HI 1

Earl

HANDBOOK

for the

HAWAIIAN FIELD TRIP

4-11 April 1974

Sponsored by the

California State University, Northridge

Geology Club

John Hardin — Pres. (Fall, 1973)

James Vander Giessen — Pres. (Spring, 1974)

Peter Weigand — Faculty Advisor and Organizer

CONTENTS

SEMINAR SCHEDULE

Oct. 1	Dr. Christopher Buckley, CSU Fullerton; talk on their Hawaiian field trip
Dec. 5	First organizational meeting
Jan. 30	Second organizational meeting
Feb. 6	Movies: 1955 Eruption of Kilauea Volcano; Eruption of Kilauea 1959-60
Feb. 13	Talk by P. Weigand on geology and origin of Hawaii
Feb. 20	Talk by P. Kane on volcanic landforms
Feb. 27	Talk by Dr. Wendell A. Duffield, USGS Menlo Park with movies on recent Hawaiian volcanic activity and underwater lava flows
March 6	Logistics and group planning
March 13	Talks by Dr. Kenneth Wilson, Biology Department, on Hawaiian flora and by R. Howard on erosional landforms
March 20	Student talks on Hilo-Kapoho area and Kilauea area
March 27	Student talks on Kilauea, South Coast, Kona Coast, and Kohala-Mauna Kea areas
April 3	Delivery of luggage and last-minute details

PARTICIPANTS

Gina Alberti	ES, 1	Jeannie Heffernan	Geog
Carol Bacchilega	S	Joan Howard	S
Frank Bacchilega	Geog	Robert Howard	F
Martha Baxter	Phil	Philip Kane	F
Richard Berger	Geol, 2	Kevin Lant	Geol
Ted Bigbee	Geol, 3	Gerda MacGregor	Geol
Howard Brown	Anthro	Anne Marocco	Geog
Marjorie Bushnell	Geol	Peter McClosky	ES
Sharon Cabeen	Geog	Brent Miyazaki	Geol, 2
Jim Clark	ES, 4	Candace Morga	Geol
Barbara Deacon	Geol	Franz Orsan	ES
Lloyd DeKay	Geol	Stephen Reid	Geol
Brad Einstein	ES	Olivia Robinson	Geog
Creed Evans	S	Milton Stimson	Geol
Dianne Evans	Geol	Mike Tacsik	Geog
Dennis Grasso	Geog	Cathy Thielen	Geol
Nancy Gruver	ES	Julia Van Auker	ES
William Gustafson	F	Steven Van Wagoner	Geol
John Hardin	Geol	Jim Vander Giessen	Geol
Steve Hariton	Geog	Peter Weigand	F
William Harms	Geol	Gerald Whiteford	Geog
Dianne Harms	S	Randy York	Geol

F = faculty
S = spouse
1 = Food Committee Chairperson
2 = Camping Committee Chairperson
3 = No credit
4 = Not on flight

RESEARCH GROUPS

Area	Volcanic Landforms	Erosional Landforms	Historical Volcanology	Geology & Petrology
Hilo-Kapoho	Heffernan Tacsik	Bacchilega Haritan	Deacon	Hardin
Kilauea-Mauna Ulu	DeKay Reid	Alberti	Harms MacGregor Morga	Thielen York
South Coast	Grasso Van Auker	Orsan	McClosky	Brown Van Wagoner
Kona Coast	Marocco Einstein	Baxter Robinson	Cabeen	Lant Stimson
Mauna Kea	Whiteford	Gruver	Clark	Evans Vander Giessen

MEAL GROUPS AND COOKING
SCHEDULE

Meal Groups:

#1-Clark
C. Evans
D. Evans
Gruver
Vandergiessen
Whiteford

#2-Brown
Grasso
Orsan
McClosky
Van Auker
Van Wagoner

#3-Baxter
Lunt
Marocco
Bigbee
Cabeen
Stimson

#4-Bushnell
J. Howard
R. Howard
Tacsik
Berger
Weigand
York

#5-D. Harms
W. Harms
Thielen
Macgregor
Morga
Reid

#6-Alberti
Gustafson
Miyazaki
Dekay
Kane
Robinson

#7-C. Bacchilega
F. Bacchilega
Heffernan
Deacon
Einstein
Hariton

* Within each Meal Group the top three people are responsible for dinner, and the bottom three people for breakfast.

Responsibilities:

Breakfast: Cook or prepare breakfast, set out lunch, and clean up previous dinner
Dinner: Cook dinner, clean up next breakfast and lunch

Schedule:

	Thurs Apr 4	Fri Apr 5	Sat Apr 6	Sun Apr 7	Mon Apr 8	Tues Apr 9	Wed Apr 10	Thurs Apr 11
Breakfast:	-	#1	#2	#3	#4	#5	#6	#7
Dinner:	#1	#2	#3	#4	#5	#6	#7	

PRE-SARA LEE MENU

(Just in case we can't find the room for Sara Lee coffeecakes, steaks, pies, etc.)

BREAKFAST*

Friday: French Toast
Saturday: Dry Cereals and Oatmeal
Sunday: Scrambled Eggs and Bacon
Monday: Cereals
Tuesday: Boiled Eggs and Breakfast Rolls
Wednesday: Cereals
Thursday: Eating out if we're in the money, Poi if we're broke.

*Including Coffee, Tea, Chocolate Milk, Juices, and Fruit.

LUNCH*

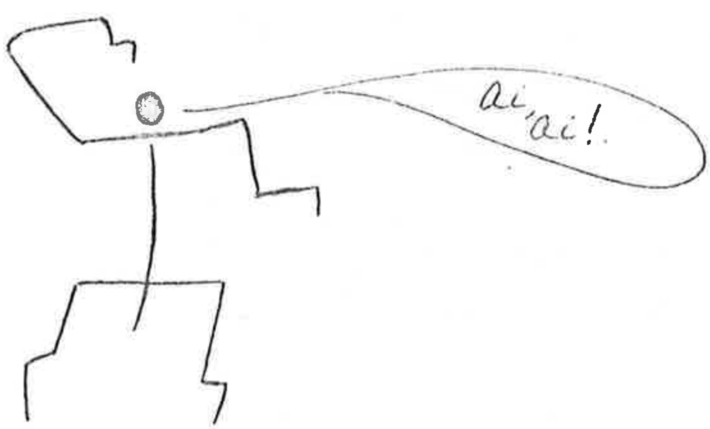
Saturday: Pizza Bread and Peanut Butter-Jelly Sandwiches
Sunday: Peanut Butter-Jelly and Tuna Fish Sandwiches
Monday: Cold-cut Sandwiches
Tuesday: Peanut Butter-Jelly and Egg Salad Sandwiches
Wednesday: Cold-cut and Peanut Butter-Jelly Sandwiches
Thursday: Depends on Finances

*Including Drinks, Potatoe or other Chips, and Fruit.

DINNER*

Friday: Chili Casserole - Green Salad - S'mores
Saturday: Mushroom Patties - Tuna Salad - Fruit Compote
Sunday: Spagetti - Green Salad - Fondue
Monday: Chili - Carrot and Pineapple Salad - S'mores
Tuesday: LUAU!
Wednesday: Hamburgers - Potatoe Salad - Pies

*including Dinner Rolls or Garlic Bread, Vegetables, and Drinks.



WHAT DOES IT COST TO GO TO HAWAII?

RECEIPTS as of March 27th

payments per person, not including books		
43 @ $250.		
1 @ 50. providing own transportation		$ 10,800.00
payments for books		
32 copies Volcanoes in the Sea	$288.	
30 copies National Parks	30.	
25 copies Road Guide	50.	368.00
December interest on bank account		3.68

ESTIMATED ADDITIONAL INCOME

refund from unused cabins	$256.50	
interest on bank account	15.00	
sale of 10 copies Road Guide	20.00	291.50
TOTAL INCOME		$ 11,463.18

PREPAYMENTS as of March 27th

maps	$ 9.50	
Northridge Travel Service		
air fare	8,578.08	
car expenses	496.00	
cabins	256.50	
luau	105.00	
books	318.00	$ 9,763.08
REMAINING FOR EXPENSES IN HAWAII		1,700.10
estimated expenses		
food	$ 900.00	
gas and additional milage	~~200.00~~ 380.00	
camping supplies	100.00	
Sterns Road Guide	70.00	
printing of group reports	50.00	

REMAINDER TO BE REFUNDED

TENATATIVE ITINERARY - VERSION #3

Th 4/4 Assemble on Lindley, bus leaves 8:45 a.m.
Leave LAX 11:40 a.m., United 197, arrive Hilo 2:00 p.m.
Afternoon open, camp at Onekahakaha B. P.

F 4/5 Drive to Pahoa, Kapoho, Kumukahi Point, Kaimu, Kupaahu.
See 1955 and 1960 cones and flows, Lava Tree S. M., surrounded lighthouse, Wahaula Visitor Center.
Camp at Harry K. Brown B. P.

S 4/6 Drive to Hawaii Volcanoes N. P., camp at Kipuka Nene Campground.

S 4/7 Kilauea Crater - Halemaumau - Kilauea Iki hike.

Other things to do and see: Thurston lava tube, Hilina Pali scarp, Mauna Loa Road, Bird Park, Crater Rim Drive, Sulphur Bank, Mauna Iki.

M 4/8 Hike to Huluhulu cone with Dr. P. W. Peterson to observe Mauna Ulu
Drive to Punaluu and camp at Punaluu B. P.

T 4/9 Drive to Kalae (hike to olivine beach) and to Hookena.
Luau at Kona Surf Hotel on Keauhou Bay at 6:00 p.m.
Camp at Hookena B. P.

W 4/10 Drive to Kamuela and Kawaihe, camp at Spencer B. P.

Th 4/11 Drive to Waipio Valley Overlook, backtrack to Kamuela, then to Hilo via Saddle Road.
Assemble at airport at 1:00 p.m.
Leave Hilo 3:10 p.m., United 118, arrive LAX 11:00 p.m.
Return to CSUN by bus.

Lloyd DeKay

VOLCANIC LANDFORMS OF HAWAII

Forms related to Halemaumau, the house of everlasting fire, the main caldera of Kilauea Crater.

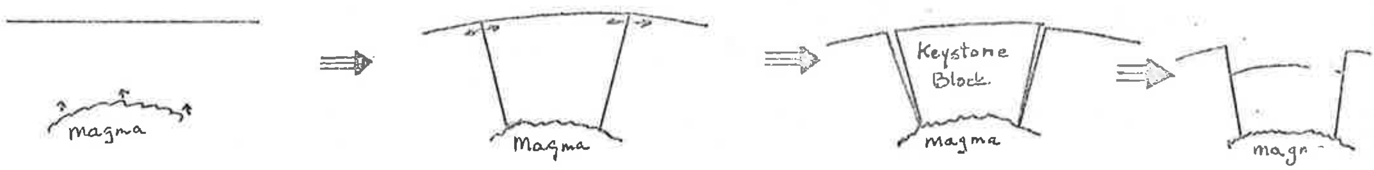
Rift Zones- zones of linear cracks on the flanks of active volcanoes through which lava is extruded during eruptions. Caused by cracking of the surface above an enlarging magma chamber as molten rock fills the chamber and causes the crust above to bow up. Lava moves up along the cracks generated to become a surface eruption. The East Rift Zone of Kilauea is an example of this.

Pit Craters- Small collapse craters caused by molten rock working its way toward the surface, melting a cavity as it goes. Then the magma is suddenly drained away through another outlet leaving a thin crust with no support below it. The crust collapses to form a pit crater. Two examples are:

Devil's Throat- near Kilauea Iki, 50 ft. across and 250 ft. deep.

Makaopuki- the eye of the eel, near the end of the East Rift Zone, 900 ft. deep.

Graben Faulting- Downdropping by normal faulting of "Keystone" blocks caused by crustal swelling during subsurface magma injection causing tensional faulting of the surface. Examples may be found in numerous localities along the East Rift Zone.



Tangential Faults- Normal faults aligned tangent to contour lines of a volcanic cone. These may result from two possible actions:

1) Slumping and subsidence of the flank of a volcanoe to the seaward side along a normal fault.

2) Rise of the central cone caused by injection of lava.

The second hypothesis is probably the dominant cause of these features, evidenced at Mt. Etna, Italy, where earthquake activity and displacement along tangential faults has been recorded both as magma is intruded and as it is drained away. Examples of this on Kilauea are the cliffs formed at Halina Pali and Poliokeawe Pali by tangential faults.

Forms related to lava flows

Pahoehoe lava- Lava with roundish vesicles, smooth, billowy, satiny, glistening, shiney, a result of lava with high gas content allowing for fluidity and easy flow.

Aa lava- Lava with deformed vesicles, clinkery, dull, spiney, a result of dead lava, lava with low gas content and therefore high viscosity.

It is known that lavas tend to grade downstream from pahoehoe to aa. This may be caused in two ways:

1) Gradual degassing of the lava downstream can cause the transition from pahoehoe to aa (Jagger).
2) Pahoehoe may extrude first, crusting over to form tubes through which the later extruded aa can flow and appear downstream (Washington).
The first mechanism is generally more acceptable as there is no evidence of these eruptive cycles, however there is much in the present research to support the second.

Ponded lava- Lava in a pit or crater which solidifies without movement or disturbance. It forms a planar surface. Found in Keanakakoi Pit Crater, adjacent to Kilauea caldera.

Stump scarp- Lava benches left in a pit crater when the lava level recedes in the crater after marginal cooling has taken place.

Columnar jointing- Jointing in a cooling lava which forms normal to the lava surface. It is controled in part by the crystalline structure of the lava such that shrinking between joints produces polygonal columns. An example may be seen at the boiling pots near Hilo (or see pg. 32 in Macdonald).

Kipuka- An uncovered island in the midst of a lava flow, which may be lower than the surface of the flow due to levees built by the lava.

Lava tube- A tunnel in lava with an arched roof and flat floor, caused by the cooling of a flow surface and gradual draining of the still liquid interior. Some are near Kilauea crater.

Stalactites- Stick-like lava forms hanging from the roof of tunnels, caused by roof remelting by hot gasses and downward dripping of melted lava.

Stalagmites- Upward pointing lava sticks found under stalactites, portion of melt which dripped onto the floor of the tunnel.

Lava benches- Linear shelves on the sides of tunnels showing the levels of the subsiding lava.

Pahoehoe toes- A string of bulbous pods of lava caused by multiple breakouts of the toe of lava flows.

Tumuli- Symmetrical, oval shaped bumps with longitudinal cracks and extruded entrail lava. Caused by byckling of flow crust where a flow advance is blocked and the hydrostatic pressure of accumulated lava pushes up the buckled crust. 5m high x 10m wide x 30-40m long.

Lava blister- Same shape as tumuli but caused by expanding gasses under a solidified surface of lava.

Pressure ridges- Same shape as tumuli except these are folded over in the direction of flow. Same cause as tumuli except more of it. Generally same height and width but 100-500m long.

Squeeze-up- A linear rounded ridge a few cm. high formed when lava wells up along joint cracks and cools at the surface.

Lava cascades- Lava which has solidified when going over a fall.

Lava molds- Lava will chill quickly around almost any plant or other obstacle, preserving the form down to the tiniest details.

Fern molds- near Kilauea crater delicate ferns have had their impressions preserved down to the spores on the undersides of the fronds.

Tree molds- In Lava Tree Park on the East Rift Zone there are molds preserved where the lava flowed around trees, entering shrink cracks in the burned, charcoal bark to produce a boxwork pattern on the inside of the mold.

Side curtains- Banks and levees self-created by the lava flow as cooled material is pushed to the sides of the flow as it advances.

Shark's tooth projections- Pointed projections of small dimension which extend outward from the sidewalls of lava stream channels. They are caused when partially cooled lava on the flow margin is pulled off the wall; sharp projections which curve in the direction that the material was removed are left behind on the walls. Some of these may be found in the lava tubes as well as elsewhere.

Forms related to lava ejecta

Bombs- Ejected lava blobs which cooled completely or partially in flight and remained a descreet mass upon and since landing. There are several types of these bombs:

1) Spindle bombs- Elongate bombs which narrow at each end to look like the spindle of a spinning wheel.
2) Ribbon bombs- Flattened and very elongate bombs which originated from squirts of somewhat viscous lava.
3) Cowdung bombs- Bombs which only partially cooled in flight to become squashed and flattened upon impact such that they resemble cow plop.
4) Pele's tears- Small teardrop shaped bombs which are said to be the tears of the goddess of Kilauea crater
5) Pele's hair- Drawn out, thin threads of viscous lava which freeze to form slender glassey filaments. They range in color from jet black to golden brown. May be found on the lee sides of rocks in the Kau desert.

Bomb sags- Depressions in unconsolidated ash made by the impact of bombs. The ash may become fused later on to preserve these features.

AGE OF HAWAII

Hawaii is the youngest of the chain of islands comprising the Hawaiian Islands which range in age from 5.6 mil years (Kauai) to less than .7 mil years (Hawaii). Kilauea is the youngest of the volcanoes on Hawaii and very active. The other volcanoes on Hawaii echo the generally south-easterly orientation of age progression of the Hawaiian Island chain. The ages range from Kohala .7 mil years, to Mauna Kea at .6 mil years, Hualalai .4 mil years, Mauna Loa at .1 to .05 mil years, to Kilauea at present.

The dating of the Hawaiian rocks now exposed above sea level was done radiometrically by the K-Argon method.

There are very few fossils found in lava flows and so no help in age correlations.

The south-easterly progression of age in the islands is thought to be due to the movement of a part of the earth's lithosphere - the Pacific plate - over a hot spot which supplies the magma to form the volcanoes.

Volcanism along the chain seems to occur in pulses at either one or several locations. The formation of the volcanoes progresses at an ever increasing eruption rate along the chain, until the pulse ends. A new pulse may begin before the previous one has ended.

Kilauea has a very high eruption rate and may be close to the end of an eruptive pulse.

STRUCTURAL GEOLOGY of the ISLAND of HAWAII

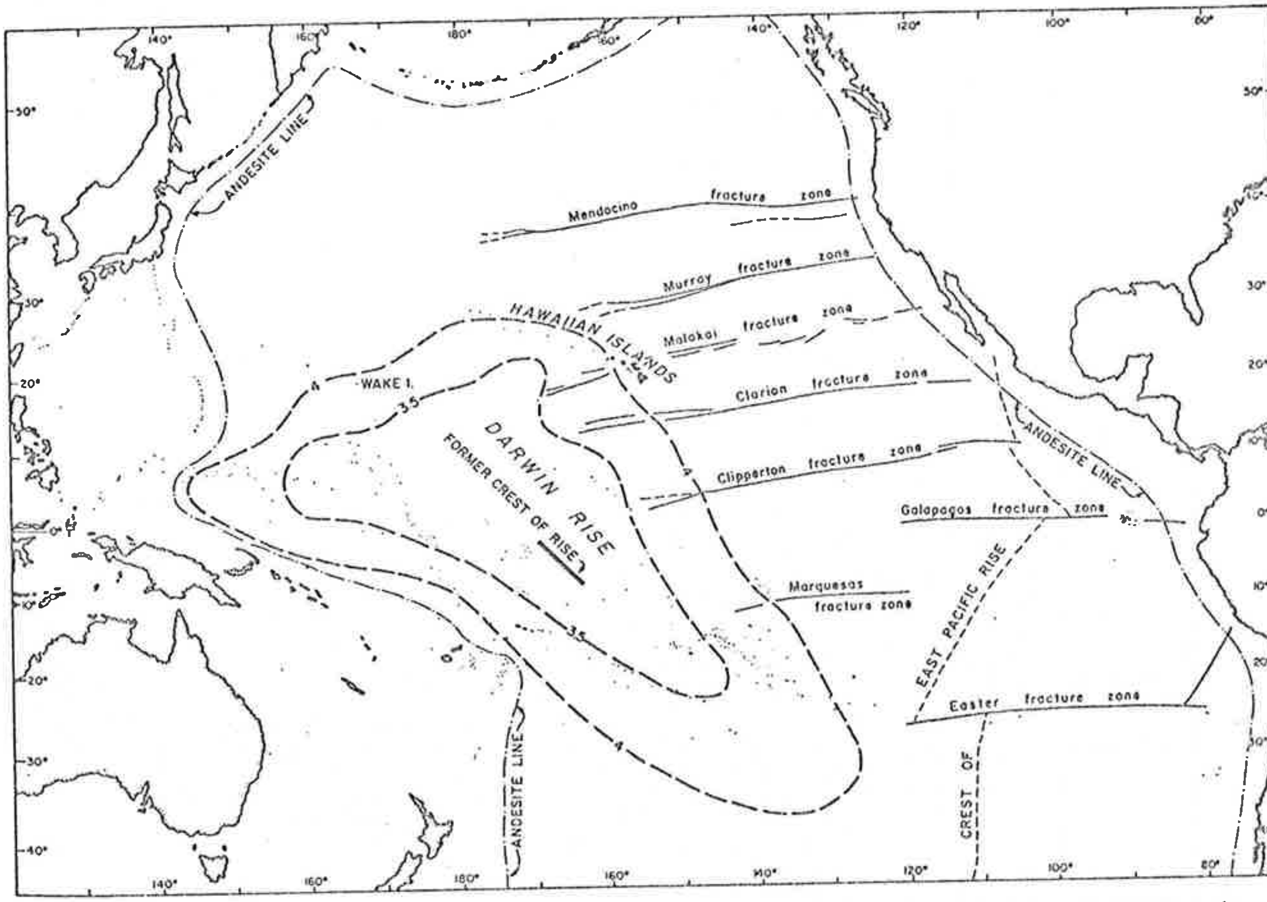
by R. Berger

Structures of Hawaii are the causes and results of Hawaiian volcanism. The radial faults and rift zones of the five shield volcanoes reflect a basic instability of the earth's crust. This instability gives rise to the Molokai fracture zone (fig. 1). The volcanic induced structures include unconformities and faults. Unconformities are discussed elsewhere in the guidebook.

Two major divisions of faults, radial and tangental, can be distinguished on the island. Radial faults parallel and lie within the rift zones. The are generally horst and graben structures related to extensional and tensional rifting. Tangental faults are roughly tangent to the shields (normal to the radial faults) and are zones of expansion related to the summit swelling of the shield volcanoes caused by magmatic injection. Three major tangental faults--Hilina, Honuapo-Kaoiki, and Kealakekua-Kaholo-- occur on Hawaii (fig 2). These are discussed in detail under the following sections.

