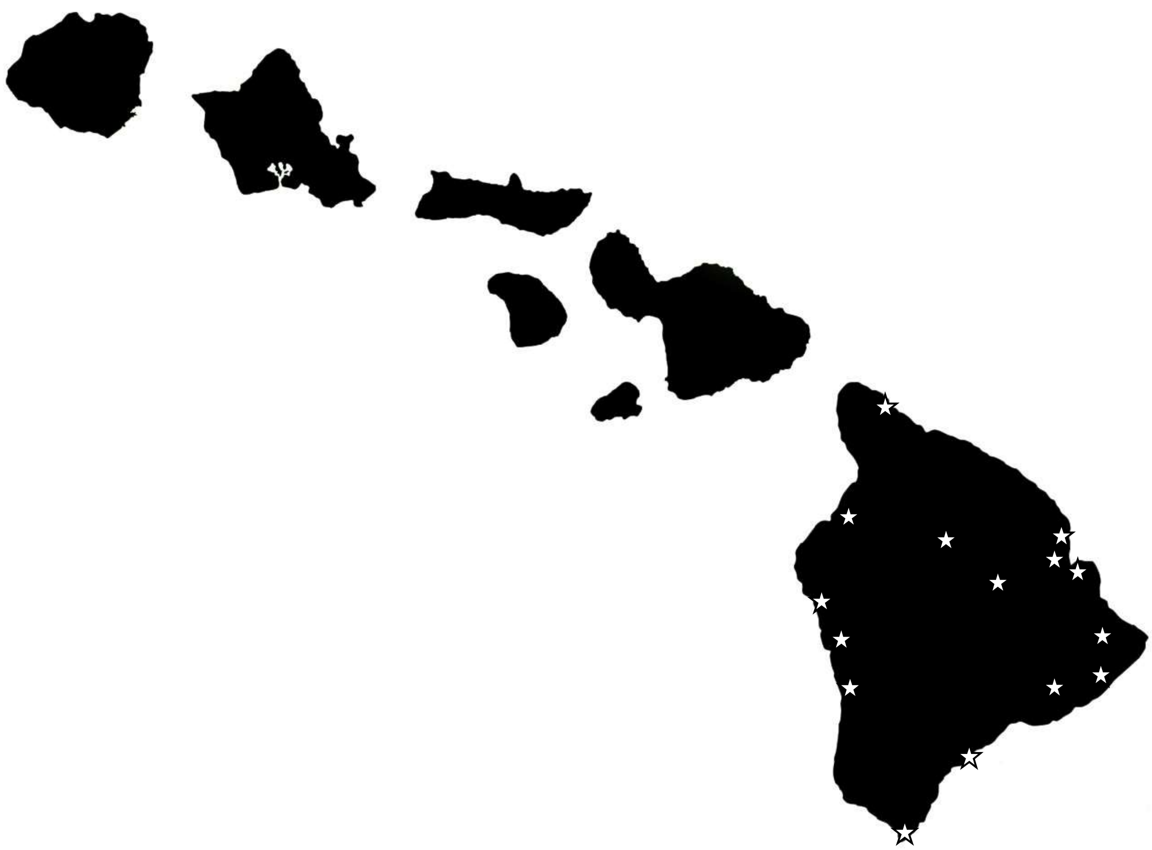
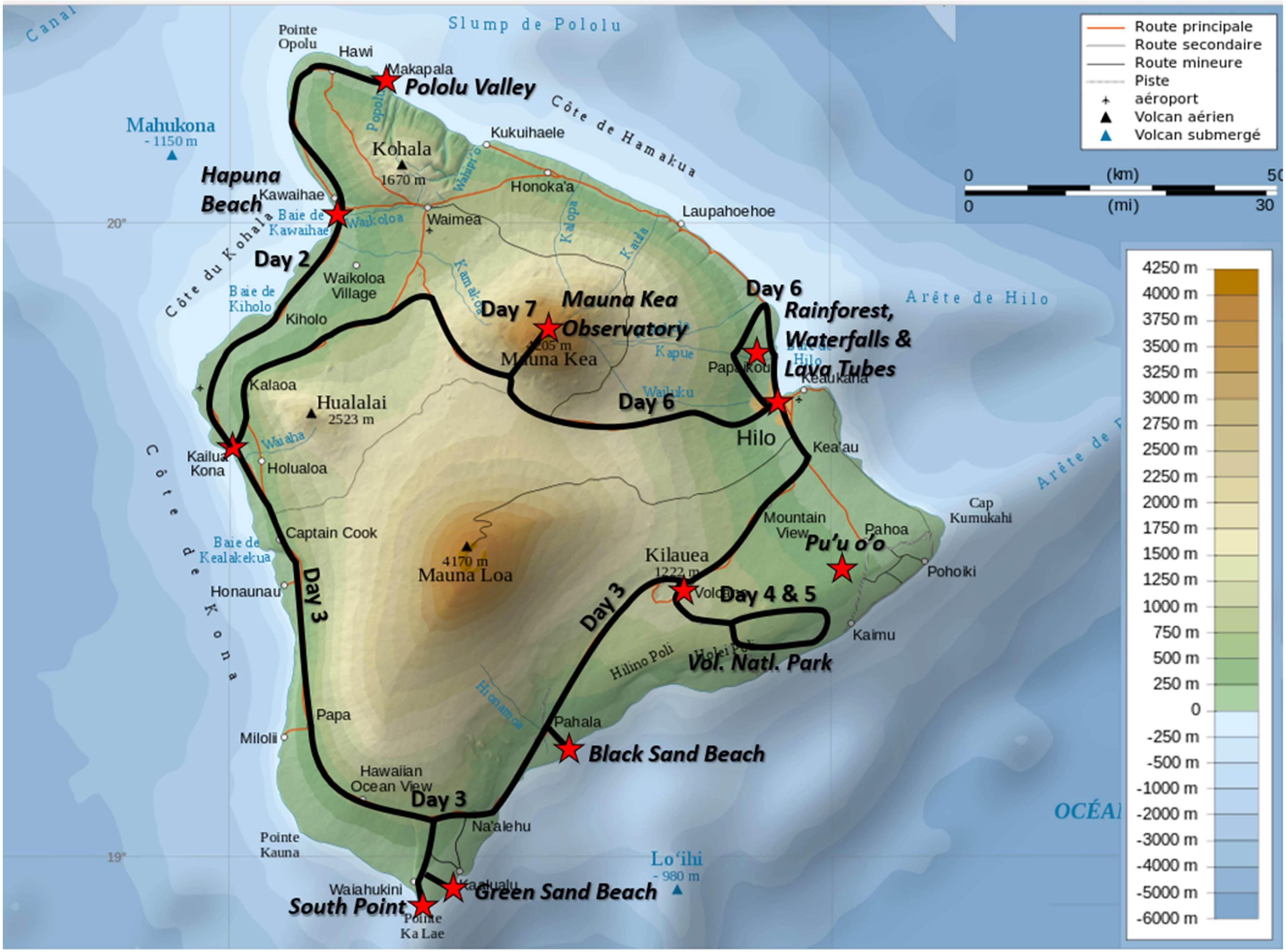
SPRING BREAK TRIP 2022

UNIVERSITY OF PITTSBURGH AT JOHNSTOWN
DEPARTMENT OF ENERGY AND EARTH RESOURCES



HAWAII !!!


Pololu Valley
Hapuna Beach
Day 2
Day 7
Mauna Kea Observatory
Day 6
Rainforest, Waterfalls & Lava Tubes
Day 6
Day 3
Day 3
Day 3
Day 4 & 5
Pu'u o'o
Vol. Natl. Park
Black Sand Beach
Green Sand Beach
South Point
Mahukona
- 1150 m
Kohala
1670 m
Hualalai
2523 m
Mauna Kea
Mauna Loa
4170 m
Kilauea
1222 m
Hilo
Lo'ihi
- 980 m
Slump de Pololu
Côte de Hamakua
Côte du Kohala
Côte de Kona
Arête de Hilo
Canal
OCÉA
Pointe Opolu
Hawi
Makapala
Kukuihaele
Honoka'a
Waimea
Kawaihae
Baie de Kawaihae
Waikoloa Village
Baie de Kiholo
Kiholo
Kalaoa
Kailua Kona
Holualoa
Captain Cook
Baie de Kealakekua
Honaunau
Papa
Milolii
Hawaiian Ocean View
Na'alehu
Pointe Kauna
Waiahukini
Pointe Ka Lae
Pahala
Hilino Poli
Kaimu
Pahoa
Pohoiki
Cap Kumukahi
Mountain View
Kea'au
Keaukaha
Laupahoehoe
Route principale
Route secondaire
Route mineure
Piste
aéroport
Volcan aérien
Volcan submergé
(km)
(mi)
0
50
0
30
4250 m
4000 m
3750 m
3500 m
3250 m
3000 m
2750 m
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2250 m
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1000 m
750 m
500 m
250 m
0
-250 m
-500 m
-1000 m
-2000 m
-3000 m
-4000 m
-5000 m
-6000 m

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LOGISTICS AND BASICS

Flight	Departs	Arrives
Alaska 003 6hrs 5min	Washington, DC-Reagan (DCA) **5:35 pm** Fri, Mar 4	Seattle (SEA) **8:40 pm** Fri, Mar 4
Alaska 807 6hrs 20min	Seattle (SEA) **5:55 pm** Sat, Mar 5	Kailua/Kona (KOA) **10:15 pm** Sat, Mar 5
Alaska 880 5hrs 55min	Kailua/Kona (KOA) **10:20 pm** Sat, Mar 12	Seattle (SEA) **7:15 am** Sun, Mar 13
Alaska 004 5hrs	Seattle (SEA) **8:30 am** Sun, Mar 13	Washington, DC-Reagan (DCA) **4:30 pm** Sun, Mar 13

Big Island Basics

Emergency Number: 911
Kona Police Department: 74-611 Hale Makai Place, Kailua-Kona, HI 96740, (808) 326-4646
Hilo Police Department: 349 Kapiolani St, Hilo, HI 96720, (808) 935-3311

- *Time zone:* Hawaiian-Aleutian Time Zone (-10 UTC), 5 hours minus Johnstown
- *Daylight:* In March sun rise occur around 6:30AM and sunset at about 6:30 PM.
- *Temperature:* March weather and climate:
    - *Kona* - daily highs average around 80°F and lows around 69°F.
    - *Hilo* - daily highs average around 78°F and lows around 65°F.
- *Cloud Cover:* does not vary substantially over the course of the month
    - *Kona* - median cloud cover is 30% (mostly clear)
    - *Hilo* - median cloud cover is 75% (partly cloudy)
- *Precipitation:* does not vary substantially over the course of the month
    - *Kona* - there is a 17% chance of precipitation in early March with a 4% chance of moderate to heavy rain – welcome to the dry side!
    - *Hilo* - there is a 75% chance of precipitation in early March with a 50% chance of moderate to heavy rain – in Hilo it is called *liquid sunshine!!!*
- *Relative Humidity:* does not vary substantially over the course of the month
    - *Kona* – early March average daily high is 84% and average daily low is 66%
    - *Hilo* - early March average daily high is 91% and average daily low is 60%
- *Wind:* does not vary over the course of the month
    - *Kona* – early March daily mean is 9 mph (light breeze) from the south-southwest-west
    - *Hilo* - early March daily mean is 7 mph (light breeze) from the south-southwest-west

COVID Related Items

Hawaii COVID Policy for Domestic Travels

"Domestic travelers must follow all Safe Travels Hawaii protocols. To avoid mandatory quarantine, prior to departure, upload proof of vaccination or have a negative result from a Trusted Testing Partner (see below). All vaccines approved or authorized by the U.S. Food and Drug Administration, and vaccines listed for emergency use by the World Health Organization will be accepted." https://www.gohawaii.com/travel-requirements

We will exhibit an abundance of caution for this trip. We don't want something to happen and have our action ruin it for future groups hoping to travel. It will be required for each participant to be vaccinated and provide a negative Covid test at least two days prior to travel.

Vaccines:

The following vaccines are accepted by the state of Hawaii:

Single Dose: Janssen/J&J

Two-dose series: Pfizer-BioNTech, Moderna, AstraZeneca, Covaxin, Covishield, BIBP/Sinopharm, Sinovac, and Novavax/Covovax

NO OTHER VACCINES ARE ACCEPTED BY HAWAII

Testing:

For travelers arriving from the U.S. and its Territories, the state of Hawaii will ONLY accept molecular tests (NAAT or PCR) from a certified lab.

What do you need to do?

1. *Upload your vaccination info, vaccination card, and travel details into the State of Hawaii's Safe Travels website* (https://travel.hawaii.gov/#/).
    a. They will ask for flight and hotel info (both found in the itinerary). For the hotel, I just gave the Kona hotel info since we are flying in and out of there.
    b. They will email you a QR code, YOU WILL NEED THIS TO BOARD THE FLIGHT!!! Make sure you download the QR code to your phone to show at the airport
2. *Get tested for Covid on Thursday, March 3rd or Friday, March 4th*. I am still figuring out these details.

Precautions during travel

1. *Social distance when possible.*
2. *Wear masks whenever possible, especially in enclosed areas.*
3. *Sanitize regularly, bring your own sanitizer and use it frequently.*
4. *Ventilate vehicles and hotel rooms, to keep air circulating.*
5. *If you feel symptomatic, please tell one of the Professors on the trip. Professors will have several rapid tests available during the trip if needed.*

THINGS YOU SHOULD BRING

Most Important:

- Driver's License *or some form of identification*
- Vaccination Card *you can probably just have an image of this on your phone*
- A credit card

Personal Items:

- Toiletries (including lotion/sunscreen)
- Van/Plane Entertainment (iPod, books, cards, small board games, etc.)
- Backpack for day hikes
- One night's clothes for our layover in Seattle

Clothes:

- Good hiking boots
- Sneakers
- Rain jacket
- Wool socks (good for long days of walking or hikes)
- Some warm clothes, think polyester and gore-tex (It will be wet and chilly in Seattle, count on it), I tend to wear layers rather than big bulky stuff
- Bathing suit and beach towel

Equipment:

- Sunglasses
- Charger(s)
- Field Notebook & Hand lens
- Pencils/Pens/Sharpie
- Nalgene/Water Bottle

I will likely bring a couple of rock hammers for us to share, so don't worry about that.

Note: ***The airline limits you to a checked bag (not to exceed 51 lbs), a carry bag, and a personal item. We can't bring more than that, we just won't have the room to transport a lot of stuff.***

Money: Most everything will be covered except the following:

Your Money - souvenirs, occasional meals, and drinks.

Food - We have some group money, but not a whole lot.
Most breakfasts will be provided by the hotels.
Most lunches and snack we'll get at the grocery store.
Most evenings you'll be on your own for dinners. We can eat as a group, but we do not have enough "group money" to cover every meal.

Extra Stuff – snorkeling and helicopter rides are the things that come to mind right away. But there might be other stuff that you want to do that will not be covered by the trip….

USEFUL HAWAIIAN WORDS (*taken from http://hawaiian-words.com/)*

HAWAIIAN WORD	ENGLISH TRANSLATION
Aloha	Love, affection, hello, goodbye
Mahalo	Thank You
Makai	Towards the sea; the ocean side.
Mauka	Towards the mountain; the side facing the mountain.
E Komo Mai	Welcome!
Pau	Done, finished
Hana	Work
Pau Hana	Work is done
Hana hou	Encore, do it again. The name of Hawaiian Airlines magazine.
Aina	Land–especially Homeland
Kamaaina	One of the land. Native-born but also used as a long-term resident of Hawai'i.
Akamai	Smart, clever
Alii	Chief
Hale	House or home.
Haole	Literally, means a person without a country or of known beginning. Often used to identify a person of Caucasian ancestry but is incorrect.
Honu	A turtle–especially Hawaiian green sea turtle.
Hula	Hawaiian dance
Kahuna	Expert, usually refers to a priest, minister, or person held in esteem.
Kane	Man
Wahine	Woman, female
Kuuipo	Sweetheart. Often used on jewelry–especially the Hawaiian

HAWAIIAN WORD	ENGLISH TRANSLATION
	bracelets worn by wahine.
Malama	To take care of, to tend. Mālama aina: to care for the land.
Kapu	Forbidden. Do not enter.
Kokua	Help, aid, provide assistance.
Kuleana	Responsibility
Lei	A necklace, usually, of flowers. Also, shells or kūkui nuts.
Luau	Hawaiian feast or party
Maikai	Excellent, goodness. Sack and Save grocery has a Maika'i discount card.
Malihini	Newcomer, visitor
Ohana	Family, kin, relative
Ono	Good or tasty as in ‘ono grinds (food).
Paniolo	Hawaiian cowboy
Poi	A paste made from Taro root. A mainstay of the traditional Hawaiian diet.
Pupu	Snacks or appetizers
Pupule	Crazy (especially referring to a mentally deranged person).
Wikiwiki	Speedy or fast. Honolulu Airport has a Wikiwiki shuttle.

BRIEF ITINERARY

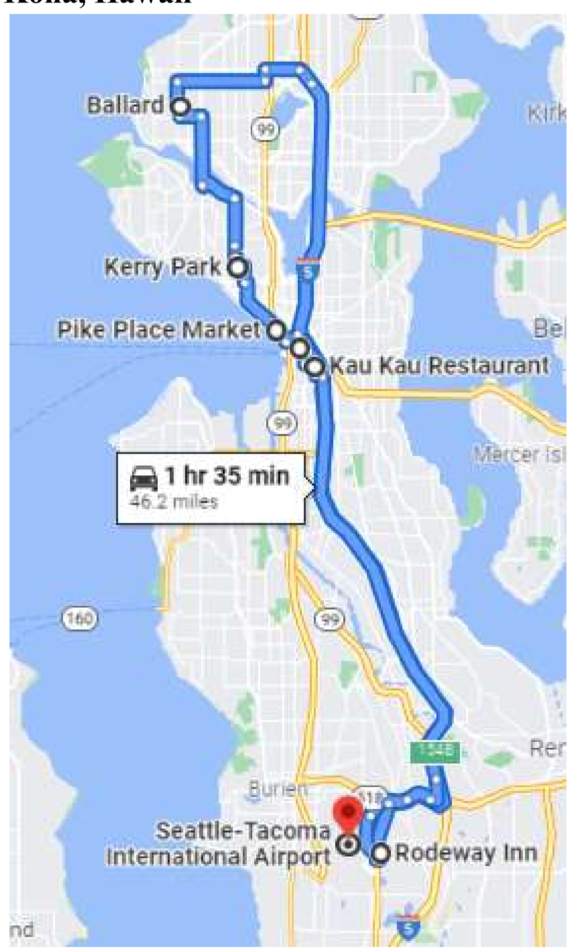
Day 1: Friday, March 4th, 2022 – Board flight

12:00 PM: Depart Johnstown driving to Reagan National Airport. Each person is responsible for getting themselves to-and-from the airport.
3:00 PM: Arrive at Reagan National Airport
5:00 PM: Board Flight to Seattle (Alaska Airlines Flight 003)
5:35 PM: Depart from DC to Seattle (flight duration 6 hrs and 5 min)
8:40 PM: Arrive in Seattle, WA (This will be 11:40PM EST), Pick up the rental cars:
Enterprise Rent-a-Car - Seatac
3150 S 160th St Ste 508,
SeaTac, WA 98188
(833) 329-8464
and get to the hotel.
Rodeway Inn
2930 S 176th St
SeaTac, WA 98188
(206) 246-9300

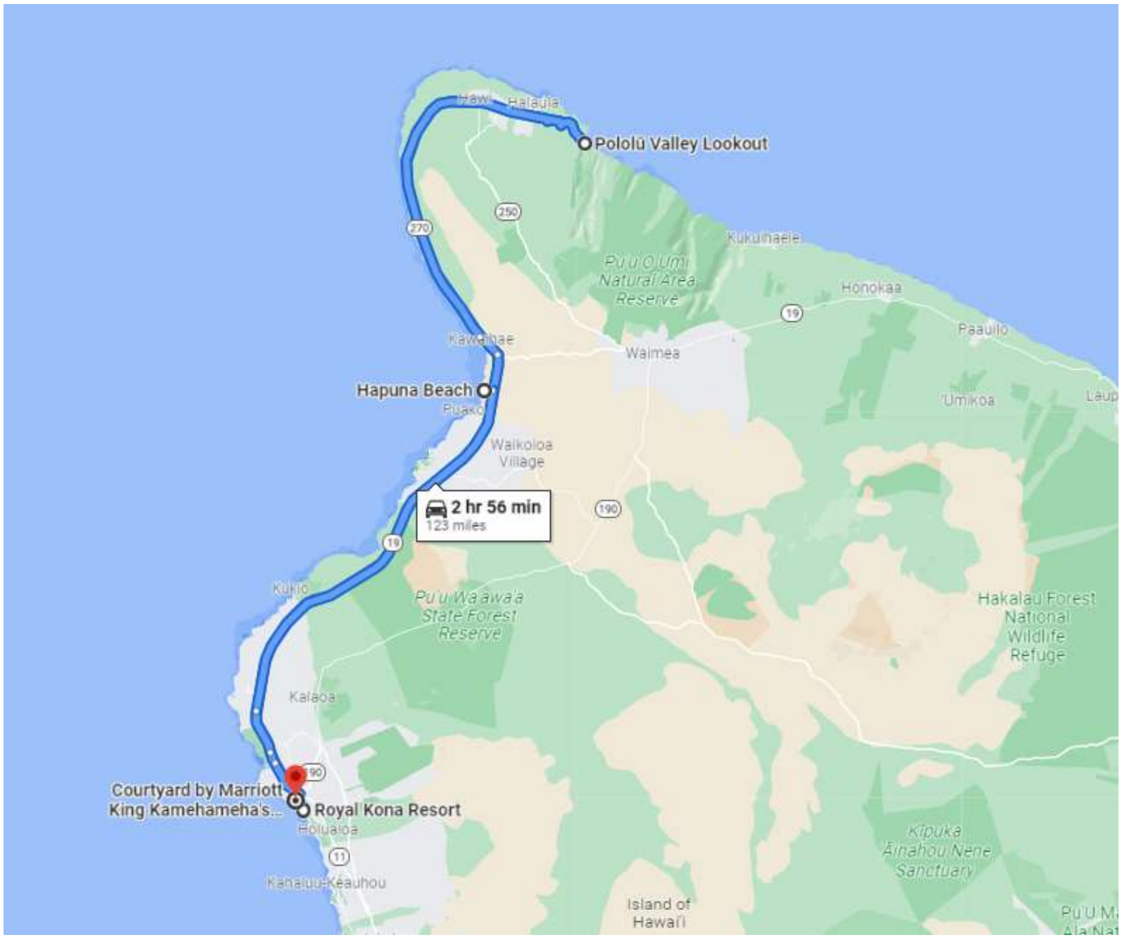
It should be noted: your checked bags will remain at the airport. You must bring a day-pack with you on the flight containing toiletries and a change of clothes. You will not have access to your checked bags while in Seattle.

