

## *Chapter Thirty-Six*

# **HUMAN DECISIONS AND NATURAL HAZARDS: A CASE OF THE EAST RIFT ZONE OF KILAUEA VOLCANO ON THE ISLAND OF HAWAII**

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## **INTRODUCTION**

Every human settlement is subject to the risks imposed by some type of natural hazard. Most settlements are places of choice, although these locations often seem to be dictated by necessity. The reasons for settlement most often include water, soil and/or mineral availability, trade opportunities, favorable climate conditions, land speculation, or simply "the view." Whether the risks imposed by natural hazards are fully recognized or understood prior to settlement by either the settling individual or the involved governmental agencies is often a confusing matter of personal and institutional perceptions and responsibilities. Individual and community behavior patterns suggest that after settlement has occurred, the location is generally considered to be "worth the risk."

The human choices and compromises that have been made in adapting to living in a physically hazardous environment differ from place to place. The relationships between humans and their environment can be exceedingly complex. Moreover, perceptions of the choices which are made by one culture may not be well understood by those living in another. While accepting one's own natural hazard, it is common

to criticize the foolishness of someone else who might be living under the threat of a different hazard. Thus, understanding a hazardous situation in one context may not necessarily give one a greater understanding of how and why people adapt and cope with hazardous situations elsewhere.

A large portion of the world's population lives in regions that have evolved from volcanic processes. The hazard imposed by the presence of dormant or inactive volcanoes on "desirable" land is of considerable concern. Examination of the historical geography of a specific example may shed some light on how to adapt and cope with similar future situations. The case under consideration is the East Rift Zone of Kilauea Volcano on the island of Hawaii and the implications which the recent destruction of property by lava flows may have for the risks to life and property posed by future eruptions elsewhere on the island.

## THE PHYSICAL SETTING AND HISTORICAL BACKGROUND

Unlike the "classic" volcanoes of the Pacific Rim, the West Indies, or the Mediterranean, the eruptive nature of Hawaiian volcanoes is vastly different. Classified as "quiet" or non-violent volcanoes, their eruptions have historically threatened property, not life. This "gentle" characteristic was among the primary factors in selecting Kilauea as a site for what was to become the world renowned Hawaiian Volcano Observatory (HVO).

Thomas A. Jaggar, the former chairman of the Department of Geology at the Massachusetts Institute of Technology, was instrumental in this development. His efforts, begun in 1909, resulted in the construction of the initial volcano observatory in 1912, where he served as director (scientist-in-charge) from its beginning until 1940. Jaggar noted from the outset that his goals were more than just scientific investigation: "The main object of all the work should be humanitarian - earthquake prediction and methods of protecting life and property on the basis of sound scientific achievement." (Bevens, 1988). This human concern was central to Jaggar's research throughout his life. Until recently, however, much of the gathered data has not been utilized for the stated humanitarian objective.

Located on the southeastern side of the island of Hawaii, the Kilauea volcano complex is one of the most active in the world (Figure 1). The frequency of volcanic activity in this region was among the primary reasons for Jaggar's decision to establish the HVO at this site. The summit of Kilauea is at an elevation of 4,000 feet. To the northwest, the enormous volcanic shield of Mauna Loa (elevation 13,677 ft.) looms over Kilauea. A large caldera, or circular depression in the landscape, occupies the summit of Kilauea. This caldera is two-and-a-half miles long by two miles wide. Within the caldera and close to its southwest wall is the large crater called Halemaumau. Three-quarters of a mile in diameter and four hundred feet deep, Halemaumau is almost a perfect circle.

Two rift zones spread outward from the caldera of Kilauea. Both run off the island into the ocean and define where lava originates from Kilauea. The first, the Southwest Rift Zone, is eighteen miles long. The area on either side of this rift zone,

extending to the sea, is generally known as the Ka'u Desert. It is characterized by low rainfall and sparse vegetation. No roads or settlements exist in this region today. Even in prehistoric times there were apparently few native Hawaiian settlements on the *makai*, or seaward, side of this rift zone. Significant volcanic activity along this rift occurred most recently in 1974. The resulting lava flows did no more damage than cover the land that was not being utilized by people. The second rift zone, the East Rift Zone, is thirty-five miles long and runs through the Puna district of Hawaii. This rift zone has seen considerable volcanic activity since 1955 with lava flows affecting the coastal region between Apua Point and Cape Kumukahi (Figure 1).

Early nineteenth century documents and maps indicate that there were a number of native settlements along the Puna coast. In describing this area in the early 1820s, Reverend William Ellis expressed surprise at the size of the population found here. Excellent fishing and an established trade network with inland communities helped to make this area a desirable region for settlement (Ellis, 1827). The attractions of climate, vegetation, and general lure of the landscape have led to growth and development in more recent times.