Regional Structural Setting:

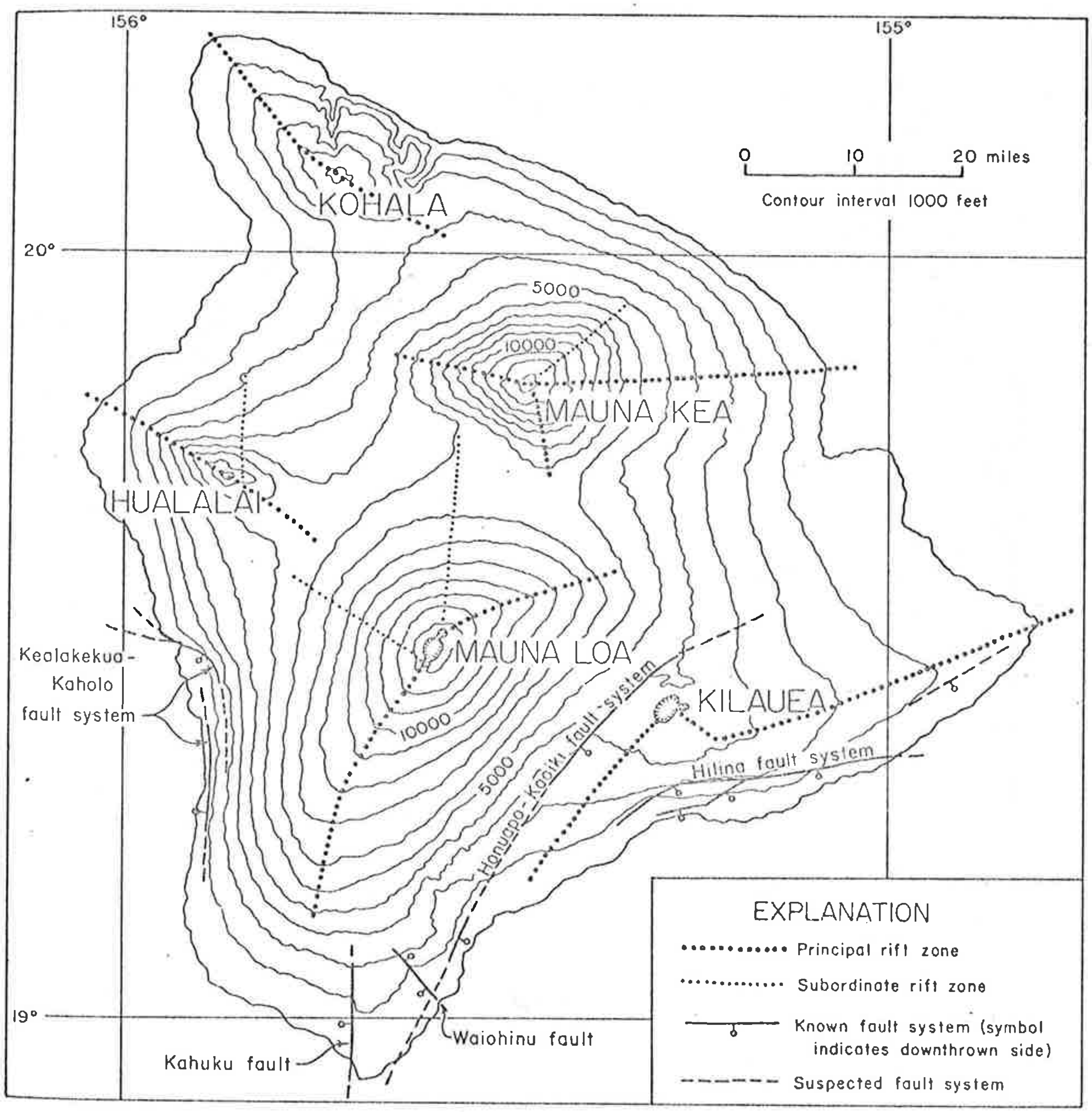
Structural elements of the Island of Hawaii reflect the three dominant trends of the Pacific basin. The Islands lie in the center of the Pacific basin on the Molokai fracture zone (fig. 1). This east-west trend is expressed on Hawaii as the rift zones of Mauna Loa and Kilauea. A second structural element apparent in the basin is the northwest-southeast trend of the Darwin Rise (fig. 1). This trend is present on the Hawaiian chain as seen from the northwest-southeast alignment



Map of the Pacific Ocean, showing the "andesite line" that marks the boundary between the true ocean basin and areas underlain by continental-type rocks, the principal great fracture zones of the eastern Pacific, the course of the East Pacific Rise, and the position of the former Darwin Rise in relation to the Hawaiian Islands. The dashed contours on the Darwin Rise represent the depth (in kilometers) of water over the Rise about 100,000,000 years ago. (Modified after Menard, 1964.)

PACIFIC BASIN STRUCTURE

(Figure 1)



Map showing volcanic rift zones and faults on the island of Hawaii.

(Figure 2)

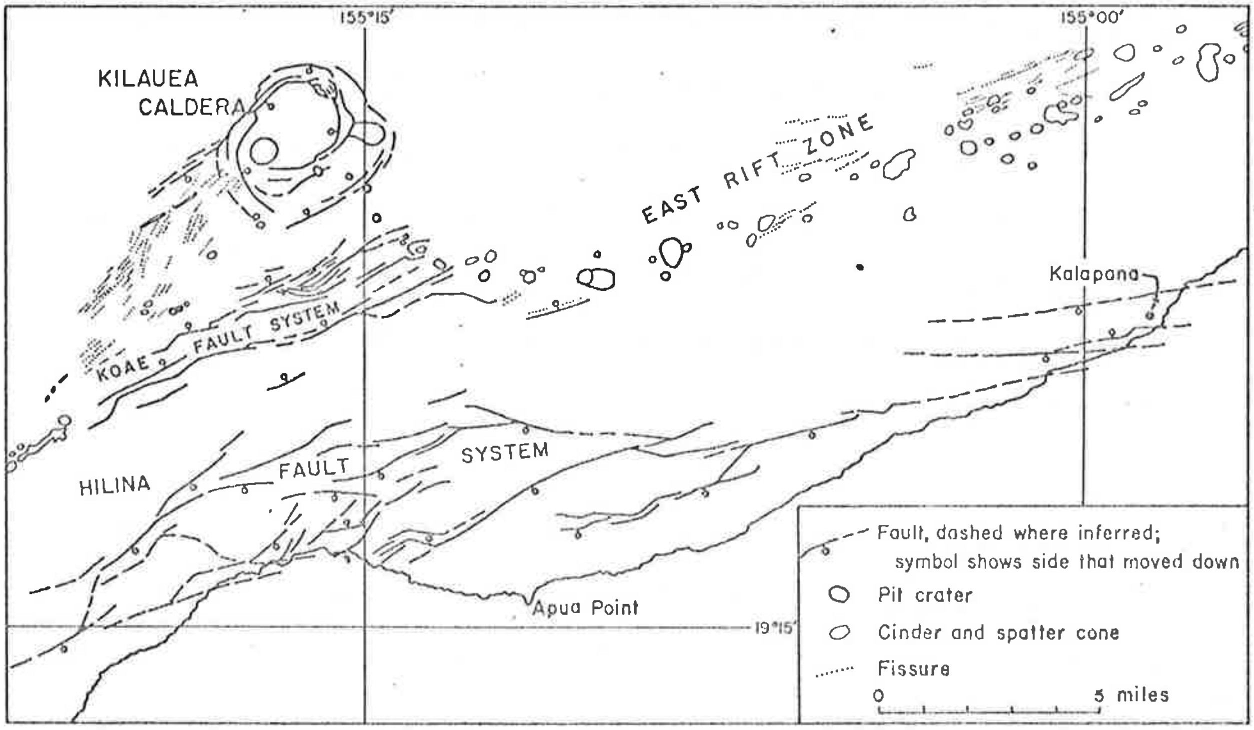
of the islands.and on the Island of Hawaii in the principle rift zone of Kohala volcanoe.(fig. 2). Third, the northerly trend of the Emperor seamount chain seems to represent a similiar but distinct trend along the basin floor. Evidence of this north-south trend is found in post-erosional vents of Kauai and Oahu and probably represents an abandoned drift direction of the Pacific plate.

Faults:

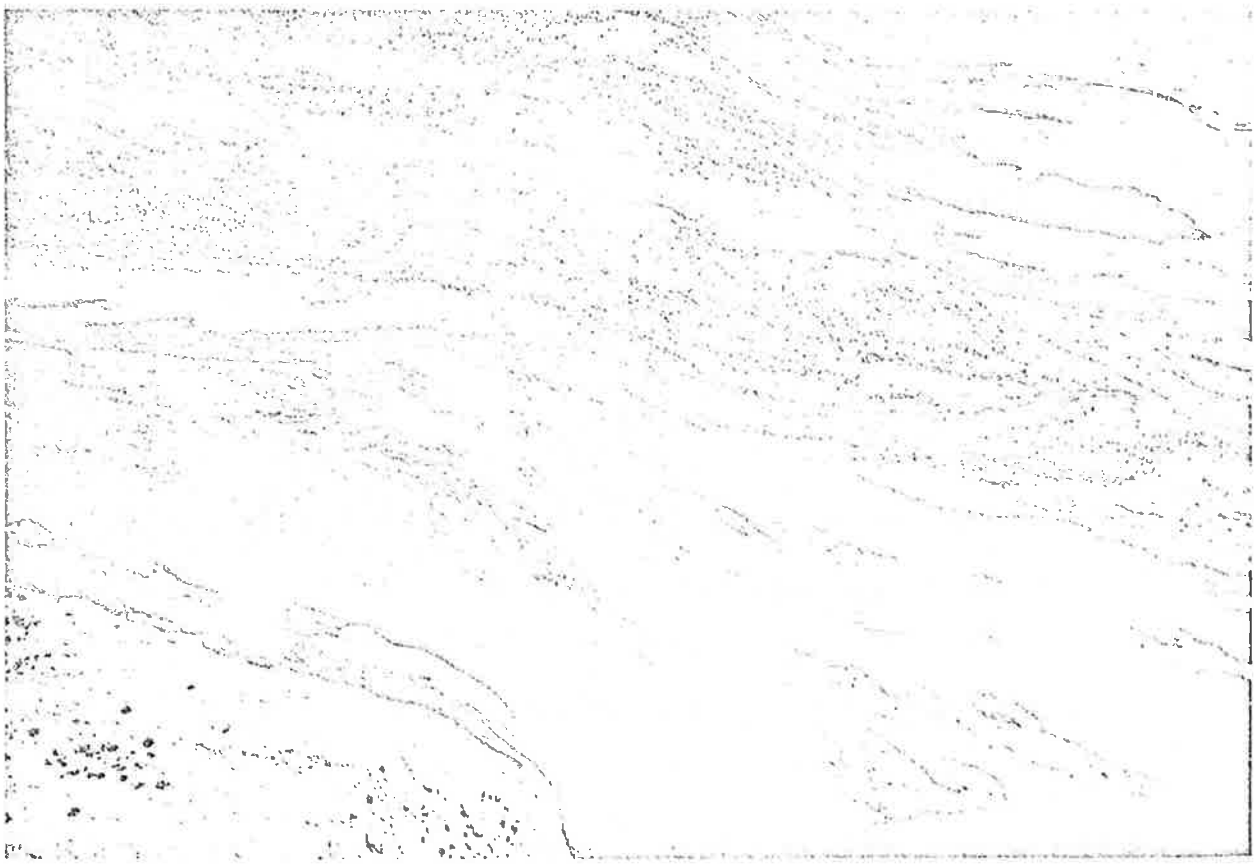
Five major fault systems other than the rift zones occur on the Island of Hawaii. These are Hilina-Kaoe fault system, Honuapo-Kaoiki fault system, Waiohinu fault, Kahuku fault, and Kealakekua-Kaholo fault system (fig. 2).

Hilina-Kaoe fault--

Hilina fault system lies along the southerly edge of Kilauea shield (figs. 2 and 3). It is a zone of sub-parallel, en echelon, step-faults trending parallel to the east rift zone (N75E to N85E). Displacement is "down to the ocean" with a vertical separation on the order of 2,000 feet. Hilina fault is a typical tangental fault and is one of the only two active tangental fracture zones on the island. Generally, the scarp (Hilina Pali) is visible from the coastal road to the west of Kalapana and south of Kilauea crater. It is 1,000 to 1,500 feet high and has been active throughout the history of Kilaeua. Locally, it is mantled by recent volcanics of the 1960's eruptive phase. A mass of earthquake swarms occured along the zone during the period March through April of 1952. No surface activity accompanied these swarms. However, swelling of Kilauea summit indicates that volcanic activity was present at shallow depth.



. Map showing the pattern of faults in the Hilina fault system, on the southern flank of Kilauea volcano. (Modified after Stearns and Macdonald, 1946.)



View eastward along Poliokeawe, one of the fault scarps of the Hilina system on the south slope of Kilauea. Converging with it from the right is another of the fault scarps, the Holei Pali. The black lava flows in the foreground, between the camera and the Kalapana road, were formed in 1969. Other older flows can be seen mantling the scarp.

(Figure 3)

Honuapo-Kaoiki fault--

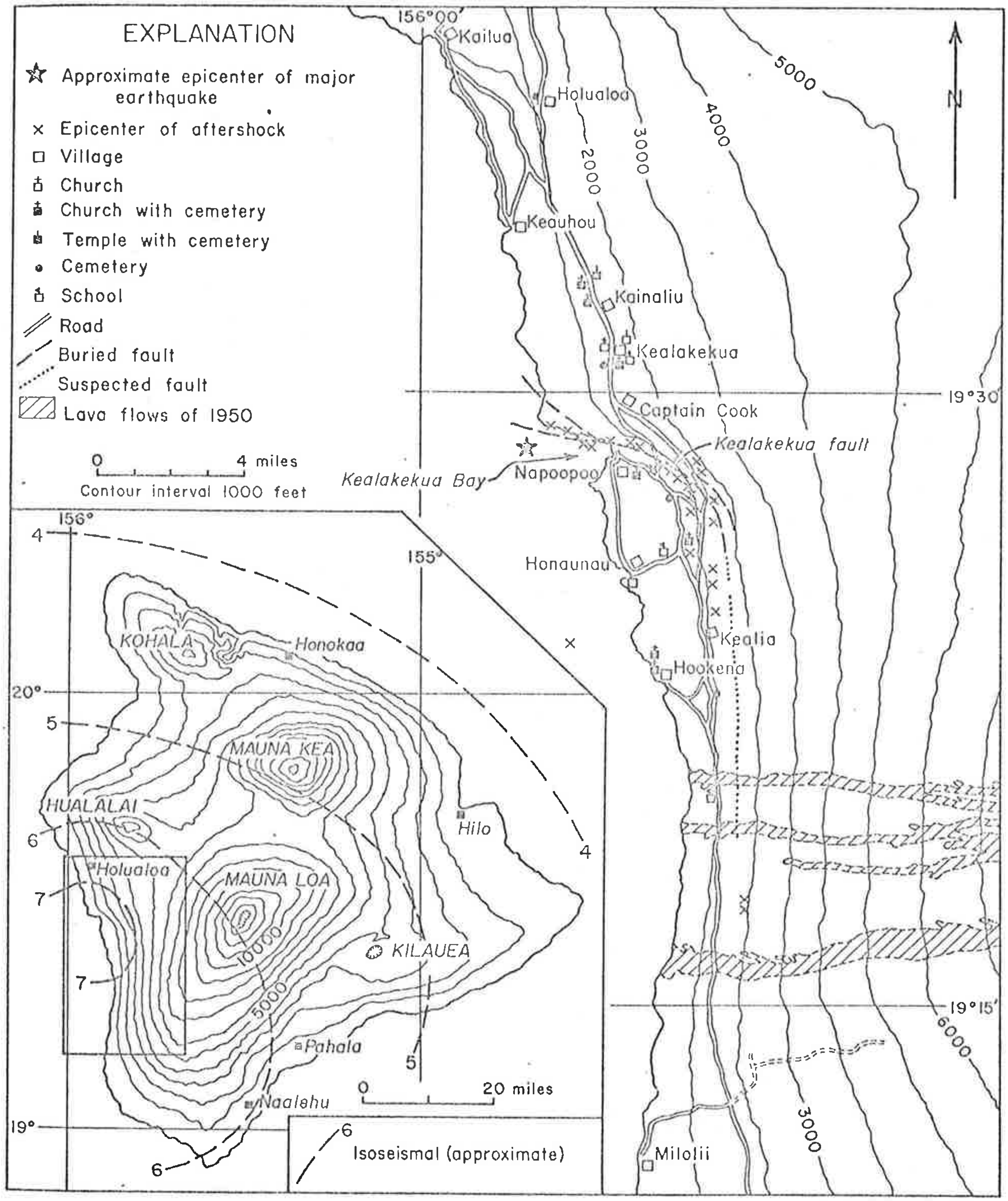
Honuapo-Kaoiki fault system lies along the northern flank of Kilauea shield and separates Kilauea from Mauna Loa (fig.2). It is a typical tangental fault. Displacements are generally "down to the ocean" along a series of en echelon faults. Vertical separation has not been determined but is greater than 1,000 feet. This zone behaves as a buffer between the two shields. When summit swelling is occuring on Kilauea, that side is raised by as much as fifty feet. Conversely, summit swelling of Mauna Loa displaces the northern block upward. Thus, this fault may best be described as an activated-joint system that compensates for expansions of the two volcanoes. The pali parallels the road from Kilauea crater to Honuapo. Lavas of the Kahuku volcanic series are exposed along the scarp and it is mantled by the Kau volcanics of Mauna Loa. A series of earthquake swarms along this system preceeded the 1952 Kilauea eruption.

Waiohinu Fault--

The Waiohinu rotational fault is approximately ten miles northeast of South Point (fig. 2). It trends northwest-southeast for 4.5 miles and is down thrown to the east. Displacement is on the order of 50 to 70 feet. This is the eastern boundry of a large horst that includes South Point. An earthquake on April 2, 1868 destroyed the town of Waiohinu and triggered a great mudslide. Lateral displacement offset the old Waiohinu road by ten feet.

Kahuku Fault--

The Kahuku fault is approximately one mile west of South Point (fig. 2). It trends ten miles inland along a north-south direction and is down thrown to the west. It's seaward extension



Seismic Map

(Figure 4)

can be traced for 18 miles by a bathymetric escarpment. This is the western boundry of the horst described above.

Kealakekua-Kaholo fault--

Kealake-Kaholo fault system lies alont the Kona coast between Kealakekua Bay and Milolii (fig. 2). Kealakekua falut zone lies inland of Kaholo fault and is north-south trending, parallel to the coast, and "down to the ocean". It is of the tangental type. Kaholo fault is the same type. No historic activity has occured along this fault. Kahuku lavas are exposed in the pali.

Few major earthquakes have occured on Hawaii in historic time. However, the Kealakekua-Kaholo fault has been responsible for damage several times in recent history. In 1929, quakes along this zone caused extensive damage in central Kona. A great quake in August of 1951 caused extensive damage along the Kai-Kona coast and was felt all across the island(fig. 4).

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HAWAIIAN CULTURE

The Hawaiian Islands, often called the "Crossroads of the Pacific", are a natural meeting place of East and West. It has a mixture of many cultures. Its citizens can trace their lineage back to nearly every area and major culture region of the world. In ancestry they include, Japanese, Hawaiian, Chinese, Spanish, German, Korean, Puerto Rican, Filipino, Portuguese, Indian, Somoan, and Anglo-Saxon.

Hawaii was named for Havaiki, the legendary homeland of the Polynesians. The early history of Hawaii is shrouded in mystery for the Polynesians had no written language.

In ancient Hawaii, religion had a leading part in community affairs. The ancient Hawaiians had many gods, among them, Ku, God of War, Lono, God of Harvest, Pele, the volcano goddess, and Kane, the God of Life. In Hawaii, as in other parts of Polynesia, the Kapu (Tabu) system was a central figure of religion and life. The Kapu system had many rules for conduct. It provided morals and social organization. Some Kapus stated that certain days were sacred and others that a commoner must not stand when a chief was present. The Hawaiian Kapu system also stated that women must not eat with men and women were also forbid to eat bananas and coconuts.

On January 18, 1778 Captain James Cook of the British Navy discovered Hawaii by accident on his way from Tahiti to North America. Cook named his discovery the Sandwich Islands in honor of Lord Sandwich, the head of the British Admiralty.

As foreigners began to arrive they enriched Hawaii in many ways. They brought horses, cattle, turkeys, goats, fruits such as the guava and mango, and a variety of plants.

On the other hand, foreigners also brought to Hawaii many diseases, among them smallpox and measles. The Hawaiian population, who had long lived in isolation, had no immunity to these diseases. The Hawaiian population, estimated at about 300,000 in1778 fell to about 135,000 in1819. In 1850 it fell to about 85,000 and in 1890 down to 40,000.

During the mid 1800's plantations began to control much of the land in Hawaii. Sugar cane cultivation during that period expanded so rapidly that workers had to be brought in from Japan, China, the Philipines, and other places to create an adequate labor force.

Currently, the ethnic composition of Hawaii is as follows;

Caucasians	24.0%
Chinese	7.0%
Filipino	12.0%
Japanese	37.0%
Hawaiian	17.0%
Others	3.0%

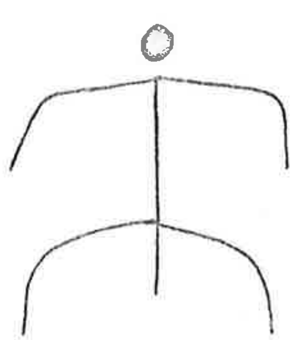
"Today few pure-blooded Hawaiians exist, and the ancient Hawaiian way of life has almost vanished. But the spirit of ancient Hawaii still hovers over the islands in the many Hawaiian words still in use, in the relaxed pace of living, and in the gentleness alive in every spoken "Aloha" ".

Gina Alberti
Jim Vander Giessen

Petrogyphs in Hawaii

The Island of Hawaii has more drawings carved into its rocks than any other area of equal size in the world. The art of making these petroglyphs, since they resemble those found in other Pacific Islands, was probably brought with the first Hawaiians from their Polynesian homelands. The earliest petroglphs were carved over a thousand years ago as a magical insurance of long life and personal well being. These consisted of shallow holes and simple stick figures. The place of greatest "mana" and the center for the piko ceremony was a low pahoehoe hill, covered with thousands of petroglyphs, called Puuloa- or "Hill of Long Life." The hill is located in Panua-nui Puna, 1/2 mile NW from Chain of Craters Kalapana Road, about 1 1/2 miles from the shore along the upper trail from Kealakomo to Kalapana. Here families from Hawaii and nearby islands would carve a hole for their children's pikos (umbilical cords) and leave them overnight; if they were gone in the morning the babies were assured of a long life. If there were many children in a family, the holes were arranged in a circle. One circle contained 62 holes! The stick figures of Puuloa are usually family groups;

Father

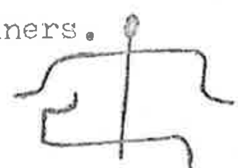


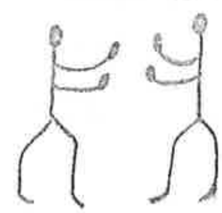
Mother-with child

Perhaps  and  denote twins and triplets.

The most active time for petroglyph making was just before Cook's discovery of the islands in 1778. The Hawaiins had a well developed system of upper trails connecting the coastal villages and would leave a tally of their travels at the rest area along the way. A circle with dots  meant that a party of four had traveled completely around the island. A semi-circle with dots  meant three had travelled as far as the petroglyph marker and then returned home. Once a year the trails were used by the tax collectors. At Puako, (in Lala-milo,South Kohala- about 1/2 mile south of Kapanian Point and 200'- 500' inland at Paniau) the pahoehoe is covered with several thousand petroglyphs commemorating tax collecting time. Collec-tors carrying Lono sticks followed by marching soldiers, 

athletes of the accompanying games, surfers fighters and runners.





The last petroglyphs, many of them names and dates written in English- as taught to the Hawaiins by the missionaries- were made in the 1860's when the isolated villages and old foot trails were abandoned. At Anaehoomalu, in South Kohala-on the boulders at the edge of an aa flow- along the trail from Puako to the border of Waikoloa, are four succesive stages of petroglyph mar-kings. The oldest are the stick figures into which erosion has cut most deeply. Next are the more complex muscled figures overlapped by carvings of sailing ships and guns- implying post-contact. The youngest petroglyphs are those written in English. Only relative dating, of the earliest petroglyphs, is possible since the age of the basalt on which the petroglyphs are drawn can't be accurately determined.