Day 2: Saturday, March 5th, 2022 – Seattle and fly to Kona, Hawaii

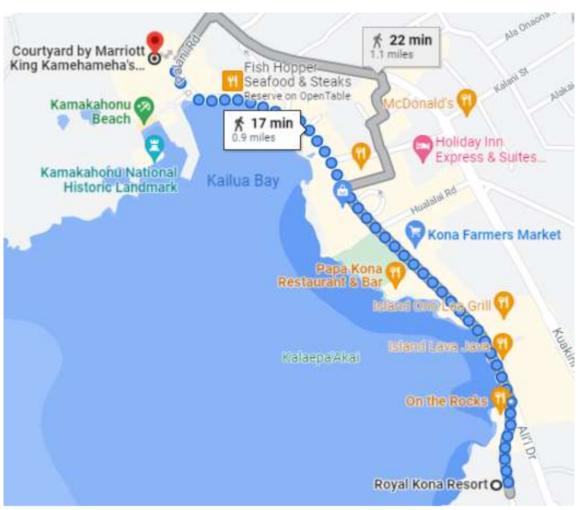
8:00 AM: Leave the hotel
9:00 AM: Ryan Driving tour of Seattle which will include: Capital Hill, Ballard, Kerry Park, Pike Market, the Columbia Tower, and others. This itinerary is highly dependent on the visibility in Seattle that day, likely it will be overcast, but if it's clear, you'll be in for a treat!
12:00 PM: Lunch at Kau Kau in the international district with Daryl.
1:00 PM: More stuff
3:30 PM: Return rental and go to airport.
5:55 PM: Depart Seattle for Kona, HI
10:15 PM: Arrive in Kona, HI. (This will be 12:15AM PST or 3:15AM EST, yikes). Pick up the rental cars:
Enterprise Rental Cars
73 107 Aulepe St
73-200 Kupipi St
Kailua Kona HI 96740-2645
(844) 914-1549
and get to the hotel.
Royal Kona Resort
75-5852 Alii Dr.
Kailua-Kona, HI 96740
(808) 329-3111 in Kona, HI



Day 3: Sunday, March 6th, 2022 – North Side, Kohola Area, and Luau

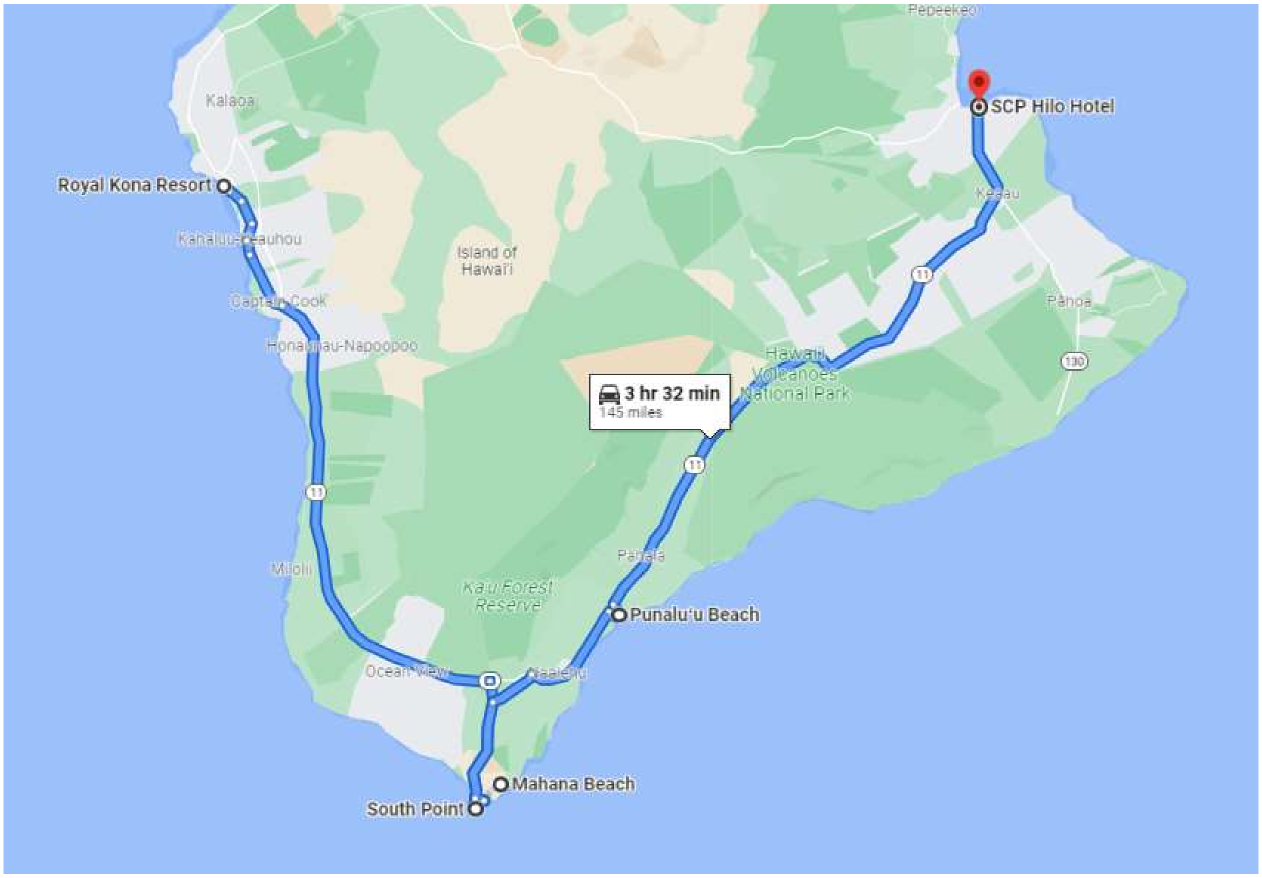


8:00 AM: Load up the vans, find some breakfast, then go get groceries
10:00 AM: Depart Kona for the North Side of the Island
11:30 AM: Kohala Mountain Overlook and Lunch
12:30 PM: Pololu Valley Lookout and hike down into valley
2:30 PM: Hapuna Beach for some "coastal processes"
4:00 PM: Return to Hotel
5:00 PM: Walk from the hotel to the luau (luau starts at 5:30PM)



Luau Location:
King Kamehameha's Kona Beach Hotel
75-5660 Palani Rd
Kailua-Kona, HI 96740

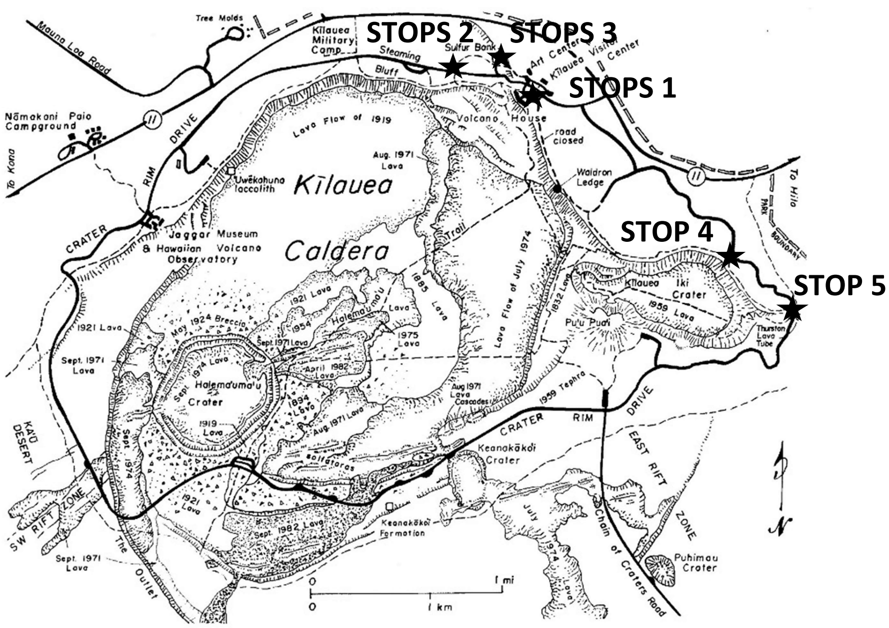
Day 4: Monday, March 7th, 2022 – Kona to Hilo: South Point, Mahana Beach (Green Sand Beach), and Punalu'u Beach (Black Sand Beach)



7:00 AM: You are on your own for breakfast
8:30 AM: Load up the vans and depart Kona for the South Point
10:00 AM: South Point Cliffs
11:00 AM: Mahana Beach (Green Sand Beach) and Lunch. It is about a 1 hr hike to the beach, hopefully we can drive to it but we'll see, it is worth the hike.
2:00 PM: Punalu'u Beach (Black Sand Beach). Pretty cool to see but likely a quick stop.
4:00 PM: Arrive at the hotel in Hilo: SCP Hilo Hotel
126 Banyan Way
Hilo, HI, 96720, United States
(808) 935-0821

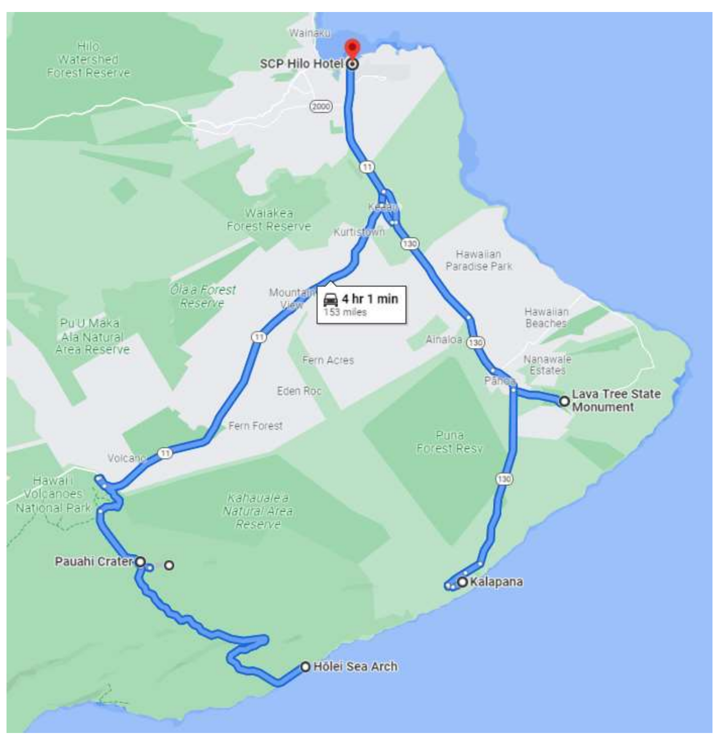
Day 5: Tuesday, March 8th, 2022 – Hilo: Volcanoes National Park

7:30 AM: Depart from the hotel and drive to Volcanoes National Park
9:00 AM: Arrive at the Kilauea Overlook and meeting with Dr. Drew Downs (USGS)
10:30 AM: Steam vents and Sulphur Banks (Ha'akulamanu) – short hike
12:00 PM: Lunch at the Volcano House
1:00 PM: Hike the Kilauea Iki Trail
3:30 PM: Hike the Nahuka - Thurston Lava Tube
4:30 PM: Depart Volcanoes Natl. Park and Return to Hilo for Dinner



Day 6: Wednesday, March 9th, 2022 – Hilo: Volcanoes National Park

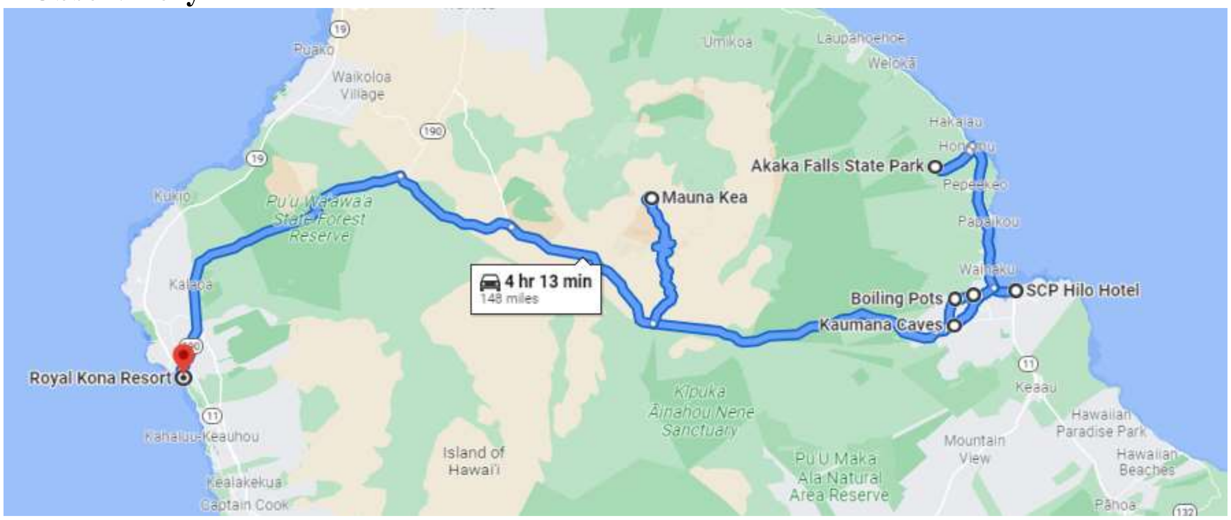
7:30 AM: Depart from the hotel and drive to Volcanoes National Park
8:45 AM: Overview at Pauahi Crater
9:30 AM: Hike the Mauna Ula trail
11:00 AM: Drive a bit of the Chain of Craters Road
12:00 PM: Lunch at the end of the Road
2:00 PM: Drive to Lava Tree State Monument
3:00 PM: Hike from Kalapana to the lava viewing point (hopefully!!!)
8:00 PM: Return to the car and drive back to Hilo for a late dinner



Day 7: Thursday, March 10th, 2022 – Free Day in Hilo: Helicopters and Boats

??? AM: Today will be a "Free Day". Some may choose to take a Helicopter ride around the volcano, others may choose to take a boat ride out to where the lava is entering the ocean. AND others may choose to hang out in town to do the shops. We'll play this by ear as we see how the trip plays out.

Day 8: Friday, March 11th, 2022 – Hilo to Kona: Rainforests, Waterfalls, Lava Tubes, and Observatory



8:00 AM: Pack up all your stuff, load up the vans
8:45 AM: Kaumana Cave Lava Tube
9:30 AM: Boiling Pots
10:30 AM: Rainbow Falls
11:00 AM: Akaka Falls
12:00 PM: Lunch
1:00 PM: Drive Saddle Road to Kona
3:00 PM: Arrive in Kona and check into the hotel

Royal Kona Resort
75-5852 Alii Dr.
Kailua-Kona, HI 96740

5:00 PM: If we can get a tour of the Keck Observatory on the top of Mauna Kea, we'll try to do this this evening.

Day 9: Saturday, March 12th, 2022 – Kona: Free Day and Fly out that evening

??? AM: Wake up whenever you want. Today is a free day. I suggest snorkeling, surfing, renting scooter, shopping in Kona.
6:00 PM: Last group dinner with everyone!
10:20 PM: Board flight (Alaska Airlines Flight 880) from Kailua/Kona (KOA) to Seattle (SEA).

Day 10: Sunday, March 13th, 2022 – Fly back to DC

7:15 AM: Arrive in Seattle (Alaska Airlines)
8:30 AM: Depart from Seattle (Alaska Airlines Flight 004) to Washington, DC-Reagan (DCA)
4:30 PM: Arrive in Washington, DC- Reagan (DCA)

INTRODUCTION

This entire section was taken from the 2007 Field Guide Geology For Teachers and Travelers: The Geology of Hawaii produced by Charles Merguerian and Steven Okulewicz, Geology Department, Hofstra University, Hempstead, NY 11549

General Information about Hawaii

Luxurious vegetation, spectacular beaches, surfers, hula skirts, and umbrella drinks are most people's lasting impression of the Hawaii. Indeed, a paradise for landlubbers from the continent but also a unique field experience for geologists and students of geology. This spring's geology field trip will focus on what occurs when thin oceanic lithosphere is dragged with purpose and majesty across a more distant oceanic hot plume and what the geological products and landscape development of such an interaction have created over a relatively brief period of time. Although our trip will certainly focus on volcanism and volcanic products, evidence for glaciation, earthquake activity, groundwater interactions, and coastal processes will be discussed in the field. The guidebook will present a brief overview on the geology of the Hawaiian Islands and Hawaii in particular and provide specific background information on our planned itinerary. Appendix 1 provides a primer of geological terms and concepts deemed central to our field trip and should probably be read before the guide itself. Appendix 2 is a glossary of volcanic and geologic terms.

Figure 1 - False color infrared satellite image of the SE coast of Hawaii showing the plumose structure of modern and ancient lava flows which have emanated from the summit of Mauna Loa (upper left) and from lava tubes on the flanks of Kilauea volcano. (NASA image.)

GEOLOGIC OVERVIEWS

Geological Background

Presiding over the central Pacific Ocean and over 3,000 km from the nearest continent, the island of Hawaii extends from the sea floor to produce a small island roughly 122 x 150 km in size that marks only the very tip of a huge shield volcano, so named for the overall outline in the shape of a badge or shield (Figure 2). Listed by decreasing age, Hawaii actually consists of five large coalesced volcanoes known as Kohala, Mauna Kea, Hualalai, Mauna Loa, and Kilauea (Table 1). By far the largest volcanic construct on Earth, Hawaii is the youngest of a roughly 44 Ma (million year old) line of genetically related volcanic islands that stretch over 2,400 km in a southeasterly direction from the dogleg bend in the Emperor Seamount – Hawaiian Island chain (Figure 3). From oldest to youngest (and NW to SE) they are known as Kure Island, Midway Island, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Gardner Island, the French Frigate Shoals, Necker Island, Nihoa Island, Niihau, Kaula, Kauai, Oahu, Molokai, Lanai, Maui, Kahoolawe, and Hawaii. The islands diminish in size from SE to NW and are mostly submerged, the result of subsidence and the erosive effects of wave-action as they drift away from the tumescent hot plume that created them. The newest Hawaiian Island (Loihi) has begun to sprout in the subterranean realm of the Pacific Ocean to the SE of Hawaii.

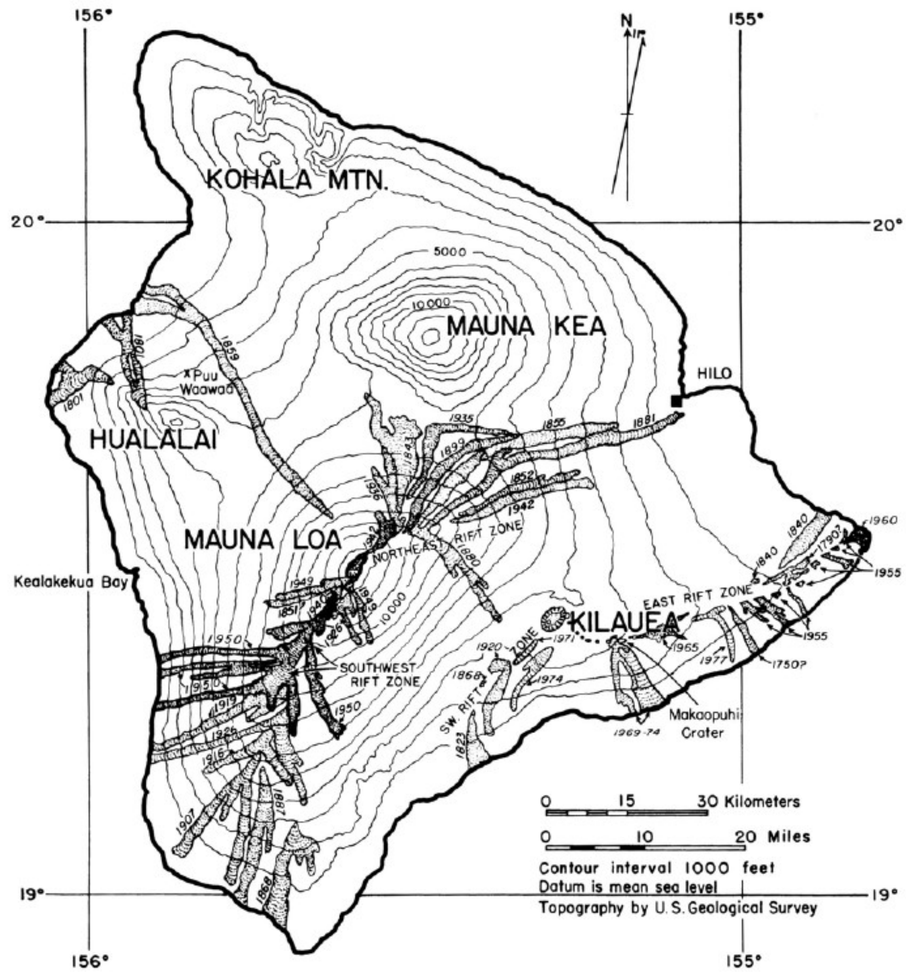


Figure 2 – Topographic map of the island of Hawaii showing the five major volcanoes that constitute the island and the major historic lava flows that have been extruded. (From Macdonald and others, 1983, Fig 3.2, p. 59.)

Table 1 – Geographical data for the Hawaiian Islands. (From Macdonald and others, 1983, p. 3, Table 1.)

Island	Length (km)	Width (km)	Area (square km)	Length of shoreline (km)	Name of mountain	Altitude (meters above sea level)
Hawaii	150	122	10,451	504	Mauna Kea	4,205
					Mauna Loa	4,169
					Hualalai	2,521
					Kohala Mountain	1,670
					Kilauea	1,248
Maui	77	42	1,902	240	Red Hill (Haleakala)	3,055
					Puu Kukui (West Maui)	1,764
Oahu	71	48	1,600	336	Kaala (Waianae Range)	1,225
					Puu Konahuanui (Koolau Range)	960
Kauai	53	40	1,446	177	Kawaikini	1,598
Molokai	61	16	683	171	Kamakou (East Molokai)	1,515
					Puu Nana (West Molokai)	436
Lanai	30	21	366	84	Lanaihale	1,027
Niihau	30	10	182	81	Paniau	390
Kahoolawe	18	10	119	58	Lua Makika	450
TOTAL	—	—	16,749	1,650	—	—

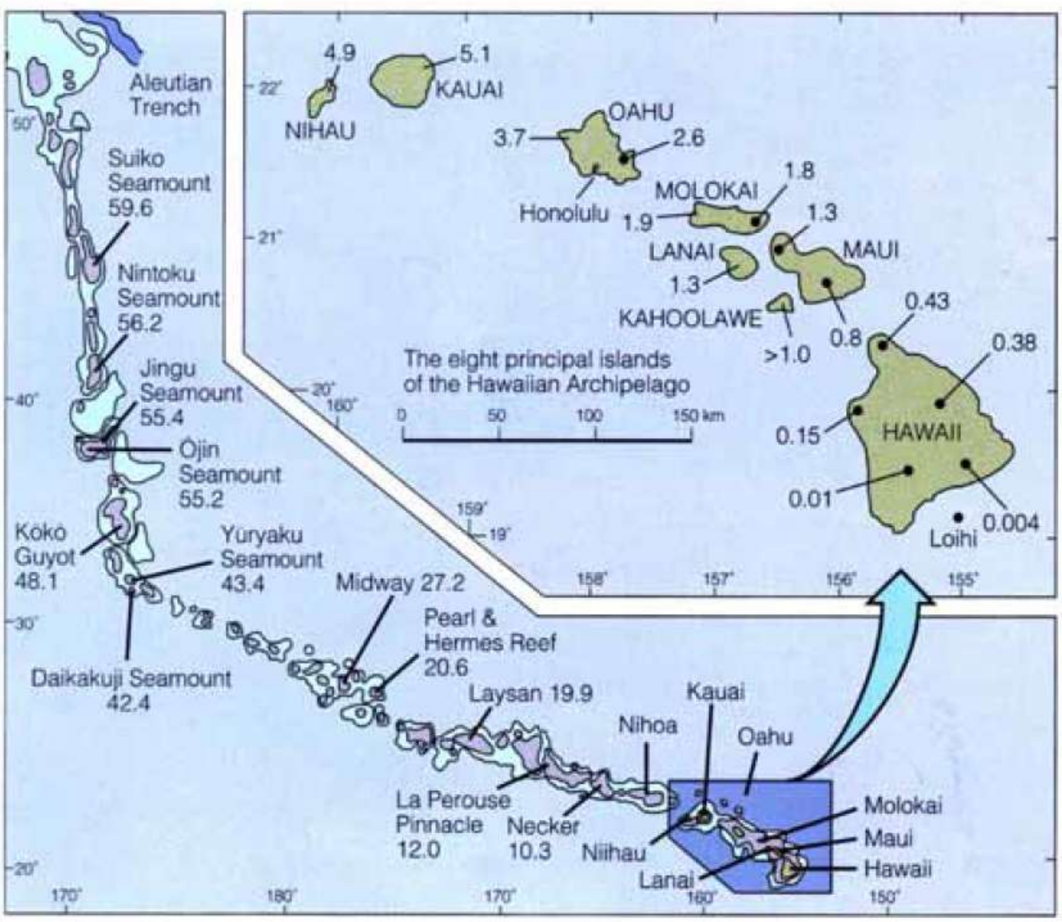


Figure 3 – Map showing the relationship of the eight principal islands of the Hawaiian archipelago to the vast island and seamount chain with which they are genetically related. Ages of radiometrically dated volcanic rocks are shown. Note that the Hawaiian Islands are less than ~5 million years old (5 Ma).