In the area of Kalapana, the land slopes upward from the sea at the rate of approximately four percent for a mile or so. Behind this sloped plain, or on what the Hawaiians call the *mauka* or mountain side, rise the *pali* or cliffs. From an elevation of a thousand feet or more, the view overlooking the landscape and the ocean is spectacular. Some sections of the *pali* are not steep enough to discourage construction.

The land's boundary with the sea is nothing short of dramatic. With the exception of a few small black sand beaches, the imposing coastline is made up of volcanic cliffs which reach heights of a hundred feet or more. Waves pound relentlessly against these cliffs, creating towering columns of spray which dwarf the cliffs and etch the scene into the viewer's mind.

The vegetation and the rainfall of the area vary with elevation and northeast-southwest location. Between Kalapana and Cape Kumukahi, the land is generally lush with both native and exotic species. Numerous large mango trees and various other tropical lowland bushes, plants, vines, and grasses cover most of the land. The heavy annual rainfall averaging one hundred inches is a major factor in producing the abundant growth. Prior to the lava flows of 1990, the coconut groves which formed the background to the black sand beach at Kaimu were photogenic landscape signatures. No rivers or streams flow in this area as the land is mainly composed of layer upon layer of old, porous lava flows.

Southwest of Kalapana the climate patterns begin to change rather abruptly with markedly lower rainfall. Dryland brush and low grasses mark this as the transition zone into the Ka'u Desert and the region downslope from the Southwest Rift Zone.

In Puna, the heavy cover of vegetation is deceptive. Most of the region has little or no topsoil; with heavy reainfall, native plant species can rapidly grow to maturity directly on a lava substrate. However, there are areas on both sides of the rift zone in the northeastern section of Puna where the soil is relatively free of rocks and deep enough to have attracted sugar cane growers.

The Puna Sugar Company was established in the late 1800s at Kapoho. By 1900, a rail line linked this region to Hilo, the island's main port. Besides promoting the

agricultural development of the area, the railroad also served the short-lived Hawaiian Mahogany Lumber Company at Pahoa. Both of these commercial activities have ceased to exist.

Containing about 17 percent of the Big Island's population, Puna has been a rapidly growing area in recent years. Most of the 21,000 people in this region live on the northern side of the East Rift Zone. Many work in Hilo, the island's most populous town and the main shipping port, several miles north of Puna.

Pahoa, with a population of less than a thousand, is the only sizable town in the Puna area. It is located almost directly on the East Rift Zone. The population living below the rift zone is mixed. The ethnic Hawaiians trace their occupation of the land to pre-missionary days. Those of Japanese and Filipino ancestry trace their heritage to the sugar cane laborers of the early 1900s. As mechanization occurred and sugar declined, land owners switched to other agricultural pursuits such as growing papayas, vanda orchids, anthuriums, and macadamia nuts.