Most petroglyphs are carved an inch deep into the relatively soft outer glaze of pahoehoe mounds. Turtle Cave- located in Kauhuhuula Kau, 2 $\frac{1}{2}$ miles NNE of Pahala between Wood Valley Road and Volcano Highway in Piikea Gulch- is a lava tube with a two foot dome resembling a turtle's shell. This dome on the cave floor formed by the hardening of a lava bubble around which the lava flowed out of the tube. The petroglyphs drawn in the whitish powder plaster like coating of the tube walls contrast with the dark inner pahoehoe.

Petroglyphs are also drawn on the faces of boulders, cliffs, and along beach shelves. These hard surfaces required the use of a hard basaltic cutting tool. First a sketch was scratched onto the face of the rock, then small holes were pecked along the lines, finally the spaces between were pried away. The small petroglyphs took at least a half hour to make so that they aren't just doodles in the rock. They were carved for as previously stated for magical reasons, tallies, and for commemorating events. Legend has it that some of the petroglyphs were made by Menehunes which were like leprechauns who left prints in the night.

HILO-KALAPANA CONES AND CRATERS

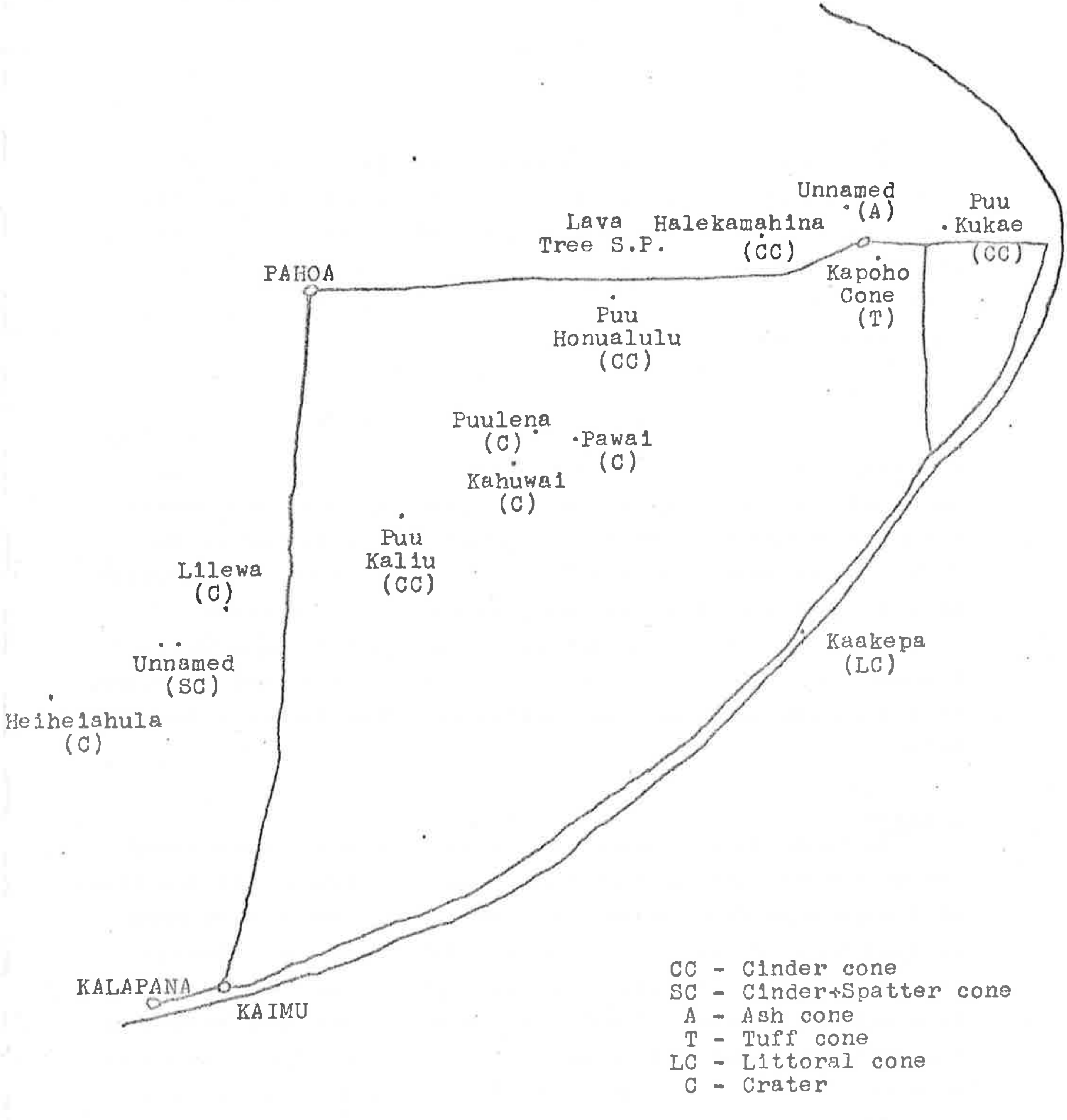
We are fortunate to have in this area five different types of cones. They are ash, tuff, cinder, cinder+spatter, and littoral. Without getting too detailed it will be shown how these five different types can be formed from basically the same type of magma.

Most ash cones are formed by explosions that are termed hydromagmatic. This type occurs when sea water or ground water that is very near the surface comes in contact with the magma, causing explosions of steam and what will become airborne fragments of magma. Being near the surface, the explosions shoot these fragments out at relatively low angles causing a broad cone with wide shallow crater to form as the fragments cool and settle back to the ground. The cooling of these fragments is rapid and the result is a pale brown type of glass called sideromelane which is about the unstablist of the generally unstable basaltic glasses. Over a period of years the sideromelane, with the addition of water, changes into palagonite. With this change and the addition of zeolite and calcite cements the unconsolidated ash cone becomes a consolidated tuff cone. In this area, Kapoho cone is of the tuff variety while just across the road, less than one-half mile away an unnamed cone from the flow of 1960 is of the unconsolidated ash type. It will be interesting to compare the two.

The cinder cones and the cinder+spatter cones form when ground water and magma meet at depth and combine to create a phreatic explosion. Being at depth, magma laden steam rises through a long tube to the surface and is shot almost directly upwards. This results in a cone that is generally taller, thinner, and more symmetrical than those of hydromagmatic origin. The cinder cones, being unconsolidated, form at angles near that of repose but the partly cemented cinder+spatter cones can form at a slightly steeper angle. The material in these two types of cones is a basaltic glass called tachylite and is the result of slower cooling than the type in ash and tuff cones. It appears very black and is more stable than sideromelane.

Littoral cones form when aa lava flows enter the sea. Due to the fragmented nature of aa lava, the water is able to penetrate into the hot central part of the flow and steam explosions send clouds of steam and lava particles into the air. The particles cool and settle back down, some landing in the water, some onto the flow, others on land where they may form into cones (often two, one on each side of the flow). Little or no crater may exist at the top and if there is one it is due to erosion and is not an explosive opening. These cones are very susceptible to wave erosion and therefore do not remain very long except under unusual circumstances. The erodedmaterial may collect in the form of black sand beaches if the conditions are favorable. We will see Kaakepa cone, approximately seven road miles south of Kapoho.

The craters in our area are found along the east rift of Kilauea. They form on the tops of parasitic shields in much the same way that calderas form i.e. from a lowering of the magma level and collapse due to lack of support. The road parallels the east rift from Pohoiki to Kalapana and is at a distance of about three miles. The shields that the craters are in may or may not be obvious or visable from the road.



CONES AND CRATERS HILO-KALAPANA

Historical Volcanology
Barbara Deacon

HILO

Location

Hilo Bay lies at the intersection of the slope of Muana Loa with that of Muana Kea to the north (figure 1). The Wailuku River flows along the edge of Muana Loa lava flows where they intersect the slope of Muana Kea. The city of Hilo sits on Muana Loa flows, most of which are less than 2,000 years old.

Geology

Muana Loa eruptions occur mainly in the summit cauldera or along one of the two major rift zones (figure 2). The one that concerns Hilo is the one extending east-northeast from the summit (figure 3). It heads directly toward the city. It is approximately a mile wide and lies at the crest of a ridge formed from its own extrusions. The flows occuring near its south edge flow away to the south but the ones near the north edge, below the 11,500 foot altitude, flow into the Wailuku River valley and flow directly toward Hilo.

History

In TABLE I, the major eruptions that took place along the northeast rift zone of Muana Loa are listed with the flows that were directed toward Hilo indicated. There were five of them between the years 1850 and 1950, and one actually entered the city itself. This was the one in 1881 and it has been calculated that if this flow had had the same volume as the 1859 flow that poured down the northwest slope, it would have filled Hilo Bay. It stopped erupting before it even reached the coast.

There are three small cinder cones within Hilo itself, the Halai Hills, but they are ancient and very little activity has taken place on the lower section of the rift (below 6,000 feet) in recent times. There is one vent that was active between 2 and 4,000 years ago, but its the only one that

TABLE I
Northeast Rift Flows: Muana Loa

ERUPTED		DURATION (days)	ALTITUDE	REPOSE SINCE LAST ERUPTION (months)	AREA OF FLOW (mi^2)	VOLUME OF LAVA ($-x\ 10^6\ yds^3$)
1852	Feb 17	21	8,400	6	11.0	140
*1855	Aug 11	450	10,500 (?)	41	12.2	150
1880	Nov 1	280	10,400	6	24.0	300
*1881	----	--	----	--	--	250
*1899	July 4	9	10,700	38	16.2	200
*1935	Nov 21	42	12,100	23	13.8	160
*1942	Apr 26	13	9,200	20	10.6	100

TABLE II
East Rift Zone Flows: Kilauea

*1750 ?	----	--	1,700	--	1.57	19.5
*1790 ?	----	--	1,100- 750	--	3.04	37.67
*1840	May 30	26	3,100- 750	--	6.60+	281
1884	Jan 22	1	-60	--	?	?
1923	Aug 25?	1	3,000	15	0.20	0.1
*1955	Feb 28	88	150-1,310	8.9	6.1	120
*1960	Jan 13	36	100	0.8	4.1	155
1961	Sept 22	3	2,600-1,300	2.2	0.3	3
1962	Dec 7	2	3,250-3,100	14.4	0.02	0.43
1963	Aug 21	2	3,150-2,700	8.4	0.06	1.1
1963	Oct 5	1	2,750-2,300	1.4	1.3	9
1965	Mar 5	10	3,000-2.300	17.0	3.0	23
1965	Dec 24	1	3,150-3,000	9.5	0.23	1.16
1968	Aug 22	5	2,900-1,900	1.3	0.01	0.05
1968	Oct 7	15	3,000-2,400	1.3	0.8	9
1969	Feb 22	6	3,100-2,900	4.0	2.3	22
1969	May 24	(a)	3,150	2.0	4.8	greater than 1

(a) still in progress December 1972.

has been found.

Of the five lava flows, two have been prevented from entering Hilo by bombing. This method was first suguested by L.A.Thurston and later developed by T.A.Jagger and R.H. Finch. The 1935 flow was halted in its advance toward Hilo by bombing the main lava tube. This collapsed the roof and the lava flowed out the opening, running beside the older flow. The old toe stopped its advance within two days.

The 1942 lava flow was diverted by bonbing the natural levees of an aa river (built by constant overflowing of its banks by the flow), and allowing the molten rock to use other paths.

PAHOA--KAPOHO

Geology

The flows that concern this trip in this area are all from the east rift zone of Kilauea. This zone is marked by thirteen pit craters and there are more than 60 small cones between Kilauea cauldera and Cape Kumukahi.

History

TABLE II lists the major eruptions that took place along the east rift zone of Kilauea. The flows we shall see will be the two oldest found from Kilauea, 1750 ? and 1790 ? flows, and the 1840, 1955, and 1960 flows.

The explosive cauldera eruption that took place around 1790 was witnessed by Keoua's army. He was at that time chief of Puna in southern Hawaii. When the offerings to Pele that they had gone to Kilauea to give only resulted in more violent explosions, Keoua ordered his army (which was composed of warriors, women, children, and domestic animals) divided into three parts to proceed down a certain trail. The first part proceeded unharmed but the second was apparently caught by a cloud of poisonous gas that caught them unawares. They were found by the third part who only found a few pigs alive. They had evidently survived because there was breathable air near the ground or in hollows below surface level.

The 1840 flow proceeded daily, by 6 mile intervals, to move along the east rift zone til on the fourth day it flowed from fissures 18 to 25 miles from the crater and it entered the sea. It crosses the road near Pahoa.

In 1923, no lava flowed but several cracks opened and then closed again in the Kapoho area. These reports are commonly disregarded by geologists but there is a photograph showing where a cow fell in one and was crushed with only its leg remaining above ground level.

The 1955 earthquake proceeded northeast from a point five miles east-southeast of Pahoa to the small village of

Kapoho, then re-erupted southeast of there. It began as a series of earthquakes that accompanied the swelling of the East rift begining with 25/month and building up to 700/day. On March 1, it broke through a crack in the Pahoa/ Kapoho road and there were subsequent fissures that proceeded through a section of the village. An ancient low spatter rampart protected the main part of the village so there was little actual damage. The flow did not reach the sea in this area. On March 12, new eruptions proceeded west from a point two miles southwest of the first outbreak. Three flows eventually reached the sea and the roads from Pahoa to Kalapana and Opihikao were both destroyed (the people of the two villages had been previously evacuated because of such a potential outcome).

During the eruption, the development of a pit crater, from inception through completed structure, was observed and recorded.

The 1960 eruption began in 1959 with the eruption of Kilauea Iki. By January 10, 1960, the earthquakes were concentrated in the Kapoho area. The village was located almost entirely within a graben formed by cracks, on the south side, from that eruption and cliffs on the north formed by the sinking of the ground south of them almost 50 feet. Most of the sinking had been done before the 1960 eruption. On January 13, fountains burst forth ¼ mile north of the village and the lava flowed down the graben into the ocean. It entered the sea on the north side slowin the flow from that direction and forcing the lava to flow south along the beach. The graben eventually filled and overflowing lava destroyed the village despite the walls that were constructed to prevent this. One was only prevented from protecting the schoolhouse by the swelling of the earth on its other side and the lava breaking through the new opening. Its success if this had not occured is desputed.

Also desputed is the success of another wall they built to save the lighthouse on Cape Kumukahi. The lava flowed right up to the base of the lighthouse but the wall of the base remained intact. Several beach houses were also saved and some believe the walls diverted enough of the lava to accomplish this and if the walls had not been there the houses and the lighthouse would have been destroyed.

This eruption added approximately ½ square mile to the island of Hawaii.

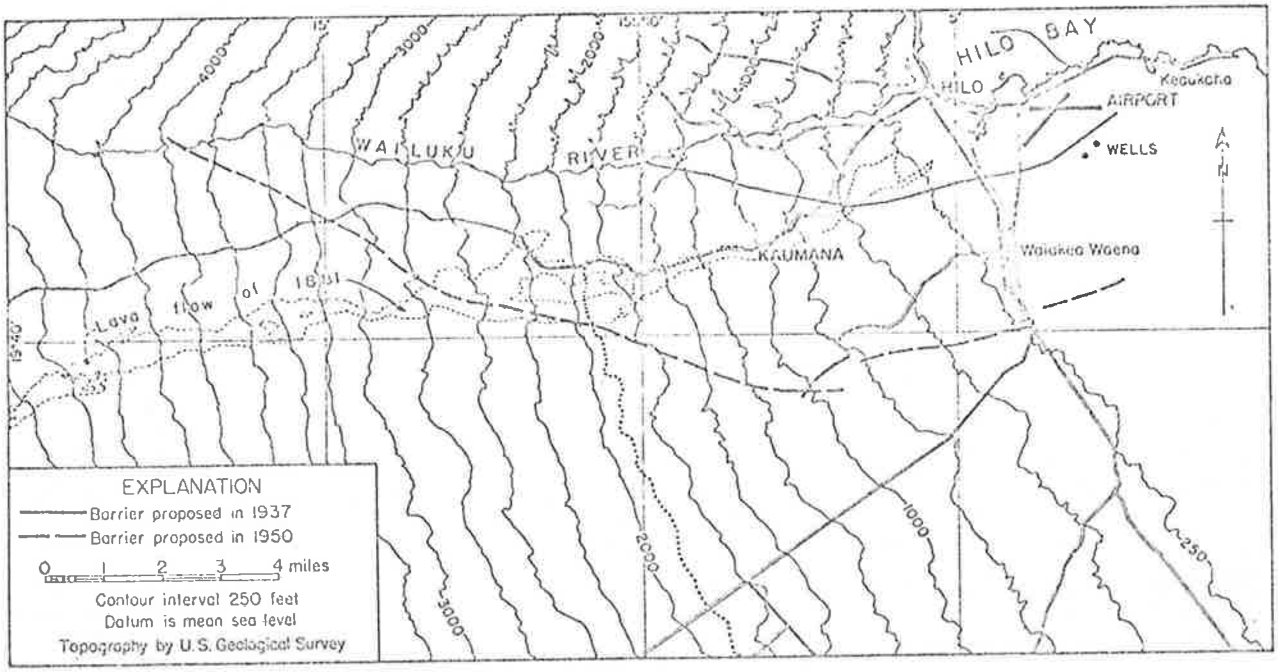


Figure 80. Map of the region around Hilo, showing the position of barriers suggested to divert lava flows from the city and harbor.

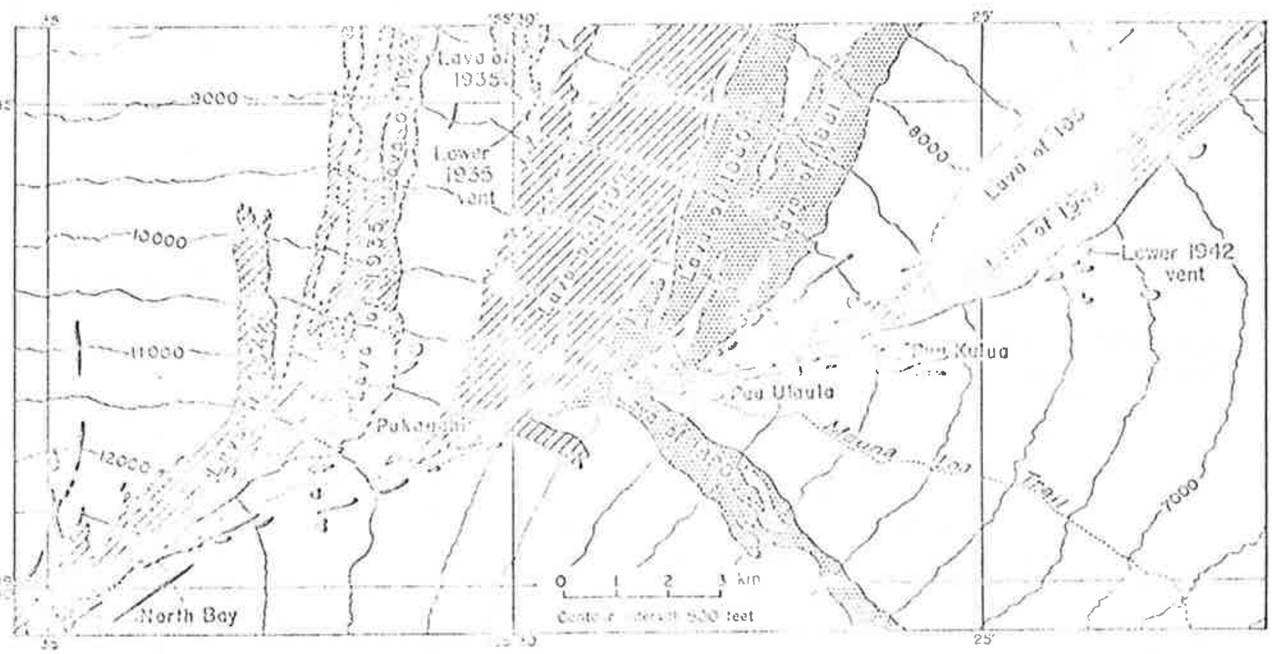


Figure 50. Map of the northeast rift zone of Mauna Loa, showing the upper portions of historic lava flows.

Tony Reid
Randy York
Kandee Morga

VOLCANIC LANDFORMS - THE KILAUEA CALDERA

The Kilauea Caldera was formed by the collapse of the summit of the volcano, because of weakening by the molten rock, or by removal of the magma. The collapsed area is about three miles long and two miles wide, and is about four hundred feet deep at its northwestern edge. The walls of the caldera are generally steep, except in the northeast, where they have been step-faulted, and in southwest, where the filling of the caldera floor has overflowed the walls.

In the southwest portion of the caldera floor is Halemaumau, the collapsed crater of a very flat cone. It is about a half mile in diameter and about two hundred fifty feet deep below the caldera floor. This has been the main area of activity in Kilauea in the last 150 years, and is responsible for most of the flows on the caldera floor.

Many unusual landforms can be seen on the Kilauea caldera floor, most of which can be reached by the Halemaumau Trail. The two and a half mile trail starts at the Park Headquarters down the step-faulted wall to the caldera floor, and across the flows of 1971, 1954, and 1894 to the edge of Halemaumau. Some of those landforms that can be seen are: Pahoehoe Blisters - formed by the pushing of gas up on the overlying plastic skin. Several can be seen on the 1919 flow to the north end of the caldera.
Tumulus (plural Tumuli)- large, oval, dome shaped mounds of pahoehoe lava formed by a heaving up of the lava crust. Some on the caldera floor can be up to forty feet high. Driblet Spire - when lava comes up through cracks in the tumuli and becomes welded into a spatter heap several feet high. A Hornito is a larger driblet spire.
Pressure Ridges - Tumuli that are longer and narrower.
Solfataros - Vents from which gas only is evolved. The gas is mostly water with minor amounts of sulfur and other gases. Solfataros usually die out after several months but there is usually one present in Halemaumau.

GEOLOGY OF KILAUEA

The rocks of Kilauea are divided into two series. The first is the Hilina Volcanic Series which is capped by Pahala ash. The Hilina Series os believed to correspond to the Kahuku Series on Mauna Loa.

The Puna Volcanic Series which overlies the Pahala Ash is the younger of the Kilauean rocks and is corelative with the Ka'u Series of Mauna Loa. Lava flows of the Ka'u and Puna intermix along the boundary of the two volcanoes.

Both the Puna and the Hilina are composed of pahoehoe and aa flows of tholeiitic and olivine basalts, oceanite, cinder and spatter cones and ash deposits. The Hilina Series is exposed only in fault scarps along the southern coast in the Hilina Pali. About 1,000 feet of successive flows are so exposed. The flows are separated by a few thin beds of glassy tuff. A similar section is exposed on the seaward face of Puu Kapukapu.

For the most part it resembles the outcrops found on Mauna Loa - a sandy to silty yellow, glassy ash. But in Hilina Pali are found abundant coarse beds containing Pele's tears and pumiceous lapilli.

The Puna lavas were almost entirely erupted along two rift zones which extended eastward and southwestward from the summit and from vents in the area of the present caldera. The entire inner caldera floor is covered with lava erupted from this century. In the immediate area of the caldera the surface flows are mantled with an ash deposit. Along the southwest rim, the deposit is 10 feet thick and on the southern edge it is more than 30 feet in thickness.

The East Rift Zone of Kilauea extends east northeast from the faults in the southwest rift zone 28 miles to Cape Kamukahi and at least 70 more miles beneath the ocean. The Rift Zone and Kilauea are linked by 7 pit craters. This row of craters is crossed at right angles by the boundary faults at the southwest rift zone.

Lava beds in the caldera wall slope away from the caldera and prject into the air where the caldera is now. This would indicate that either the caldera was once very small or may not have even existed at all. Kilauea summit was composed of several small coalescing shields, one occupying the position of the present caldera, another is still visible on the east edge of the caldera. It's summit collapsed to form Kilauea Iki.