The image below (Figure 4) is a shaded "Bathymetric map" of Loihi Seamount as it now looks, following the July 1996 eruption and coseismic events. "Bathymetry" refers to the depth from the ocean's surface to features on the seafloor. As you might expect, low numbers on a depth map refer to shallow regions, or the high point on a submarine mountain such as Loihi. Shallow regions are given in warm colors on this map; cool colors are the deep regions. The 3 depressions in the summit area are pit craters; the lower-left most crater was formed in July 1996.

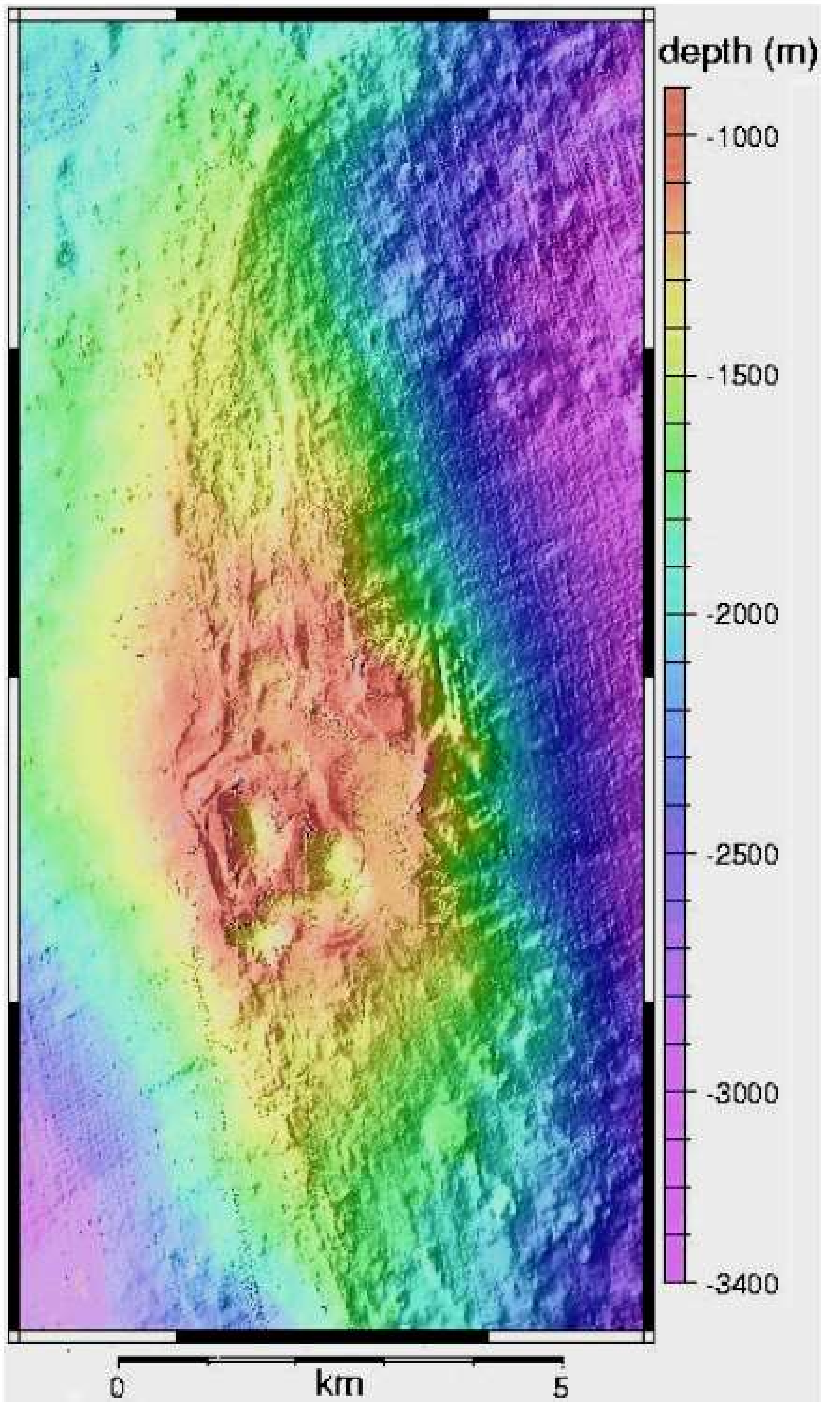


Figure 4 – Shaded bathymetric relief map of the Loihi Seamount whose growth is the result of suboceanic hot spot volcanism to the southeast of Hawaii. Map made by UH graduate student Nathan Becker using 1997 seabeam bathymetry and the GMT program.

Hawaii, the focus of our 2007 Geology IDEAS field trip offering, is the youngest island in the archipelago and is a volcanologists hot dream as modern volcanism and the products of recent volcanic activity are wonderfully preserved there for all to walk over, see, and experience. As we all know from reading the back of cereal boxes, the Hawaiian Islands were produced by northwestward drift of the Pacific Ocean plate at the rate of about 3.2 to 4 inches/year (8-10 cm/yr) over a relatively stationary hot plume roughly 50 miles in diameter in the Earth's mantle (Figure 5).

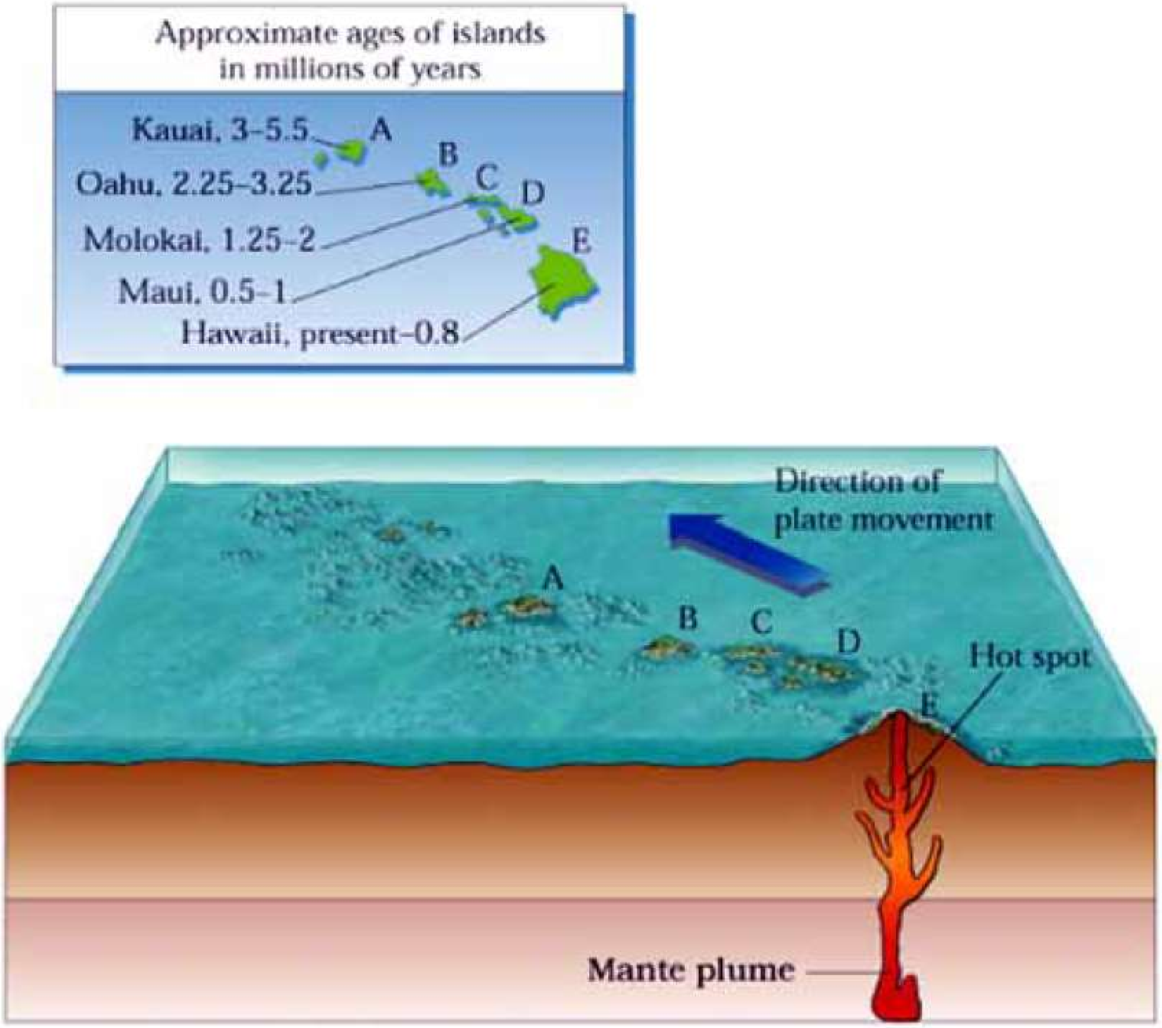


Figure 5 – Diagram illustrating the growth of the Hawaiian volcanic islands as they drift across a hot spot on the Earth's mantle.

The lower part of the ~100 km thick oceanic lithosphere consists of ultramafic rocks (peridotites, etc.) belonging to the uppermost mantle. Above that occur gabbroic rocks which grade eventually into a thin, 4-8 km thick veneer of oceanic crust. This layer consists of basal gabbro overlain by a sequence of vertical sheeted basaltic dikes with chilled margins which feed into a thick stack of pillow basalts that cap the ocean crust. King, Queen and Standard pillow sizes have been reported in the literature. Passage of the oceanic lithosphere over the concentrated blowtorch that is a mantle plume creates wholesale (and in some cases, retail) melting at the base of the lithosphere which, in turn, produces rising plumes of basaltic magma.

Indeed, seismic evidence and petrogenetic studies suggest that Hawaiian magmas originate 50 to 80 km deep and that the magma rises along roughly cylindrical conduits to pool 2 to 5 km beneath their respective volcanic summits (Figure 6). A self-fulfilling prophecy, fracturing of the brittle basaltic crust by periodic rising magma allows faulting and localized volcanism which empties the shallow magma chambers. Recharge by the hot plume mechanism affords a steady supply of juicy basalt which, over the last million years or so has creates the overlapping outpourings of basalt that have built the Hawaiian shield volcano over 31,000’ from the base of the ocean floor (Figure 7) and have produced a broad arch (the Hawaiian arch) in the ocean.

Growth of the islands by purely igneous mechanisms has been interrupted from time to time by massive earthquakes and significant downslope movement of loose volcanic materials to develop submarine fans (Figure 8). A great volume of material has been displaced into the ocean in this fashion and over time the islands have fanned outward in extent. This is very depressing for oceanic lithosphere – having not as yet heard about the uplifting effects of Prozac or Tequila it eventually started to sink. Thus, as we will experience firsthand at Hilina Pali, faulting and large scale downslope movement have had an important erosional effect on pre-existing volcanic materials. Remember from previous trips the effects of mean old Mr. Gravity – it’s the Law! And it’s a good one!

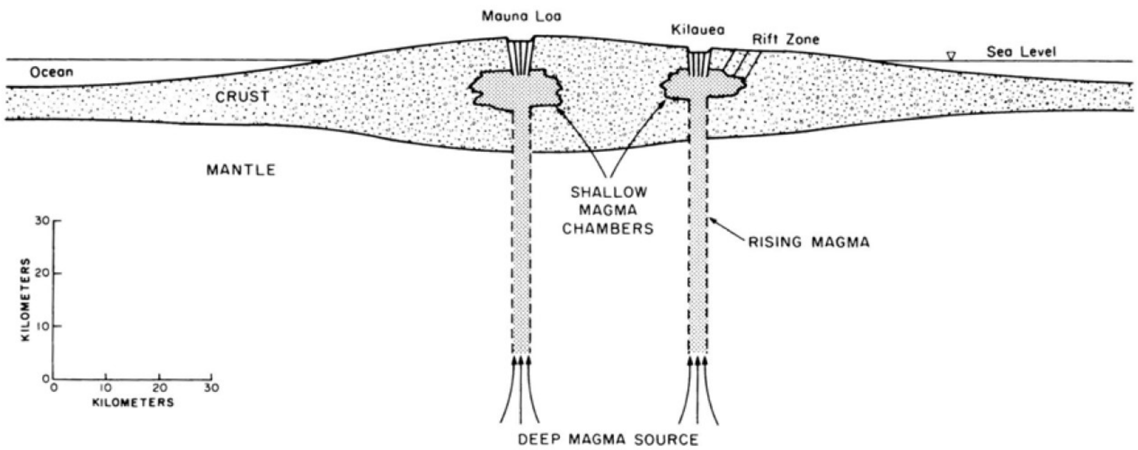


Figure 6 – Diagrammatic section through the outer part of the earth at Hawaii showing the magma source for Mauna Loa and Kilauea and the relative position of shallow magma chambers that control the volcanic activity. (From Macdonald and others, 1983, p. 10, Fig. 2.3.)

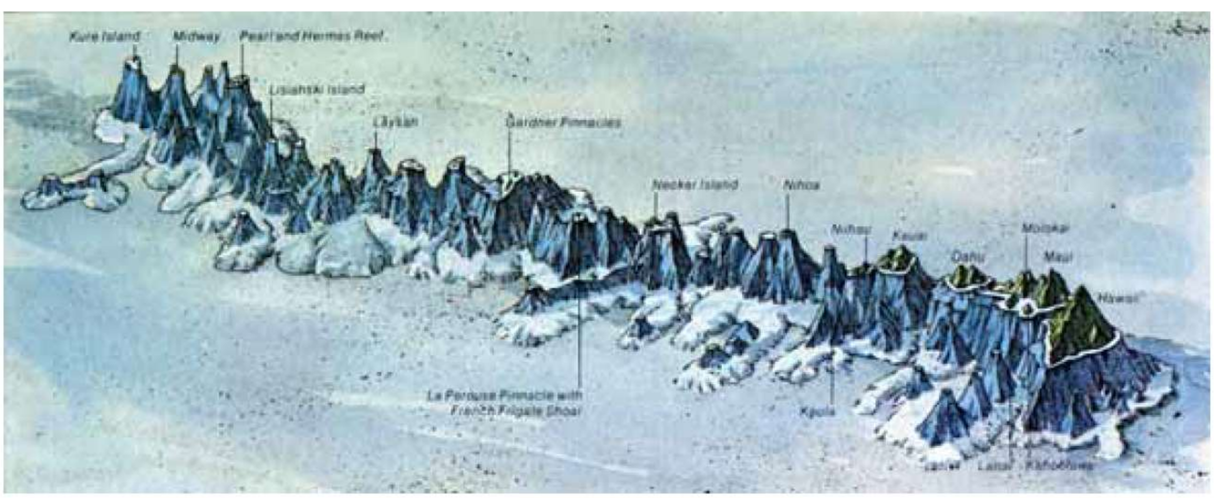


Figure 7 – Physiographic diagram showing the submerged ~30 Ma Hawaiian volcanoes atop the Hawaiian arch.

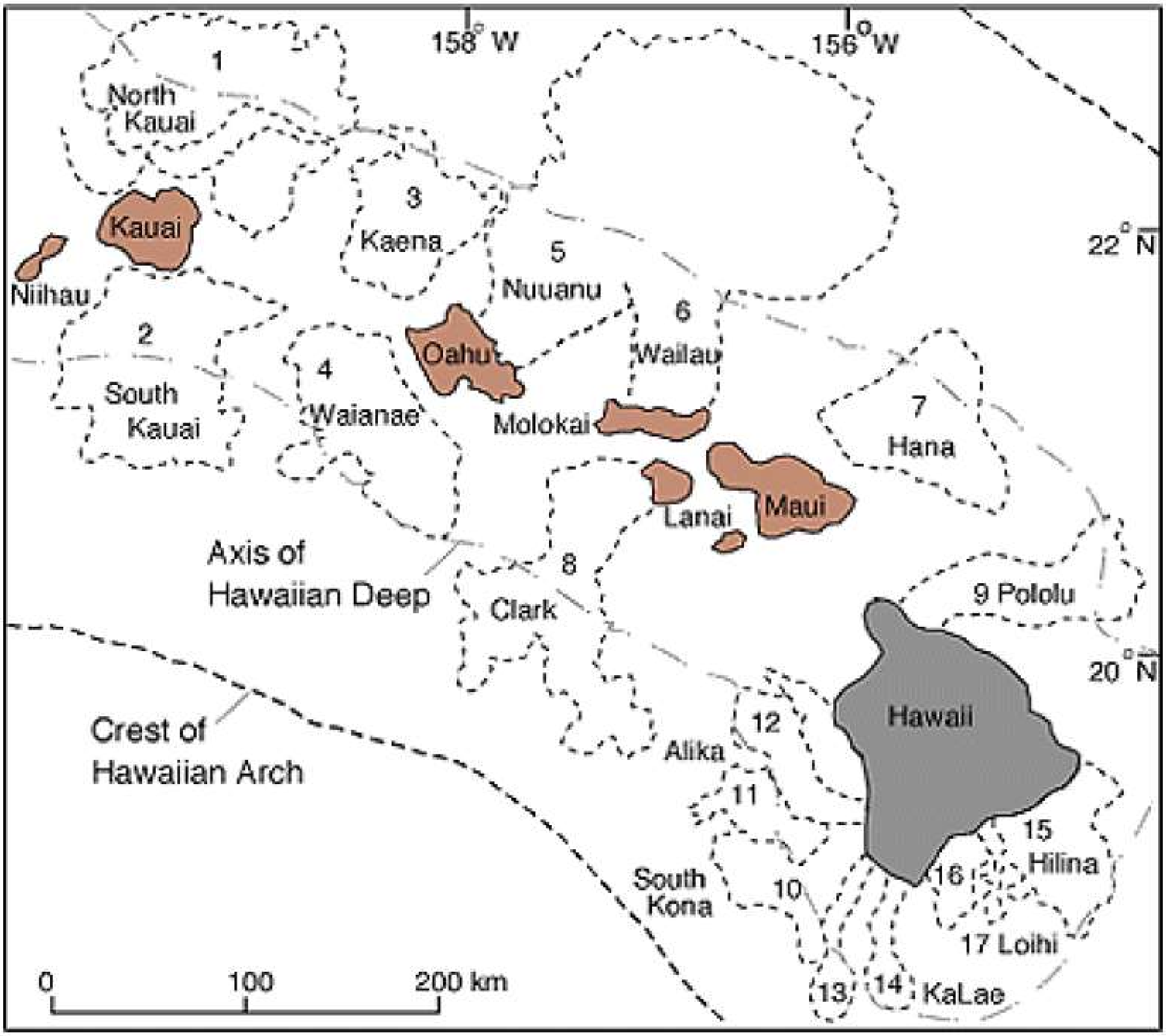


Figure 8 - Drawing from side scan sonar data showing submarine landslides off the Hawaiian Islands. (From www.uhh.hawaii.edu/~kenhon/GEOL205/petrology/default.htm.)

A location map showing the linear distribution of basaltic volcanic islands and seamounts in the Pacific Ocean (Figure 9) indicates that the geometry of the Emperor-Hawaii bend is mimicked by the Marshall-Ellice Island – Austral seamount chain, the Line Island – Tuamoto chain, and also partially in the Cobb seamount chain. The volcanic island chains (red in Figure 9.) are all the result of a similar hot plume mechanism and thus locate active hot plumes in the Pacific basin. No one knows what causes hot plumes in the Earth's mantle but CM often advances the idea that they may represent fossil asteroid scars of dense meteorites (*Remember folks, you heard it here first!*).

Obviously, a change in the geometry of Pacific plate motion took place coincident with the age of the bend in the Emperor seamount-Hawaiian island chain. Such a fundamental shift (~120°) in plate motion can be accurately dated since we know the age of the volcanic rocks preserved at the dogleg bend in the Emperor-Hawaiian chain, roughly 44 Ma (Figure 10). The sharper angle of the Emperor-Hawaii chain (~120°) compared to other chains in the Pacific (~160° to 170°) could be the result of latitudinal variations in north Pacific plate motion associated with loss of the northern spreading ridge of the East

Pacific Rise beneath the western North American Cordillera. As we witnessed on our Geology 280 trip to California (to be repeated in 2008, by the way!), the western Cordillera experienced nearly continuous subduction for ~ 200 Ma until what started out life as the "mid-ocean ridge" of the Pacific approached the west coast subduction zone.