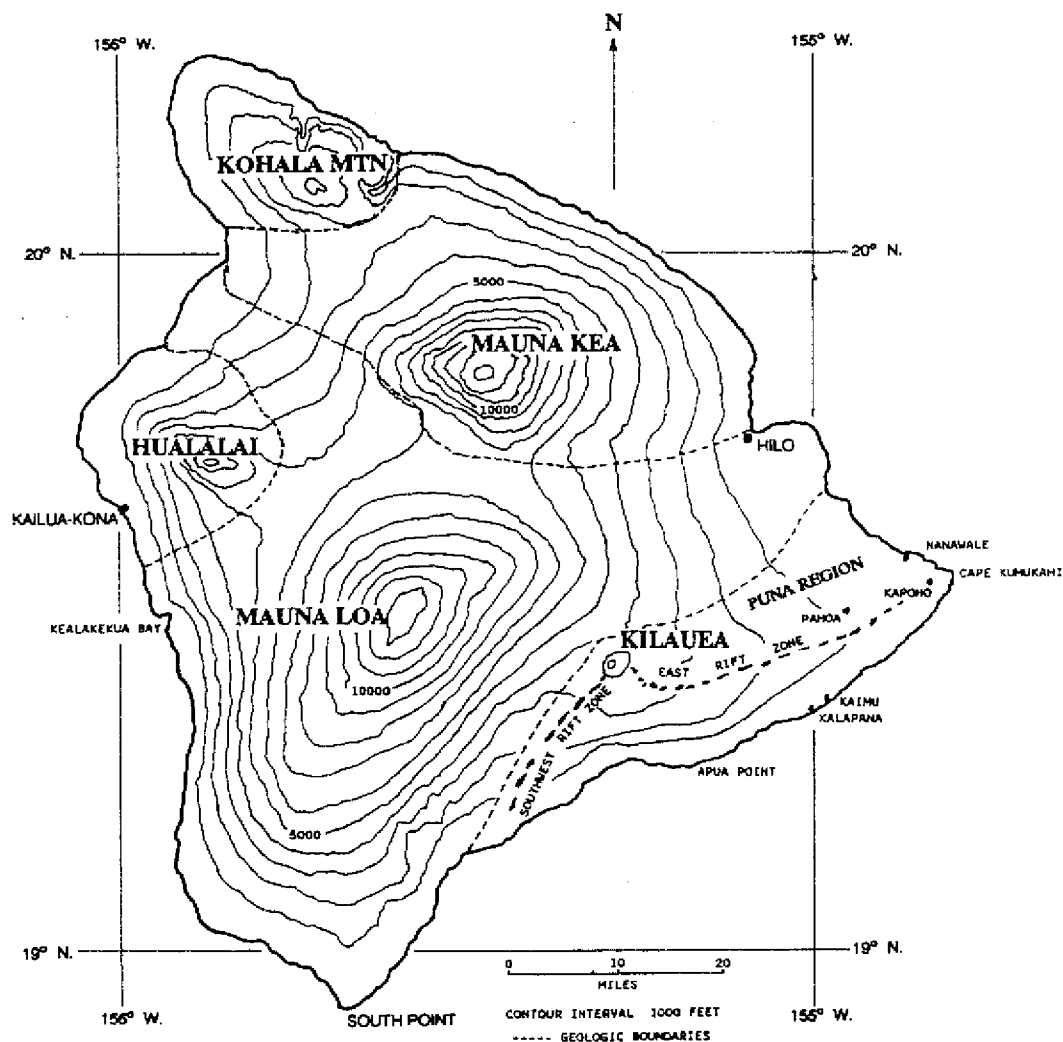


FIGURE 1. Island of Hawaii (After Macdonald and Abbott, 1970).

In recent years, real estate development has attracted a different population, many of whom have dreams of a vacation or retirement home. Some have sought a primary residence away from "civilization." A number of these people are from the Mainland and are comparatively recent "natives."

## ERUPTION HISTORY

Prior to 1955, the only historical eruption of any consequence along the East Rift Zone occurred in 1840, at the extreme northern end of the rift zone. It resulted in the destruction of the coastal village of Nanawale, northwest of Kapoho (Figure 1).

The people who have lived in this region have always been aware of the volcano. Nevertheless, although evidence of the land's geological formation is everywhere, fear of volcanic destruction has not been of as much concern as one might expect in such a situation. Ever since the early 1800s, eruptions had been largely centered in Halemaumau at the Kilauea summit. When asked by Reverend Ellis in 1823 about the historical eruptive activity at Kilauea, the natives said, "mai ka po mai." In Hawaiian this means "from a time of chaos until now," or since the beginning of the world (Ellis, 1827). Throughout the nineteenth century and into the twentieth, the pattern of almost continual activity in Halemaumau remained unchanging.

Although Jaggar warned that more eruptions along the East Rift Zone were highly probable, one hundred and fifteen years of volcanic inactivity in the region resulted in many residents overlooking any such warnings (Macdonald, 1970). In fact, when the area became the focus of real estate development in the 1950s and 1960s, support for settlement in the region was heavily influenced by political and economic considerations which overrode any opposition based upon volcanic hazards (Aleshire, 1990).

The century of quiet along the East Rift Zone came to an end with the Pu'u Ki'i and Pilewa eruptions of February 28 - May 26, 1955. Most of the new activity took place in forested areas. Lava covered some six square miles, including 1100 acres of sugar cane and other crops. Lava flows entered the sea in three places along the coast. Iwasaki Camp, a small plantation community, was overrun with lava. Including an area on the outskirts of Kapoho, more than twenty homes were destroyed and approximately forty others were rendered uninhabitable (Macdonald and Eaton, 1964).

Five years later, on January 13, 1960, fountains of lava lit the evening sky only a half mile northwest of the town of Kapoho. By the time the eruption ended on February 19, the entire village of Kapoho with approximately seventy structures, including homes, stores, and a school, had been covered by lava. A number of homes along the coast two miles away were also destroyed.

During the next twenty-two years, between 1961 and 1982, a number of significant eruptions occurred along the East Rift Zone. Most of these were clustered along the rift a few miles southeast of Kilauea (Figure 2). Although many of these eruptions were spectacular, of long duration, and high in volume output, the lava flows they produced were generally confined within the boundaries of Hawaii Volcanoes National Park. Consequently, these flows did not destroy agricultural land, nor,

with the exception of the 1977 eruption, did they threaten any communities.

On January 3, 1983, the longest sustained Hawaiian rift eruption in historic times began. At the time of this writing in January, 1992, the eruption continues to pour lava out at the rate of more than a half a million cubic meters per day. Known as the Pu'u O'o-Kupaianaha eruption, lava flows have covered in excess of thirty-five square miles, most of which lie outside the eastern edge of Hawaii Volcanoes National Park. More than 180 structures have been lost as numerous flows passed through the communities of Kalapana and Kaimu and the adjacent subdivisions of Royal Gardens and Kalapana Gardens (Figure 3).

### HUMAN PERCEPTIONS

Human perceptions of a hazard are often culturally-biased and misunderstood. One of the most prevalent criticisms heard regarding volcanic hazards centers around the belief that such hazards are "avoidable."