LEGENDS

The early Hawaiians incorporated in their legends various theories to explain the nature of volcanic eruptions. Most of these legends involve the great goddess of fire, Pele and her sisters and brothers. These gods, goddesses, and ghost gods in the Pele family almost all had their home in volcanic fires and were connected with all the various natural fire phenomena such as earthquakes, eruptions, smoke clouds, thunder and lighting. Pele's brother Kamohoalii and her sister Namakaokahai belonged to the powers of the sea. According to legends Namakaokahai, a sea goddess, became Pele's most bitter enemy fighting her with floods of water from the skies and the oceans.

The ancestor ghost gods (au-makuas) were supposed to have been sent into the family by sacrifices. When death came among the Hawaiians, a part of the body of the dead person would be thrown into Kilauea. It was said that the spirit also went into the flame and found a permanent home. The spirit became a Pele-au-makua (ancestor ghost god of Pele).

Pele's home was in the fire pit of the Kilauea volcano, and all the eruptions of lava have borne her name. The word "Pele" has been used with three different definitions. Pele the fire goddess; Pele a volcano or fire pit in any land; and Pele an eruption of lava.

Many of the legends of the area surrounding Kilauea are thought to be based on actual historical events but few can be verified. However some of these legendary accounts are of actual events whose remnants can be seen today. There are two of these legends mentioned in Macdonald in the chapter on Historical Eruptions. One tells of Chief Kahawali from Kauai who came to Hawaii to challenge Pele to a sled riding contest. The Chief's arrogance angered

Pele , and as legend goes Pele stamped violently on the ground. The hillside opened and a flood of lava burst forth chasing the Chief down into the valley and into the sea killing many people on the way. Rocks scatteredalong the bank of this old channel are pointed out as the people and remnants of the houses destroyed by Pele as she tried to kill the Chief. Kahawali escaped to Oahu but Pele stood on the beach hurling hot rocks at him which the natives say can still be seen on the bottom of the sea.

One of the cinder-and-spatter cones on the east rift zone in Puna is named Kaholua o Kahawali (Kahawali's holua slide), Extending from there to the ocean is a line of small spatter cones that marks the path Kahawali took running from Pele.

Other kahunas (priests of power) came to Hawaii to avenge Kahawali and challenge Pele, all were killed but three of these priests left their names to some localities near Kilauea. Uwekahuna was a high hill on the northwestern side of the crater, overlooking the fire pit and the region around Kilauea. Ka-au-ea (the fiery current) was the name given to a precipice in the walls of the crater. Halemaumau (house of ferns) had his house upon a precipice in back of the present Volcanic House. From there the name has been changed in meaning and location to the lava pit in the living lake of fire in the southwest part of the caldera floor. Through the last 150 years Halemaumau has been the main focus of surface activity of Kilauea.

The mention of fires, flowing hot rivers, bubbling lakes and deep pits in the legends of Kilauea show the forces of nature which terrified the Hawaiians for centuries and have made them build up legends around these terrors. The lack of knowledge of the science of the earths structure created a demand for a special fire goddess to take rank among the other gods worshipped by the early Hawaiians.

KILAUEA CRATER AREA

For the mineral collector, the area around Kiluea crater does not have the variety nor the quality of minerals as some of the other islands or of some areas on the island itself. However, obsidian can be found in quantities of a variety known as Pele tears. Pele tears are small black drop-shaped pellets ejected from the volcano during eruption. They can be found in the ash deposits on the southwest of Kiluea Iki Crater and at about the 11,200 foot level along the Mauna Loa trail. The only other mineral of note is olivine and when found in sizes and quality of gem worth is known as peridot. Large crystals have been found in the ash around Halemaumau Crater and also on the Mauna Loa trail for a stretch of about 2 miles below Pau Ulaula.

Since most of the rocks on Hawaii are extrusive, it might be worth a side trip to see a small laccolith. Laccoliths are lenticular bodies intruded parallel to bedding, more succinctly described as pregnant sills. One well formed laccolith can be found on the lower wall of the northeast side of the Kiluea caldera at Uwekahuna; it measures about 940 feet in length and 90 feet in width and is composed of porphyritic olivine-rich gabbro. Several other similar, smaller structures can be found on the floor of Kiluea crater about 1/4 mile east of Halemaumau and on the side of Mauna Iki shield.

There are several trails and roads around and across the Kiluea crater. Strating at the Hawaii Volcano Observatory and travelling counterclockwise, we find examples of tree molds.

These features result when the advancing lava solidifies around a tree trunk and the trunk is then burned away or otherwise removed, leaving the hollow mold behind. (Better examples of this can be seen along the road between Pahoa and Kapoho.) Next is Uwakahuna, the site of the laccolith and the on to Halemaumau. North of Halemaumau is a trail leading down to the Kau desert and I strongly recommend a trip down to this desert. Kiluea Iki and the Thurston Lava Tube are on the far west side of the Kiluea caldera. The Thurston Lava Tube is supposed to be spectacular; it can be followed for about 1/2 mile into the side of one of the craters. This feature resulted from the crusting over and solidification of the surface of a lava flow and the subsequent draining of the lava.

Finally, south of the Kiluea area along Chain of Craters Road is Puu Huluhulu and Mauna Ulu, where we will be given a personally guided tour by Dr. Peterson of the Hawaii Volcano Observatory. And if we're really lucky we may see Mauna Ulu in action!!

Gerda McGregor

VOLCANIC HISTORY OF KILAUEA ON HAWAII

Kilauea is a shield volcano built up against the east flank of Mauna Loa, with a summit caldera 2 1/2 by 2 miles bordered by faults and fault blocks forming steep cliffs. The caldera floor is covered with many lava flows and contains at its south-west edge another collapsed crater, a virtual fire pit, Halemaumau. This seems to be the point where the principal lava conduit of Kilauea reaches the surface.

1790- Apparently the first recorded eruption. This was a violent steam explosion caused by ground water entering the zone of heated rock. It is memorable because of its unusual violence.

Since that time all eruptions except one other have been lava flows in the caldera and on the flanks of Kilauea in the two rift zones running north-east and south-west from the main crater.

The volcano has been extremely active with eruptions practically continuous. The following flows have been mapped:

1832- Thin pahoehoe

1877- pahoehoe and some spatter

1879- thin pahoehoe

1882-1885 pahoehoe

1888-1889 thin pahoehoe

1892-1894 pahoehoe and aa

1918-1919 pahoehoe, lavatubes and pits formed

1921 pahoehoe

1924- Prior to 1924 there was a continuously rising and falling liquid lava lake in Halemaumau pit. From Jan to May 1924 the lake subsided several 100 ft, and many earthquakes and tremors suggested movements of magma away from its reservoir under the pit into the east rift zone. In May, when the pit was about 600 ft deep, enormous explosions occurred, throwing out huge clouds of dust and blocks of rock consisting of old lava. The walls of the pit caved in enlarging it to 3000 ft. The dark cloud lasted for about 7 days and was then replaced by white steam. After May 24 the explosions subsided. It seems that the movement of magma towards the east rift away from the crater caused the collapse of the pit, and ground water hitting the very hot pipe walls was turned to steam causing the explosions.

The lava lake had disappeared, leaving a pit 1300 ft deep.

1924-1934 Several eruptions filled the floor of the pit, but did not leave a lake.

1952- After a fairly quiet time Halemaumau erupted again through a fissure and filled with thin lava flows to 460 ft below the rim.

1954-1955 Eruptions started in Halemaumau in May, moved across Kilauea crater to Kilauea Iki, into the east rift zone, and sent 3 lava flows all the way to the ocean.

1959- A crack in the wall of Kilauea Iki opened up, spurting lava fountains and filling the floor of that crater. The activity was intermittent with the lava draining back out again. The fountain at one time grew to 1900 ft-a spectacular size- built a spatter cone and threw pumice 1/2 mile from the vent.

1960- Lava erupted from the east rift zone and flowed to the sea, destroying a village, but adding 500 acres to Hawaii.

KILAUEA--1961 to Present

1961
Feb. & Mar.-- Small eruptions partly filled the pits formed by the collapses in 1960 in Halemaumau.

July-- Further eruptions completely filled the pits thus establishing again a flat floor in the crater.

Sept.-- 13 small flows occuring over an area 12 miles in length along the east rift zone beyond Napau Crater. A volume of less than 2,000,000 cubic yards flowed out but subsidence of the mountaintop indicated removal of 70,000,000 cubic yards. The major portion of the magma must have been injected into rift fissures below the surface. This 4 th eruption in a single year constituted a record for frequency of eruption of a Hawaiian volcano during historic time.

1962
Dec.-- 6 small flows along the east rift zone filled Aloi Crater 40 ft. but most drained back down leaving only 6ft. flow. Caused many cracks and displacement of the centerline on the Chain of Craters Road.

1963
July-Aug.-- Earthquakes and again movement in the east rift zone. Chain of Craters Road displaced 4ft. horizontally and 3ft. vertically. Small eruption in Alea Crater.
Oct.-- Small eruptions in Napau Crater. 2 miles NE of Napau Crater 2 flows formed with one flow reaching nearly 8 miles. Total activity lasted 30 hours. 1963 eruptions totaled 9,500,000 cubic yards. It seemed the rift zone was so full it leaked at the weak points.

1965
Mar.-- Volcanic tremors and the summit of volcano began to sink therefore magma was again moving into the east rift zone. Eruptions began in a series of fissures over a total distance of 8 miles through Makaopuhi and Napau Craters. 20,000,000 cubic yards of lava flowed in 8½ hours making a pool in Makaopuhi Crater 260 ft. deep. After a few days of weak activity, the eastern vents stopped and the fountaining in Makaopuhi greatly increased. When the lava pool reached 340 ft. of depth the vents were covered and fountaining ceased. Lava drained back in the vents leaving a permanent lava fill of 290ft.

Nov. 1967 thru Aug. 1968
Lava fountains began along a N-S line across the floor of Halemaumau. There were alternating periods of fountaining and lava-lake activity with periods of drainback for 3 months. In Feb. periods of activity ceased and entire floor began to rise at an average rate of 1ft/day. Total fill of the crater was 440ft. This whole period of activity lasted 251 days, the second longest period of time for continuous activity for Kilauea. The longest was 294 days in 1919.

1969
Feb.-- Activity began again along the east rift zone with flows covering 3 miles of the Chain of Craters Road. The top of Kilauea deflated indicating additional activity might occur along east rift zone.

May-- Lava again flows from the east rift over the Chain of Craters Road and into Alea Crater.

June-- After 2 weeks of quiet accompanied by swelling of Kilauea, lava fountaining 500ft. high commenced along a fissure between Aloi and Alea Craters. For the next few months there were alternating periods of strong activity and quiet. The repeated flows plus spatter and cinders from the fountains built a shield cone 1 mi. wide and 400ft. high called Mauna Ulu. Activity in Mauna Ulu continued with flows filling in Aloi and Aloa Craters.

1970-1971
Lava reached the sea in Sept. 1970 and in March 1971 with a front several hundred yards wide.

July 1971-- Activity subsided and the lake level in Mauna Ulu sunk 300ft. below the crater rim. At the end of this total period of activity (1969-1971), approximately 300,000,000 cubic yards of lava had been extruded. This is the largest amount in Kilauea history.

Aug. 1971-- Fissures open in the floor and rim of Kilauea Caldera. After a brief period of quiet, eruptions began again. Lava eventually crossed Crater Rim Road and extended 2 miles from its source. This was only the second time in recorded history that the lava has spilled out of Kilauea Caldera. The first time was in 1921.

1972
Feb.-- Mauna Ulu became active again and lava flowed down the east side into shallow depression at the site of the former Alae Crater. Activity continued through the spring and summer. A new vent opened at the north edge of former Alae Crater forming a lava lake in the old depression. Activity in Alae lava lake sent occasional cascades of lava flowing into Makaopuhi Crater. From August to October the Alae lava lake drained through lava tubes and destroyed much of the Naulu forest. Activity resumed again in Alae during late October and two new small lava lakes were formed. Mauna Ulu continued active.

SOUTH COAST

by

H. Brown, D. Grasso, P. McClosky, F. Orsan,
J. Van Auker, S. Van Wagoner

I. Kaoiki Pali

The Pali, parallel with the road on the northwest side, is a fault scarp in lavas of the Kahuku volcanic series. It is partly veneered with later lavas of the Kau series from Mauna Loa. Kahuku lavas covered with yellow Pahala ash are exposed in small kipukas along the scarp.

The Kaoiki fault system just north of the highway between Kilauea and the town of Pahala forms a series of steep escarpments at the base of the slope where Mauna Loa meets Kilauea. Evidence suggests that this fault system acts as an adjustment joint on which slippage occurs during swelling and shrinking of the volcano. The lower part of the mountain has been displaced downward.

Steep faulting has produced a series of terraces separated by southeast-facing scarps that can be traced for 18 miles, from Bird Park near Kilauea. In places the total height of the escarpment is more than 500'. However, in some parts the escarpment is covered by lava flows, and the visible height represents only part of the fault. The Kaoiki fault system can be viewed from the Halfway House.

II. Kamakaia Hills

Most cones on Kilauea and Mauna Loa are spatter cones because of the fluidity of the erupting lava, but a few cinder cones are present. The Kamakaia Hills are examples of cinder cones. They are about 100' high and are located on the southwest rift zone. They are to be seen on the left side of the road about 2 miles from the highway.

III. Mauna Iki

Eruption on the rift zone 5.5 miles from the cauldera of Kilauea Iki built the small shield volcano and sent a lava flow 6 miles downslope to the sea in 1920. A shallow intru sion heaved up the lava into a dome 25' high before the lava burst through the side as an aa flow.

A trail leads from the highway to Mauna Iki. Northwest of Mauna Iki, fossil foot-prints in the ash of 1790 are believed to have been made by Keoua's army, one division of which was annihilated by the explosions of that year. Some of the ash layers contain pisolites, which are small mud balls formed by raindrops. A park sign indicates the trail to the footprints. Mauna Iki is located 2 miles off the highway from the Halfway House, on the seaward side.

IV. Halina Pali

Near the coast south of Kilauea caldera a group of faults form the Halina Pali. Vertical displacement has amounted to more than 2,000' in some spots, but the fault scarps have been largely mantled by flows of younger lava.

Evidence suggests that the Halina Pali, like the Kaoiki Pali, acts as an adjustment joint during swelling or shrinking of Mauna Loa and Kilauea.

The system consists of a series of subparallel faults with a total down-throw on the seaward side of more than 2,000'. It has a maximum height of 1,500'. Pahala ash 30' thick is exposed in the Halina Pali.

The Halina Pali is located 6 miles from the Halfway House on the seaward side of the highway.

V. The Great Crack

The great crack from which came the lava flow of 1823 extends uninterrupted for 14 miles along the southwest rift zone. In places the crack is as much as 50' wide.

The flow of 1823 which issued from this crack rose to the surface and flowed out quietly. There has been found little spatter. The lava was very fluid and left a thin sheet of lava up to 5' thick. On the top are preserved many lava tree molds. It may be viewed 1½ miles from the highway on the left side at the Halfway House.

VI. Turtle Cave

Turtle Cave is located 2½ miles north-northeast of Pahala between Wood Valley Road and Volcano Highway. It is about a few hundred yards off the highway in Piikea Gulch. Located in a side cave are petroglyphs. The petroglyphs are a line of human figures. There are about 60 petroglyphs.

VII. Pahala

Near the town of Pahala the remnants of the Ninole Volcano are covered with more than 50' of yellowish volcanic ash known as Pahala ash. Remnants of the Ninole shield are Makaalia Hill and Puu Enuhe. A thickness of 2100' of Ninole lavas is exposed. The hills represent the high parts of ridges that lay between valleys cut by streams and into the ninole shield. Their tops have remained unburied by lava flows. They have a thick accumulation of Pahala ash, which is 55' thick on Puu Enuhe.

Most of the Pahala ash consisted originally of ash called Pele's Hair, Pele's Tears and fragments of pumice ejected into the air by lava fountains. The once glassy ash has been largely altered, however, by weathering to a mixture of clay minerals and aluminum oxides--which explains the reddish brown to yellow colors. As a result of alteration, it has been difficult to determine the original sources. In the Pahala area it is fairly certain that the ash came from Kilauea and Mauna Loa.

VIII. Wood Valley

It is seldom realized that mudflows are among the most destructive phenomena. A mud flow occurred in Wood Valley in 1868.

In March of 1868 the area experienced heavy rain and the Pahala ash, which exhibits thixotropic properties (it behaves as a solid but if agitated if flows like a liquid), was throughly saturated from the heavy rains. On April 2 an earthquake occurred and the ash was agitated and transformed into fluid mud and flowed down the hillsides. The flow was in two branches. The smaller branch flowed into Wood Valley. It was more than a mile long. More than 500 animals and a village of 31 people are said to have been buried.

The unsorted debris is well exposed in the walls of a stream gulley that crosses the Wood Valley Road 3.5 miles north of Pahala.

IX. Punaluu Junction

This area is 5 miles south of Pahala. A side road leads to Punaluu, where springs discharge 25 million gallons a day into the ocean from the basal zone of saturation. Inland are prominant high ridges on an ancient surface formed in Ninole lavas and eroded by streams. The valleys between the ridges were much deeper and have been partially filled with later lava flows.

Also at Punaluu on the ocean side is located a nice fishing cove and a black sand beach.

Some black sand beaches such as Punaluu consist of glassy volcanic debris from littoral explosions. In the case of Punaluu, the source of the black volcanic glass sand originated in a single littoral explosion where an aa flow entered the ocean. There is no continuous supply of sand and the beach will eventually disappear.

Punaluu Beach is a small pocket beach. It is 800' long and 70' wide and lies between lava flows at both ends. The beach is composed almost entirely of volcanic glass, and the sorting is bimodal with modes of very coarse and medium size. The village of Punaluu occupies the back shore.

Numerous exposures of lava bedrock and lava boulders occur along sea level as well as offshore, where they form an irregular natural breakwater.

X. Waiohinu Rotational Fault

The southwest trending Waiohinu Fault extends 4.5 miles from Waiohino to the sea. Faulting has produced an eastward-facing scarp generally less than 50' high. In 1868

lateral movement of several feet took place on this fault. Every building in Waiohinu was destroyed and horizontal movement caused the old road crossing the fault to be offset about 10'.

XI. Kahuku Pali

Near the lower end of the branch road to South Point the Kahuku Pali is reached by a short walk eastward.

The sinking of the surface along the rift zone has produced a fault on only one side. The largest fault of this type is the Kahuku Pali. In some places 600' high the scarp is 10 miles long and has been traced southward for 18 miles beneath the ocean.

The Kahuku Pali is 2.5 miles northwest of South Point. It is a fault scarp of the southwest rift zone of Mauna Loa.

Lavas of the Kahuku volcanic series are exposed in the face of the cliff and are capped by Pahala ash.

On the southern slope of Mauna Loa from Kapapala to South Point a succession of large and small kipukas exist. These consist of tholeiitic lava flows covered by Pahala ash. The lavas have been named the Kahuku series and are best exposed in the Kahuku Pali.

Near South Point large individual crystals of olivine are found in gullies near the top of the Kahuku Cliff. They have been washed out of the layer of Pahala ash that covers the ground in that area. To reach Kahuku Pali turn left on Branch Road (6 miles) toward South Point near Rockwall.

Along the south shore of Hawaii for about 14 miles west of South Point a row of cinder cones has been built by littoral explosions where lava flows from the southwest rift zone of Mauna Loa entered the sea. The most recent of the cones formed in 1868 is 240' high and is known as Puu Hou which means new hill.

XII. South Point

Puu O Mahana is a littoral cone 3 miles northeast of South Point. It is the source of the olivine at the best green sand beach in Hawaii which as been concentrated in a small bay.

This olivine is concentrated as sand. The grains are too small to constitute gemstones but the green sand is highly valued by collectors. The name of the beach is Papakolea.

Directions to location: "At the end of the road to South Point we turned left onto a jeep road leading through grassy pasture along the shore.. This was a green sand area. In every indentation we could pick up small handfulls of this material mixed with the soil, but we wanted to find a large accumulation. By following the jeep trail through the pasture we found the green sand accumulation 2-3 miles up the coast where a great shelf in the bank was eroded away and was covered with the green sand. The best concentration was at the waters edge. To get there we scooted down a 45^{o} slope in a sitting position."

Petrified wood has been found at Puu O Mahana on the other side of the small bay at Papakolea, the location of the olivine beach. Puu O Mahana is about 2.5 miles northeast of Kalae, the southernmost point on the island and in the United States for that matter. Annual average rainfall is 20". April average is 4".

Puu O Mahana is a littoral cone containing an abundance of olivine crystals.

The petrified wood occurs plentifully in the uppermost 10' of the cone. The wood apparently grew on the cone prior to the deposition of Pahala ash which overlays it.

The wood ranges up to about 2½" in diameter and pieces up to 2' long have been recovered. Almost every piece has a crusty layer of ash adhering to it. The colors of the wood range from tan to dark brown with some cream colors. The material is 94% SiO_2.

Sizeable dust storms are seen in the vicinity of South Point and there are extensive deposits of yellow loess formed of dust-sized volcanic ash blown by the wind from the Kau Desert.

In some drier areas, calcium carbonate has been deposited in the lower part of the soil. The calcium carbonate forms irregular sheets and concretions around plant roots or casts deposited in holes left by decayed roots and stems. These are also well known in the South Point area.

XIII, XIV, XV, XVI, XVII, XVIII.

This is a series of lava flows which occurred in 1868, 1887, 1907, 1919, 1926, and 1950. These were all from Mauna Loa (southwest rift zone).

Upon leaving South Point, back up the road to Highway 11; make a left turn. At Kahuku Ranch (water tank) it is a half mile to 3 craters: Lua Palalouhala, Lua Poai, and Lua Puali. They are depressions in Kahuku Scarp.

After the 1907 flow, go two miles west to Manuka State Park. This is a naval facility, or was at one time. Turn left onto the jeep trail for 3/4 mile to petroglyphs. Continue to ocean 4 miles for ruins and lava tubes at Manuka Bay.

Hookena Beach is a pocket beach 600' long. At either end it is bounded by basaltic rock. To the south end along the back shore, lava is exposed as a 100' fault scarp. Sand extends inland beneath a coconut grove. A talus at the base of the fault scarp can be seen here. In the back shore area the beach is made up of nearly equal portions of volcanic and calcareous grains, medium-sized and moderately well sorted.

A rock reef lies offshore and underlies the beach.

April's tradiational weather in Hawaii is a cycle of transition between winter and summer. Although never very severe, it can be highly varied.

Temperature

Pakao	Low 63°; High 87°
Kapapala Ranch	Low 66°; High 85°
Pahala	Low 41°; High 78°
Naalehu	Low 63°; High 83°

Precipitation

South Point	5.87; rained 5 times, 3" one day
Manuka	4.00; rained 7 times, 2.5" one day
Pahala	6.60; rained 10 times, 3" and 2"
Nualehu	6.50; rained 10 times, 2.5" and 2"

Temperature ranges from 58 to 87 degrees, averaging 64-78°.

Precipitation ranges from 4" to 10"; typically small daily storms with occasionally 3" in one day.

Relative humidity is 80%.

Wind averages 6 mph; maximum 20 mph.

Figure 176. Topographic map of the island of Hawaii. (Modified after Stearns and Macdonald, 1946.)