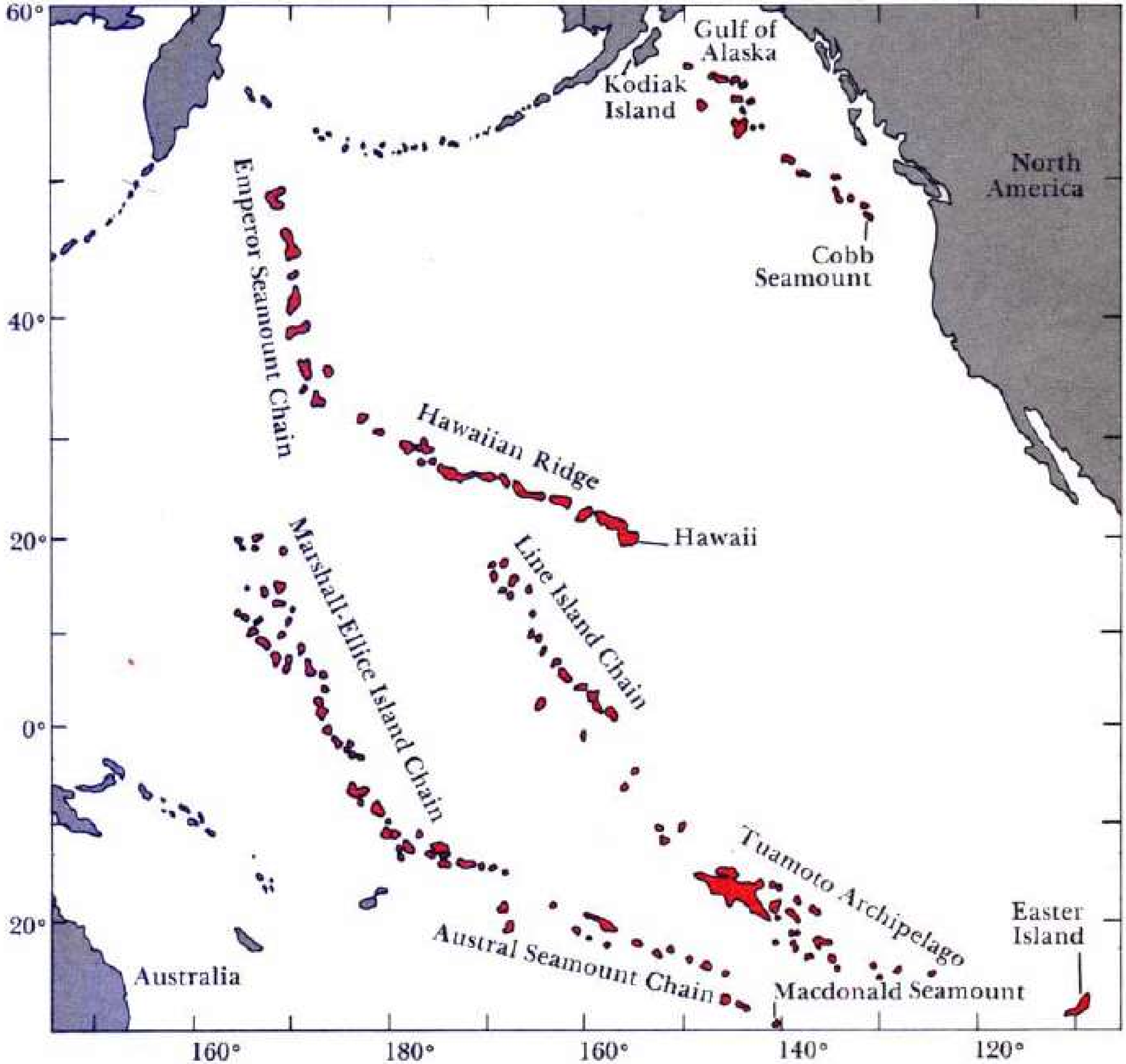


Figure 9 – Location map showing the distribution of volcanic islands and seamounts (in red) in the Pacific Ocean.

The timing is good for our suggestion, since we know that about 44 Ma impingement of the East Pacific Rise and generation of the San Andreas transform system began. This may have resulted in major jostling of lithospheric plates in the north half of the Pacific and created the angular difference in the island chains noted above. Soon, in the northern Pacific, it will be party time again! Note that the northernmost volcanos in the Emperor Seamount chain are on course for northwestward subduction into the Aleutian and/or Kamchatka trenches. It will only be a few Ma in the future but no one can predict constancy of plate motion. Any bets on the table? How about under the table?? At present rates, Hawaii is on schedule to plunge into the Aleutian trench in roughly 40 Ma.

Volcanism has been a continuous friend to the Hawaiian volcanoes, creating real estate like no tomorrow. Table 1 lists the dimensions of length, width, area, length of shoreline, major mountains, and altitudes for the chain. Note the SE to NW decrease in area and subsequent length of shoreline in response to contraction cooling, densification, and subsidence with passage away from the active plume area.

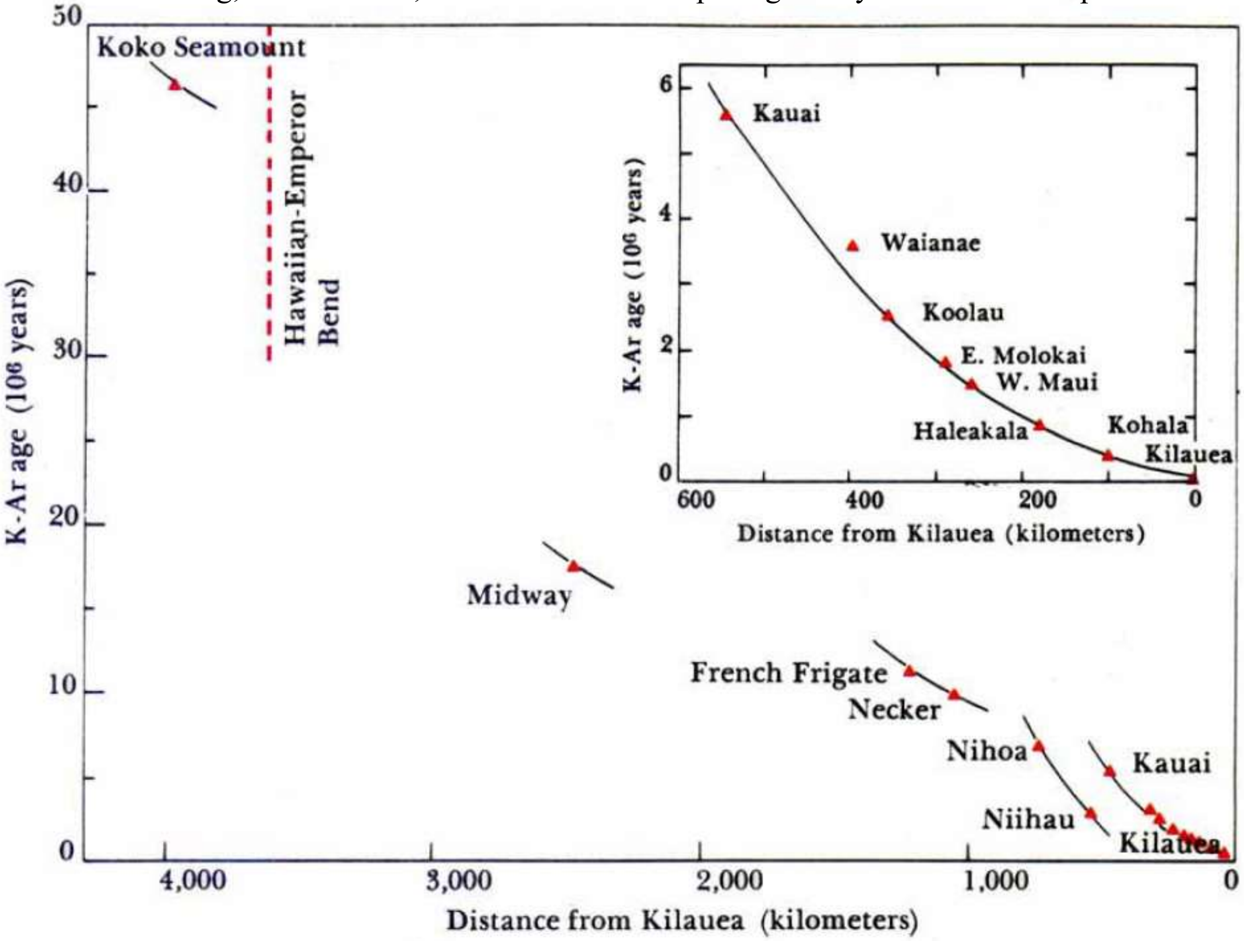


Figure 10 – Graph showing age vs. distance from Kilauea for the Emperor-Hawaiian chain. Note that the age of the bend in the Emperor-Hawaiian Seamount chain is roughly 30 Ma. Inset shows age-distance relationships of the nearby "Hawaiian" islands.

The symbiosis between seismicity and volcanism has been well established. As earthquakes and related fractures in the earth occur in response to abnormal stress in volcanic districts, magma and lava can move upwards to fill the openings. The force of moving magma can introduce stress that, before the effects of igneous heat permeate the rock mass and decrease brittle response, creates more earthquakes. Naturally this provides more openings for more lava or magma to intrude and invigorates the process toward repetition.

Monitoring devices at Kilauea summit indicate that during the interval 15 January to 20 February 1974, shallow focus earthquakes increased to hundreds per day and tiltmeters showed maximum departure just preceding an eruption (Figure 11). At Mt. St. Helens in May 1980 harmonic earthquakes (*they got rhythm, baby!*) heralded the flank eruption that killed "I ain't leaving" Harry Truman and vaporized his rocking chair, porch, and multicultural cat collection. In addition, plots of Kilauean tilt over longer time periods (1957-1981) show a marked correlation between tilt, eruptions, and intrusion (Figure 12).

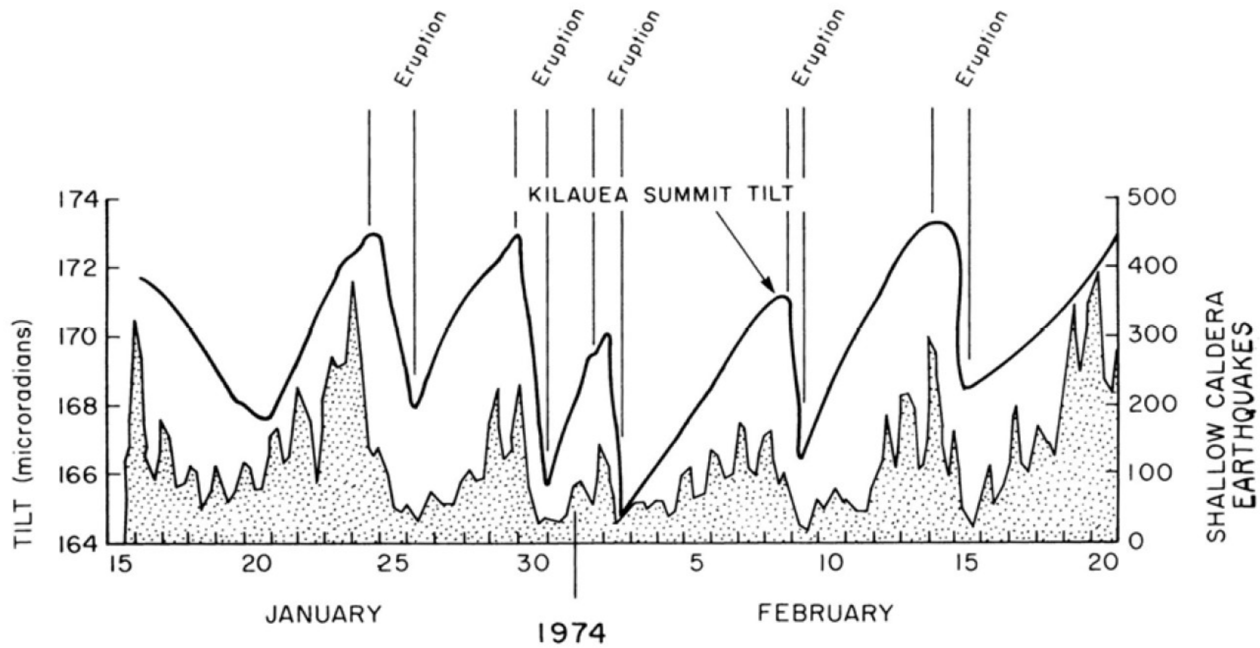


Figure 11 – Summit tilt and earthquake frequency (shaded area) from 15 January to 20 February 1974 at Kilauea volcano. (Source of data: U.S. Geological Survey Hawaii Volcano Observatory.)

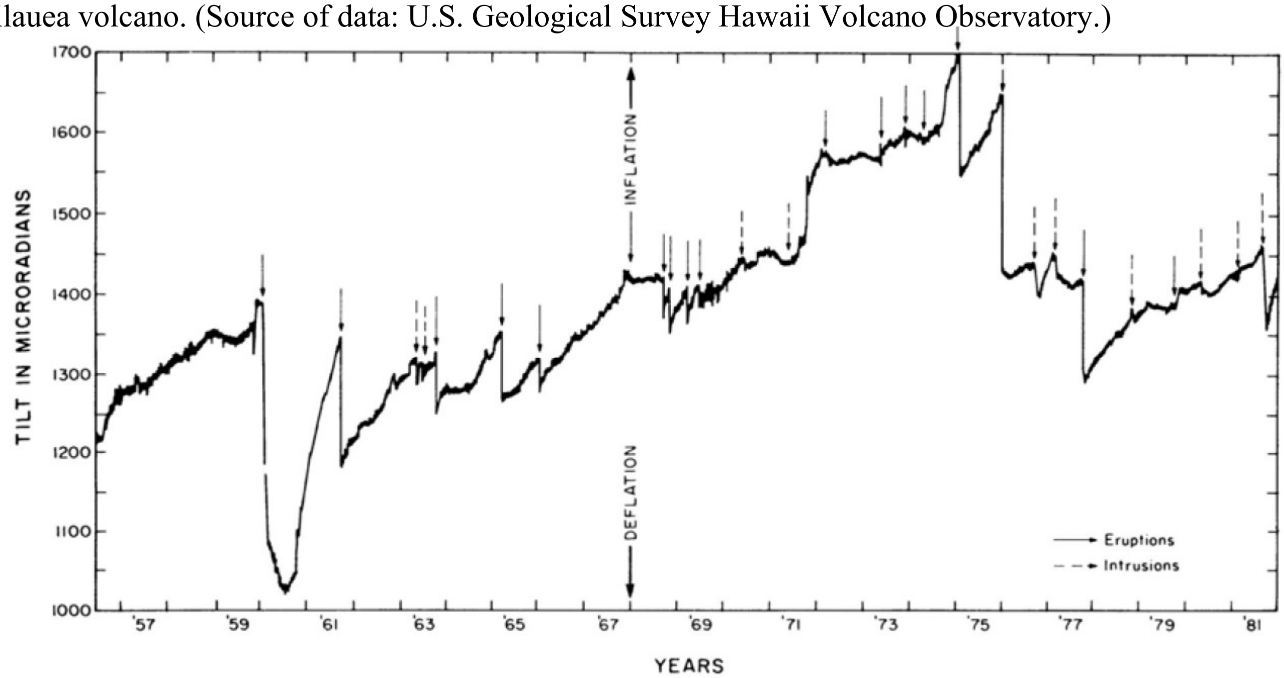


Figure 12 – Record of Kilauea summit tilt from 1957 to 1981. Increasing tilt indicates inflation and decreasing tilt deflation. Note that intrusions and eruptions are preceded by episodes of increasing tilt. (Source of data: U.S. Geological Survey Hawaii Volcano Observatory.)

Clearly the graphs above are records of the heartbeat of an active volcano, with its surface heaving and issuing forth lava on a periodic basis. Over the past 800,000 years, this process has created the island of Hawaii, the focus of our field trip. The rest of this guidebook will focus on the specific places that we plan to visit on our 10-day excursion. Figure 13 is a map of the island of Hawaii showing many of the place names mentioned in the itinerary. But before we get to the itinerary and information on specific stops, let's chat a bit about basalts.

Figure 13 – Map of Hawaii with place names. (From Macdonald and others, 1983, Fig 19.2, p. 347.)

Origin of Basalts

The Earth's surface can be divided into two general silicate rock types: low density and light colored **granite** which makes up the continents and high density dark-colored **basalt** which underlies the ocean basins. Granites are relatively easy to study since they are readily accessible on land but basalt is more difficult to access because it mostly lies beneath deep oceans and is covered by varying amounts of sediment. The chemistry of both types is variable, depending upon location and how much melting of parental rock has occurred prior to its formation.

Basalt is typically derived from various degrees of melting of the Earth's upper mantle, whose initial composition is thought to be that of a **peridotite**. Peridotite generally contains the minerals calcium feldspar, pyroxene, and olivine and perhaps some minor chromite and magnetite. As a result, this dark rock has a density higher than basalt. The partial melting of peridotite can form relatively shallow magma chambers of basalt beneath active plate boundaries such as the north-south trending Mid-Atlantic Ridge of the Atlantic Ocean. This is a **divergent plate boundary** where new ocean floor basalt is created as a result of active seafloor spreading. Because the oldest basaltic sea floor is only about 180 to 200 Ma and the Earth is approximately 4.6 Ga (billion years old), the seafloor must have been recycled many times along **convergent plate boundaries** or **subduction zones**. This "recycled" basalt process produces a unique chemistry to the resulting basaltic oceanic crust and it is referred to as mid ocean ridge basalt or **MORB**; they are also known as **tholeiites**, named after a type-locality in Iceland. To describe and compare the chemistry of "recycled" versus "not recycled" basalt, chemical analyses are given in the form of percentages of mostly metallic oxides such as SiO_2, Al_2O_3, FeO, MgO, CaO, Na_2O, K_2O, MnO, TiO_2, and P_2O_5, whose sum equals about 100%. Refer to Table 2 for some selected average chemical silicate rock analyses. SiO_2 is chemical shorthand notation for silicon dioxide or silica and generally, igneous rocks contain between 30% to 80% silica. By comparison, a continental granite is rich in SiO_2, K_2O, TiO_2, and P_2O_5. While being low in FeO, MgO, and CaO. These oxide amounts reflect the types of minerals present in granite such as quartz, potash feldspar, micas, and perhaps some hornblende. A MORB tholeiite is characterized by having lesser amounts of SiO_2 and K_2O, with higher FeO, MgO, and CaO, which corresponds to the presence of pyroxene, calcium feldspar and rare olivine; minerals that are very different from those in granite.

Table 2 – Selected Average Basalt Compositions

Oxide	Kilauea Tholeiite	Hawaiian Alkali Basalt	Mid-ocean Ridge Basalt	Continental Hornblende Granite
SiO_2	50.5	46.4	48.8	71.1
Al_2O_3	13.5	14.2	15.9	14.1
FeO	11.2	12.6	9.8	2.6
MgO	7.4	9.5	9.7	0.3
CaO	11.2	10.3	11.2	1.6
Na_2O	2.3	2.9	2.4	3.0
K_2O	0.05	0.09	0.01	6.1
MnO	0.02	0.02	0.02	0.2
TiO_2	2.6	2.4	1.2	0.4
P_2O_5	0.03	0.03	0.03	0.1
Totals	99.7	99.7	99.6	99.5

Basalt that forms away from plate boundaries or on "hot spots" within an oceanic plate are known as oceanic island basalts or **OIB**s. Their chemistry is slightly different than those of MORBs. Partial melting of deeper mantle beneath Hawaii, produces a basalt known as a **Hawaiian tholeiite**. Compared to a **MORB**, a Hawaiian tholeiite is richer in SiO_2, FeO, and K_2O and poorer in Al_2O_3, and MgO. This corresponds to the abundance of calcium feldspar and pyroxene with minor olivine phenocrysts. As Hawaii sits atop the hotspot, the chemistry of the basalt does not change much. However, as the island moves away from this area, the degree of partial melting of the mantle decreases due to an increased distance from the heat source and melting occurs at shallower depths. As a result, a new type of basalt (**alkali basalt**) is created. This type is lower in SiO_2 and CaO, while higher in Na_2O and K_2O. Correspondingly, there are more sodium+calcium (plagioclase series) and potash feldspars present and overall the magma is much more sticky or viscous.

Viscosity is described as the resistance to flow for fluids. For example, water has a very low viscosity since it flows readily, while ketchup has a very high viscosity, since it flows with great difficulty when poured from its container (unless you pound on the 57). Molten lava behaves in a similar manner. The ability of a lava to flow *increases with decreasing silica content* and increasing temperature; or conversely, the *higher the silica content, the higher the viscosity* and the more difficult it will be for it to flow. Alkalic lavas formed from older volcanoes on Hawaii are very viscous. At the Kohala volcano on the north shore of the Big Island of Hawaii, two types of unusual alkali basalts are known as **benmoreite and hawaiite.** The former has weathered brown olivine crystals, sodium feldspar crystals, thin black hornblende needles, and is gray in color. The latter is red brown with alkali feldspar in the form of sodium-rich plagioclase and some type of amphibole. Although not shown on any of the diagrams, it represents a type of alkali basalt that is very high in alkalis with about 50% SiO_2 present usually indicative of very old volcanoes fed by very shallow magma source or reduced melting of a tholeiite basalt.

Plotting the chemical abundances of a combination of alkalis (sodium [Na_2O] and potassium [K_2O]) versus overall silica (SiO_2) content from different types of basalt produces a diagram as that shown in Figure 14. Examination of this diagram shows the compositional difference between each type of basalt and the effect of melting and crystallization of the magma and resulting lava. As crystallization increases, the silica content increases slightly and the alkali content decreases forming a tholeiite. As the degree of melting decreases, the alkali content increases and the silica content decreases, forming alkali basalt.

Therefore, Hawaiian tholeiites have not been recycled as much as the MORB tholeiites, probably from sampling different depths with the mantle; MORBs sampling shallower mantle depths, while Hawaiian tholeiites sample deeper mantle depths. One way to determine this is to compare the abundance of certain radioactive elements that occur in trace amounts in certain minerals of the basalt. Two well known and used elements are generally combined isotopes of neodymium (Nd) and strontium (Sr). A plot of their abundances also illustrates the differing compositions and origins of these basalts. Refer to Figure 15 for a plot of neodymium versus strontium isotopes. The composition of the Hawaiian tholeiite is not too different from that of Earth's original mantle composition which has a relatively high abundance of strontium isotopes and lower amounts of neodymium, similar to very old stony meteorites. This suggests the upper mantle away from plate boundaries is fairly primitive in composition and has not been recycled much if any, while the alkalic basalts occupy a transitional location with low amounts of strontium and MORBs even a lower amount, meaning they have been recycled (melted) many times or only partially melted. Use of these diagrams serve as good tools for geologists to use in determining the origin of particular rocks, in this case basalts.

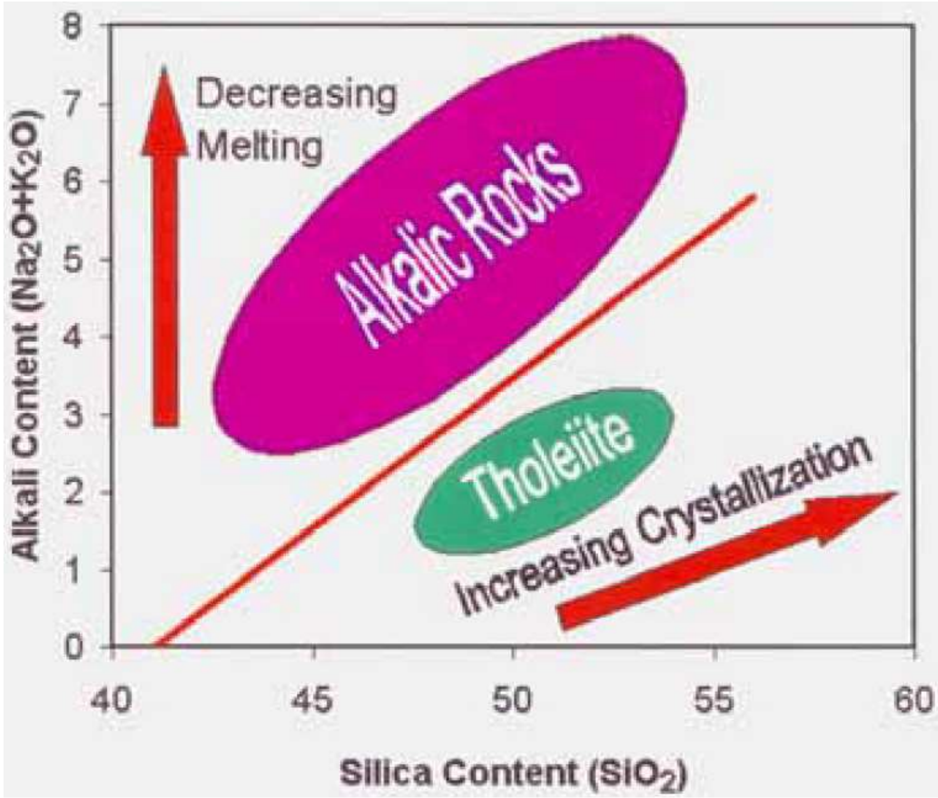


Figure 14 – Silica vs. alkali content of basaltic rocks.
(From www.uhh.hawaii.edu/~kenhon/GEOL205/petrology/default.htm.)