In the legends of ancient Hawaii, Pele, the goddess of the volcano, is considered to be one of the more powerful deities. Hawaiian history is replete with accounts of Pele's power. It is a story that every *kama'aina* or native resident has grown up with. Pele established her home in the crater of Halemaumau after a series of bitter conflicts with one of her sisters who chased her from one island to another. She would periodically visit her other "houses" or craters, announcing her travels, and her displeasures, with the earthquakes of her stamping feet. Defiling and desecrating her houses or showing disrespect to her in any manner would bring sure destruction.

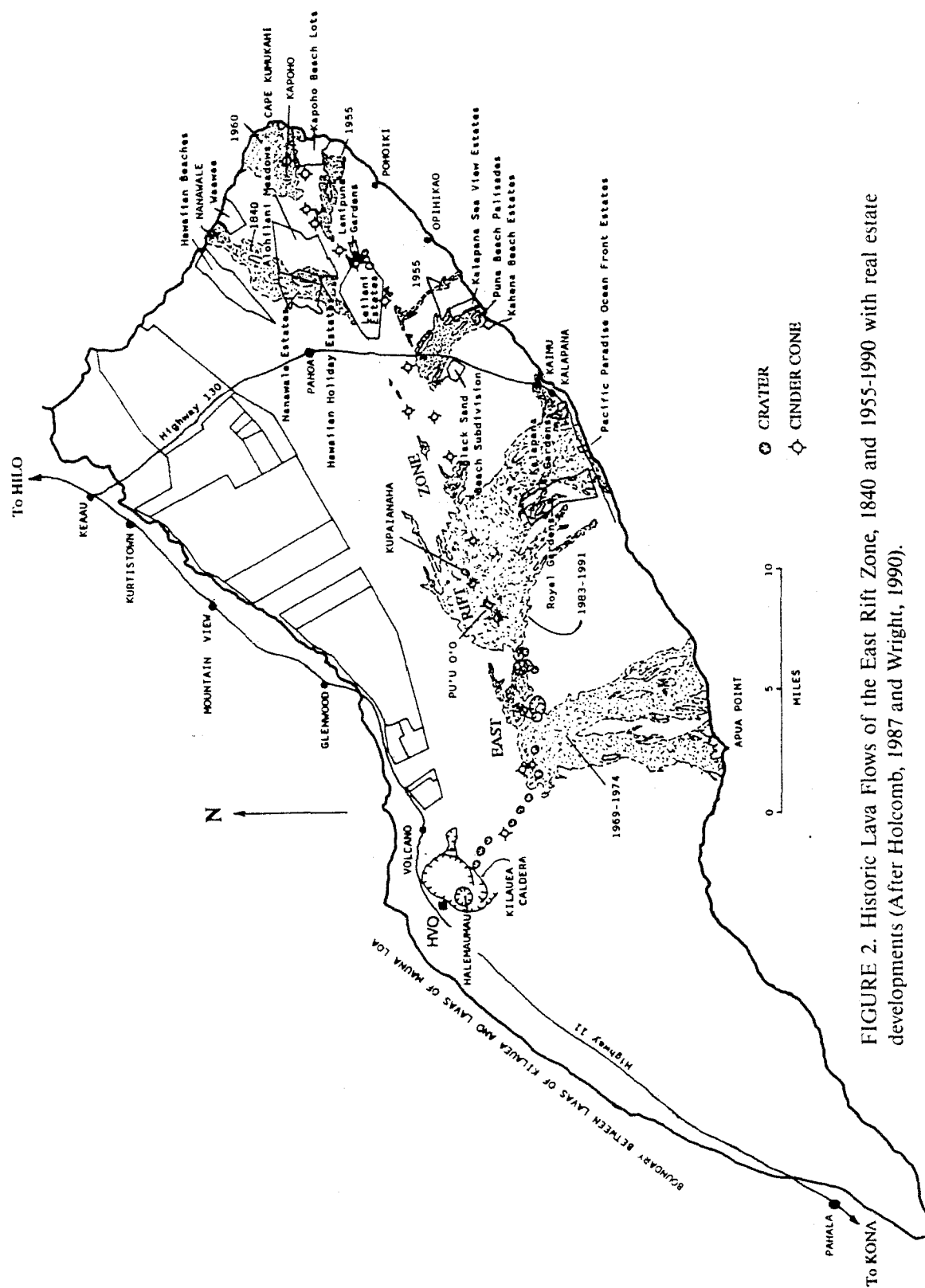
Belief in Pele is still strong today. Her residence is still considered to be Halemaumau, and offerings of food and flowers may be seen at her "house" or before her lava flows. Stories of Pele appearing before and during an eruption as a beautiful young girl or an old woman persist to the present. Meeting Pele and being rude to her or refusing her a simple request is believed to result in a person's property being inundated with lava.