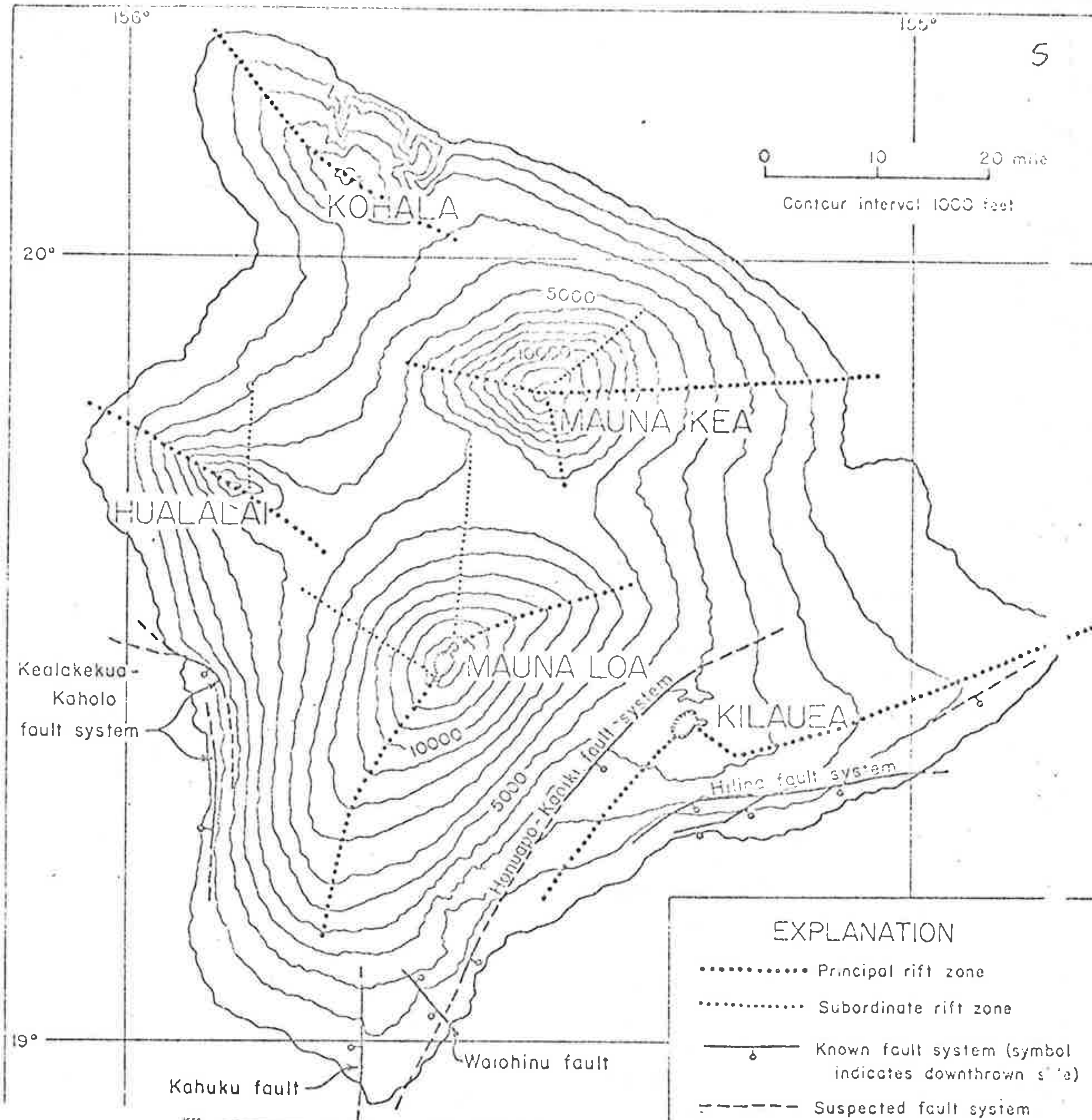


Figure 189. Map showing volcanic rift zones and faults on the island of Hawaii.

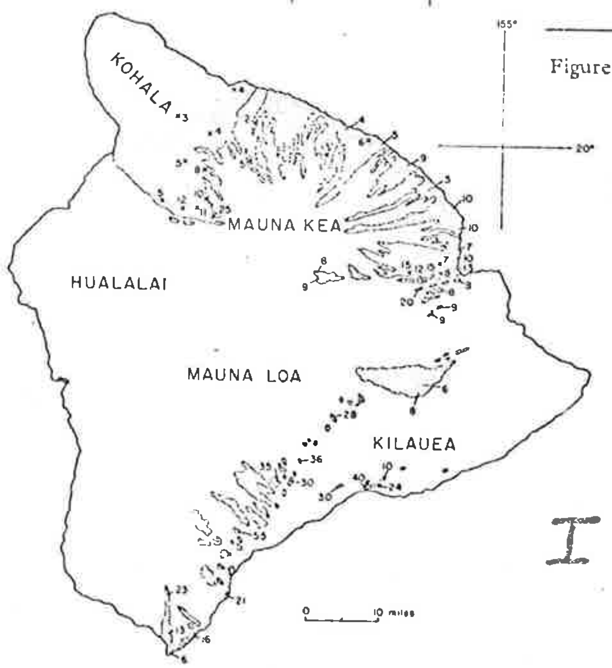
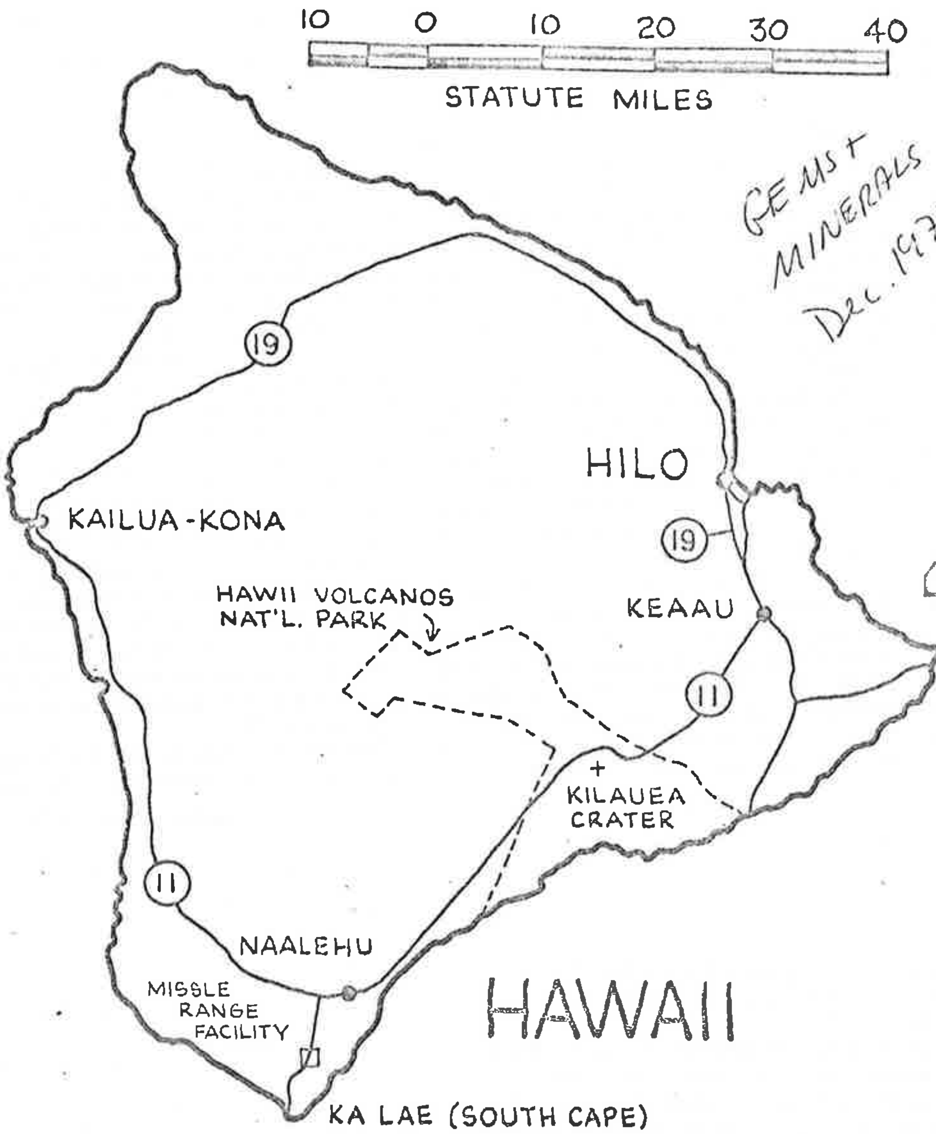


Figure 179. Map showing the distribution of Pahala ash on the island of Hawaii. The numerals indicate the approximate thickness of the ash at different points. (After Stearns and Macdonald, 1946.)

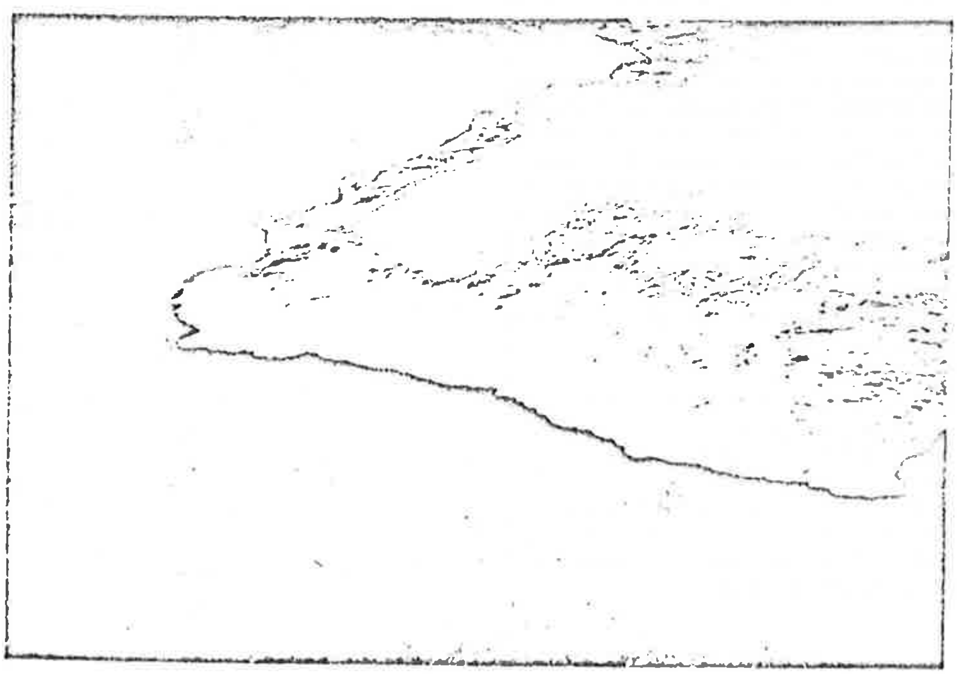
GEMS + MINERALS Dec. 1973



A Field Trip For Hawaiian "Diamond" Sand

By Nancy Nellans

The covering of green sand is deep.



Hawaii — gentle trade winds, beautiful beaches, lush green plants. Every year so many people fly and sail to the Islands to relax in the sun that tourism (the Malahini) has become the number one resource.

But, even in this lazy luxury, "vacationing" rockhounds can begin to be restless for a rock hunting adventure. What minerals does one hunt for in Hawaii?

The nature of the rock that makes up the Islands — all of it volcanic in origin — makes mineral collecting unlikely. The chief gem, black coral, is found two hundred feet and more under the Pacific Ocean. Shells and coral are all located beyond the sheltering reefs, and any loose specimens are crushed in the waves before reaching shore. In the numerous tourist shops on the islands, jewelry can be purchased containing stones sold as Hawaiian "diamonds", light green glassy particles which are actually olivine, called peridot as a gemstone.

It is olivine that the rockhound can search for and find in Hawaii in the form of green sand. Although too small to constitute gemstones, the green sand is valued by collectors, and its collecting can make for an exciting adventure. The Hawaiian "diamonds." light green glassy particles which are actually olivine, called olivine particles are not large enough for commercial use.

Scooping up green sand requires no heavy equipment so it is ideal for the tourist who has flown to the islands. The only chore is locating the place to begin collecting.

My husband and I were living on Oahu recently and, being avid rockhounds, were chafing at the lack of opportunity for collecting excursions in the islands. Knowing green sand was present there, we determined to find some for ourselves.

Diamond Head, the famous landmark of Oahu, is said to be named for the sparkling olivine on its surface. But, this material is in small quantities over the entire crater.

The best locations for green sand are beaches at Hanauma Bay on Oahu and at Papokolea on Hawaii. At both places the sand in some areas consists predominately of green crystals of olivine, separated out of the volcanic rocks by erosion.

Hanauma Bay is a very popular and populated beach near Honolulu frequented by scuba divers and snorkel swimmers. For more solitude and freedom to search, we chose Papokolea on the south coast of Hawaii. It turned out to be the better locality for olivine sand.

At Papokolea, olivine has been washed out of a littoral cinder cone formed where a lava flow entered the ocean. Where slow moving lava flows into the sea, water may give access to the hot central part of the flow, resulting in a steam explosion. The out-rushing steam may carry with it a cloud of drops of liquid lava which on contact with the water chill into glassy bits. Olivine gets its green color from iron and nickel; the mineral itself is composed of iron and magnesium silicate.

We flew into Hilo airport on the island of Hawaii and rented a small car there. Driving out of Hilo, heading southeast on Highway 19, we turned onto Highway 11, at the village of Keaau. Highway 11 goes right over the most active Hawaiian volcano, Kilauea Iki, and is a very interesting drive in itself. Travel is on a thin strip of asphalt between hissing steam vents. This road (also called Mamalahoa Highway) slants visible down hill as it leaves Kileaua Iki and heads for the south shore. The highways are all clearly marked with road signs, but there is only one paved road possible for travel through the stark black ashheaps.

Fresh air and the beautiful sea make the trip for Hawaiian "diamonds" a memorable occasion.

Shortly after nearing the coast again and traveling through the village of Naalehu, we took a left turn which lead to South Point. Here, too, getting lost was impossible because only one road existed, but we had along a road map to help ascertain where we were.

Approximately five miles after turning toward South Point, we passed through an abandoned military installation. No buildings were standing, but cement foundations and housing pipes were still present.

At the end of the road (the ocean's edge) we turned left onto a faint tire track leading through grassy pasture along the shore. Here we were at the green sand area. In every indentation we could pick up small handfuls of this material mixed with the soil, but we were intent on finding a large accumulation in a cove or sheltered place.

It was very windy at this lonely spot. It was exciting to know we were on the

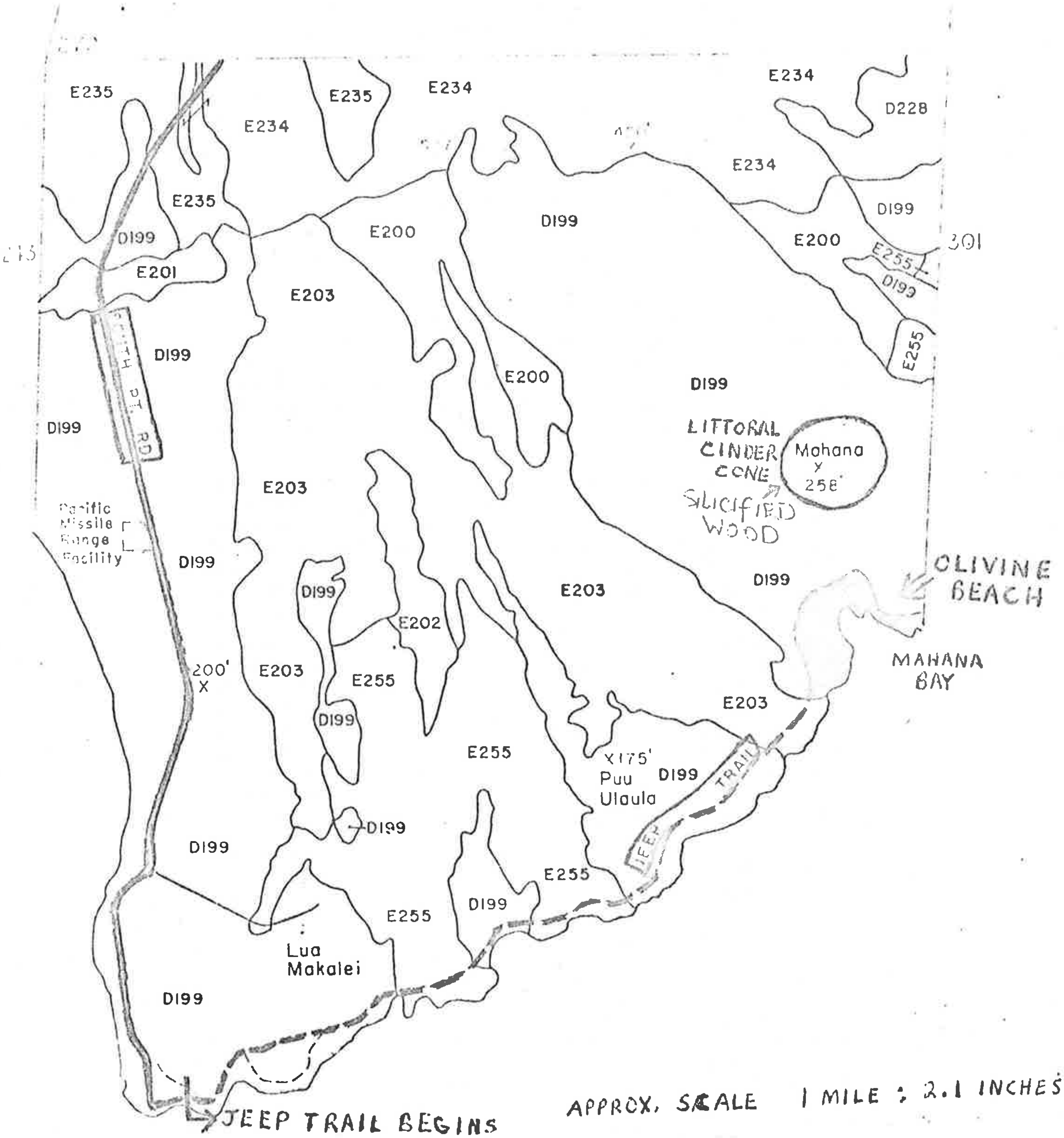
Southern-most tip of the United States and longitudinally parallel with Mexico City.

By following the faint track through the pasture, we found our green sand accumulation two or three miles up the coast where the wind had eroded a great shelf into the bank and covered it with that material. This covering went all the way to the top where we approached from the car, but the best concentration was at the water's edge. To get there we scooted down the 45° slope in a sitting position. This green sand area is accessible through a private pasture (get permission first) and we passed some grazing cattle, but its isolation affords few disturbing human visitors. We found a tourist rockhound as well as two local fishermen at the same cove. All of us managed nicely to reach the location in small foreign cars although probably a high-wheeled vehicle would be even more desirable.

We gathered the wet green sand in plastic sandwich bags and took it home to dry out. The round trip from Hilo took all day, but was not strenuous since it involved mostly driving.

Perhaps the biggest hazard of the trip was the wind which could whip sand into the eyes. We had a wonderful adventure and are delighted to have personally gathered the Hawaiian green sand which few collectors possess.

XII.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[American Journal of Science, Vol. 259, March 1961, P. 229-230]

OCCURRENCE OF SILICIFIED WOOD IN HAWAII*

R. T. OKAMURA and J. C. FORBES

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Silicified wood has been found at two localities on the Island of Hawaii. Samples have been collected from the littoral cone, Puu o mahana, about 2.5 miles northeast of Kalae, the southernmost point of the Island, and from a bed of ash on the southwest slope of Mauna Kea, 0.5 mile north of Kilohana Girl Scout Camp on the Saddle Road. The writers have not personally visited the second locality but have received samples and information about the occurrence from Glenn G. Mitchell of Hilo.

Puu o mahana is a littoral cone built by the explosions generated when a prehistoric lava flow from Mauna Loa reached the sea. It consists of alternating beds of fine-grained basaltic ash and relatively coarse lithic debris with an abundance of olivine crystals scattered throughout. Unconformably overlying the vitric-lithic beds of the cone are a series of partially indurated and highly altered (palagonitized) beds of very fine-grained ash up to 20 feet thick. This material is generally believed to represent reworked Pahala ash, which originally was produced by Kilauea Volcano, 10 miles northeast, during a prehistoric era of strong phreato-magmatic activity. The cone is being eroded by waves, and a green sand (olivine) beach of striking appearance has formed on the adjacent shore.

On Puu o mahana the silicified wood occurs plentifully in the uppermost 10 feet of the cone; none has been observed in the overlying weathered Pahala ash. In the locale studied, the wood appears as vertical tubelike concretions, many of which branch downward and presumably represent the roots of some plant that grew on the surface of the cone prior to or contemporaneous with the deposition of the Pahala ash. The upper parts of the plant probably were carried away by the wind or decayed before the process of silicification began.

Thin sections of the Puu o mahana wood show poor preservation of the cellular structure, suggestive also of some decay prior to silicification. However, enough tissue is preserved to leave no doubt as to the original vegetable nature of the petrifactions. The wood ranges from about $\frac{1}{4}$ inch to $2\frac{1}{2}$ inches in diameter, and pieces up to 2 feet in length have been recovered. Almost every piece has a crusty layer of ash adhering to it and the colors of the core run from tan to dark brown with an intermingling of cream. Chemically, the material proves to be opal, consisting of 93.83% SiO_2, 4.15% H_2O^+, 0.64% H_2O^-, and 1.33% remainder.

Volcanic ash, because of its fine grain and commonly glassy nature, weathers rapidly and releases soluble silica (Murata, 1940). Plant materials, therefore, when embedded in ash, have a much better chance of becoming

* Publication authorized by the Director, U. S. Geological Survey.

silicified before they disappear through complete decay, than in any other matrix. In the case of the Hawaiian petrified wood, the silica was very likely derived from the overlying highly weathered Pahala ash. Silica, soluble in the ground water, percolated downward through the littoral cone, and was redeposited as opal in the woody root remains and other open channelways. Although the common association of silicified wood with siliceous volcanic ash is well known, the Hawaiian material is of special interest because it indicates that a much less siliceous tholeiitic basalt ash also serves as a source of readily available silica.

Reference

Murata, K. J., 1940, Volcanic ash as a source of silica for the silicification of wood: Am. Jour. Sci., v. 238, p. 586-596.