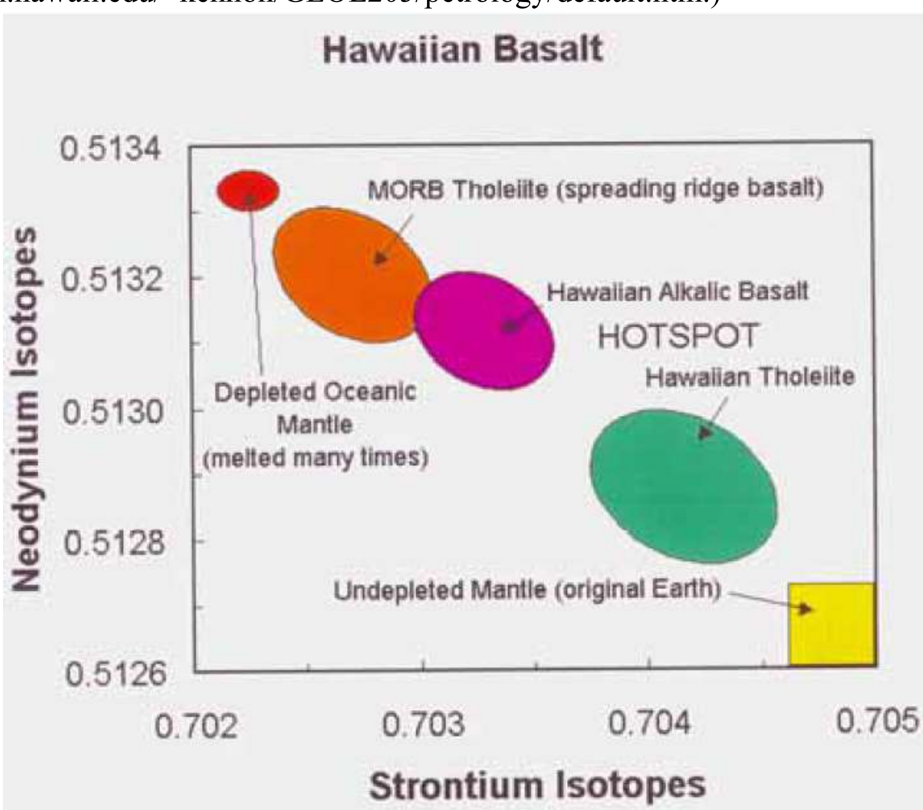


Figure 15 - Trace element isotope concentration of basalts. (From www.uhh.hawaii.edu/~kenhon/GEOL205/petrology/default.htm.)

Volcanic Features

As we will be investigating volcanic rocks almost entirely, it would be appropriate to discuss common volcanic features that we are likely to run across on our trip to Hawaii. The products of volcanism come in the three states of matter, **solid** (solidified lava flows, blocks, bombs, Pele's tears and hair, lapilli, cinder, ash, etc.), **liquid** (lava), and **gas** (volcanic gases such as CO_2, H_20, H_2S, SO_2, and others). Since the cooling rate of volcanic rocks ranges from instantaneous to weeks or months (rather than thousands or millions of years) little time is available for migrating ions to develop large lattice structures. The result of this is glassy (no crystals at all) to fine-grained textures (0.1 to 1.0 mm-scale crystals) that may or may not be visible to the naked eye. Geologists classify such rocks a **hyalohaline** (100% glass) to **aphanitic** (100% crystals) and define ratios of glass vs. crystals by performing careful petrographic examination.

Lava flows are typically viscous liquids that flow rather slowly. A function of composition (especially silica content), temperature, vapor content, flow rate, topography, slope, gravity, and air pressure, lava flows can cascade as ribbon-like flows for great distances, simply pool up into a small area, or fragment and flow as a semi-solid mass. The terms **Aa** (which means "rocky or stony" in Hawaiian) and **Pahoehoe** (which means "to paddle") refer to "blocky" (viscous) and "ropy" (fluidal) lava types ranging in thickness up to 10 m, each with characteristic surface and internal features. Variations (shelly, slabby) occur. A change in velocity down steep slopes or cooling causes changes in viscosity that results in a change from pahoehoe to aa types. All basalt is thought to be derived from partial melting of lherzolite peridotite or melting of peridotite from a greater depth. Although the magma is derived from 40-55 km deep in the mantle the rising partial melt feeds a magma chamber roughly the size of Connecticut, 3-5 km below surface. Derived from large amounts of melting, no geochemical difference exists between aa and pahoehoe. The production of lava type depends upon temperature, topography, flow angle, amount of degassing, and internal shear.

Table 3 – Basaltic Lava Types

LAVA TYPES AND THEIR CHARACTERISTICS	
'A'A	**PAHOEHOE**
Forms thick flow units, 6 to 33 feet thick	Forms thin flow units, 0.5 to 6 feet thick
Forms large channels	Forms lava tubes
Higher viscosity	Lower viscosity
Forms few large flow units	Forms many flow units
Is slightly cooler	Is slightly hotter
Has a high volume flow rate	Has a low volume flow rate

Pyroclastic (fire-broken) rocks are a classification given to volcanic materials that are launched from volcanic features and deposited near or far from the source area (usually a vent, cone, or volcano). Another term, **volcanic ejecta**, is also used to describe fragments thrown up (ejected) by volcanic explosion. Ejecta are classified according to size and also by their fluidity during ejection. Fragments larger than 4 cm are termed bombs or blocks depending upon their shape. **Bombs** exhibit aerodynamic forms indicating ejection in a fluidal form while bombs (angular) were ejected as solids (Figure A1-8). Bombs vary in shape from spherical to elongate and drawn out at their ends in a spindly form are termed **fusiform** or **spindle** bombs. **Cored** bombs commonly contain an angular core, the product of liquid lava enclosing a fragment of hardened material. Frozen lava squirts produce long thin bombs termed **ribbon** bombs. Flattish and circular **pancake** or **"cow-dung"** bombs occur when the ejected lava is still fluidal when the bomb hits the ground. So, be careful when the younger generation tells you, ***"You are the bomb"*** – they may mean something quite different than you might think! Also, keep in mind use of the term bomb should be avoided in the airport or on the airplane! Ask them to be more specific. Bombs have variable texture from aphanitic and dense to vesiculated and frothy. Some consist entirely of glass and some contain mixtures of glass and crystals. Some bombs contain remnants (xenoliths or inclusions) of mantle-derived materials rich in olivine and pyroxene.

Blocks are angular and can get quite large (car-sized) since they were launched in the solid state or were so viscous that they were unable to assume a rounded shape in transit. Follow the Wiley Coyote principle - Watch beneath you for unexpected dark angular shadows that get bigger as you view them. Blocks can consist of fragments of volcanic wallrock plucked (excuse the expression) from the throat of a volcanic construct or consist of entirely non-volcanic material. Much of what we know about the subsurface constitution of volcanic areas is learned from studying exotic non-volcanic blocks. Limestone blocks, ripped from subsurface layers of coral are well known in Oahu near Koko Head, for example. Collections of angular blocks are termed **volcanic breccia**, a general term used to describe any aggregate of angular fragments (cemented together or not). **Autobrecciation** is a common feature of the tops and fronts of aa lavas since they tend to crack, break, and become overrun by an advancing flow front. The product is a breccia, a common term used when people sneeze. Explosive and non-explosive breccias are recognized in the geological record. Termed **lahars**, other types of breccia are produced during mudflows.

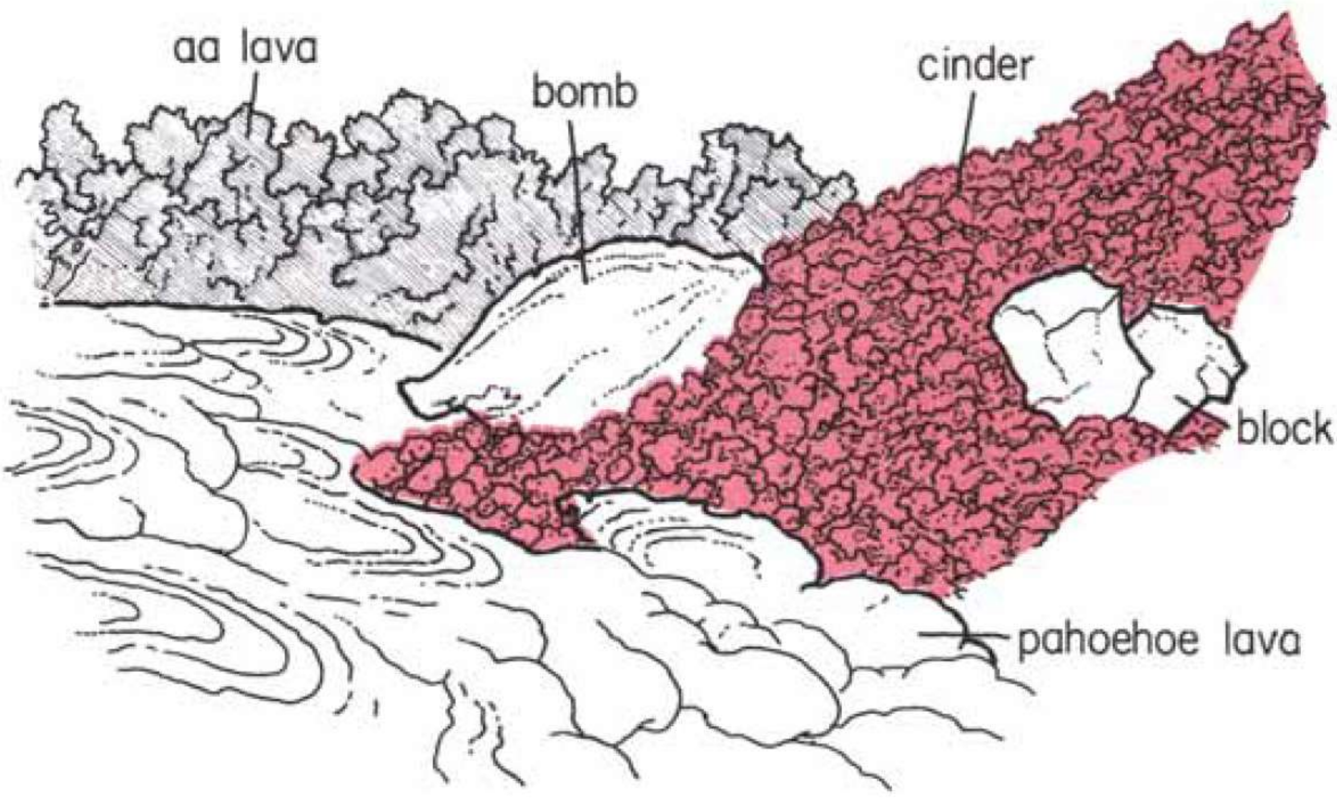


Figure 16 – Diagram showing major types of volcanic deposits. Pahoehoe and aa are types of surface flows. Conders, bombs, and blocks are lava fragments with an explosive origin. (From Hazlet and Hyndman, 1996, p. 210.)

Ejecta ranging in size from 0.5 cm to less than 4 cm in diameter are called **lapilli**, meaning “little stone” in Italian. Lapilli come in all shapes from rounded to angular in form. **Volcanic ash** refers to fragments varying from less than 0.5 cm in size and can consist of crystals, solid rock broken by explosion, or consist of particles erupted as a liquid spray that result in quenched glass. **Volcanic tuff** is produced by the quick cementation of volcanic ash. In some cases the ash is so hot that the tuff becomes solidified, as in **welded tuff**. Tuffs enriched in lapilli are termed **lapilli tuff**. When bits of liquid are catapulted into the air and solidify they can fall as rounded, typically jet black glassy globules (**Pele’s tears**) or as fine elongate strands or filaments of lighter-colored glass (**Pele’s hair**).

Cinder and **splatter cones** (or volcanic cones, in general) are produced when ejecta emanates from a vent and builds up a conical pattern on the ground. The difference lies in the nature of the materials. Cinder cones consist of spherical, ribbon, or spindle bombs and splatter cones typically contain more fluidal cow-dung bombs. Mixtures of cinder and splatter and quite common in Hawai’i. The effects of volcanic explosions near the ocean produce **hydromagmatic eruptions** which involve both magma and superheated water and produce ash cones and tuff cones. Heated groundwater explosions are termed phreatic and those explosions which involve magmatic gases are termed phreatomagmatic. Ash and tuff cones are typically broader in proportion to their height than are cinder or splatter cones with broad saucer-shaped craters. The best examples include Diamond Head and Punchbowl on Oahu (Macdonald et al., 1983).

Calderas are large semi-circular to oval features a few km in size and are produced when a shallow magma chamber is evacuated and a void develops below a volcanic summit. A series of circular inward dipping ring fractures develop and coalesce and eventually the tip of the volcano can subside into the voided chamber leaving a caldera in its wake. **Pit craters** and **craters** are smaller features that are secondary to calderas in size but are very similar in geology. They are sometimes found within caldera floors or found distributed along fractures emanating from the caldera area. Commonly found within caldera and crater floors, **ramparts** form as walls around eruptive fissure zones. **Tumuli** are cracked uplifts consisting of plates of basalt caused by accumulated gases or subsurface lava flow obstruction.

Recent Activity

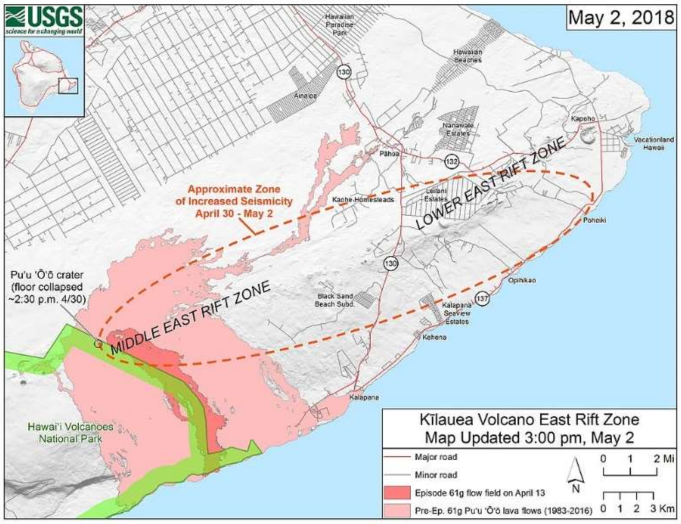
2018 eruptive episodes (*Copied from Wikipedia*)

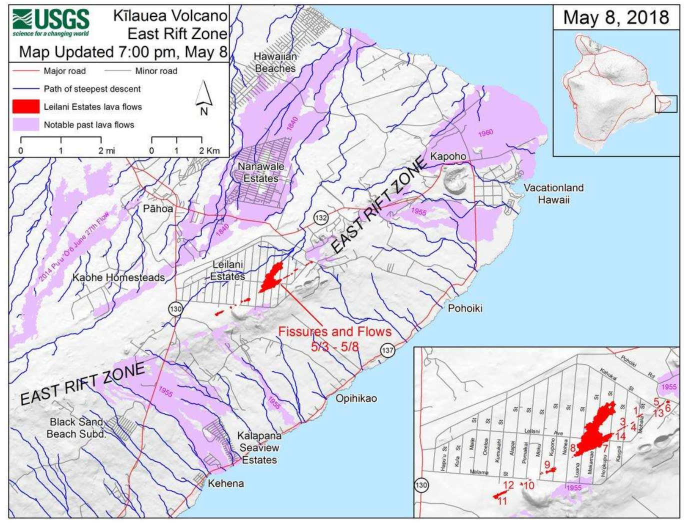
Lava from a fissure slowly advanced to the northeast on Hoʻokupu Street in Leilani Estates subdivision (May 5, 2018) Beginning in March 2018, Hawaiian Volcano Observatory began to detect rapid inflation at Puʻu ʻŌʻō, leading scientists to warn that the increased pressure could lead to the formation of a new vent at Kilauea.

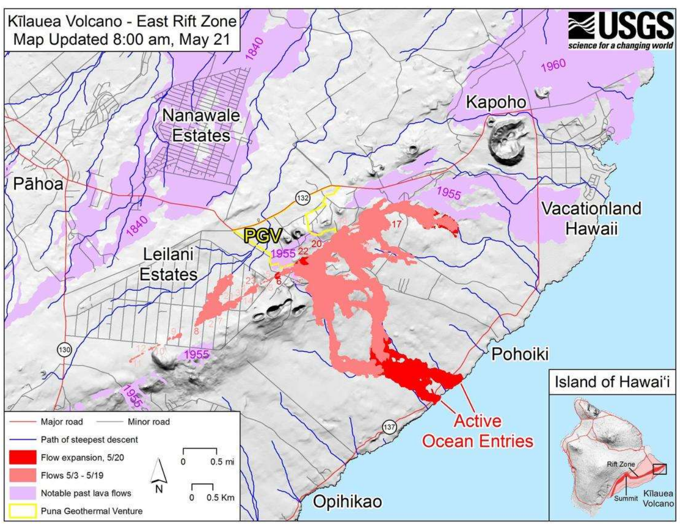
Following weeks of increased pressure, the crater floor of the cone of Puʻu ʻŌʻō collapsed on April 30, 2018, as magma migrated underground into the lower Puna region of Kilauea's lower east rift zone. Over the next few days, hundreds of small earthquakes were detected on Kīlauea's East rift zone, leading officials to issue evacuation warnings. On May 3, 2018, new fissures formed, and lava began erupting in lower Puna after a 5.0 earthquake earlier in the day, causing evacuations of the Leilani Estates and Lanipuna Gardens subdivisions.

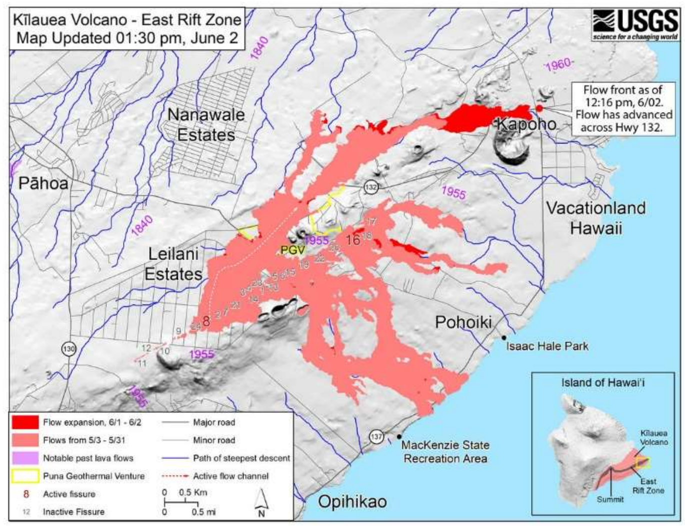
A seemingly related 6.9 magnitude earthquake occurred on May 4. By May 9, 27 houses had been destroyed in Leilani Estates. By May 21, two lava flows had reached the Pacific Ocean, creating thick clouds of laze (a toxic lava and haze cloud), which is made up of hydrochloric acid and glass particles.

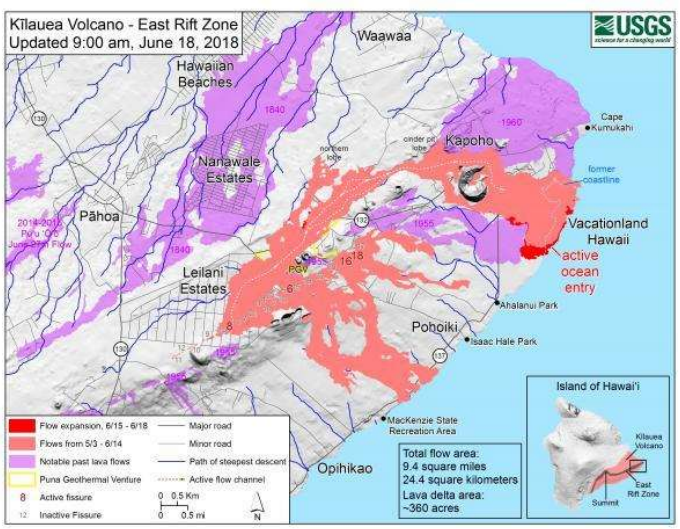
By May 31, 87 houses in Leilani Estates and nearby areas had been destroyed by lava. Advancing lava flows caused additional evacuation orders, including the town of Kapoho. By June 4, with the lava having crossed through Kapoho and entered the ocean, the confirmed number of houses lost had reached 159. Two weeks later, the confirmed number of homes lost was 533, and as of June 25 it had risen to 657.