In religious matters, little has changed since Reverend William Ellis noted that in a conversation with a priestess of Pele in the early 1820s, "She did not dispute that Jehovah was a God, but that he was not the only God" (Ellis, 1827). This integration of religious beliefs is not viewed as being contradictory to the many *kama'ainas* and native Hawaiians who are Christians and who regularly attend church on Saturday or Sunday. It is a culturally harmonious response to the supernatural.

Regardless of religious or even educational background, the generally philosophical response to property destruction by Pele is, "If she want 'em, she can take 'em." The belief is that humans are permitted to live on and utilize the land which was created by Pele. She has the right to reclaim it at any time and for any reason.

Over the years there has also been the perception by some that since the *haole* scientists were not really part of Hawaii, they did not understand the workings of Pele. Although this perception has changed somewhat, one can still hear it being expressed from time to time.

While the *kama'ainas* accept the supernatural and rely on fate or the uncon-



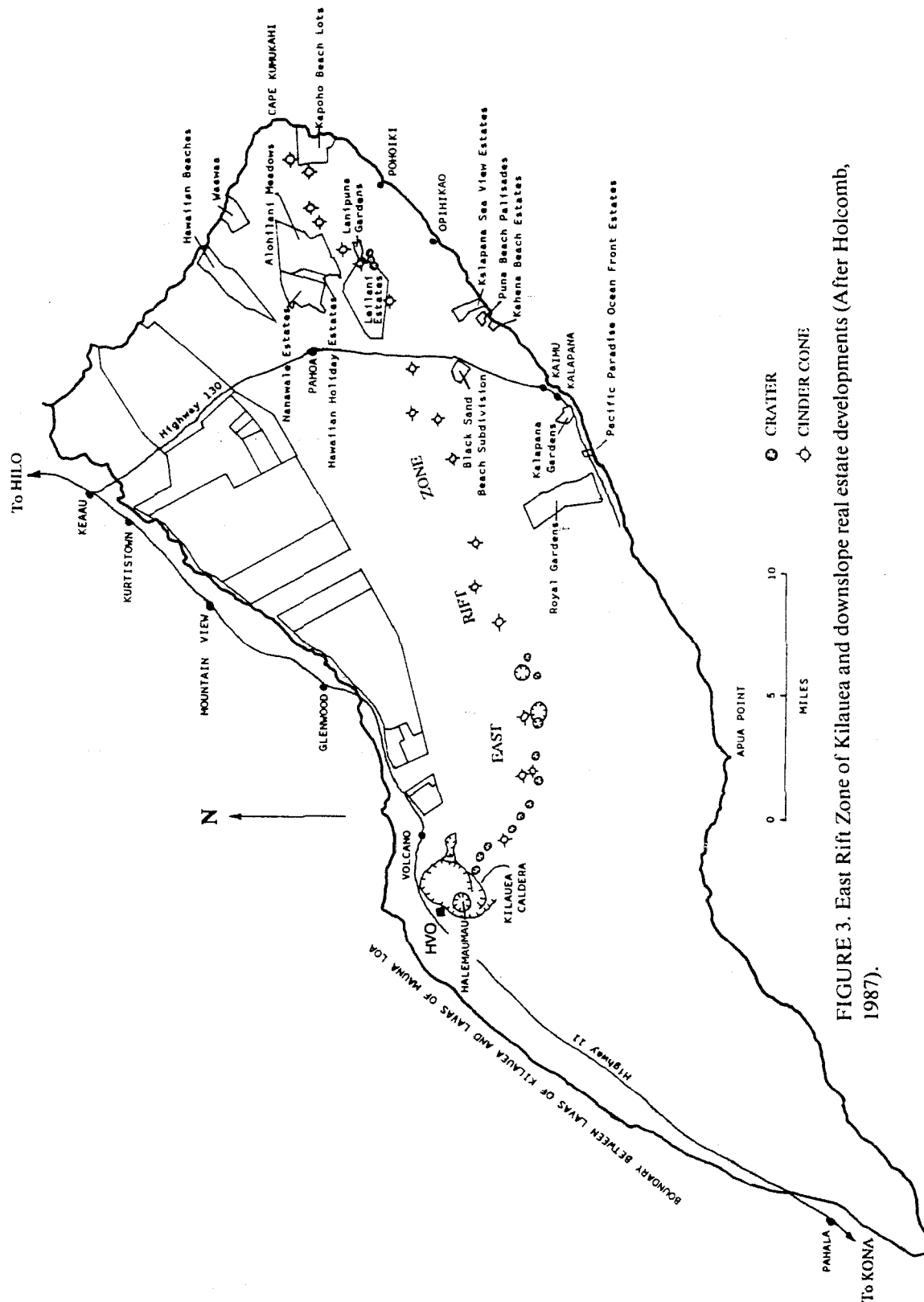


FIGURE 3. East Rift Zone of Kilauea and downslope real estate developments (After Holcomb, 1987).



trollable forces of nature, the perceptions of the *malihini haole*, or newcomer Caucasian, are somewhat different. Some embrace local tradition and belief, but there is a greater reliance on the pronouncements and predictions of science (Murton and Shimabukuro, 1972). Regardless of personal backgrounds or group identification, many are naive in regard to scientific and geographic principles.