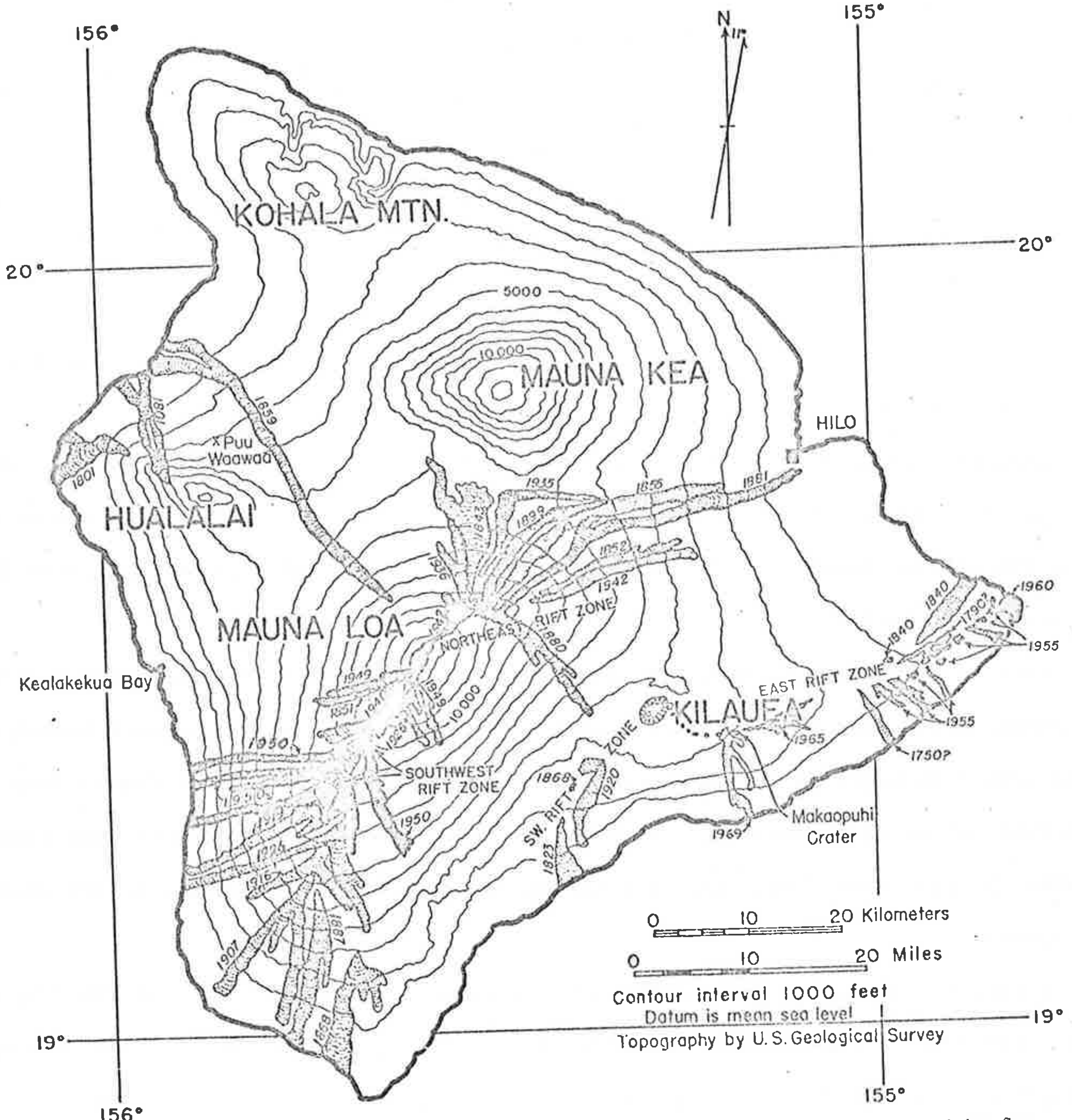

Figure 45. Map of the island of Hawaii, showing the five major volcanoes that make up the island, and the historic lava flows.

XIII, XIV, XV, XVI, XVII, XVIII.

KONA COAST

GEOLOGY-PETROLOGY

by

K. J. Lant and M. C. Stimson

Along the Kona coast, two distinct episodes of vulcanism are encountered: Mauna Loa to the south and Hualalai (Wa - La - Lai) to the north.

Basaltic extrusions from Mauna Loa represent the younger of the two events and are assigned to the Kau volcanic series. A percentage approximation of the Kau series reveals 40% olivine basalt; 26% basalt; 21% picritic basalt; 13% hypersthene basalt (see compositional chart).

From Kauluoa Point to Napoopoo in the Kau volcanic series, the road somewhat parallel the Kealakekua-Kaholo fault system. North of Kealakekua Bay and Napoopoo a branch of the fault system diverges to the northwest, forming a readily identifiable fault scarp. This escarpment shows lava from Mauna Loa has flowed over the scarp to form the Kaawaloa Peninsula. Displacement along the fault system was responsible for damage of the 1951 Kona earthquake.

Basalt flows sampled beneath the City of Refuge, Honaunau, were classified by Washington (1923) as an "oligoclase basalt". Subsequent investigations have not been able to duplicate such findings and the basalts are classified as olivine basalts.

The basalts that flow over the Kealakekua Bay fault scarp contain small brown acicular crystals which are most probably rutile.

Two and a half miles north of Kealakekua, picrite basalts from Mauna Loa have olivine inclusions up to one centimeter across with minor amounts of scattered magnetite.

Just north of Kainaliu, the lava flows change from Mauna Loa to Hualalai! (Welcome to ultramafic nodule territory!)

The Hualalai volcanic series is composed of olivine basalts, basalt, with minor amounts of picrite basalt and trachyte (see compositional chart).

One-half mile north of Kuamoo Point angular gabbro inclusions up to five centimeters in length occur in olivine basalt. The gabbro is composed of labradorite, augite, olivine, and iron ore.

Along the highway at Huehue Ranch numerous xenoliths of dunite, werhlite (augite-peridotite), and olivine gabbro are found in the 1801 flow from Hualalai. Yet two miles upslope from the highway the ultramafics are numerous. The resulting accumulation of partly-rounded black to brown masses is described by MacDonald (1970, p. 304) as "a heap of potatoes buried by lava".

Six miles north of the summit of Hualalai and readily seen from the road to the south, is Puu Waawaa. Puu Waawaa is a large cone of trachyte pumice with obsidian fragments. The Puu Waawaa trachyte represents a higher degree of magmatic differentiation than any other rocks associated with Hualalai. The current hypothesis regarding the origin of the trachytes is that they were formed by differentiation in a small magma chamber isolated from the main magma chamber of Hualalai.

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6

Principal rock types of the Island of Hawaii

Rock name	Texture		Composition	
	Megascopic texture	Groundmass texture	Phenocrysts	Groundmass
Olivine basalt.	Porphyritic, less commonly nonporphyritic.	Generally intergranular or intersertal. Thin chilled crusts and glassy pyroclastic ejecta are hyalopilitic or hyaloophitic. Average grain size, 0.02 to 0.2 mm.; most commonly about 0.07 mm.	Olivine, 0–20 percent, 1–8 mm. long. Plagioclase, 0–25 percent, rarely more; 1–10 mm. long, rarely as much as 25 mm., zoned from Ab_{20}–Ab_{30}. Augite, 0–15 percent, 1–10 mm. long.	Plagioclase ($Ab_{[illegible]}$–$Ab_{[illegible]}$), 25–45 percent; a little interstitial andesine; monoclinic pyroxene, 25–45 percent; olivine, 1–15 percent; iron ore, both magnetite and ilmenite, 7–15 percent; apatite recognizable in a few specimens; some contain glass.
Basalt.	Porphyritic, less commonly nonporphyritic.		Olivine, 0–3 percent, 1–4 mm. long. Plagioclase, 0–20 percent, 1–5 mm. long, zoned from $Ab_{[illegible]}$–Ab_{30}. Augite, 0–3 percent, 1–5 mm. long.	Plagioclase ($Ab_{[illegible]}$–$Ab_{[illegible]}$), 30–50 percent; a little interstitial andesine; monoclinic pyroxene, 30–50 percent; olivine, 0–3 percent; iron ore, both magnetite and ilmenite, 7–15 percent; rare rutile; apatite recognizable in a few specimens; some contain glass.
Hypersthene-bearing basalt.	Porphyritic, rarely nonporphyritic.		Olivine, 0–10 percent, 1–8 mm. long. Plagioclase, 0–20 percent, 1–5 mm. long, zoned from Ab_{25}–Ab_{15}. Augite, rare. Hypersthene, 1–5 percent, rarely more; 0.4–1.5 mm. long.	Plagioclase ($Ab_{[illegible]}$–$Ab_{[illegible]}$), 37–45 percent; a little interstitial andesine; monoclinic pyroxene, 30–48 percent; olivine, 0–7 percent; iron ore, both magnetite and ilmenite, 8–15 percent; apatite recognizable in some specimens; some contain glass.
Primitive picrite-basalt.	Porphyritic.		Olivine, 20–50 percent, 1–10 mm. long. Plagioclase, 0–5 percent, 1–5 mm. long, zoned from Ab_{25}–Ab_{15}. Augite, 0–5 percent, 1–10 mm. long.	Plagioclase ($Ab_{[illegible]}$–$Ab_{[illegible]}$), 20–30 percent; monoclinic pyroxene, 20–35 percent; olivine, 1–5 percent; iron ore, both magnetite and ilmenite, 5–15 percent; rare rutile; some specimens contain glass.
Augite-rich picrite-basalt.	Porphyritic.		Olivine, 15–25 percent, 5–10 mm. long. Plagioclase, 0–7 percent, 1–5 mm. long, zoned from $Ab_{[illegible]}$–$Ab_{[illegible]}$. Augite, 10–30 percent, 6–10 mm. long.	Plagioclase ($Ab_{[illegible]}$–$Ab_{[illegible]}$), 20–30 percent; monoclinic pyroxene, 20–35 percent; olivine, 1–5 percent; iron ore, both magnetite and ilmenite, 5–10 percent; some specimens contain glass.
Andesine andesite.	Porphyritic or nonporphyritic.		Olivine, rare, 0–5 percent, 1–4 mm. long. Plagioclase, 0–15 percent; 1–5 mm. long, rarely up to 20 mm., zoned from $Ab_{[illegible]}$–$Ab_{[illegible]}$. Augite, rare, 0–1 percent, 1–2 mm. long.	Plagioclase ($Ab_{[illegible]}$–$Ab_{[illegible]}$), [illegible]–55 percent; monoclinic pyroxene, 20–[illegible] percent; olivine, 1–10 percent; iron ore, magnetite commonly predominant over ilmenite, 10–20 percent; biotite, 0–[illegible] percent; apatite recognizable in many specimens; a riebeckitelike amphibole, rare; some specimens contain glass.
Oligoclase andesite.	Porphyritic or nonporphyritic.	Trachytic. The trachyte pumice of Puu Waawaa is largely glass, but glass is not abundant elsewhere. Average grain size is commonly about 0.04 mm.	Olivine, rare, 0–1 percent, 1–7 mm. long. Plagioclase, 0–5 percent, 1–8 mm. long, zoned from Ab_{15}–$Ab_{[illegible]}$. Riebeckitelike amphibole, 0–1 percent, less than 1 mm. long. Basaltic hornblende, rare.	Plagioclase ($Ab_{[illegible]}$–$Ab_{[illegible]}$), 50–60 percent; monoclinic pyroxene, 15–30 percent; olivine, 1–5 percent; iron ore, mostly magnetite but some ilmenite, 10–25 percent; biotite, 0–2 percent; riebeckitelike amphibole, 0–1 percent; apatite, about 1 percent; hornblende, rare, 0–1 percent; some specimens contain glass.
Trachyte.	Porphyritic or nonporphyritic.		Olivine, 0–1 percent, rarely more; as much as 1 mm. long. Plagioclase, 0–10 percent, 1–4 mm. long, zoned from $Ab_{[illegible]}$–$Ab_{[illegible]}$. Hornblende, 0–1 percent, 1–2 mm. long, both brown and green. Riebeckitelike amphibole, 0–1 percent, less than 1 mm. long. Biotite, rare.	Plagioclase ($Ab_{[illegible]}$–$Ab_{[illegible]}$), 65–85 percent; monoclinic pyroxene, 5–25 percent; olivine, 0–5 percent; iron ore, largely or entirely magnetite, 5–15 percent; apatite, about 1 percent; biotite, 0–2 percent; green hornblende, 0–1 percent; some specimens contain glass.

FROM MACDONALD (1949, p 55)

Brad Einstein

KONA COAST CLIMATE

The expected climate for this area of the island is derived by compiling information from the thirteen weather stations on the western side of the island. The stations vary in elevation from sea level at Kona to eleven thousand feet at Mauna Loa.

There is a tremendous difference in the weather on the island when comparing the western side (Kona) to the eastern side (Hilo). The main difference is the rainfall; which for the months of April during the years 1951-1960, was recorded at Hilo Airport to be 11.92 inches. Last year it was a little lighter; only 7.34 inches. For the Kona airport, the 1951-1960 average is 1.31 inches; with only .65 inches recorded for last year.

There is a chain of weather stations extending in a line from just south of Kona to almost the top of Hualalai. Last years April rainfall, ascending the hill was 1.78, 3.17, 4.45, 2.70 and 1.07 inches. Notice that the rainfall is proportional to altitude to a certain point then falls off. This is caused by the topography of the area in conjunction with the general wind patterns.

The Kona area is situated on the leeward side of Mauna Loa and Hualalai and is blocked off from the prevailing trade winds, which blow onto the east (Hilo) side of the island, carrying large amounts of moisture. On the western side of the island (Kona), the heat radiated by the mountains warms the surrounding air causing up-drafts. This draws the moist air up the mountain. As the air masses ascend they cross an inversion layer which is the reason for the decrease in rainfall at the top.

The amount of rainfall in the first part of last April for the western side ranged from .26 inches, on the fourth to .05 on the fifth, tenth, and the twelfth. However, even if it didn't rain, there was cloud cover almost every afternoon as the moist air moves back down the mountain-side and over the ocean. This means gentle winds every day; onshore winds in the morning and offshore winds in the afternoon.

Last years temperature at Kona for the early part of April had an average maximum of 80.5°F and an average minimum of 66.0°F. To the south and up about 1000 feet the temperature averages were 82.4°F and 58.4°F.

Last years highest April temperature for Kona was 85°F and the lowest was 62°F.

Two items worthy of note are that sunrise and sunset will be one half hour later than at Northridge; and that at noon the suns elevation is 80°, something never found in California.

Martha Baxter
Olivia Robinson

EROSION ON THE KONA COAST

Hawaii island, except for the windward slope of Kohala, is little eroded. The only perennial streams are on the north-east slopes of Mauna Kea and Kohala. The high permeability of the fresh lavas forming the surface of Kilauea, Mauna Loa and Hualalai inhibit the development of permanent streams. Large areas of these mountains are covered with black rock and are bare and devoid of vegetation.

The tradewind influence is dominant throughout all seasons and extends over the greater part of all the islands. There are, however, a number of local influences. In the Kona district mountains to the east project high above sea level and cut off the trades, resulting in prevailing southwesterly winds, with land and sea breezes in evidence.

A broad shelf 1,200 feet below sea level follows the coast of Mauna Kea, Kohala, and part of Hualalai indicating a submergence of this amount following a long period of marine erosion. Wave action is a drastic form of erosion that can eat away the cliffs rapidly. Some portions of the shoreline resist wave-attack readily. Small islets or stacks are an example of the more resistant material left standing a short distance from the shoreline and are clearly marked on the USGS topo sheet of the Hawaiian Islands 1:250,000. The large occurrence of these resistant features appears to be an indication of the low wave intensity on this side of the island.

Most beach sand in the island is derived from pulverization of corals, and is bright white in color. This is to be expected because corals cover most offshore areas where contours are shallow enough to permit formation of beaches.

Cattle, pigs and goats have been ruinously destructive in Hawaii almost from the days of their introduction. Polynesian colonizers brought the pigs, and also apparently brought rats as stowaways in their great seagoing canoes. Captain Cook fetched goats to the islands in 1778. Goats, which both graze and browse, eat the native grasses down to the roots and destroy small trees and shrubs by devouring their twigs and tearing off their bark. Goats and pigs run wild in the islands and their destructiveness seems unlikely to be curbed until they are wiped out. Hawaiians hunt and eat them but do not kill enough to make much of a dent in the population -- the breeding potential of wild goats is such that 100 of them in 15 years can increase to about 20,000!

The City of Refuge is situated on a small peninsula built into the sea by a pahoehoe lava flow. This sacred spot was established in the early 15th century to give santury to breakers of the religious law, to women and children in times of war and to defeated warriors seeking protection. Brackish springs issuing in the cove nearby supplied the fugitives with water. Hawaiian artifacts indicate submergence of about two feet since the city was built.

A cliff on the north side of Kealakekua Bay is believed to be a fault scarp, somewhat modified by wave erosion, exposing Kahuku lavas. The scarp extends inland in a southeasterly direction but is heavily veneered with later lavas of the Kua volcanic series.

Sharon Cabeen

HUALALAI

Hualalai is 0.4 million years old and rises 8,269 feet above sea level. Considered dormant, its last eruption was in 1800-01. The eruption produced two major flows from separate vents. The Kaupulehu flow escaped from a vent at 5,500' to 6,000' and flowed 10 miles to the sea destroying a village. A large spatter cone formed around the second vent at 1,600'. It also entered the sea along a 4 mile front. Three other very small flows from vents between the two main ones added to cover an area approximately 17.7 square miles.

The eruptions occured along a rift zone trending N50°W across the summit. A less defined N-S rift fans out on the north flank. Most of the flows are alkalic ovivine basalt with a few hawaiite flows. All the tholeiitic basalts have been buried. As differentiation progresses magma becomes more viscous. The gas content increases because it is unable to escape as easily. Eruptions become more explosive. Hualalai eruptions have not been as explosive as Kohala and Mauna Kea which are older, but are more explosive than Mauna Loa and Kilauea which are younger. More than 100 spatter and cinder cones along the rift zones attest to increased explosiveness. Abundant ash has been deposited, especially on the southern slope where most of the flows are covered. Thicker flows result from the increase viscosity. No direct evidence has been found to prove that Hualalai ever possessed a caldera. If it did it is completely buried.

On Hualalai's north slope is a large trachyte pumice cone and aa flow. The flow is thicker and shorter than those of the alkalic basalts due to increased viscosity. Reaching a maximum of 900' thick, the flow is composed of several flow units ranging from 250' to 500'. The flow surface is very irregular and hummocky. Crescentic flow ridges up to 50' high point convexly down flow. Portions of the flow are covered by later basalt flows from Hualalai or Mauna Loa. The Puu Waawaa trachyte flow represents more advanced magma differentiation than the rest of Hualalai. The nearest other site of trachyte is on Kohala. It is possible Puu Waawaa was produced by magma which migrated laterally from Kohala. However, since the cone lies on the north rift, it was probably from a small isolated chamber which had undergone greater differentiation.

Thousands of earthquakes from beneath Hualalai's north flank shook the mountain in 1929. Some were felt as far away as Honolulu. These subsurface movements of magma and readjustment by the rocks in the mountain prove Hualalai's hearth is still alive. Further, more explosive eruptions, can be expected.

Jim Clark
Nick DeMott
Diane Evans
Nancy Gruver
Jerry Whiteford

KOHALA

Introduction

Kohala Mountain has an elevation of 5,505' and covers only a little over 5% of the island. Its small area is partially due to its age, as it is continually being buried by flows of still active volcanoes.

The rocks of Kohala have been divided into two series, the older Pololu volcanic series which forms the main tholeiitic mass of the volcano, and the younger Hawi volcanic series.

The Pololu volcanic series is largely composed of tholeiitic basalt, tholeiitic olivine basalt, and primitive picrite basalt (oceanite), but some alkalic olivine basalts appear in the upper part of the series. The olivine basalts of the Pololu series differ slightly from those among the early lavas of other volcanoes on the island of Hawaii in that they contain more abundant phenocrysts of feldspar. The most common rock type is a fine grained, medium gray basalt containing a few scattered phenocrysts of olivine. The series is made up of typically thin bedded units consisting largely of pahoehoe.

The Pololu volcanic series is separated from the younger Hawi volcanic series by an unconformity which marks a considerable period of erosion when the volcano was dormant, or only erupted infrequently. The lavas of the Hawi series are largely composed of oligoclase andesite (mugearite), but a few flows and domes of trachyte are present. Thin ash beds, some showing partial weathering, lie between the flows of the Hawi series. The Hawi lavas are widespread on the northern, western, and southern slopes of Kohala, but on the northeast side are confined to the heads of the big valleys. The Hawi flows are much thicker and more massive and produce a more rugged topography than the Pololu series.

Kohala volcano is an asymmetrical shield volcano elongated in a northwest-southeast axis. Two main rift zones intersect at the summit, one trending N 35° W, and the other trending S 50°W. There are many dikes in the northern side of the volcano, which may indicate a collapse of an elongated magma reservoir. The collapse produced a graben that extends for 6 miles along the summit and is about one-half mile wide, and paralleled by several echelon faults " that bound a sunken area 3 miles wide." They have a curved pattern which may suggest the former existence of an oval caldera at the close of the Pololu activity.

The fault scarps play an important role in the distribution of andesites. They reach a height of 250 feet and average 50 feet, apparently no flows passes over "either scarp between Kawainui and Honokane Nui streams or over the scarp of the opposite side of the graben, leaving large areas of basalts uncovered by the andesite flow."

The last stage of Kohala's eruptions were probably moderatley explosive and formed a series of large andesitic cinder cones along the rift zones.

In general, the stream pattern on Kohala is radial. The pattern is determined by the configuration and constructional form of the dome. The positions of the headwaters are determined by faults.

Kohala has four major deep canyons, Waipio, Waimanu, Honokane Nui, and Pololu, located on the northwestern slopes where the rainfall is about 200 inches at the headwaters. The depth of the canyons is between 1000 - 2500 feet. The flat floors are caused by alluviation concurrent with submergence of the land. The deepness of the canyons and the steepness of the walls is unsurpassed anywhere else on the island. A few reasons for the depth of the canyons include: (1) They cut in a kipula segment of the rim, that lay sheltered from subsequent flows by a caldera rim, hence they are older than the other gulches of the dome. (2) They cut the Pololu volcanic series, the weaker volcanics of the dome. (3) They drain the slope of greatest rainfall. (4) They tap saturated dike complexes of Kohala and ground water reaches them from beyond the crest.

There is only one deep gulch, Honokoa Gulch, on the leeward side of the mountain.

ROAD GUIDE TO KOHALA

S. M. Spencer Beach Park

Kawaihae Bay is the re-entrant of the coast between the slopes of Kohala and Mauna Kea. A small patch of coral reef lies in the bay.

Fossils. There are fossiliferous marine conglomerates about 20 feet above sea level, north of Kawaihae Bay, on the west slope of Kohala Mountain.

Waimea - Honokaa - Waipio Valley and Adjacent area

Waimea (Kamuela Post Office)

Waimea Plain. Waimea lies in a saddle formed by the lavas of the Hamakua volcanic series of Mauna Kea banking against the lavas of Kohala. The plain extends for 11 miles south of Waimea and covers an area of 25 square miles, having an elevation between 2500 and 3000 feet above sea level. The plain is covered with ashy soil and Pahala ash.

Puu Pa is a cinder cone containing well formed crystals of augite and olivine, and is located 3 miles southwest of Waimea.

Waimea Canyon is a tributary to the Waimea Valley. It is 2,200 feet deep and has numerous springs issuing form dikes on its floor. It can be reached by taking the Uper Hamakua Ditch trail for two miles, which is located 2.5 miles to the east of Waimea.

Waimea - Honokaa. The road continues to cross the Hamakua lavas. The body of water 2.5 miles to the northeast of Waimea is the Puu Pulehu Reservoir. Beyond this the road crosses sections of the Laupahoehoe volcanic series. It may be possible to see cinder cones looking to the south, on the slopes of Mauna Kea.

Waipio Valley - Pololu Valley

Formation of Waipio Valley

The Waipio stream flows along the boundary of the Hawi and Pololu volcanic series. It was quite distinctive from the neighboring Waimanu stream. A northwest-southeast trending fault partially controls the location of their upper reaches and forms the northern boundary to a swarm of dikes. The streams cut their valleys in the weak basalts, but the Waipio stream tapped water confined in the main dike swarm, mentioned above, whereas the Waimanu stream tapped water confined between a few stray dikes. Due to the greater discharge, the Waipio stream cut its headwaters faster following the direction of the fault until it captured the upper reaches of the Waimanu stream.

Rise in sea level, due to glacial melt, and submergence of the island more than 1200 feet caused by its weight on the earth's crust, lessened the stream gradient, and thus caused alluviation of the valleys.

A late Pleistocene Laupahoehoe flow of Mauna Kea poured into Hiilwae Canyon, a tributary of the Waipio Valley, and proceeded down into the Waipio Valley, filling it to a depth of 150 feet. The flow has since been cut through by the stream to the level of the old canyon floor.