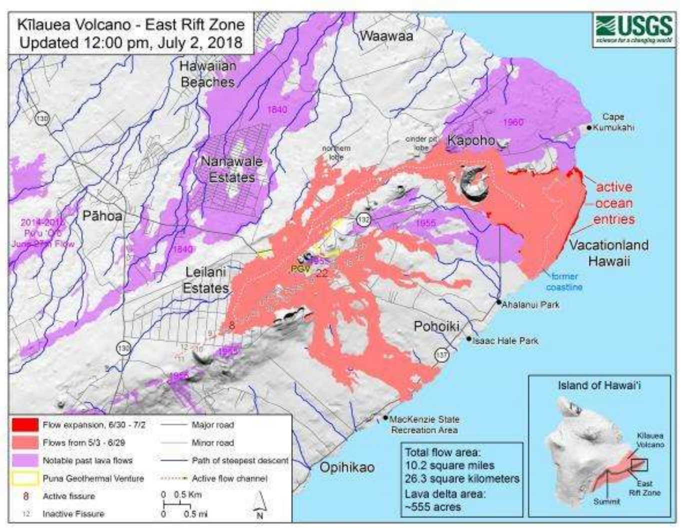

USGS
science for a changing world
May 2, 2018
Approximate Zone
of Increased Seismicity
April 30 - May 2
LOWER EAST RIFT ZONE
MIDDLE EAST RIFT ZONE
Pu'u 'Ō'ō crater
(floor collapsed
~2:30 p.m. 4/30)
Hawai'i Volcanoes
National Park
Kīlauea Volcano East Rift Zone
Map Updated 3:00 pm, May 2
Major road
Minor road
Episode 61g flow field on April 13
Pre-Ep. 61g Pu'u 'Ō'ō lava flows (1983-2016)


USGS
Kīlauea Volcano
East Rift Zone
Map Updated 7:00 pm, May 8
May 8, 2018
Major road
Minor road
Path of steepest descent
Leilani Estates lava flows
Notable past lava flows
Hawaiian Beaches
Nanawale Estates
Kapoho
Vacationland Hawaii
Pāhoa
Kaohe Homesteads
Leilani Estates
EAST RIFT ZONE
Fissures and Flows
5/3 - 5/8
Pohoiki
Opihikao
Black Sand Beach Subd.
Kalapana Seaview Estates
Kehena


Kīlauea Volcano - East Rift Zone
Map Updated 8:00 am, May 21
USGS
science for a changing world
Nanawale
Estates
Kapoho
Pāhoa
PGV
Vacationland
Hawaii
Leilani
Estates
Pohoiki
Active
Ocean Entries
Opihikao
Island of Hawai'i
Major road
Minor road
Path of steepest descent
Flow expansion, 5/20
Flows 5/3 - 5/19
Notable past lava flows
Puna Geothermal Venture


Kīlauea Volcano - East Rift Zone
Map Updated 01:30 pm, June 2
USGS
Flow front as of
12:16 pm, 6/02.
Flow has advanced
across Hwy 132.
Nanawale
Estates
Kapoho
Pāhoa
Vacationland
Hawaii
Leilani
Estates
PGV
Pohoiki
Isaac Hale Park
MacKenzie State
Recreation Area
Opihikao
Island of Hawai'i
Flow expansion, 6/1 - 6/2
Flows from 5/3 - 5/31
Notable past lava flows
Puna Geothermal Venture
Active fissure
Inactive Fissure
Major road
Minor road
Path of steepest descent
Active flow channel


Kīlauea Volcano - East Rift Zone
Updated 9:00 am, June 18, 2018
USGS
Waawaa
Hawaiian
Beaches
Nanawale
Estates
Kapoho
Cape
Kumukahi
former
coastline
Pāhoa
Vacationland
Hawaii
active
ocean
entry
Leilani
Estates
PGV
Ahalanui Park
Pohoiki
Isaac Hale Park
MacKenzie State
Recreation Area
Opihikao
Flow expansion, 6/15 - 6/18
Flows from 5/3 - 6/14
Notable past lava flows
Puna Geothermal Venture
Active fissure
Inactive Fissure
Major road
Minor road
Path of steepest descent
Active flow channel
Total flow area:
9.4 square miles
24.4 square kilometers
Lava delta area:
~360 acres
Island of Hawai'i


Kīlauea Volcano - East Rift Zone
Updated 12:00 pm, July 2, 2018
USGS
Waawaa
Hawaiian
Beaches
Nanawale
Estates
Kapoho
Cape
Kumukahi
active
ocean
entries
Pāhoa
Vacationland
Hawaii
former
coastline
Leilani
Estates
PGV
Ahalanui Park
Pohoiki
Isaac Hale Park
MacKenzie State
Recreation Area
Opihikao
Flow expansion, 6/30 - 7/2
Flows from 5/3 - 6/29
Notable past lava flows
Puna Geothermal Venture
Active fissure
Inactive Fissure
Major road
Minor road
Path of steepest descent
Active flow channel
Total flow area:
10.2 square miles
26.3 square kilometers
Lava delta area:
~555 acres
Island of Hawai'i

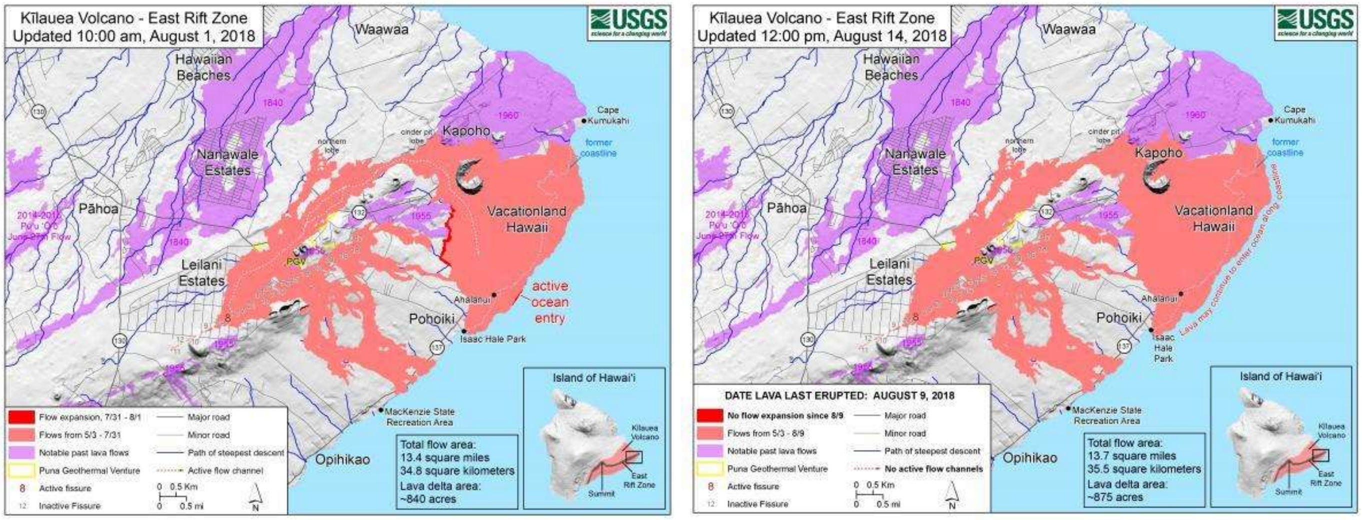


Figure 17 – A series of maps showing the Lower Puna Eruption of 2018. This eruption began on May 3rd, 2018 to September 4th, 2018. (https://www.usgs.gov/volcanoes/kilauea/maps)

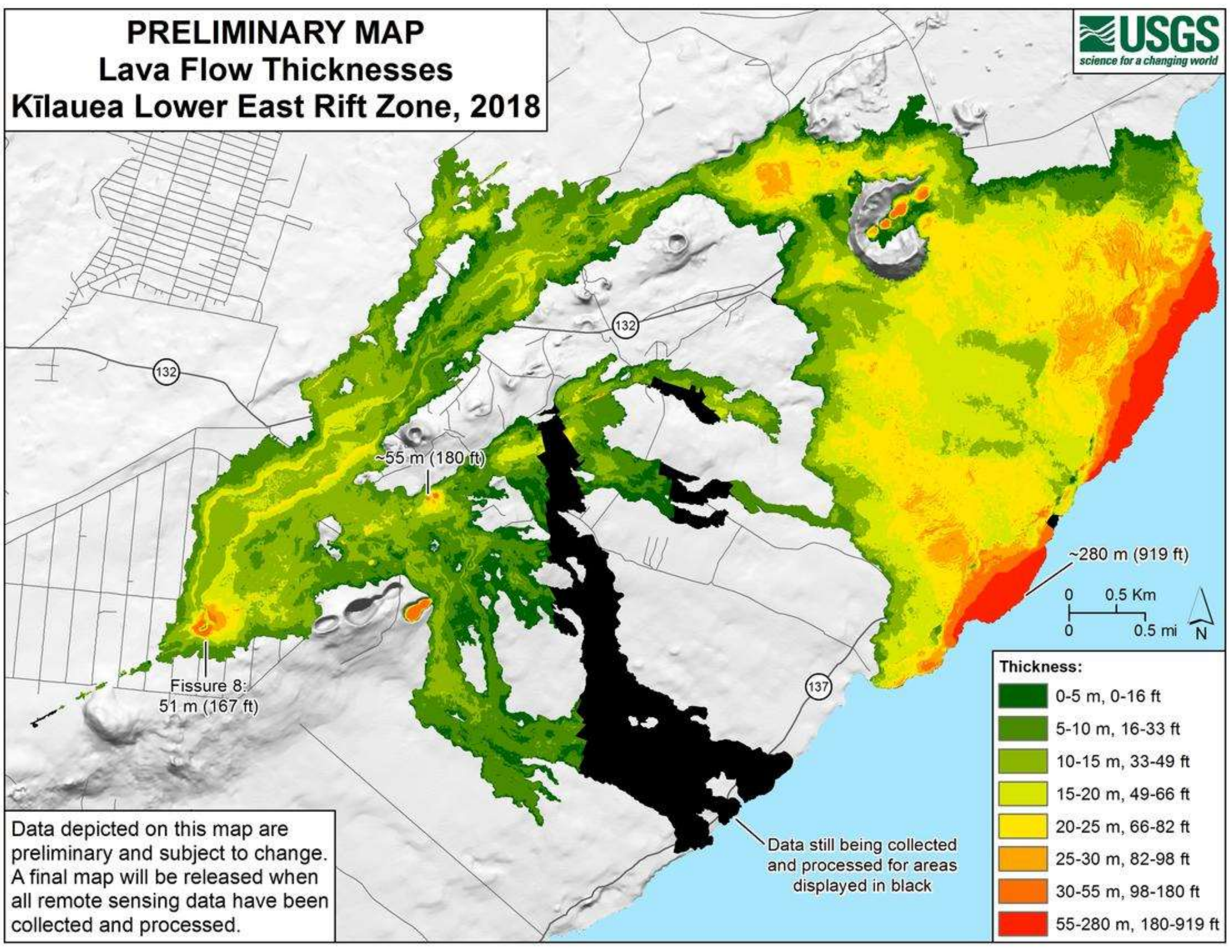


Figure 18 – Lava flows erupted from fissures 1-24 in 2018, which buried an area of about 35.5 sq km (13.7 sq mi) and added about 875 acres of new land to the island, vary in thickness across the flow field. The greatest thickness on land, at fissure 22, is approximately 55 m (180 ft), and the greatest thickness in the lava delta (new land created where lava entered the ocean) is approximately 280 m (919 ft). These values could change when data are finalized.

Effect of the 2018 lower Puna eruption on Kilauea's summit

Two views of Halemaʻumaʻu from roughly the same vantage point. At left is the view from 2008, with a distinct gas plume from the Overlook vent, the location of what would become a long-lived lava lake. At right is a view of Halemaʻumaʻu after the eruptive events of 2018, showing the collapsed crater. Two views of Halemaʻumaʻu from roughly the same vantage point. At left is the view from 2008, with a distinct gas plume from the Overlook vent, the location of what would become a long-lived lava lake. At right is a view of Halemaʻumaʻu after the eruptive events of 2018, showing the collapsed crater.

Together with the outbreak of lava in lower Puna, a lava lake at Halemaʻumaʻu at Kilauea's summit began to drop on May 2, 2018. The Hawaiian Volcano Observatory warned that the lowering of the lava lake increased the potential for phreatic (steam) explosions at the summit caused by interaction of magma with the underground water table, similar to the explosions that occurred at Halemaʻumaʻu in 1924. These concerns prompted the closure of Hawaiʻi Volcanoes National Park. On May 17, at approximately 4:15 a.m., an explosive eruption occurred at Halemaʻumaʻu, creating a plume of ash 30,000 feet into the air. This marked the beginning of a series of vigorous explosions that produced significant ash plumes from Halemaʻumaʻu. These explosions, accompanied by large earthquakes and inward slumping and collapse within and around Halemaʻumaʻu, continued until early August.

2019–20: Water lake appears at the summit

In late July 2019, a water lake appeared on the bottom of Halemaʻumaʻu for the first time in over 200 years, as water from the rebounding water table began entering the crater. Afterward, the crater lake gradually grew in size. On December 1, 2020, the lake was approximately 49 metres (161 ft) deep. Within a month, the water lake would be replaced by a lava lake during the new eruption.

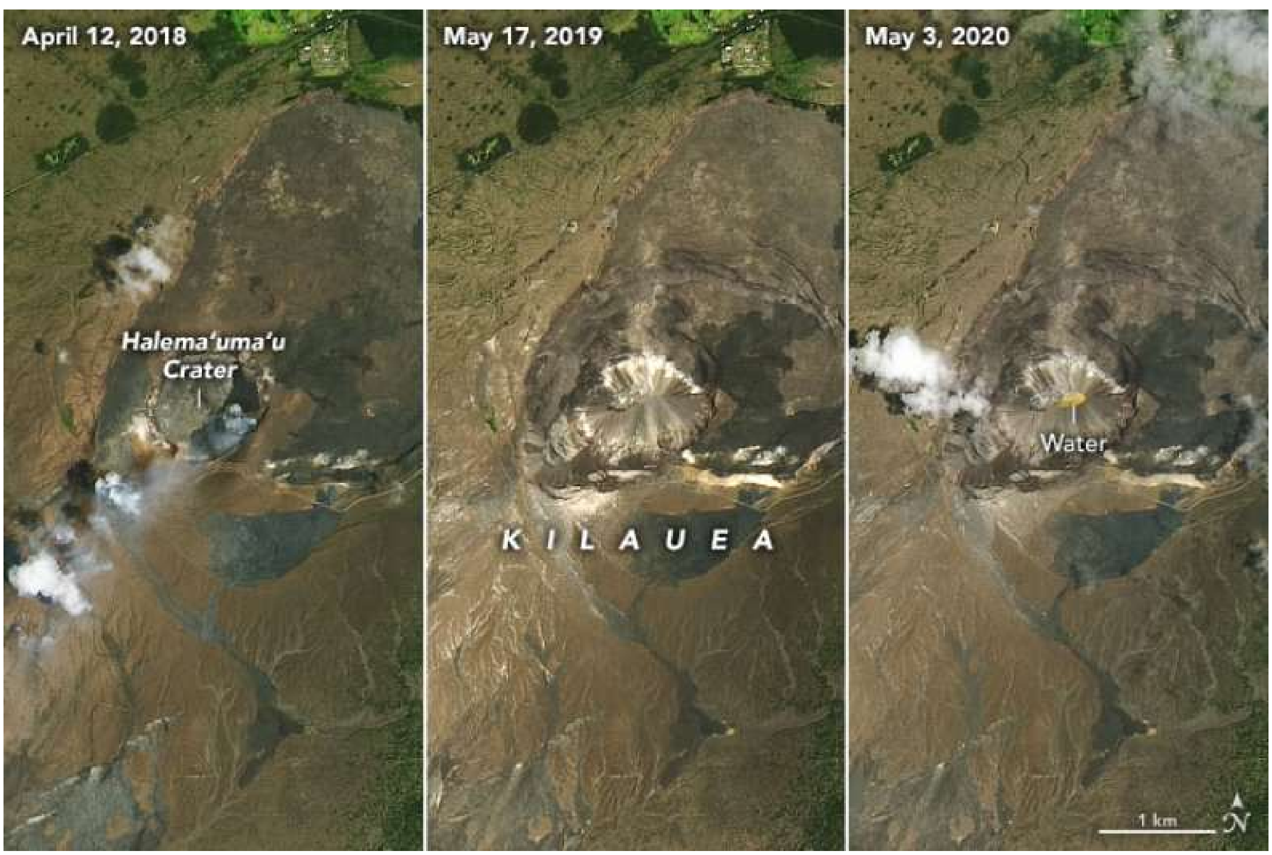


Figure 19 – After its lava lake drained and the floor dropped, water has been pooling up in the bottom of Halemaʻumaʻu crater for several months. (https://www.newsweek.com/ via NASA)

December 2020 – May 2021 summit eruption

On December 20, 2020, at 9:30 PM local time, an eruption broke out within Halemaʻumaʻu at Kīlauea's summit caldera. The US Geological Survey's Hawaiian Volcano Observatory reported that three vents were feeding lava into the bottom of Halemaʻumaʻu Crater, boiling off the water lake that had been growing since summer 2019 and replacing it with a lava lake. The eruption created a plume that reached 30,000 feet (9,144 m) in elevation. The eruption was preceded by earthquake swarms centered at Kīlauea Caldera on November 30, 2020, and December 2, 2020, the second of which was interpreted as a small intrusion of magma. By the following morning, emergency officials reported that the eruption had stabilized and that two of the three vents remained active and continued to fill the floor of Halemaʻumaʻu with lava. By 7:30 a.m. on December 25, 2020, the lava lake had filled in 176 metres (577 ft) of the crater, and the level of the lake was continuing to rise. On January 8, 2021, the depth of the lava lake had increased to 636 feet (194 m). By February 24, the depth of the lava lake in the western, active portion had increased to 216 metres (709 ft). A spatter cone had also formed around the western vent.

The eruption continued for another few months, though activity steadily decreased. On May 26, 2021, the Hawaiian Volcano Observatory announced that Kīlauea was no longer erupting. Lava supply to the lava lake appeared to have ceased between May 11 and May 13, and the lava lake had completely crusted over by May 20. The last surface activity in Halemaʻumaʻu was observed on May 23. At the time activity ceased, the lava lake was 229 metres (751 ft) deep.

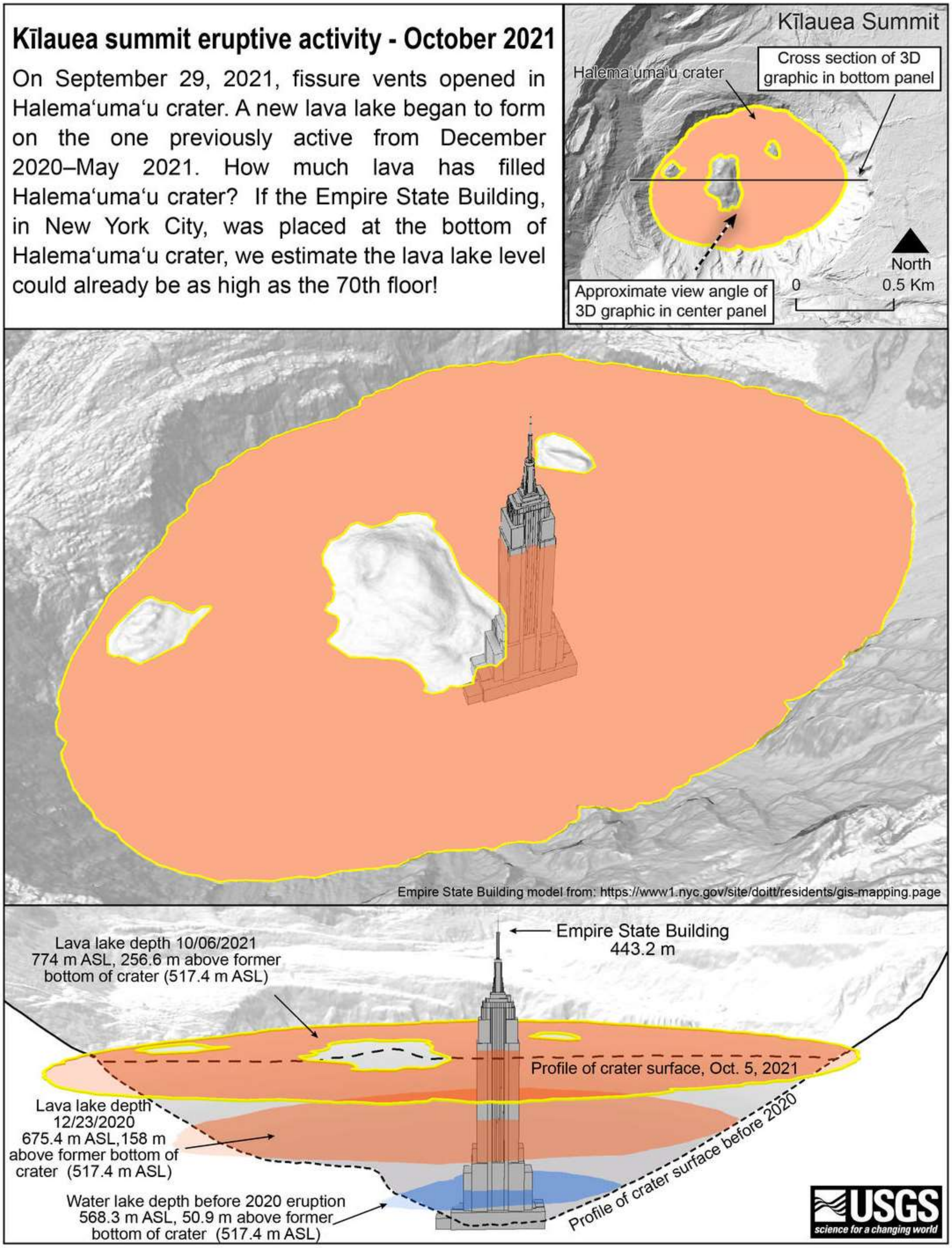
On August 23, 2021, the Hawaiian Volcano Observatory raised Kīlauea's alert status from "Yellow/Advisory" to "Orange/Watch" due to an earthquake swarm and a concurrent increase in ground deformation at the volcano's summit. The observatory stated that the activity potentially indicated "the shallow movement of magma beneath the south part of Kīlauea caldera." The observatory lowered Kīlauea's alert status back to "Yellow/Advisory" two days later after the earthquake swarm and ground deformation waned.

September 2021 summit eruption (ongoing)

The Hawaiian Volcano Observatory began to record increased earthquake activity and changes in ground deformation patterns at Kīlauea's summit at about noon local time on September 29, 2021. An eruption began at 3:20 p.m. local time when several fissures opened within Halemaʻumaʻu crater in Kīlauea's summit caldera. During the initial stages of the eruption, lava erupted in fountains more than 200 feet (61 m) tall, though the height of the fountains declined as the level of lava in the crater rose, partially drowned the erupting vents.

As of December 9, 2021, one eruptive vent continues to be active within Halemaʻumaʻu. Since the start of the eruption, an estimated 36.7 million m^3 (9.7 billion U.S. gal) of lava has erupted, creating a lava lake 66 meters (217 ft) deep and 70 hectares (170 acres) in area (of which 7 hectares (17 acres) has an active surface).

Figure 20


Kīlauea summit eruptive activity - October 2021
On September 29, 2021, fissure vents opened in Halemaʻumaʻu crater. A new lava lake began to form on the one previously active from December 2020–May 2021. How much lava has filled Halemaʻumaʻu crater? If the Empire State Building, in New York City, was placed at the bottom of Halemaʻumaʻu crater, we estimate the lava lake level could already be as high as the 70th floor!
Kīlauea Summit
Halemaʻumaʻu crater
Cross section of 3D graphic in bottom panel
North
0
0.5 Km
Approximate view angle of 3D graphic in center panel
Empire State Building model from: https://www1.nyc.gov/site/doitt/residents/gis-mapping.page
Empire State Building
443.2 m
Lava lake depth 10/06/2021
774 m ASL, 256.6 m above former bottom of crater (517.4 m ASL)
Profile of crater surface, Oct. 5, 2021
Lava lake depth
12/23/2020
675.4 m ASL,158 m above former bottom of crater (517.4 m ASL)
Profile of crater surface before 2020
Water lake depth before 2020 eruption
568.3 m ASL, 50.9 m above former bottom of crater (517.4 m ASL)
USGS
science for a changing world

DETAILED ITINERARY

Day 1: Friday, March 4th, 2022 – Board flight

12:00PM: Depart Johnstown driving to Reagan National Airport. Each person is responsible for getting themselves to-and-from the airport.
3:00PM: Arrive at Reagan National Airport
5:00PM: Board Flight to Seattle (Alaska Airlines Flight 003)
5:35PM: Depart from DC to Seattle (flight duration 6 hrs and 5 min)
8:40PM: Arrive in Seattle, WA (This will be 11:40PM EST), Pick up the rental cars:

and get to the hotel.