The longer period of volcanic inactivity between 1840 and 1955 led many to believe there was no real danger along the East Rift Zone. This belief was strengthened by the fact that during this same period, activity was almost continual in Halemaumau. Even after the 1955 and 1960 rift zone eruptions, the perception persisted among some that these eruptions were unique and not likely to be repeated. The eruptions of the late 1960s and 1970s also seemed to suggest that such activity would be confined to that section of the rift zone closest to Halemaumau and within the boundaries of the national park. These perceptions were evidenced by the agricultural expansion and real estate development that not only continued, but increased in the region.

The natural vegetation of the Puna region also aided in camouflaging the true nature of volcanic hazard in the area. High rainfall and excellent drainage combined with a tropical climate conducive to rapid growth, produce a lush landscape within a very short time. In 1991, many parts of the 1955 lava flows exhibit remarkable vegetation coverage. Instead of evoking a response of caution toward the possible dangers that would be suggested by a black, jagged landscape, one is drawn to the beauty of an area softened by greenery.

Yet it is erroneous to conclude that people living in the East Rift Zone region have failed to perceive volcanic eruptions as hazardous. A 1972 study of area residents indicated that most people in the area were well aware of the geological realities of the landscape. A majority stated that the hazard was to property and not to life. In spite of the threat and understanding that there were other places on the island which were considered safer, more than ninety percent of those responding stated that the advantages of the region outweighed the disadvantages (Murton and Shimabukuro, 1972). Personal conversations in 1990 and 1991 with a number of people living both in and out of the area confirm that those same perceptions continue.

## HUMAN DECISIONS

Prior to the 1983 outbreak at Pu'u O'o, the main human response to a volcanic eruption has been to evacuate. Given the perceptions, attitudes, and cultural values of the population in general, leaving one's house and land behind was part of the initial pact one made with nature. Prayer and/or an appeal to Pele was also high on the list of actions. There were no other significant adjustments made toward the emergency, either at the time of an eruption or prior to one (Murton and Shimabukuro, 1971).

Previous eruptions have seen some human attempts to mitigate the hazard. In 1935, and again in 1942, bombs were used on the source end of Mauna Loa eruptions, whose lava flows threatened the town of Hilo. The results of these efforts

to break long lava flows into several shorter ones or to rechannelize them were largely inconclusive. Initial assessment gives some credibility to the utilization of this method, but the eruptions ceased shortly after the bombing and before sustained change in flow behavior could be observed. (Jaggar, 1936, Macdonald, 1942).

In 1937, the construction of embankments for the protection of Hilo was proposed (Jaggar, 1937). No action was taken then. The idea was revived in 1960 at Kapoho. Almost every bulldozer on the island of Hawaii was mobilized to construct earthen walls in an attempt to divert the flow of lava away from the community. Six separate walls twenty to thirty feet high were built in different places. Their combined length was a little more than three miles.

The effectiveness of the walls is still in dispute as, in reality, the effort failed to accomplish anything except to buy some time for those evacuating. Observers in 1960 witnessed that lava either overflowed these barriers or, in at least one case, melted its way under and through the barrier. All barriers were eventually either destroyed or carried away by the flows.

The feasibility of diversion barriers may never be known. Legal considerations have since put such projects on hold. Any interference of the natural flow of lava might result in the destruction of property that would have otherwise been untouched. The responsibilities and liabilities involved in these decisions are complex and would require legal and legislative attention.

The human response to volcanic eruptions in Hawaii reflected no change until the 1970s. Change was initiated by the fact that human populations, and their property, were more affected than at any other time in Hawaiian history. The explosion of tourism and land development following statehood in 1959 resulted in dramatic increases in real estate prices. While speculation investments were driving prices higher everywhere in the state, the Puna region contained properties which were considered "affordable." A number of subdivisions were started here during the 1960s. Royal Gardens was laid out on the *pali* slope to the northwest of Kalapana. Farther downslope and closer to the sea was Kalapana Gardens, then known as Kalapana Vacation Lots (Figure 3). Lured by lots selling for an average of less than \$2,000 at \$100 down and \$15 a month, the Hawaiian property seemed like a speculator's dream come true. In fact, the value of many lots increased to more than \$20,000 before the lava flows of the 1980s rendered them temporarily valueless (Figure 4).

An examination of local real estate developments reveals that these projects appear to have been driven by the all-too-familiar economics of the "fast buck." For example, the 159-acre subdivision of Kalapana Gardens had an original price of \$53,200 when it began in 1959. At least \$4.8 million in estimated sales was realized before the subdivision was covered with lava in 1990. Those involved in the various subdivision developments included a former governor of Hawaii, several state legislators, and a number of other high-ranking political figures who also had other interests in companies related to the infrastructure of the state.