Other Tributaries to Waipio Valley

Kowawe Canyon intersects a spring discharging 2 million gallons of water per day, from an eroded dike, into the head of the canyon.

Tributaries of Waimanu

Waihilau Canyon has conspicious faults are exposed on the canyon walls. The fault nearest the head is bordered by two feet of red gouge on the east side, and 8 inches of gray gouge on the west. Two dikes, 18 inches wide, are truncated by the fault and are downthrown more than 100 feet. One half-mile downstream, on the southern wall there is a fault next to a waterfall. The compact breccia and gouge have resisted erosion and form a sheer smooth cliff 200 feet high.

Waiiliahi Stream on the west wall of Waimanu Valley has multiple waterfalls and plunge pools.

Honokane Nui Canyon. The two faults in Waihilau Canyon parallel faults at the head of Honokane Nui Canyon and bound a horst raised One-half mile. This has been buried by later flows and does not show well in the topography. A fault striking N 15° W and dipping 80°W cuts across the head of the east branch of the valley.

Landslides

Waimanu Canyon. Mass transfer occurs on the walls of Waimanu Canyon. The stream is not adequate to carry away the debris, hence, the head of the valley is filled with landslides and other rock debris.

1 Mile North of Waimea Canyon. Following the earthquake of 1868, a landslide fell from a sea cliff about one mile long and one-half mile wide. It has not yet been cut away by the sea. This occured at the same time as the Wood Valley landslide, 5 miles north of Pahala, which buried a village, killing 31 people.

In Honokane Nui Valley

During Prehistoric Times, a landslide fell in the east branch of the valley, damming the stream and forming a pond. Today this is evident by 30 feet of striated silt and clay deposits.

1929. There were many earthqukae associated landslides in the valley.

1942. A landslide fell into the west branch of the Honokane Nui Stream at an altitude of 1500 feet. It formed a pond 100 yards long that was still in existance in 1944.

Wind

Waipio and Pololu Valleys. Black dunes of baslatic beach sands up to 50 feet in height are in the mouths of both the Waipio and Pololu Valleys.

Waipio Bay was formed by the drowning of the mouth of the canyon, and by the intersection of the andesitic lava from Mauna Kea with the basalts of Kohala.

Coast Between Pololu and Waipio. The cliffs are between 400 and 1400 feet in height. They attain this height because they lie on the windward side of the coast where the waves are strong and cut the weak basalts of the Pololu series. The cliffs are somewaht higher to the west of Waipio Valley than to the east because of the cap of andesitic Hawi volcanic series on the eastern side. There are also spectacular hanging valleys cut in the Pololu series. Along this side of the coast, there is as much as 20 feet of soil.

Waimea to Hawi (Includes the windward side of the mountain with the exception of Kawaihae Bay)

Waimea --Kahua Ranch

Cinder cones in considerable number are visible along this road, they lie along the north rift zone of the mountain.

Two Miles northwest of Puu Kawaiwai the road crosses the lavas of the Hawi volcanic series.

Kahua Ranch. Hawaiians have trouble holding their water. The rocks are so permeable that the reservoirs leak heavily. Many are known to leak their capacity in twenty-four hours. Ronald von Holt of the Kahua Ranch made several permanent water holes on the ranch with minimum expense. He merely placed feeding troughs for the cattle in damp depressions on the ranch. The cattle standing around these troughs puddled the ash soil sufficiently to cause the ground water to "collect in the depressions where formerly the soil was too porous to retain the water."

Note: The Flumes that are seen throughout the state are means of transporting water from one place to the next without allowing it to percolate into the earth, NOT giant hydrology labs.

Hawi to Mahukona

Hawi. Sugar cane grows here, and is irrigated by waters diverted from the canyons to the southeast by way of an 18 mile long ditch and tunnel system.

Mahukona. The road to Mahukona goes from the windward to the leeward side of the mountain. The soils on this side of the mountain are thin and sparce, and the coast is not cliffed. There is only one deep gulch, the Honokaa Gulch, about nine miles to the south of Mahukona along the coast. Its upper part is a shallow stream flowing over strong andesite. Farther down it forms a narrow, deep, gulch where it flows over primitive basalts.

Hawi Pololu Valley

The road crosses both of the volcanic series which make up Kohala Mountain and terminates at the Pololu Valley. From here it is possible to walk down into the Honokane Nui Valley.

MAUNA KEA

Introduction

Mauna Kea Mountain is the highest insular peak. It has an elevation of 13,784 feet and covers about 22 % of the island. Along the northern coast, the most dominant geomorphic features are the narrow V-shaped valleys whose streams plunge in waterfalls over the high sea cliffs. These can be seen following the main highway to Hilo. Other more diverse landforms, such as dunes and moraines can be observed along the Hamuula Saddle Road which traverses the intersection of the Mauna Loa and Mauna Kea lavas.

The lavas of Mauna Kea dip outward in all directions from the summit. Three rift zones radiating from a center near the summit area, are present, but not clearly defined. One trends northeastward and diverges north, the second trends northwest, and the third extends southeastward.

The dome is 30 miles across. Near the top there are many cinder cones, clustered in two zones, that are arranged roughly concentric to the summit. This suggests the existence of concentric fissures at depth occupied by ring dikes.

The lavas of Mauna Kea are divided into two series, the older Hamakua volcanic series, exposed only on the lower slopes of the mountain in kipukas that were not covered by later flows and in highway cuts along the Hamakua Coast, and the younger Laupohoehoe volcanic series which has largely buried the original shield above sea level.

The Hamakua volcanic series consists of two members, lower and upper. The lower member of this series is composed of an assemblage of rocks similar to that of Mauna Loa and Kilaeua. They consist largely of tholeiitic basalts, olivine basalts, and basalt, and primitive picrite-basalt (oceanite) in lesser amounts.

The transition from lower to upper member of the Hamakua series is gradual, with rocks grading into those of the upper member which includes alkalic olivine basalt, basalt, andesine andesite (hawaiite), and augite-rich picrite basalt (ankaramite). The rocks were erupted in a highly fluid state, and the rocks are the usual thin beds of pahoehoe and aa. Interbedded with the rocks of the Hamakua volcanic series are thin layers of ash. Covering the Hamakua series in most areas is a blanket of tan-colored vitric Pahala ash which can average 4 to 5 feet in thickness. This ash separates the Hamakua volcanic series from the overlying Laupahoehoe series which forms a cap of differentiated lavas over the top. These lavas are composed primarily of andesine andesites (hawaiite), with a few alkalic olivine basalts, and picrite-basalts (ankaramite) present. The lavas of this series form a thin veneer over the upper part of the cone, and reach a maximun thickness at the summit. Six recent andesitic flows comprise the upper member of this series. Flows above 10,500 feet overlie glacial drift. Coarsely crystalline plutonic ejecta are found in many of the late cinder cones on the upper slopes of Mauna Kea. They are of two general types, gabbro, largely ordinary olivine gabbro, and ultrabasic rocks.

ROAD GUIDE TO MAUNA KEA

Honokaa to Onomea Bay, Along the Hamakua Coast

This is the windward side of Mauna Kea. The cliffs are 50 to 380 feet high. According to MacDonald, the erosion of the coast gained a "head-start" on stream erosion on Mauna Kea, therefore many of the streams plunge down the sea cliffs in waterfalls.

A broad shelf, 1200 feet below sea level follows the coast of Mauna Kea and Kohala indicating submergence of this amount following a long period of marine erosion. The Hamakua Coast is skirted by a marine beach about five feet above sea level.

Ookala. There is a viscous dome of andesite, the lowest vent in the Laupahoehoe lavas one mile to the southeast of Ookala.

Mauna Kea Valleys

These are smaller and younger than the ones found on Kohala Mountain. Most are only between 50 and 250 feet in depth. The deeper canyons, going from north to south along the coast are Kahawailiilii, Laupahoehoe, Maulua, Hakalau, Kawainui, Honolii and the Wailuku River. These have cut deeper than the rest because they intersect perennial springs, cones and lava flows direct drainage to them, and they cut less resistant rock.

Laupahoehoe Gulch is filled with an andesitic pahoehoe flow which forms the peninsula. The flow is recent, and there is little soil, although it has already been cut greater than 400 feet by the stream.

Maulua Gulch has an alluviated vally signifying that it was probably eroded at a time when sea level was much lower, and the rise of sea level caused the deposition in the valley.

Hakalau Gulch. Upper members of the Hamakua volcanic series are exposed in road cuts on the south side of the gulch.

Kolekole Stream. A side road from Honomu leads to Akaka Falls, where Kolekole Stream "drops 412 feet into a stream eroded ampitheater cut into thin-bedded lavas of the Hamakua series."

Kawainui Stream once entered into Onomea Bay, but was diverted by Laupahoehoe lavas.

Bays

Onomea Bay is formed on the north side of an old cinder cone nearly buried by later lavas. The former Onomea arch was cut into the cinder cone. This became a sea stack in 1958 when the roof of the arch collapsed.

Along The Saddle Road From Waimea to Hilo

Interior Plain. The Saddle Road traverses the interior plain at elevations between 4500 and 7000 feet above sea level. The plain was formed by the lavas of Mauna Kea, Hualalai and Mauna Loa banking against each other. The area of the plain is 150 square miles. To the east it is known as the Humuula Saddle, and to the west has been named the Hualalai Saddle. It is covered with fresh lavas from Mauna Loa.

Between Waikaii and Pohakuloa the gravel deposits over which the road passes came from two sources, present day flood stream deposits and glacial meltwater.

2 Miles south of Waikii on the western slope, extending from Puu Io to Puu Kanalopakanui is an example of the concentric cone pattern mentioned in the introduction.

Wind

Between 2 and 3 miles southeast of Waikii in a road cut are cross sections of black sand dune deposits on the lee side of the mountain. The material comes from a deposit of volcanic ash on the upper slopes of Mauna Kea from some of the late stage eruptions.

3 to 6 Miles West of Pohakuloa is an example of "man as a geomorphic agent." During military maneuvers tanks and trucks have run over the surface of the Humuula Saddle, destroying much of the vegetation. This has caused an increase in wind erosion, and new sand dunes are forming to the lee side of the plain.

On The Lee Side of Mauna Kea Cones, high winds during eruptions have caused deposition of black vitric ash from 5 to 50 feet thick on the lee side of Mauna Kea cones.

Pohakuloa Camp

Glaciation. During the Wisconsin Glacial Stage, the Makanaka Glacier covered 28 square miles of Mauna Kea above 11,000 feet and extended down to 10,500 feet above Pohakuloa. It averaged 200 feet in depth, with a maximum of 350 feet. The glacier left many erosional features. From Pohakuloa Camp the terminal moraine of the glacier can be seen. Other evidence of the existence of the glacier are; removal of ash and cinders, smoothing of aa, lower slopes of cinder cones eroded and steepened, polished and striated rock surfaces, and roches moutonees. There is still permanent ice on summit cones a few feet below the surface of the cinders.

Erosional Features on the Upper Slopes of Mauna Kea (These features can only be seen near the summit of Mauna Kea). Hale Pohaku is as far as it is possible to go by car. From here the terminal moraine is visible at 11,500 feet, as well as other glacial features previously mentioned. There are other erosional features on the upper slopes of Mauna Kea that are not visible at this point, or along the saddle road. They will be mentioned here as it is from this point that one can continue up to the summit, either on foot or by four-wheel drive vehicle.

Gulches. The Gulches of the upper slopes are glacier related. The larger ones tend to be located down-slope from one of the lobes of the Pleistocene glacier, with their deepest parts between one and two miles of the former ice margins. Pohakuloa Gulch was cut during late glacial or early postglacial times. This is evident by the presence of glacial outwash gravel in a shallow gulch which cuts across Pohakuloa.

Lakes. Near the summit of Mauna Kea there is an alpine lake, Lake Waiau, which is probably perched on ground ice.

Freeze-Thaw. The effects of freezing and thawing are apparent on the upper slopes of Mauna Kea. The temperatures on these slopes fall below freezing during the night and rise above freezing during the day. Therefore, freezing and thawing become a daily process. During the day water moves into cracks in rock. During the night it freezes and can exert up to 30,000 lb/sq inch of pressure on the rock. This causes the rock to break up. On Mauna Kea the rock fragments are from sand size particles to a few inches in diameter. The fragments are arranged in polygonal patterns. This process takes place in spite of the small amount of rainfall on upper slopes.

Soil Creep. is the main cause of mass transfer of soil on the upper slopes of Mauna Kea, according to MacDonald. It occurs where the water in the soil freezes and expands perpendicular to the slope. When the ice melts, the water, along with the soil is pulled downslope by gravity resulting in soil creep.

Continuing Towards Hilo along the leeward side of Mauna Kea there are few well developed streams. This is, of course, due to the lack of water. Rainfall averages less than 40 inches on this side of the mountain, and most of it is absorbed or transpired. These slopes, however, do have a fair cover of ash soil.

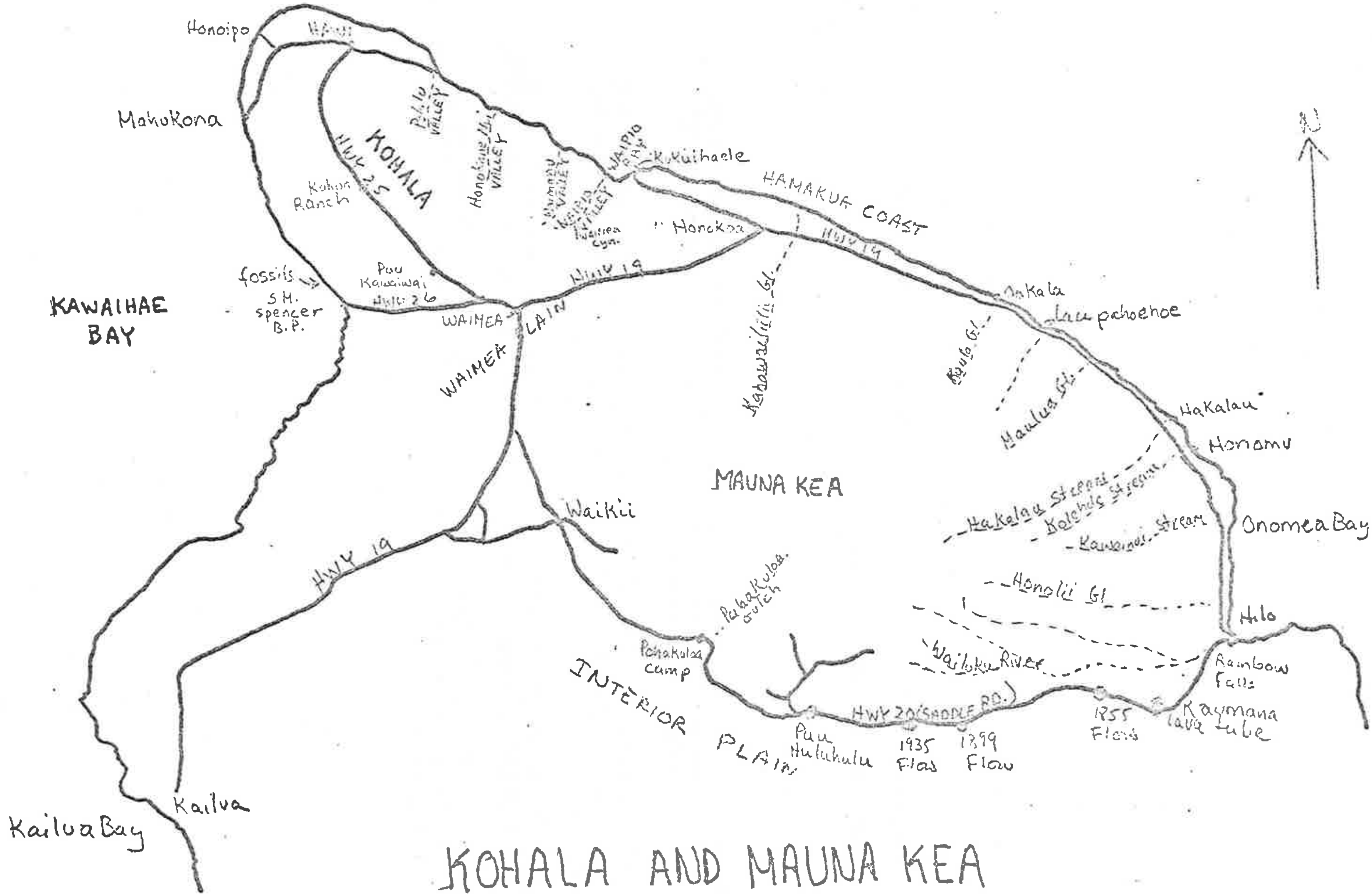
Puu Hulululu is a cinder cone surrounded by Mauna Loa lavas of 1935.. It is being quarried for road material.

Flow of 1935. The road follows this flow for 6 miles. It is partly aa and partly pahoehoe, as are the rest of the flows.

Flow of 1899 and 1855. The flow of 1899 is passed first going towards Hilo. The two flows are distinguishable by the amount of vegetative cover. The older flow, of course, has more flora..

Kaumana Cave is a lava tube from the flow of 1881. It ranges from 2.5 to 15 feet in height, 10 to 60 feet in width, and is more than one-half mile long. Between the cave and Hilo Mauna Loa lavas resting on Pahala ash can be seen in road cuts.

Rainbow Falls. Lavas under the falls are from a late valley filling flow from Mauna Loa. Lavas on the right bank are from Mauna Kea. Below the falls are the boiling pots.



KOHALA AND MAUNA KEA

traced from: Plate 2, MacDonald, G.T., and Stearns H.T., 1946

ACKNOWLEDGEMENT

Most of the information collected for the report on Kohala and Mauna Kea comes directly from works by Harold T. Stearns and Gordon A. MacDonald. The specific books are listed below. Without their work, the Kohala--Mauna Kea section of this road guide would not have been possible.

MacDonald, G.A. and H.T. Stearns, "Geology and Ground Water Resoruces of the Island of Hawaii", Hawaii Division of Hydrography, Bullitin 9, 1946.

MacDonald, G.A., and A.T. Abbott, Volcanoes in the Sea: The Geology of Hawaii, University of Hawaii Press, Honolulu, 1970.

MacDonald, G. A.,"Petrography of the Island of Hawaii", U. S. Geological Survey Professional Paper 214-D, pp 51-96, 1949.

Stearns, H. T., Road Guide to Geologic Points of Interest in the Hawaiian Islands, Pacific Books, Publishers, Palo Alto, Calif. 1969

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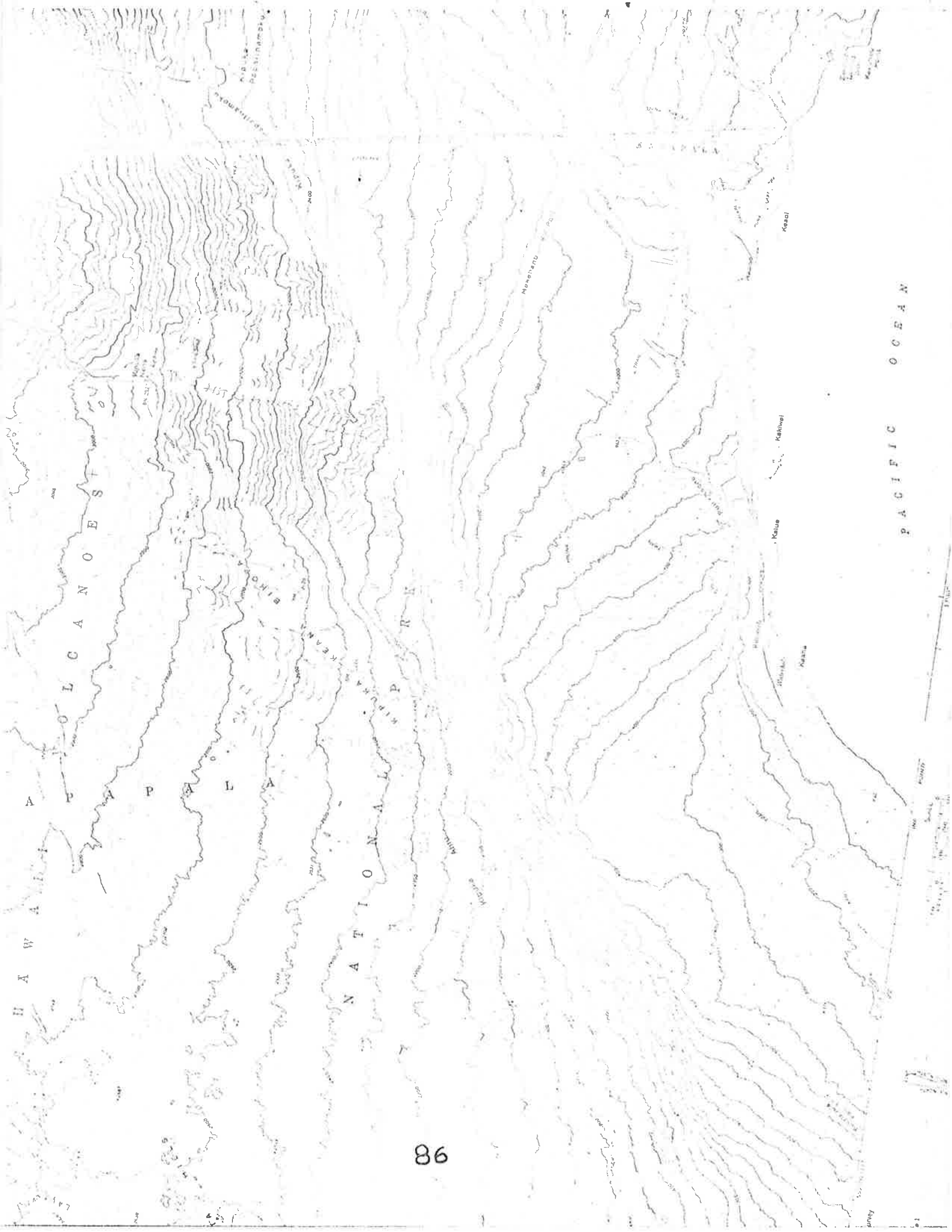
KEONEPOKO IKI
NANAWALE
KAHUWAI
LAVA FLOW OF 1840
NANAWALE FOREST RESERVE
HONOLULU
PUUA
WAAWAA
HALEKAMAHINA
KAPOHO
PUALAA
KULA


KEAHIALAKA
MALAMA-KI FOREST RESERVE
MALAMA-KI
NANAWALE FOREST RESERVE
KAUAEA
OPIHIKAO
HOMESTEADS
KAUELEAU
LAVA FLOW OF 1955
KAMAILI
KAMAILI HOMESTEADS
KEEKEE
KEHENA
KEAUOHANA FOREST RESERVE
KEAUOHANA
UPPER KAIMU HOMESTEADS
KIKALA-KEOKEA HOMESTEADS
KIKALA

