Volcano Hazards Unit 1: Monitoring Kilauea Monday Morning Meeting

Assessment Background Information: Lava Flow Diversion

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Please read the following pages to learn more about attempts to divert lava flows. Pages 2-3 are an excerpt from a USGS publication.

This reading reviews some ways people have attempted to control lava flows to prevent damages to property. The first known attempt to divert lava was in 1669 when Etna Volcano erupted and flows moved towards the town of Catania (figure 1). In an attempt to divert the lava, townspeople from Catania dug a gap through an edge of the lava flow that they continually maintained, which allowed lava to redirect away from Catania. However, the redirected lava moved to the southwest, in the direction of Palermo (figure 2). Citizens of Palermo chased the Catanians away so that the lava could fill the gap resume flowing towards and into Catania (Rittman, 1929; Finch and MacDonald, 1951).

Figure 1: Catania and lava flows of 1669, reproduced from a fresco in the Cathedral of Catania. Public Domain.

Figure 2: Map showing location of Mt Etna, Catania and Palermo, in Siclily, Italy. Modified from Google Earth.

Figure 3: House buried by Mt. Etna lava flow, 2007, from: Alle, 2007, used with permission of Creative Commons.

Diversion efforts have continued at Mt. Etna and elsewhere (figure 3). However redirected lava flows can cause issues in areas to which they are diverted so are not always an obvious solution. Civil agencies (not geologists) have to decide on the best plans and policies related to lava diversion.

To see the immensity of the process of creating lava flow diversions, see the video below (or many others available online) from the area around Mt. Etna in 2015.
https://www.youtube.com/watch?v=jTDd_WXnTIE

Mitigation of Risk from Lava Flow Hazards

Because there is no known way to stop an eruption, the main method of mitigating the risk posed by active lava flows is to divert the flow away from populated areas or to slow its advance to allow other mitigation efforts, such as evacuation (see, for instance, Peterson and Tilling, 2000). Diverting or delaying lava flows have been attempted by the use of explosives, water, and physical barriers. Any decision to attempt to control lava flows, of course, must be made by officials charged with land-use planning and (or) emergency management.

Many forms of lava flow diversion have been tried on the Island of Hawai‘i, with varying degrees of success. The first known efforts occurred in the summer of 1881 as a broad pāhoehoe flow from Mauna Loa slowly advanced toward the town of Hilo. Low earthen and rock walls were set up, but the advancing flow stalled on its own without evidence of being rerouted (Hawaiian Gazette, 1881). It is interesting to note that explosives also were authorized by the Hawaiian Kingdom for possible diversion of this flow, but the materials arrived too late to be used.

During an intense earthquake swarm beneath Hualālai volcano in late 1929, a seemingly imminent eruption of lava prompted Lorrin A. Thurston to suggest the use of explosives again (Honolulu Advertiser, 1929a). Jaggar agreed that if the explosives were placed along a feeder tube, the blast could disrupt the flow and cause lava to run over lands that had already been covered (Honolulu Advertiser, 1929b), thereby minimizing damage. The military went so far as to assess that the effort was feasible, but the anticipated eruption never took place.

Jaggar had his first opportunity to use explosives in 1935, when a Mauna Loa lava flow threatened the water supply above Hilo. He worked with a group of Army aviators who planned and executed a bombing mission, targeting sites along the upper channels of the advancing flow. The bombing was very precise and was completed days before the eruption ended. Jaggar claimed success (for instance, Jaggar, 1945a, p. 12–16), but most other volcanologists believe that the flow stopped because the eruption shut down (Lockwood and Torgerson, 1980). In 1942, under very similar circumstances, bombs were again used on Mauna Loa to blast a spatter rampart along a fissure vent feeding a flow advancing on Hilo. The rampart was successfully breached and lava diverted, but only for a short distance before it rejoined its original channel, effectively negating the diversion attempt.

The failure of the 1942 diversion suggests that the results of future bombing efforts might be improved by taking advantage of the steepest descent path maps. If the channel had been bombed at a point where the new outflow could be directed into a steepest descent path distinct from the original one, the bulk of the lava flow might have been diverted away from the original channel. Any remaining flow in the original channel would then be greatly diminished and pose less threat to areas downchannel.