Rodeway Inn
2930 S 176th St
SeaTac, WA 98188
(206) 246-9300

Day 2: Saturday, March 5th, 2022 – Seattle and fly to Kona, Hawaii

8:00: Leave the hotel
9:00: Ryan Driving tour of Seattle which will include: Capital Hill, Ballard, Kerry Park, Pike Market, the Columbia Tower, and others. This itinerary is highly dependent on the visibility in Seattle that day, likely it will be overcast, but if it's clear, you'll be in for a treat!
12:00PM: Lunch at Kau Kau in the international district with Daryl.
1:00PM: More stuff
3:30PM: Return rental van and go to airport.
5:55PM: Depart Seattle, WA for Kona, HI
10:15PM: Arrive in Kona, HI. (This will be 12:15AM PST or 3:15AM EST, yikes). Pick up the rental cars:

Enterprise Rental Cars
73 107 Aulepe St
73-200 Kupipi St
Kailua Kona HI 96740-2645
(844) 914-1549

and get to the hotel.

Royal Kona Resort
75-5852 Alii Dr.
Kailua-Kona, HI 96740
(808) 329-3111 in Kona, HI

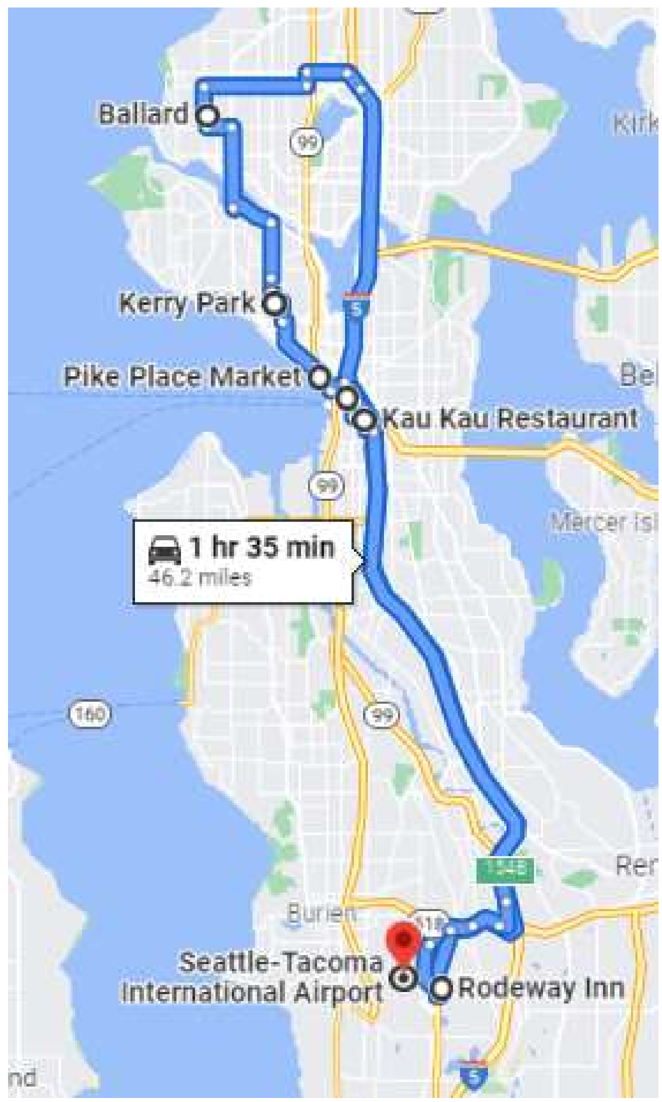


Figure 21 – Route map around Seattle

A LITTLE SEATTLE GEOLOGY:

(*from:* Troost, Kathy, G., and Booth, Derek, B. (2008), Geology of Seattle and the Seattle Area, Washington. The Geological Society of America, Reviews in Engineering Geology. pgs. 1-35.

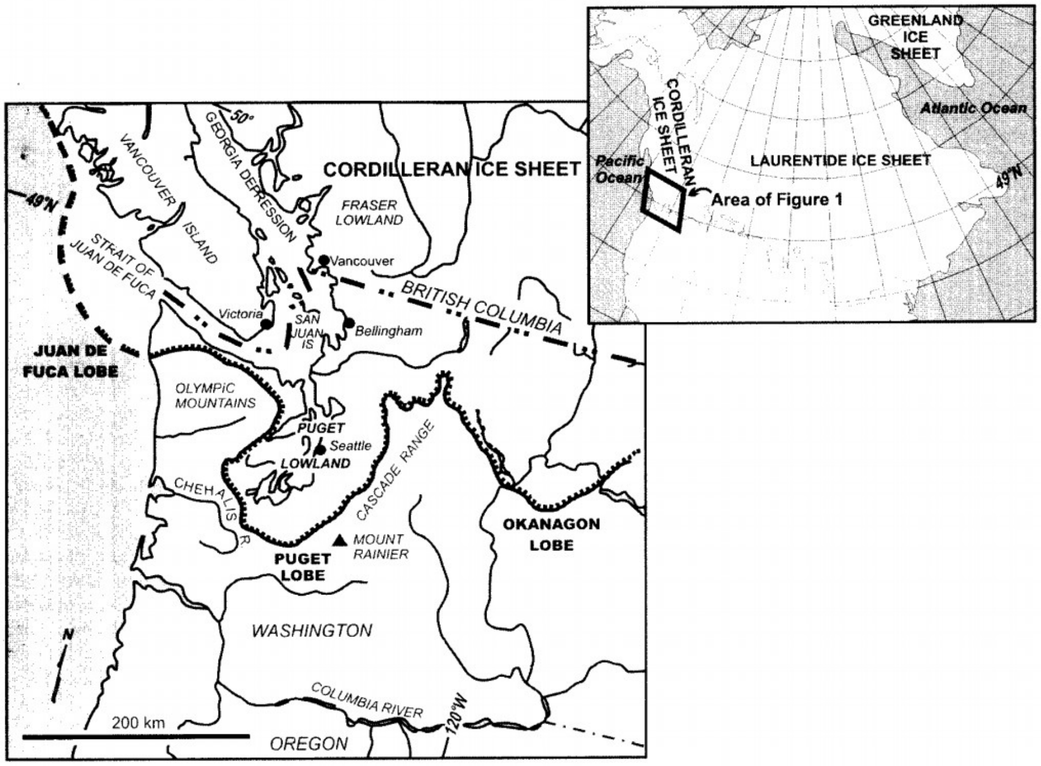


Figure 22 – Location of Seattle, Puget Lowland, and most recent ice limit (shown by hachure marks) in Washington State (modified after Booth et al., 2004)

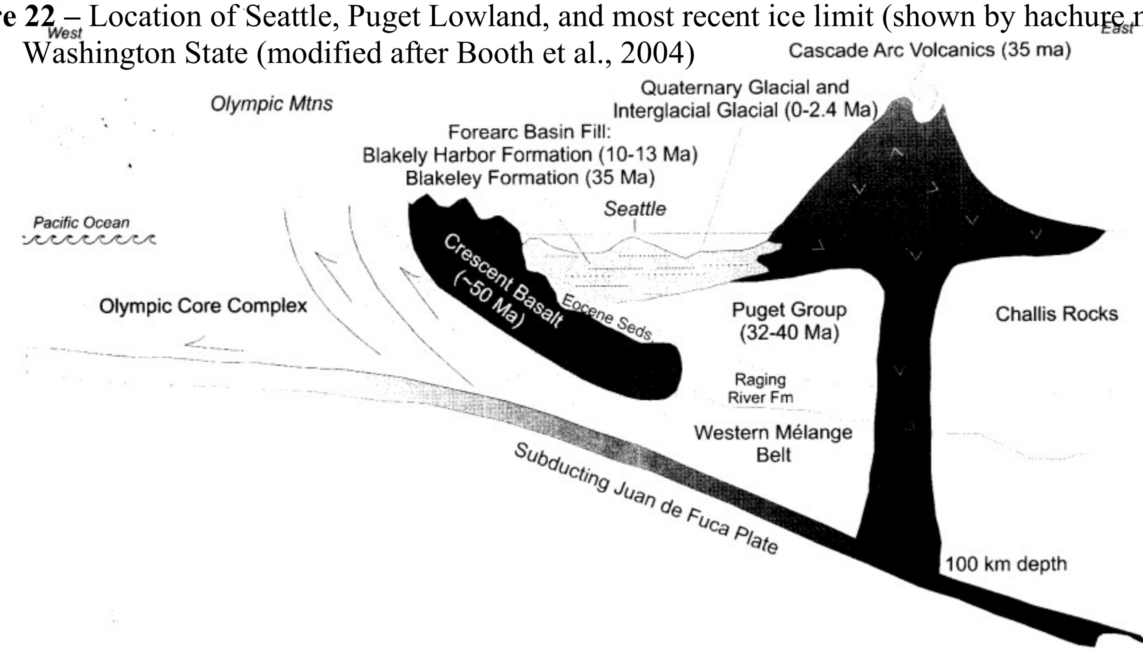


Figure 23 – Diagrammatic W-E cross section across Washington through Seattle, emphasizing the major Tertiary rock units. The Puget Lowland basin is filled with as much as 9 km of young volcanoclastic and sedimentary rocks and Quaternary deposits. Not to scale.

PRE-STOPS:

8:40 PM Friday, March 4th, 2022: Arrive in Seattle, WA (This will be 11:40PM EST). Pick up the rental cars, this will be mini-vans and will be a little tight so don't bring a lot of stuff. Most of your baggage will remain at the airport since this is just technically a layover. We are renting a car from:

Enterprise Rent-a-Car - Seatac
3150 S 160th St Ste 508,
SeaTac, WA 98188
(833) 329-8464

After getting the vehicle we will go straight to the hotel and crash:

Rodeway Inn
2930 S 176th St
SeaTac, WA 98188
(206) 246-9300

7:00AM Saturday, March 5th, 2022: We'll wake early to take advantage of the breakfast included with the price of the room. Then we will pack up all of our stuff and explore Seattle! Hopefully, we can be on the road by 8AM.

STOP 2.1: *Ballard: Ryan and Jess's Old Neighborhood!*

Ballard is Seattle's sweetheart. This historically Scandinavian neighborhood doesn't have many sights outside of the Hiram M. Chittenden Locks; you'll spend more time strolling, shopping, and hanging out than crossing attractions off your list. It's got a great little nightlife, shopping, and restaurant scene on Ballard Avenue, and an outstanding farmers' market every Sunday.

Ballard used to be almost exclusively Scandinavian and working class; it was the logical home for the Swedish and Norwegian immigrants who worked in the area's fishing, shipbuilding, and lumber industries. Reminders of its origins still exist—most literally in the Nordic Heritage Museum—but the neighborhood is undergoing inevitable changes as the number of artists, hipsters, and young professionals (many of whom have been priced out of Fremont and Capitol Hill) increases. Trendy restaurants, upscale furniture stores, and quirky boutiques abound along NW Market Street and Ballard Avenue, the neighborhood's main commercial strips. But no matter how tidy it gets, Ballard doesn't feel as gentrified as Fremont or as taken with its own coolness as Capitol Hill—Ballard still stands apart from the rest of the city.

Ballard used to be its own city: It wasn't a part of Seattle until 1907 when Ballard residents voted to be "annexed" by the city. The citizens of Ballard were responding to a water crisis—which would be solved by becoming part of Seattle—as well as to myriad promises of new and better public services made by Seattle's mayor. Today Ballard residents old and new adopt the "Free Ballard" slogan for many reasons. Although a few people would like to see Ballard revert to being its own city, many simply see it as a way to express neighborhood pride—a way to remind them and the rest of Seattle that Ballard's unique heritage and way of life must be preserved despite being one of the city's hippest neighborhoods. (*from www.fodors.com)*

STOP 2.2: *Space Needle*

Over 50 years old, Seattle's most iconic building is as quirky and beloved as ever. The distinctive, towering, 605-foot-high structure is visible throughout much of Seattle—but the view from the inside out is even better. A less-than-one-minute ride up to the observation deck yields 360-degree vistas of Downtown Seattle, the Olympic Mountains, Elliott Bay, Queen Anne Hill, Lake Union, and the Cascade Range. Built for the 1962 World's Fair, the Needle has educational kiosks, interactive trivia game stations for kids, and the glass-enclosed SpaceBase store and Pavilion spiraling around the base of the tower. The top-floor SkyCity restaurant is "revolutionary" (literally—watch the skyline evolve as you dine) and the elevator trip and observation deck are complimentary with your reservation. If the forecast says you may have a sunny day during your visit, schedule the Needle for that day! If you can't decide whether you want the daytime or nighttime view, for an extra ten bucks you can buy a ticket that allows you to visit twice in one day. (*from www.fodors.com)*

STOP 2.3: *Pike Place Market*

A cavalcade of noise, smells, personalities, banter and urban theater sprinkled liberally around a spatially challenged waterside strip, Pike Place Market is Seattle in a bottle. In operation since 1907 and still as soulful today as it was on day one, this wonderfully local experience highlights the city for what it really is: all-embracing, eclectic and proudly unique.

If you're coming from downtown, simply walk down Pike St toward the waterfront; you can't miss the huge Public Market sign etched against the horizon. Incidentally, the sign and clock, installed in 1927, constituted one of the first pieces of outdoor neon on the West Coast. From the top of Pike St and 1st Ave, stop and survey the bustle and vitality. Walk down the cobblestone street, past perpetually gridlocked cars (don't even think of driving down to Pike Pl) and, before walking into the market, stop and shake the bronze snout of Rachel the Market Pig, the de-facto mascot and presiding spirit of the market. This life-size piggy bank, carved by Whidbey Island artist Georgia Gerber and named after a real pig, collects about $10,000 each year. The funds are pumped back into market social services. Nearby is the information booth, which has maps of the market and information about Seattle in general. It also serves as a ticket booth, selling discount tickets to various shows throughout the city. (*from www.lonelyplanet.com)*

STOP 2.4: *Pioneer Square*

Seattle's birthplace retains the grit of its 'Skid Row' roots with historic redbrick architecture and a rambunctious street life tempered by art galleries and locavore restaurants. The International District broadcasts its scruffy cosmopolitanism with dim sum and pho restaurants. SoDo is an austere warehouse district that's attracting new micro-businesses and pot shops. (*from www.lonelyplanet.com)*

STOP 2.5: *Kau Kau Restaurant*

Here we will have lunch with Daryl Petrarca of Adapt Engineering, Ryan's old boss. An International District fixture for over 30 years, the Kau Kau Restaurant is famous for its terrific barbecued meats. Now you can order your favorite Kau Kau specialities online for pick up at the restaurant. Of course, we are always happy to serve you if you come by to enjoy our excellent food at the King Street location.

STOP 2.6: *Capitol Hill*

Capitol Hill is Seattle's most unashamedly hip neighborhood where the exceptionally rich mix with the exceptionally eccentric. While some of its tattier edges are being gradually gentrified, this is still Seattle's best crash-pad for dive-bar rock-and-roll, LGBTIQ frivolities and easy-on-the-environment lunches. More straitlaced First Hill is home to an art museum and multiple hospitals. (*from www.lonelyplanet.com)*

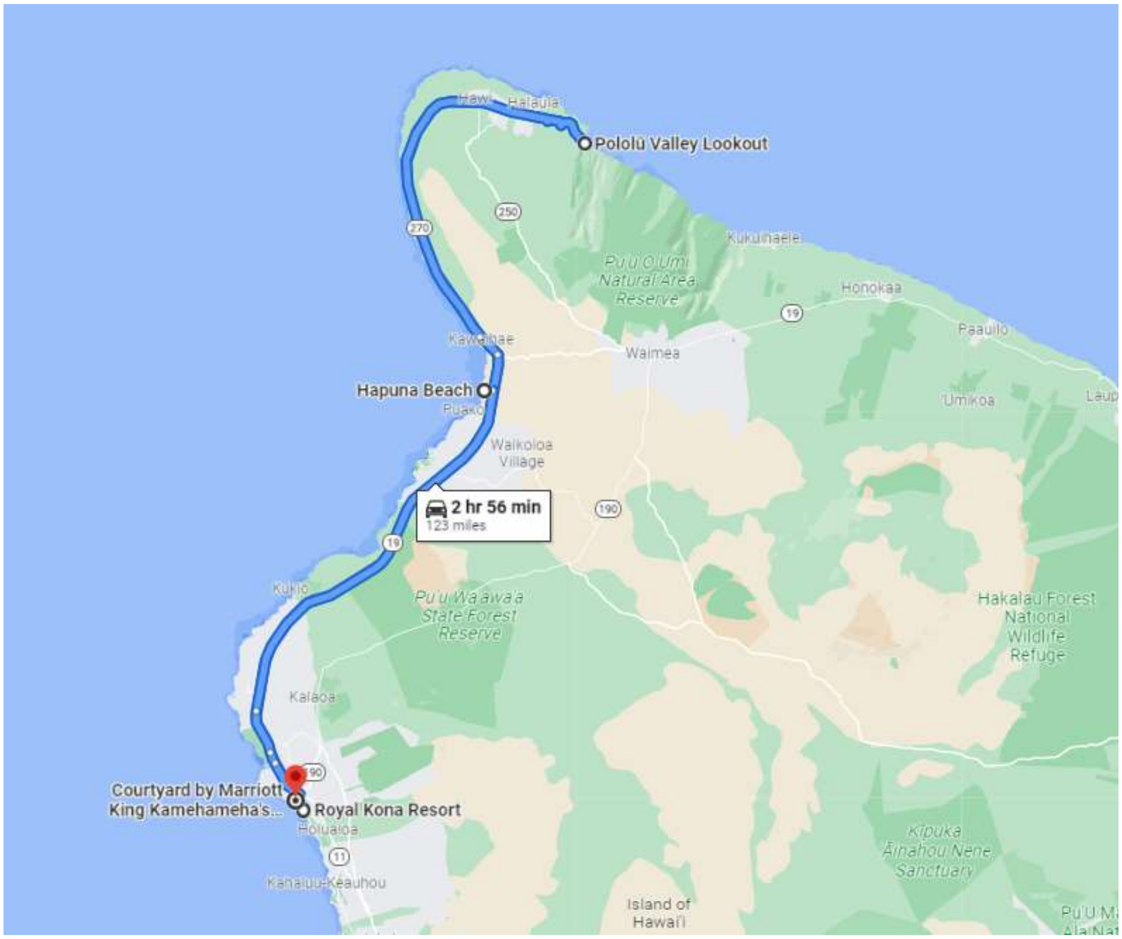
3:30 PM: Return rental van and go to airport.

5:55 PM: Depart Seattle, WA for Kona, HI

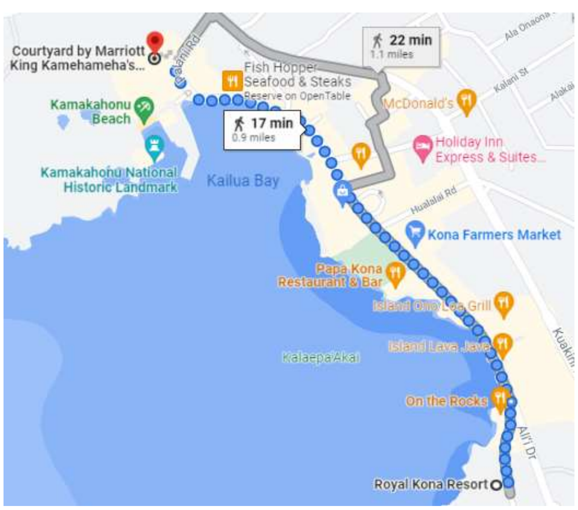
10:15 PM: Arrive in Kona, HI. (This will be 12:15AM PST or 3:15AM EST, yikes). Pick up the rental cars:

Enterprise Rental Cars
73 107 Aulepe St, 73-200 Kupipi St
Kailua Kona HI 96740-2645
(844) 914-1549

Day 3: Sunday, March 6th, 2022 – Kona to Kohola Area



8:00 AM: Load up the vans, find some breakfast, then go get groceries
10:00 AM: Depart Kona for the North Side of the Island
11:30 AM: Kohala Mountain Overlook and Lunch
12:30 PM: Pololu Valley Lookout and hike down into valley
2:30 PM: Hapuna Beach for some "coastal processes"
4:00 PM: Return to Hotel
5:00 PM: Walk from the hotel to the luau (luau starts at 5:30PM)



Luau Location:

King Kamehameha's Kona Beach Hotel
75-5660 Palani Rd
Kailua-Kona, HI 96740

STOP 3.1: *Kohala Mountain "Cherished land"*

Kohala Volcano is the oldest of Hawaii's five subaerial volcanoes and probably emerged above sea level more than 500,000 years ago. Large portions of volcano slid into ocean 150,000 to 400,000 years ago. Toward the end of its shield-building stage 250,000 to 300,000 years ago, an enormous landslide removed the volcano's northeast flank, producing a steep scarp. Twenty kilometers wide at the shoreline, the landslide cut back to the summit of the volcano, which at the time was just over 1,000 m higher than today, and traveled 130 km across the ocean floor. The famous sea cliffs of windward Kohala shoreline mark the topmost part of the headwall of this ancient landslide (Figure 24).

When eruptions had built Kohala's broad shield to its greatest extent, the volcano was more than twice as wide as it is today. Based on an abrupt change in angle of the submarine slope at a depth of about 1,000 m, scientists estimate the subaerial part of the island at this time was more than 50 km wide. Then, when the rate of eruption decreased more than 300,000 years ago, the slow subsidence of the Island outstripped the rate of growth of the volcano, which slowly began to sink beneath sea level. But to the southeast, lava flows from Mauna Kea and Mauna Loa buried the southern flank of Kohala.