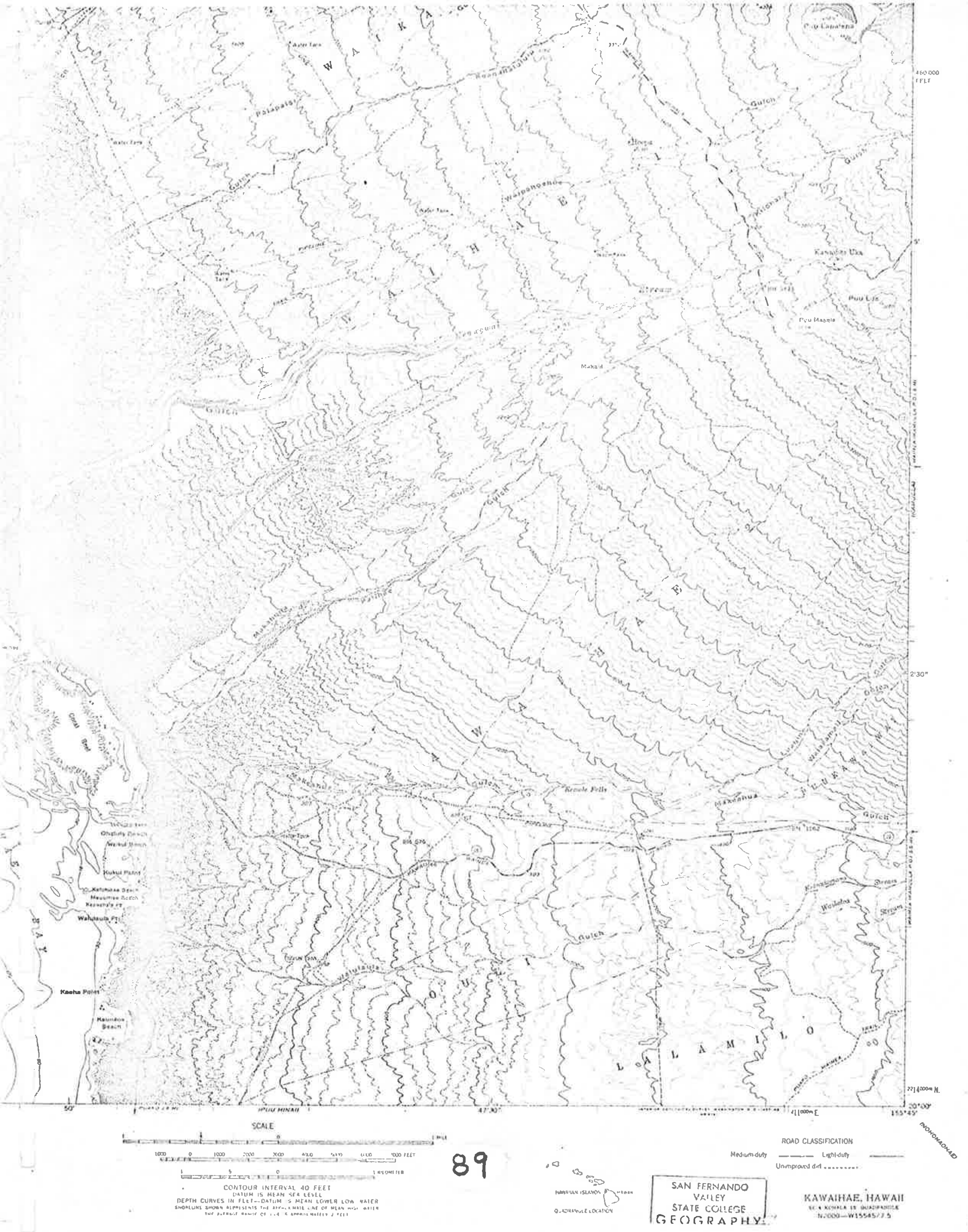

K A I M U
KAIMU-MAKENA
HOMESTEADS
M A K E N A
KAIMU MAKENA
HOMESTEADS
KAIMU
MAKENA
KALAPANA
K A L A P A N A
KALAPANA
KUPAHUA HOMESTEADS
KUPAHUA
KUPAHUA
HULUNANAI
KAUNALOA
KAPAAHU
K A U N A L O A
K A P A A H U
K A H A U A L E A
P O U P O U
P U L A M A
KAHAUALEA
K A M O A M O A
NATIONAL PARK
VOLCANOES
PARK
LAVA FLOW OF 1965


KEAUHOU
K A H A U A L E
HAWAII VOLCANOES NATIONAL PARK
CHAIN OF CRATERS
PANAU NUI
KILAUEA CRATER
KEAUHOU
SUNSET LOTS
PUNA DISTRICT
KAU DISTRICT
Water Tank
Pauahi Crater


HAWAII VOLCANOES NATIONAL PARK
PACIFIC OCEAN


WAIKA
HONOKUA
Papakolea Point
HONOKUA LAVA FLOW OF 1950
PAHOEHOE 1-4
MAUNAONI
HALEILI
KAOHE 2
PAHOEHOE 2
SOUTH KONA FOREST RESERVE
LAVA FLOW OF 1950
WAIKAKUU
KAOHE 4
KAOHE 5
Auau Point
SOUTH KONA FOREST RESERVE
KUKUIOPAE
KOLO
Puoa Point
OLELOMOANA
OLELOMOANA HOMESTEADS
OLELOMOANA 2
OPIHIHALI 1
SOUTH KONA FOREST RESERVE
OPIHIHALI 2
KAAPUNA LAVA FLOW OF 1950


KEALAKEKUA
BAY
Napoopoo
Palemano Pt
Keomo Pt
Moinui Pt
Honaunau Bay
Puuhonua Pt
Kiilae Bay
Loa Point
Kealia Beach
Palianihi Pt
Hookena
KAUHAKO
HOOKENA


W A I K A
Palapala
Gulch
Waipahoehoe
Stream
Kawaihae Uka
Puu Lua
Puu Hapala
Makahi
Pohakuloa
Gulch
Keawewai
Kawaihae
Makahuna
Hawaiian
Pauahi
Waikoloa
Waiaka
Waiakamoi
Pahoa Point
Waialoa
Keolo Falls
Kalahuipuaa
Kaunaoa Beach
Kohala Point
BAY
Coral Reef
Ohaiula Beach
Kukui Point
Waialua Pt.
Gulch
L A L A M I L O
460 000 FEET
5'
2'30"
221 4000m N.
20°00'
155°45'
411000m E
50'
47'30"
SCALE
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES IN FEET--DATUM IS MEAN LOWER LOW WATER
ROAD CLASSIFICATION
Medium-duty
Light-duty
Unimproved dirt
HAWAIIAN ISLANDS
QUADRANGLE LOCATION
KAWAIHAE, HAWAII
N2000—W15545/7.5
(NONOKAOKAD)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TERRITORY OF HAWAII

HAWAII
(ISLAND AND COUNTY OF

90


MAHUKONA 1957
HAWI 1957
HONOKANE 1957
KOHALA 1913
KEAWANUI BAY 1957
WAIPIO 1913
HAMAKUA 1912
KAWAIHAE 1956
KAMUELA
KUKUIHAELE 1957
HONOKAA 1957
KUKAIAU 1957
ANAEHOOMALU 1959
PUU HINAI 1956
NOHONAOHAE 1956
MAKAHALAU 1956
UMIKOA 1956
KEANAKOLU 1956
PAPAALOA 1956
PUAKO 1924
WAIKII 1927
MAUNA KEA 1912-27
HONOMU 1912
MAKALAWENA 1959
KIHOLO 1959
PUU ANAHULU 1959
KEAMUKU 1956
AHUMOA 1956
MAUNA KEA 1956
PUA AKALA 1956
AKAKA FALLS 1956
PAPAIKOU 1956
KEAHOLE 1924
KEAHOLE POINT 1959
KAILUA 1959
HUALALAI 1959
NAOHUELEELUA 1956
PUU KOLI 1956
PUU OO 1956
UPPER PIIHONUA 1956
PIIHONUA 1963
HILO 1963
KEAAU RANCH 1963
KAILUA 1924
KAOHE 1927
HUMUULA 1927
HILO 1914-30
MAKUU 1922
KEALAKEKUA 1959
PUU LEHUA 1959
PUU O UO 1956
KOKOOLAU 1956
PUU ULAULA 1956
KULANI 1956
PUU MAKAALA 1963
MOUNTAIN VIEW 1963
SULPHUR CONE 1956
MAUNA LOA 1956
KIPUKA PAKEKAKE 1956
HONAUNAU 1925
MAUNA LOA 1920-26
PUU HUALALAI / KAULUOA POINT
ALIKA CONE 1957
KEAIWA RESERVOIR 1957
WOOD VALLEY 1957
MAKAOPUHI CRATER 1963
KALAPANA 1922
MILOLII 1962
PAPA 1962
PUU O KEOKEO 1957
PUNALUU 1966
PAHALA 1967
HALIKAKANI POINT 1963
HONUAPO 1921
PAHALA 1921
MANUKA BAY 1962
POHUE BAY 1962
KAHUKU RANCH 1962
NAALEHU 1962
PUU HOU 1962
KA LAE 1962
KALAE 1921
20°
19°
156°
155°

TOPO INDEX

Jeannie Heffernan

VOLCANOES NATIONAL PARK & KILAUEA

POINTS OF INTEREST:

Kilauea Crater is a caldera which is 2 1/2 miles across. Halemaumau is the huge pit in the caldera floor. The floor has lava and cinder cone remnants from the 1954 eruption.

Kilauea Iki is a pit crater 440' deep next to Kilauea Crater.

A good place to start to explore the sights of Kilauea would be to follow Crater Rim Drive around Kilauea and Kilauea Iki. We can get to it from the Mamalahoa Highway, or SR 11, coming from either Hilo or the Kona area. If we are coming from Hilo we would follow SR 11 until we reached the Park Headquarters & Museum. The museum has a study of the volcanic origins of land formations. It is open Monday - Friday 7:30 - 5, and Saturday and Sunday from 6. They show free movies of recent eruptions daily from 9 - 3 on the hour.

After visiting the Park Museum we can follow Crater Rim Drive around the Craters going clockwise. Pretty soon we will run into the Thurston Lava Tube. It is a long tube which formed by the outer part of the flow hardening while the inner part flowed away leaving a tunnel. It is 1,494' long and is 20' high and 22' wide in places.

Alittle south of the Lava Tube is the Tree Fern Jungle which should be interesting to see.

While we are in the area of the Lava Tube and the Tree Fern Jungle, we will be on the east side of Kilauea Iki Crater from which we can probably get a good view.

We can drive alittle more on this road and we can either continue around the Kilauea Crater or can go south on Chain of Craters Road. If we do decide to take Chain of Craters Road we will see a number of other craters. There is Lua Manu Crater 200' deep, Puhimau Crater 550', Kohoolau Crater 100', Devils Throat 250', Heake Crater 500', Pauahi Crater 425', Aloi Crater 230', Alea Crater 440', Makaopuhi Crater which is a double pit crater. But I think this road may be closed from a recent lava flow, but maybe we can get through. If we can we can take a scenic road which leads to Kalapana Black Sand Beach.

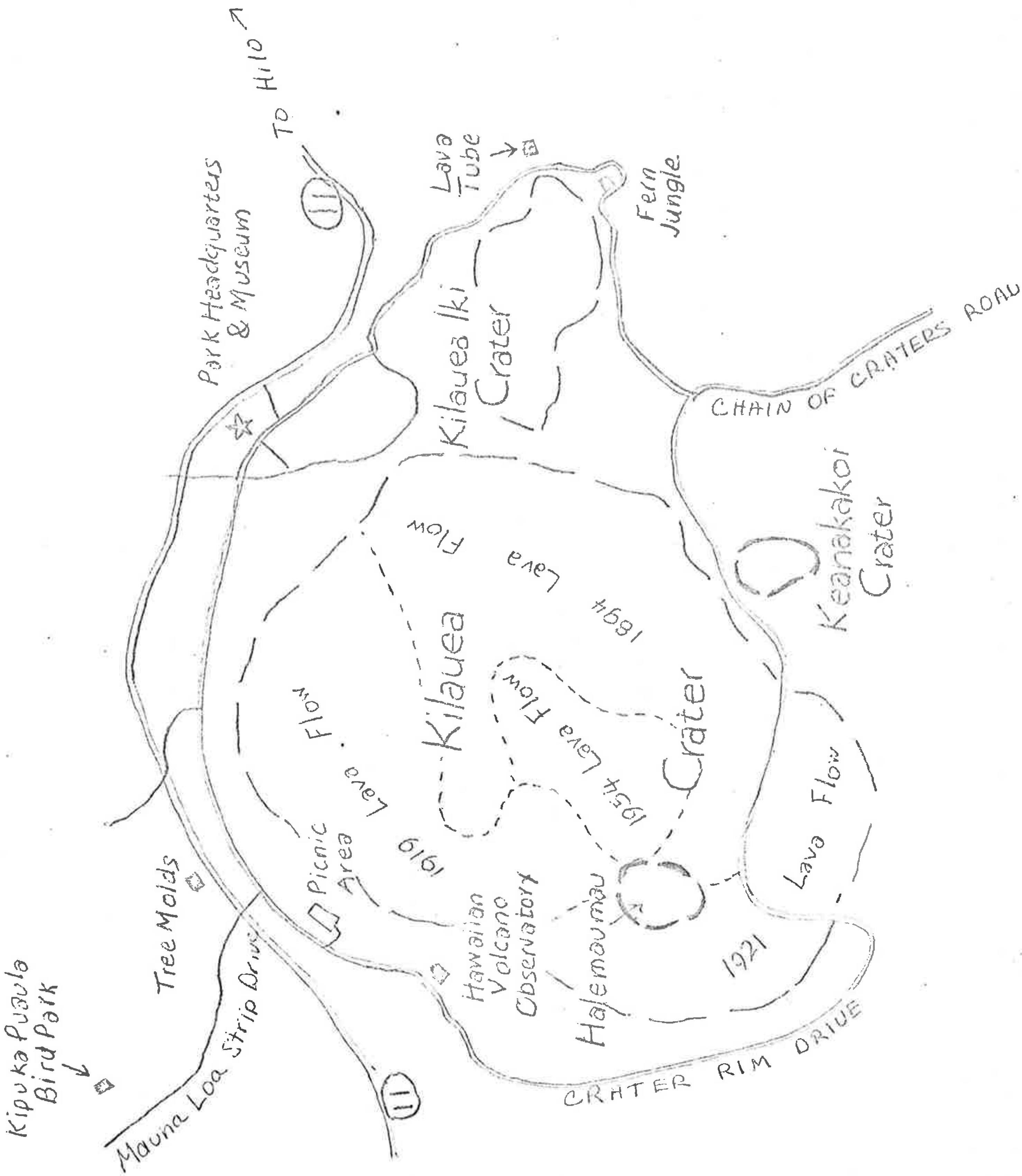
Now we are back up at the junction of Chain of Craters Road and Crater Rim Drive and we will continue around Crater Rim Drive. After a short distance we will come to Keanakakoi Crater. This is a pit crater 220' deep that last erupted in 1877.

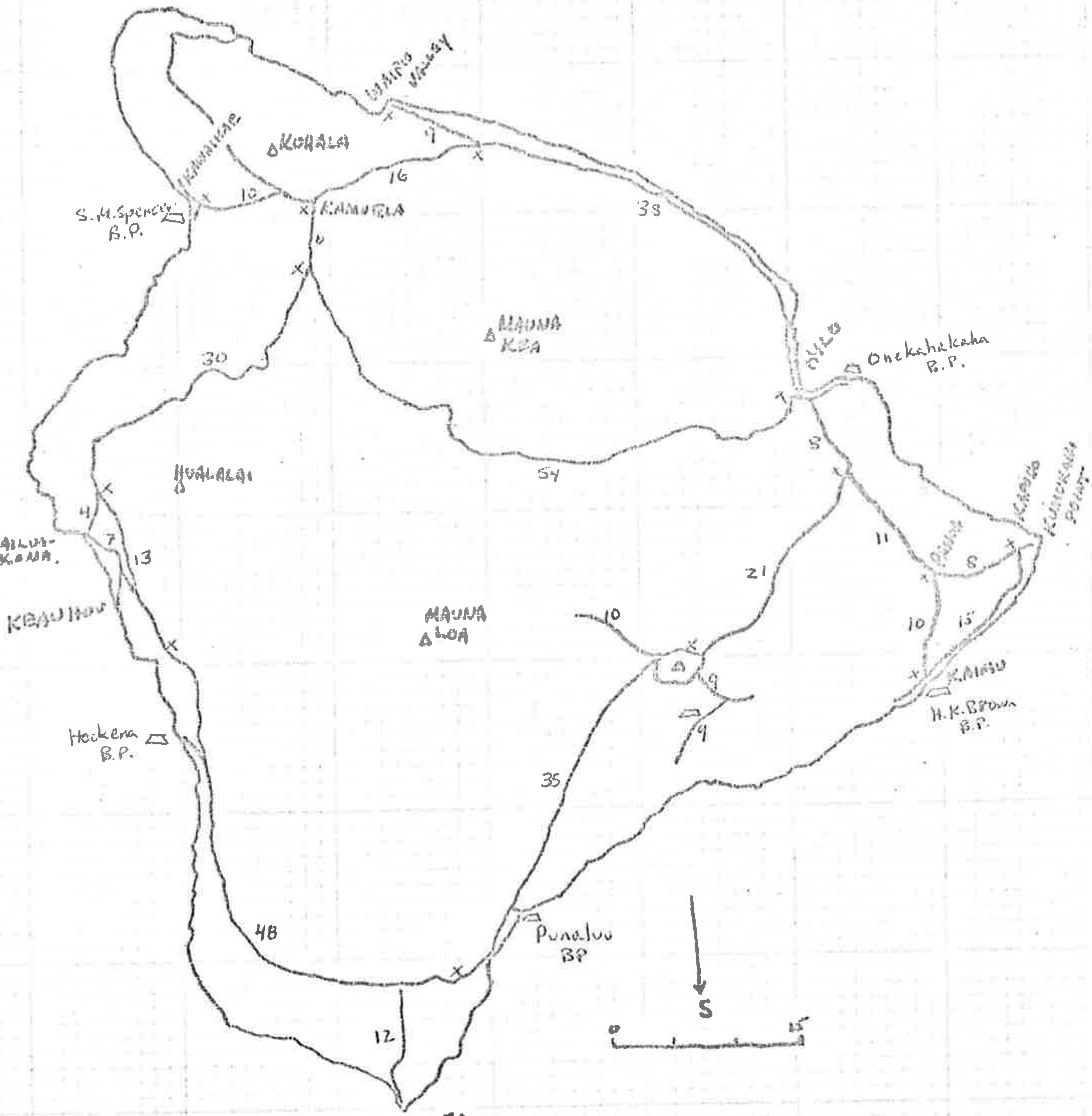
Following the road as we are near Halemaumau we will see large cracks on each side of the road. They are part of the southwest rift zone of Kilauea. There is also some brown pumice on the ground from Halemaumau in 1790.

Farther on at Uwekahuna Bluff is the Volcano Observatory. This is the only permanent volcanoe observatory in the United States. Here they record earthquakes and tilting of the earths surface. There is a good view of Kilauea Caldera and Halemaumau from here. Visitors aren't allowed in the Observatory but we can go to the visitors center.

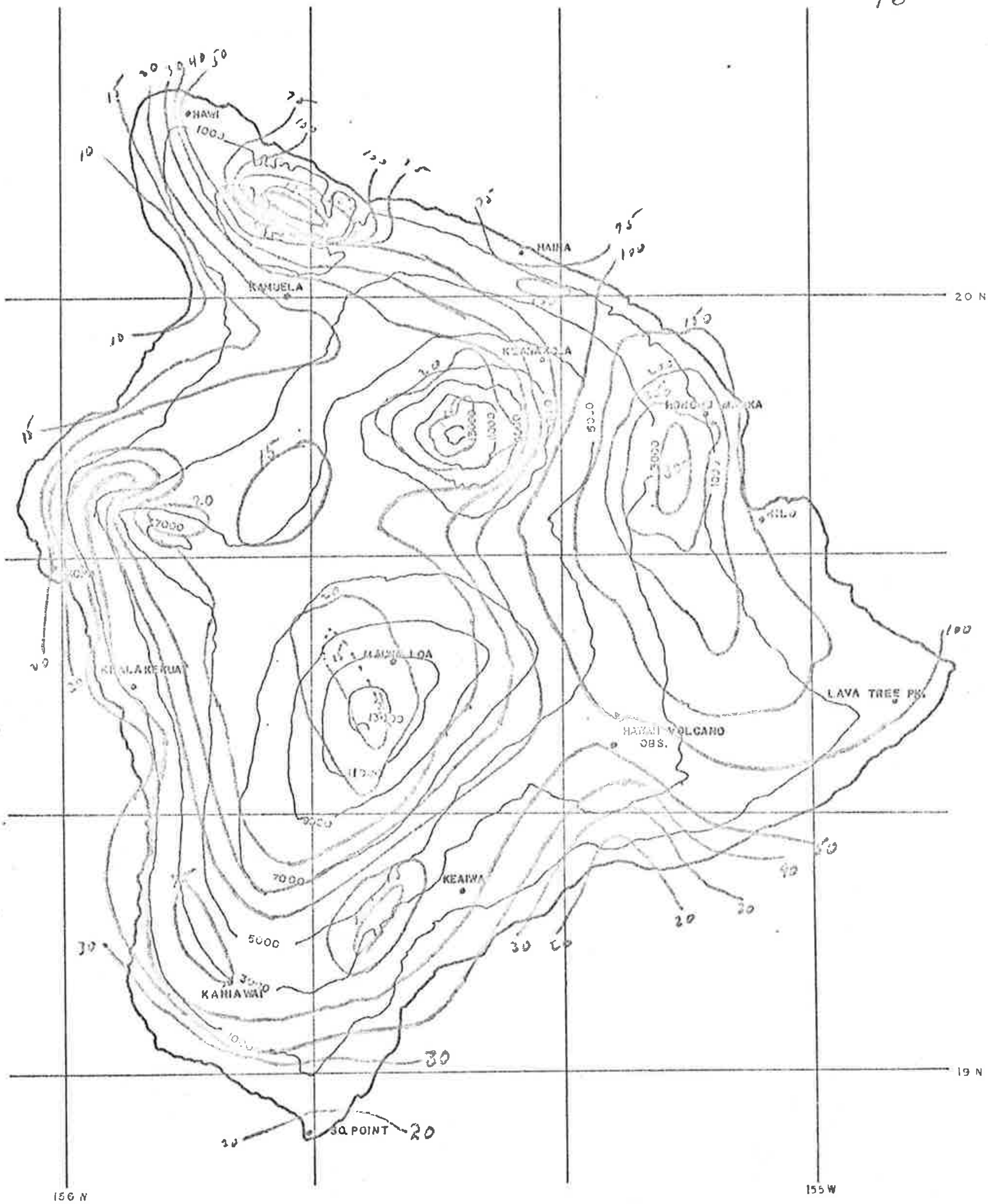
Driving north on Crater Rim Drive we will come to Mauna Loa Strip Road which we can turn on to and we can see Tree Molds. The lava engulfed the trees and then cooled aroung the trunk leaving pits in the lava as the tree died away. Bark patterns can also be seen on the molds.

Traveling alittle farther on Mauna Loa Strip Drive is the Kipuka Puaulu Bird Park. It has several recent lava flows. There is also a nature trail which leads to an area of native trees and shrubs.


To Hilo
11
Park Headquarters & Museum
Lava Tube
Fern Jungle
Kilauea Iki Crater
CHAIN OF CRATERS ROAD
Keanakakoi Crater
1894 Lava Flow
Kilauea Crater
1954 Lava Flow
1919 Lava Flow
Picnic Area
Lava Flow
1921
Halemaumau
Hawaiian Volcano Observatory
CRATER RIM DRIVE
Tree Molds
Mauna Loa Strip Drive
Kipuka Puaula Bird Park
11



WAIPIO VALLEY
KAWAIHAE
KOHALA
S.M. Spencer B.P.
KAMUELA
MAUNA KEA
HILO
Onekahakaha B.P.
HUALALAI
KAILUA-KONA
KEAUHOU
MAUNA LOA
KUMUKAHI POINT
KAIMU
H.K. Brown B.P.
Hookena B.P.
Punaluu BP
KA LEA
S
0
15



MEDIAN ANNUAL RAINFALL

Isohyetal line (inches) ~50~