The real estate subdivision boom eventually resulted in the creation of about 80,000 lots on the Big Island; 60 percent of these lots were located in the Puna district, on or near the East Rift Zone. A 1975 survey found that 88 percent of the

land owners in the Puna area lived off the island of Hawaii, and a majority of those were on the Mainland. At the time of purchase, many were unaware of the seriousness of the local volcanic hazards.

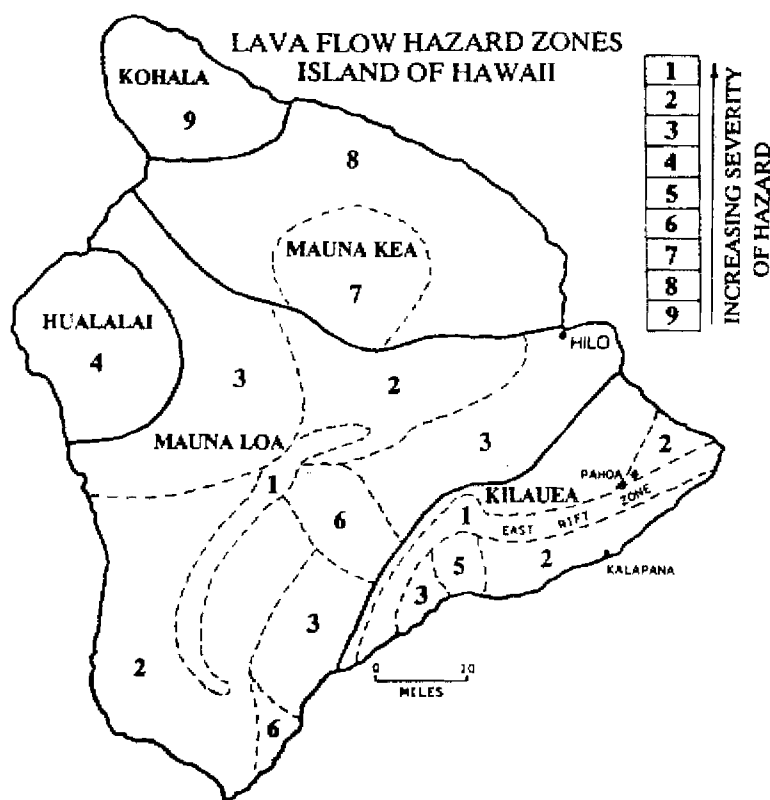
The advertised use of Hawaiian properties as “vacation lots” or “retirement properties” was apparently never the objective either. Hopes for spectacular returns on land investment were fueled by real estate prices elsewhere in the state. During the decade of the 1980s, Honolulu led the nation in appreciation of single-family dwellings at 145.3 percent.

For those who actually decided to build on the land, development conditions provided few essentials. Most lots had no access to utilities. Water was provided through individual catchment systems. Total lack of sewer hookups necessitated the added expense of blasting out cesspools in lava rock. These problems, combined with a number of other considerations, resulted in less than 5 percent of the nearly 50,000 lots in the Puna region having residences built on them (Cooper and Daws, 1985).

Until the 1970s, responses to volcanic hazards were initiated only after an eruption began. In 1974, the release of a volcanic hazard zones map of the island of Hawaii played a major role in changing that (Insurance company interviews). Revised in 1987, the map prepared by the U.S. Geological Survey caught the attention of real estate developers, financial institutions, and the general public (Figure 4). Approximately 60 percent of all speculative subdivisions lots were located within the zones of highest risk. Economic controls on the marketplace evolved based on hazard map perceptions and influenced land use decisions where previous arguments and policies had not. Land sales were still permitted, but construction on land within the high risk zones was severely curtailed by several other economic factors.

Although the Puna region has been among the least expensive real estate areas in Hawaii, construction costs are still very high. In 1990, the median price for a single-family dwelling on the island of Hawaii was \$136,000. By comparison, it was \$355,000 on the island of Oahu. Lacking the financial resources to build a home outright, most people attempt to obtain financing through a bank loan. Such loans are directly linked to an insurable property. Beginning as early as 1971, insurance policies were being refused on properties within the zones of highest volcanic risk. Having no insurance meant having no loan. Consequently, unless a person was willing and able to personally commit such funds and become involved in a “do-it-yourself” construction project, not many substantial structures were built. To be sure, a number of construction projects were undertaken by individuals acting as their own builders and contractors. While some dwellings were large and of considerable value, many were not.

During the Pu’u O’o-Kupaianaha eruption of 1983-91, some of the smaller dwellings in the Kalapana Gardens subdivision were raised off their foundations and moved by truck to safer locations. Roads of inadequate width and construction made it impossible to move larger dwellings. A number of property owners dismantled their homes board by board, hoping to rebuild elsewhere. The most dramatic move involved the Star of the Sea Painted Church in May, 1990. The entire church was jacked up and trucked to a temporary site on the shoulder of Highway 130, awaiting relocation.