After his retirement in 1940, Jaggar published a detailed proposal to divert Mauna Loa lava flows away from Hilo (Jaggar, 1945b), but the next opportunities to erect barriers were presented on Kīlauea Volcano. During the 1955 and 1960 Kīlauea eruptions in the Puna District, several barriers were built to divert or dam lava flows (fig. 5) in attempts to protect downstream homes and farms. Neither effort was successful, although it can be argued in both cases that lava inundation may have been delayed. Gordon Macdonald, the HVO Scientist-in-Charge during the 1955 eruption and a representative of the Governor during the 1960 eruption (which occurred after he left the USGS), was an advocate for lava diversion through the use of permanent barriers to protect Hilo (see, for instance, Macdonald, 1958). Unfortunately, most of the HVO staff concluded that the plan was “expensive beyond prudent economic justification” (Wentworth and others, 1961), and a very public debate over diversion ensued in the local press in 1960. Barriers have not been used since 1960, but during the 1980s, much effort went into studying the feasibility of building permanent diversion barriers above Hilo, as both Jaggar and Macdonald had advocated (U.S. Army Corps of Engineers, 1980). That study recommended construction of an emergency barrier when needed rather than construction of a permanent barrier.

Figure 5. Photograph showing bulldozers constructing a lava flow barrier in Kapoho in January 1960. Note the advancing front of an ‘a‘ā flow between the lava fountain and the trees at left. Date of photograph and photographer unknown.

The use of water to cool and solidify the advancing lava front—causing the lava to form its own barrier—has been attempted in Hawai‘i and was later also tried on a much larger scale in Iceland (see, for instance, Williams and Moore, 1973; Williams, 1997). Water, pumped from a nearby lake, was used during the 1960 Kapoho eruption to delay consumption of houses by fire upon lava contact. In 1989, when lavas from Kīlauea’s East Rift Zone were slowly engulfing the Waha‘ula Visitor Center within Hawai‘i Volcanoes National Park, water was again used in an experiment to delay consumption of the wooden structure. Although some delay was achieved, the structures ultimately burned to the ground (fig. 6).

The current State Lava Flow Hazard Mitigation Plan, written by a committee that included HVO and University of Hawai‘i scientists, found that lava diversion barriers were not appropriate in most situations; however, some critical facilities may be situated in areas where barriers could be a reasonable option (Hawaii State Civil Defense, 2002). For example, lava diversion barriers (5–7 m high, 700 m long, as designed by HVO scientists) were completed in 1986 (Moore, 1982; Mims, 2011) to protect the National Oceanic and Atmospheric Administration’s (NOAA) Mauna Loa Observatory, which is located on the north flank of Mauna Loa volcano (fig. 3). The facility is a premier atmospheric research facility that maintains the continuous record of atmospheric change since the 1950s and is the site of the measurements forming the well-known Keeling curve of CO_2 concentrations in the atmosphere.

The 2002 State plan discussed above considered, but was not based on, cultural objections, but concerns have been raised about some diversion strategies. Gregg and others (2008) mined interview data obtained from Kapoho residents shortly after their town was destroyed by a Kīlauea eruption in 1960 and found that ethnic Hawaiians favored the construction of earthen barriers but did not support the use of bombs for the diversion of lava flows. This finding echoes sentiments expressed by the Hawaiian community in response to the bombing of Mauna Loa lava flows in 1935 (Jaggar, 1936), as well as later interviews for the Hilo barrier feasibility study (U.S. Army Corps of Engineers, 1980). Only earthen barriers or dams were built to impede the advance of flows during the inundation of Puna in 1955 and Kapoho in 1960. Bombing was discussed but dismissed when it was clear that such measures would be of no use (Wilhelm, 1960).

Figure 6. Photographs of the National Park Service Waha‘ula Visitor Center near the coast on Kīlauea Volcano in 1989 and of efforts to protect it from approaching lava. *A*, Fire hose delivers water to cool approaching pāhoehoe flows (June 22, 1989). *B*, Visitor Center engulfed in flames later that day after being ignited by hot lava. *C*, Steel girders, twisted by inflating lava flows and later buried, are all that remain of the Visitor Center after it burned (October 12, 1989). U.S. Geological Survey photographs by Jim Griggs.

References and Resources

Finch RH and MacDonald G, 1951, Report of the Hawai'ian Volcano Observatory for 1948 and 1949. Contributions to General Geology, Geological Survey Bulletin 975-D, p 103-133.

Kauahikiaua and Tilling, 2014, Natural Hazards and Risk Reduction in Hawai’i, in Characteristics of Hawai’ian Volcanoes (MP Poland, TJ Takahashi and CM Landsowski, editors). USGS Professional Paper 1801, 2014.

Rittman A, 1929 Der Atna und seine Laven: Naturwissenschaften, 17, p 95-96.