills spatter — Olivine-rich, partially-welded spatter. Chemical analyses show this spatter was most likely derived from an ancient Mauna Loa eruptive vent. The age and relationship of this spatter to the Homelani ash is not known.

THE WAIPAHOEHOE/ALENAIO STREAM ANOMALY

Alenaio Stream lies directly downslope from Waipahoehoe Stream, yet in a 1-mi-long stretch midway between Chong's Bridge and Komohana Street, no well-defined channel connects the two streams (fig. 3). Substantial surface water travels directly from the Waipahoehoe Stream to the Alenaio Stream only during periods of very heavy rainfall. In times of normal rainfall, water carried in the Waipahoehoe Stream at Chong's Bridge seems to dissappear in the area above Komohana Street and does not reach the Alenaio Stream directly. Yet, despite the lack of a well-developed stream channel upslope, water continues to flow in the middle and lower reaches of the Alenaio Stream except during periods of low rainfall. Much of the water passing below Chong's Bridge is lost directly into the bed of Waipahoehoe Stream, comprised mainly of the Punahoa and 1881 pahoehoe flows. There are numerous constriction points in the lower Waipahoehoe Stream, however, and during periods of abundant waterflow the carrying capacity of the stream is exceeded. The excess water is diverted out of the normal channel into well-defined flood channels that conduct the water southward, over the 1881 pahoehoe flow (fig. 4). Some of these flood channels lead directly to large lava tube openings (fig. 5), whereas others lead to the relatively flat area above Komohana Street, an area underlain by the 1881 and Kulaloa pahoehoe flows. Floodwaters accumulate in this area during periods of abundant rainfall, and it is clear that much of this water seeps into the underlying flows. Numerous small, wet, depressions where water collected and undoubtedly percolated downward were observed in this area during a recent relatively dry period. It is assumed that most of this water eventually reached lava tubes within the 1881 and Kulaloa flows. Some of this water doubtless continues to percolate downward beneath these flows, but much is clearly transported laterally towards the central Hilo area. The lava tube shown in figure 5 measured 8 ft in average diameter and had transported large amounts of water during recent heavy rains. Debris lodged in the tube roof indicated it had been completely water filled (fig. 6).

The answer to the Waipahoehoe/Alenaio Stream anomaly lies in the fact that the area between the two streams is almost entirely underlain by relatively young pahoehoe flows. Surface water apparently percolates into these lavas and is transported laterally by subsurface flow, possibly through lava tubes, thereby leaving no well-defined surface channel.

Figure 3.--Aerial view of the central Hilo area from the northeast showing the area of the "missing" channel between the Alenaio and Waipahoehoe Streams. The three principal pahoehoe flows that dominate the surface (left to right: Kulaloa, 1881, Punahoa) are seen as dark forested areas separated by light-colored grassland. Photograph by J. R. Griggs, U.S. Geological Survey.

Figure 4.--Lower Waipahoehoe Stream showing constriction point where floodwaters are diverted into a south-flowing channel. Photograph by J. R. Griggs, U.S. Geological Survey.

Figure 5.--Flood channel emptying into lava tube south of the lower Waipahoehoe Stream. Photograph by J. R. Griggs, U.S. Geological Survey.

Figure 6.--Debris lodged in the roof of the lava tube shown in figure 5. Photograph by J. R. Griggs, U.S. Geological Survey.

FLOODING IN HILO

Surface Flooding.--Surface flooding in Hilo is related to the distribution of pahoehoe flows and the carrying capacity of the ephemeral stream channels which drain them. Although surface water can percolate slowly into fractures and voids of the pahoehoe, the infiltration rates of these openings is exceeded during times of heavy rainfall, and surface runoff occurs. This surface runoff results in flooding when the carrying capacity of the channels that drain the pahoehoe exposures is exceeded.

Subsurface flooding.--Each of the pahoehoe flows shown in figure 2 contain complex lava tube systems. The lava tubes can be seen directly at some places, for example at Kaumana Cave in the 1881 flow, or at the openings to large springs in the Punahoa flow. In other places they can be inferred where artesian water unexpectedly issues from pahoehoe lava, as for example immediately east of Akolea Road. The shape of lava tubes seen in the Alenaio area varies from circular to lenticular in cross section, and their diameter from less than a foot to 20 feet. Water is normally carried below the surface in some of these tubes, even in times of drought. During periods of heavy rainfall in the uplands above Hilo, most of these tubes undoubtedly carry water. This water normally flows to sea level springs without causing problems, but in times of exceptionally heavy rainfall, as for example in February 1979 and March 1980, the carrying capacity of these subterranean conduits is exceeded, and springs can unexpectedly develop in areas of pahoehoe outcrop, especially near the distal ends of flows. A great deal of flood damage has been caused by ephemeral lava tube springs located near the ends of the Kulaloa flow between Alenaio Stream and Mohouli Street. These springs usually develop 2-3 days after the heaviest rainfall, suggesting that the water must travel a significant distance underground from its probable source in the rain forest catchment areas outside the topographic drainage basin of Alenaio Stream as depicted by the U.S. Army Corps of Engineers (1980).

Surface water runoff has been deliberately channeled into open lava tubes upslope from Hilo. Although this alleviates surface flooding in these upland areas, it may exacerbate subterranean flooding problems in Hilo in some cases.

Flooding of basements near sea level is another recurring problem during times of very heavy rainfall, and is caused by the temporary elevation of the surface of the basal fresh water table (Ghyben-Herzberg lens).

RECOMMENDATIONS FOR FUTURE GEOLOGIC STUDIES

1) Reconnaissance mapping of the upland areas of the Alenaio Stream drainage is needed, with detailed mapping of the surface exposures of the Kulaloa and Punahoa pahoehoe flows. This is to determine where the lava tubes within these units are being charged with the water they carry to Hilo and to outline the effective drainage area of the Alenaio Stream basin.

2) Geophysical means (such as, ground probing radar, ground magnetics, seismic refraction, self potential, and so forth) to locate individual lava tubes should be developed if possible and lava tubes mapped within the Alenaio Stream project area.

3) The map shown in figure 2 should be refined to provide exact areal distribution of different lava flow units and to provide more precise information for refined planning.

4) Detailed geologic maps (at larger scale if required) should be made for specific areas that may be designated by COE-HD engineers.

PRINCIPAL CONCLUSIONS

1) The Kulaloa and Punahoa pahoehoes extend well beyond the limits of the drainage area for the Alenaio Stream depicted in the U.S. Army Corps of Engineers (1980, fig. 3) reconnaissance study, thereby enlarging the effective drainage area perhaps as much as 10 times.

2) Flooding within Hilo is caused not only by rainfall within the topographically defined drainage basin of Alenaio Stream, but also by water carried into the area by pahoehoe flows originating high on the Northeast Rift Zone of Mauna Loa. This water is mostly carried in a plexus of lava tubes, as well as beneath the flows in some areas.

3) Any viable flood control program for Hilo should include an assessment of the subterranean as well as the surface flowage of floodwaters.

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