Hazard Zones for Lava Flows

Zone	Percent of area covered by lava since 1800.	Percent of area covered by lava in last 750 yrs.	Explanation
Zone 1	greater than 25 pct	greater than 65 pct	Includes the summits and rift zones of Kilauea and Mauna Loa where vents have been repeatedly active in historic time.
Zone 2	15-25 pct	25-75 pct	Areas adjacent to and downslope of active rift zones.
Zone 3	1-5 pct	15-75 pct	Areas gradationally less hazardous than Zone 2 because of greater distance from recently active vents and/or because the topography makes it less likely that flows will cover these areas.
Zone 4	about 5 pct	less than 15 pct	Includes all of Hualalai, where the frequency of eruptions is lower than on Kilauea and Mauna Loa. Flows typically cover large areas.
Zone 5	none	about 50 pct	Areas currently protected from lava flows by the topography of the volcano.
Zone 6	none	very little	Same as Zone 5.
Zone 7	none	none	20 percent of this area covered by lava 3,500-5,000 yrs. ago.
Zone 8	none	none	Only a few percent of this area covered in the past 10,000 yrs.
Zone 9	none	none	No eruption in this area for the past 60,000 yrs.

FIGURE 4. Lava Flow Hazard Zones (After Heliker, USGS, 1990).

In early 1991, the state government was in the process of obtaining relocation property for the displaced residents of Kalapana. The state legislature was also working on a solution to the availability of volcano insurance.

Local governmental agencies have been intimately involved with hazard and disaster management ever since eruptions began along the East Rift Zone in 1955. The Director of Civil Defense has been responsible for everything from organizing evacuations and directing traffic to comforting residents and conducting news interviews. Besides having to cope with the 24-hour job of any volcanic eruption, the responsibilities of the office require overseeing all other emergencies both natural and human. Hawaii's location makes it subject to other natural hazards, such as tsunamis and hurricanes, which impose additional demands on the Civil Defense Agency. To its credit, this agency has managed to maintain a high level of efficiency and respect. Its greatest asset appears to be the perceived psychological value of genuine concern it projects to local residents.

Given the existence of active volcanoes and the frequency of various other natural hazards, one would expect an office of the Federal Emergency Management Agency (FEMA) to be located in Hawaii, yet as of 1991 none existed. The closest FEMA office is in San Francisco, where it is ironically located almost on top of the San Andreas Fault. Hawaii's state government has been attempting without much success to get a FEMA office located in Honolulu.

## CONCLUSIONS AND FUTURE IMPLICATIONS

Since 1955, approximately 30 percent of the land area downslope from the East Rift Zone has been covered with lava (Figure 2). Consequently, hazard experiences of the past few decades should provide some valuable lessons for the land use policies and decisions that have to be made in the next few years. The new real estate projects which have been started and the future developments that are planned require careful scrutiny and consideration. There are some projects seeking approval which exhibit the type of planning which brought disaster to the developments of Royal Gardens and Kalapana Gardens. It is evident that decision makers need to better utilize the information and tools at their disposal. The general public also needs to be more aware of the natural ecological cycles of the region, the nature of volcanic eruptions and their hazards, and have a clearer understanding of geologic time and sequence.

Various agencies and business institutions have also tended to consider the volcanic hazard zones as being absolute, with well-defined boundary lines separating each one. These perceptions ignore the complexities of approximations and scientific probabilities. Most importantly, responsible political and social decisions need to be driven by more than a quick profit.

In May, 1990, President Bush declared Hawaii County a major disaster area as a result of the Kilauea eruptions. Responding to that declaration, FEMA issued a Hazard Mitigation Team Report for the Kilauea volcano eruption in October of that year. The report identified, evaluated, and reviewed the various aspects of the volcanic activity. Recommendations were made for the reexamination of state and

county land use policies in Hazard Zones 1 and 2. The report expressed particular concern over development and increased population density within these zones.

Past performance has demonstrated that the land on the downslope side of the East Rift Zone is suitable for agricultural use. Papayas, macadamia nuts, and various horticultural crops do extremely well, even on lava flows that have been broken up and planted. Although there might be damage from both solid and gaseous material during an eruption, personal grief and property losses are likely to be far less than if the land were covered with dwellings and resorts.

While the two most populous areas on the Big Island, Hilo and Kona, are in no danger from Kilauea, both lie in the direct path of lava flows which could emanate from Mauna Loa and Hualalai. In 1931, Thomas Jaggar expressed concern over the fate of Hilo and called for disaster preparations. The danger is no less imminent today. As the island's population continues to grow and as future developments are considered, land use policies need to reflect a consideration of historical evidence and thoughtful concern. Society will have to decide not only the costs and benefits of such undertakings, but to determine who pays.

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