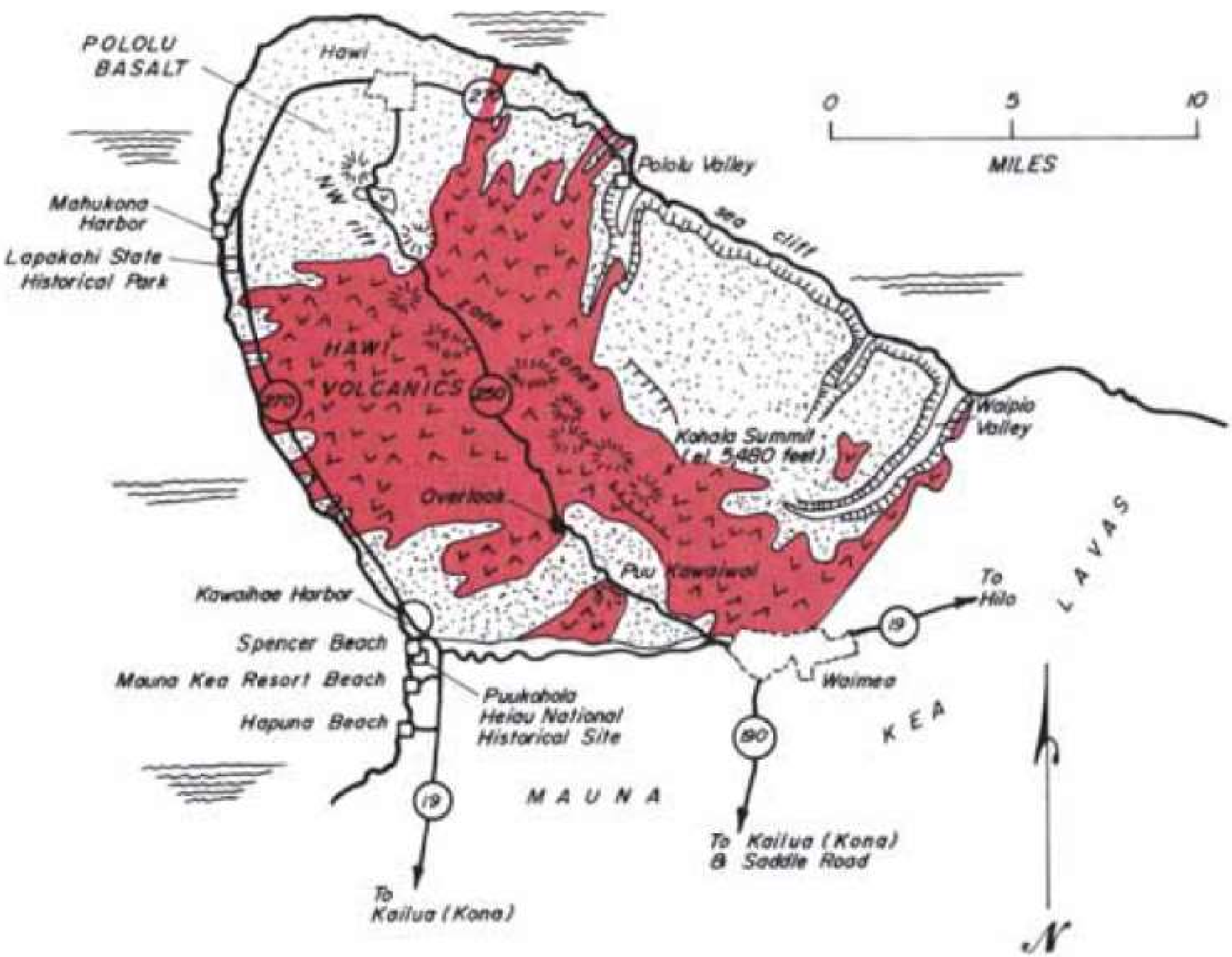


Figure 24. Location map of Kohala volcano (from Halzett and Hyndman, 1966, p.111)

The volcano is 20 miles long and has 2 rift zones (NW and SE). Route 250 follows the NW rift zone. The elevation is 5,480 feet but was 5,280 feet higher in the past. The older Hawaiian lavas are part of Pololu Formation (730,000 Ka). Local alkalic cinder cones are from the Hawi Formation, dated by ^{40}K-^{40}Ar techniques. On the way up to the **benmoreite** locality we will pass a quarry of **hawaiite** lava from

Pu'u Kawaiwai cinder cone. Near the top of the summit, note the dome of light-colored grayish benmoreite in the large road cut that locally contains phenocrysts of black hornblende and plagioclase. These rocks cap the 1,980' thick Pololu volcanic series which is tholeiitic in the lower part and alkali olivine basalt at the top. These rocks are also exposed on the cliff faces at the Waipi'o valley!

STOP 3.2: *Polulu Valley*

The following is taken from http://uwec-geog368.weebly.com/polol363-valley.html *(mostly)*

Overview:

A lookout at the end of Highway 270, which is at the top of a sea cliff, provides a fantastic view of the Pololū Valley below. The name Pololū translates from the Hawaiian language to "long spear" (Bishop Museum, 2011). The Pololū Valley is the northernmost of a series of valleys that lie along the windward east slopes of the Kohala Mountain in the district of North Kohala of the big island of Hawai'i. The Pololū trail, which goes down to the bottom of the valley, begins where the paved road of the highway

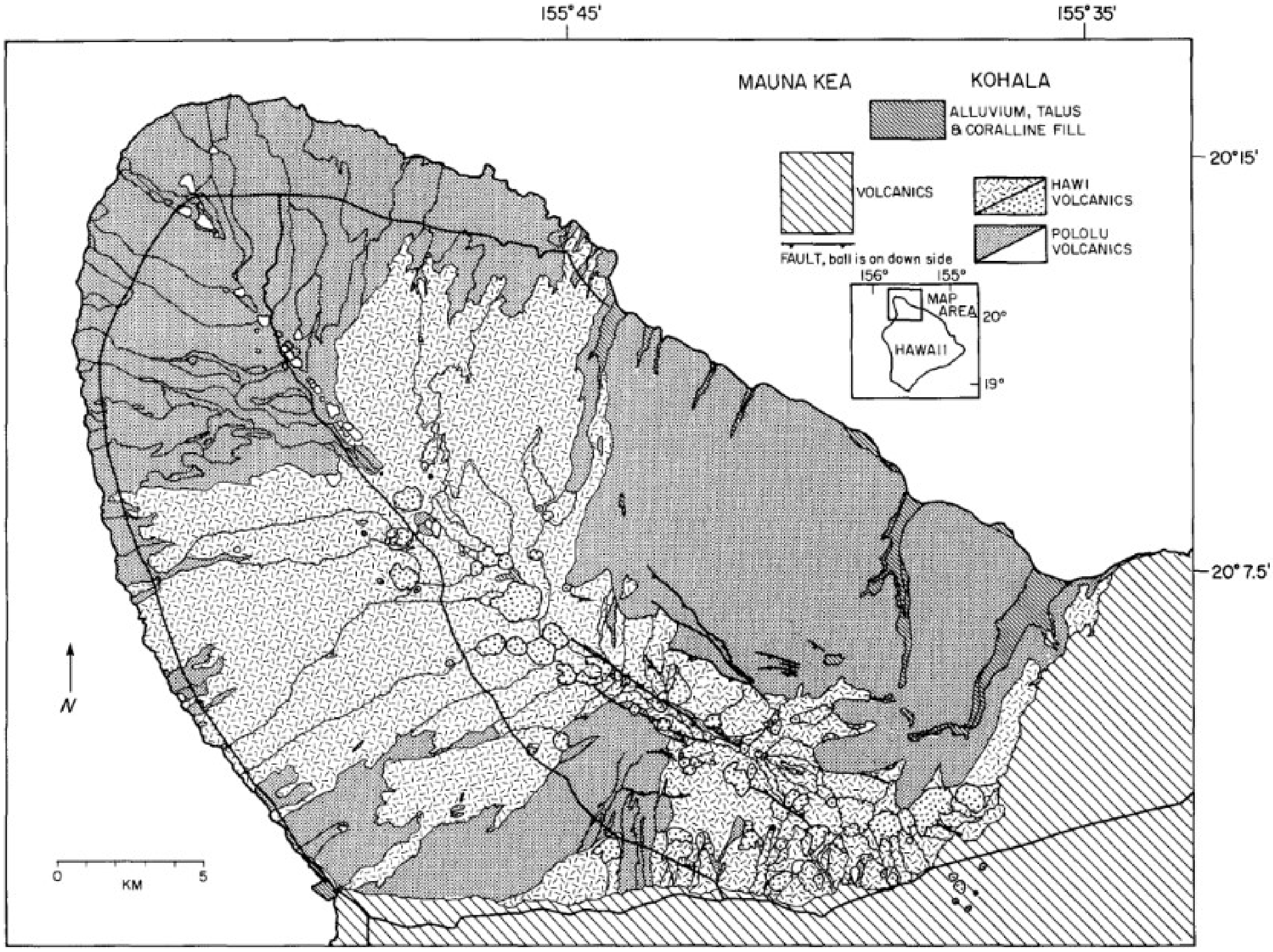


Figure 25: Geologic map of the northern portion of the island of Hawaii. Kohala Volcano is subdivided into two units: Pololu and Hawi lavas. Flows for each of these units are shown by the upper pattern in the boxes; cinder cones are shown by the lower pattern. Younger and coeval lavas from Mauna Kea abut Kohala on its southern flank. Major roads are shown by solid lines. Geology by M. Garcia, S. Porter and S. Spengler after H. Stearns (Stearns and Macdonald 1946)

ends. The topography transitions sharply from steep valley sidewalls to a relatively flat valley floor which lies close to sea level, about a mile long trail with about a 420 ft elevation difference between top to bottom. The slopes that boarder the valley increases in height gradually from downstream valley sidewalls towards the headwaters of an ephemeral stream. This is characteristic of these series of windward Kohala valleys and is a result of the headward-migrating canyon wall (Vitousek et al, 2010). At the valley bottom, the mouth of the valley consists of a black sand beach, bordered by wave-eroded and landslide-prone sea cliffs on its northern and southern, seaward sides. Tuggle and Tomonari-Tuggle (1980) offers a detailed description of the valley floor that is still relative to what is seen today:

> "Dominated by a sand dune…the mouth of Pololu extends some 500m wide [at the coast], with the stream outlet to the NW side. The valley floor extends inland for about 2500 m. at a 1 to 2 degree slope from a swampy area behind the dune to a small waterfall with plungepool, which separates the lower alluvial floor from an upper gulch. The lower valley has an area of some 100 ha."

Geology of the Pololū Valley

Kohala Mountain, once an active volcano, last erupted around 120, 000 years ago. Valleys like Pololu were initially created by large, seaward landslides that occurred along the slopes of the Kohala Volcano, as evidenced by large areas of rocks and sediments that cover the nearby seafloor. The valley was filled in by lava flows during two eruptive episodes from the Kohala volcano (Fig 25). The geology of the valley and its surrounding uplands consists of tholeiitic basalts of the Pololū volcanic formation formed from eruptions dating back 400-600 thousand years before present (B.P.), and a more alkali Hāwāi formation basalts from eruptions that occurred 150-200 thousand years B.P. (USGS, 1998; C. M. Riley, 1980).

The Pololū Dunes

The Pololū Dunes (noted as a single dune in Tuggle and Tomonari-Tuggle, 1980) located at the mouth of the valley lie directly above the beach (Fig. 26) and are estimated to be about 30 m above sea level at their highest part and extend 400 m parallel to the beach (Field and Graves 2008). The dunes are composed of eroded alluvial deposits which are argued to originate from discontinuous flood sequences of the ephemeral Pololū Stream. Wind and waves have pushed the dunes due southeast of the shoreline and have been altered by winter storm surges. According to Field and Graves (2008), these storm surges are said to be the reason for erosion on northern slopes and deposition of rounded, waterworn boulders and cobbles on the beach. Tsunamis have also morphed the landscape of the valley and most likely the dunes. In the 1950s ironwood trees (Casuarina sp.) were planted on the dunes' slopes and peaks as a means to decrease erosion (Field and Graves 2008).

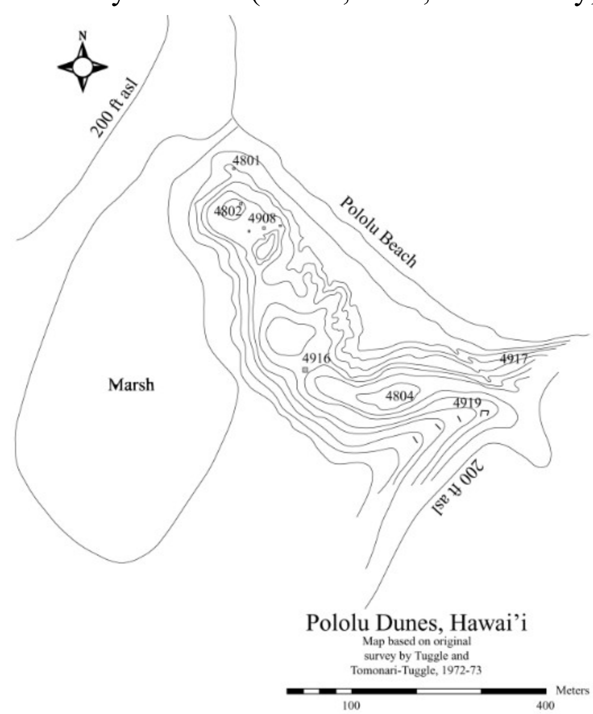


Figure 26. Map of Pololu Dunes with excavation units and sites indicated. Redrafted from original by Tuggle and Tomonari-Tuggle, 1972–1974. Topographic contour on dunes 10 feet; highest point of dunes is approximately 50 feet.

Archaeological Research in the Pololū Valley

Archaeological investigations of the Pololū Valley took place as part of a 1970s research project initiated by H. David Tuggle and Myra Tomonari-Tuggle (Fig. 27). The results of this project suggested that the Pololū Valley was used for the production of Hawaiian taro (the Hawaiian name for which is *kalo*) along with other crops. Two different systems of agriculture were evident in the valley: non-irrigated dryland agriculture and irrigated wetland agriculture. Chronometric dating work by Field and Graves (2008) revealed that the dunes that lie at the mouth of the valley may have been occupied as early as AD 1200 and occupation of the interior of the valley is said to span the 13th to the 15th centuries AD. Based on their findings, Field and Graves came to the conclusion to the following conclusion:

> "[S]ome terraces were used for irrigated cultivation, but there is also evidence for the resumption of dryland cultivation in later periods. Other terraces contained deposits that suggest that dryland and wetland cultivation was practiced simultaneously at the site. Chronometric dating from what are most likely irrigated contexts... suggest their construction after the 17th century. Historic materials at both sites indicate continued occupation and the use of these complexes into the late 18th and early 19th centuries." (2008)

This valley was also a resource for lithic and building materials and there is evidence of quarrying. One of only three known quarries on the big island of Hawai‘i, the Pololū Valley provides a coarser-grained material. This material has been used for adze production and the construction of a number of heiaus, including the Mo'okoni and Pu'ukoholā heiaus (Na Maka o ka Aina, 2011; Northwest Research Obsidian Studies Laboratory, 2011).

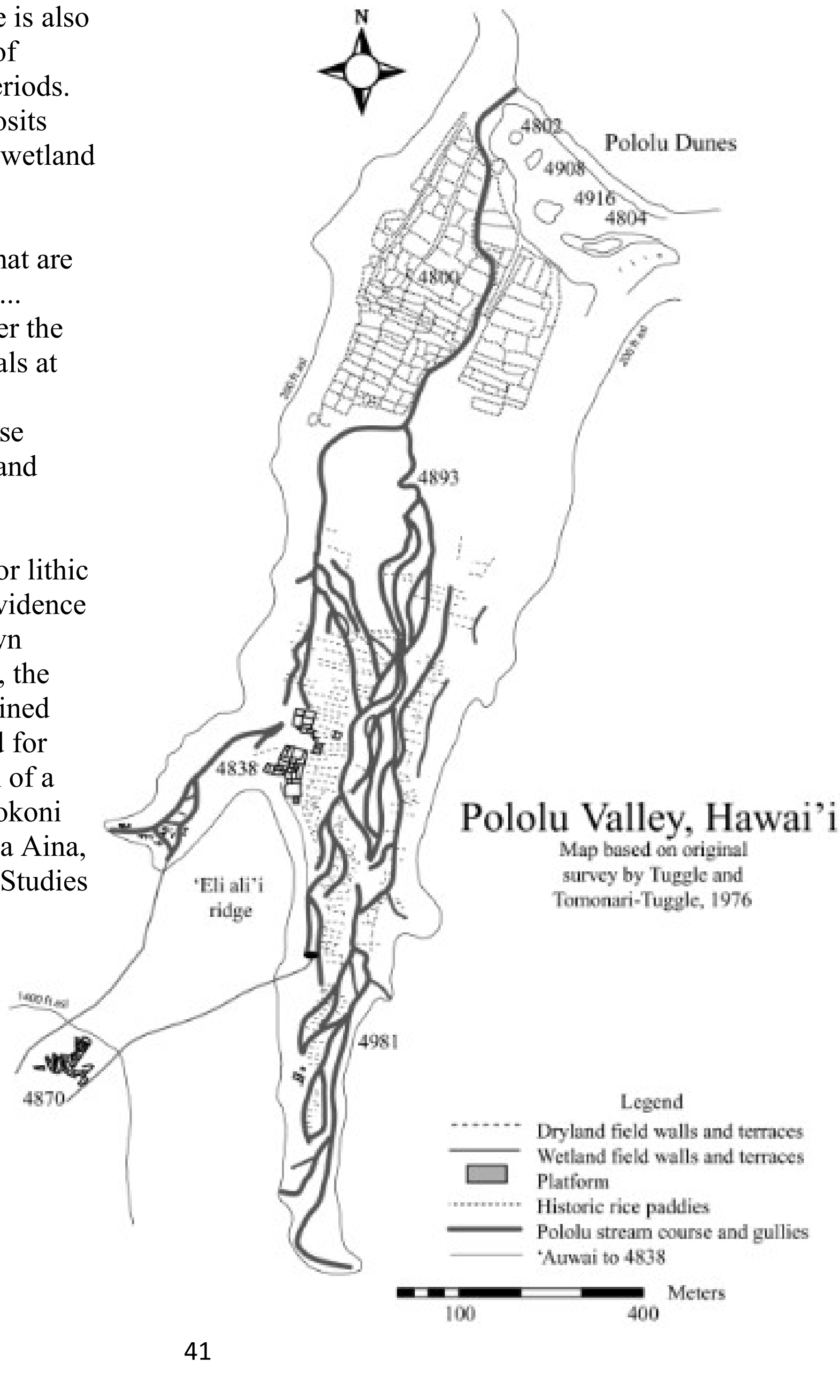


Figure 27: Map of the Pololu Valley showing major sites and features. (Field and Graves, 2008, Figure 2, p. 208)

STOP 3.3: *Hapuna Beach*

Hāpuna - (a spring or spring-fed pool)

Hāpuna Bay was named for Leina-Hāpuna, an ali'i (chief) who was married to Kalaoa. They were both master riddlers.

Hapuna Beach lies along the northern sector of the western coast of the island of Hawaii, within Kawaihae Bay. This sector has most of the good beaches, of which there are but few on Hawaii. Hapuna is a long, straight beach, more than 1/2-mile in length, that reaches a maximum width of 210 feet during the summer. By early fall, however, the beach has eroded back more than 100 feet. Sand thickness in the summer is greater than 10 feet. Calcareous grains predominate in the well sorted, medium-sized sand. Both ends of the beach are bounded by points of lava. Grass and kiawe trees occupy the sandy backshore.

Hawaii has exceptional white sand beaches. The white sand on the beaches of Hawaii is almost all broken shell pieces from marine organisms. Pieces of snail shells and coral are common in the white sand. In California the white sand on the beaches has almost no shell material and is primarily composed of light colored minerals from the continental rocks that have eroded and washed to the ocean. Although the white sandy beaches of Hawaii and California may look alike, they are very different. Hawaii's white sand beaches are biological and California's are physical in origin.

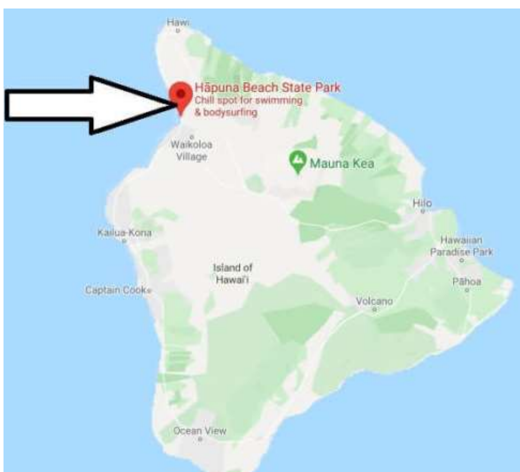


Figure 28: Location map and aerial photography of Hapuna Beach.

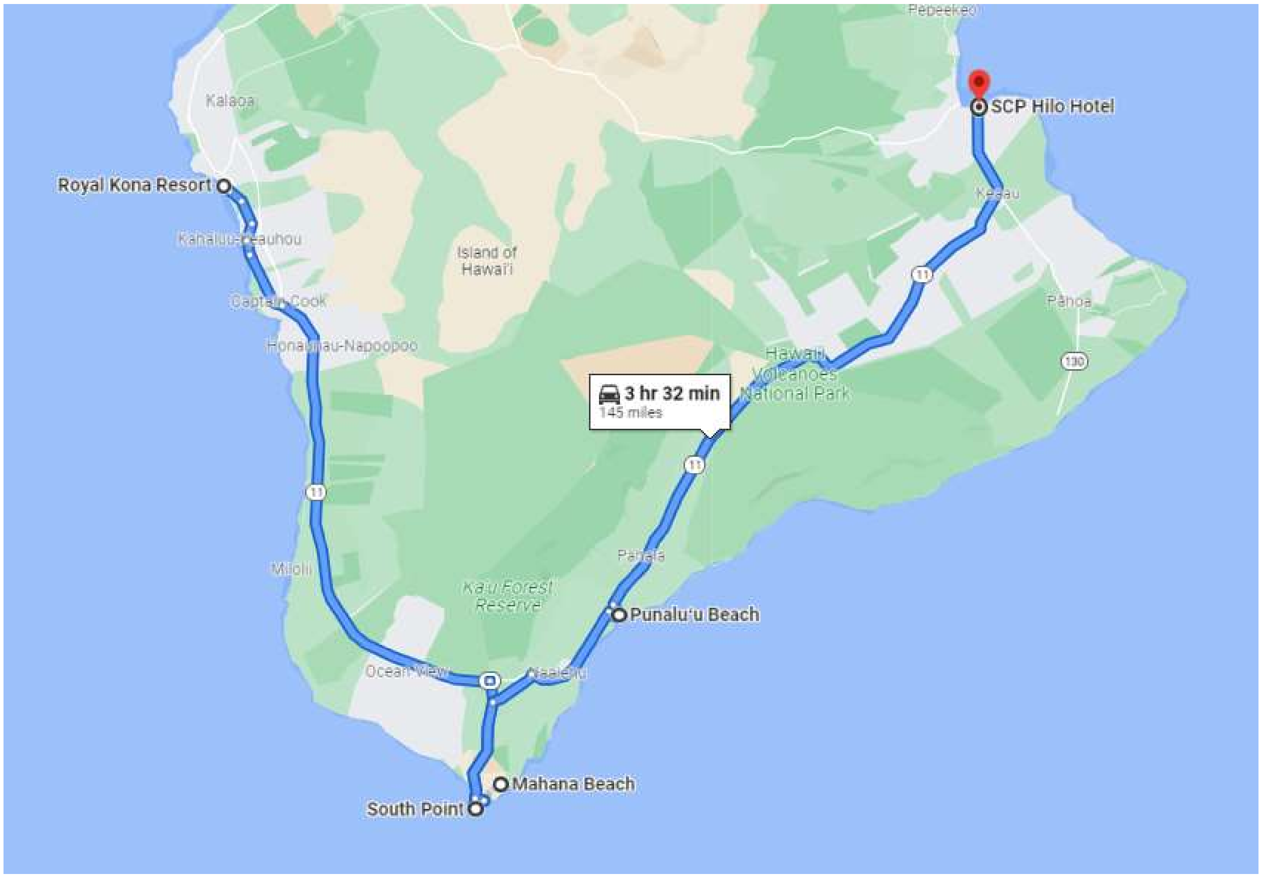
From Hazlett and Hyndman, 1996, p.109:

Hawaii 19 meets the road to Hapuna about 30 miles north of Kailua. Like ‘Anaeho’omalu, Hapuna Beach is made of tan calcareous sand eroded from offshore reefs. The beach has a gradual submarine slope, making it ideal for swimming and wading on calm days. On clear days, you can see the crest of Haleakala on Maui, 10,000 ft high and 50 miles to the northwest, across ‘Alenuihaha Channel.

A rare variety of basaltic lava called ankaramite makes up the ledges at the north end of the beach. This flow erupted from Mauna Kea during late-stage activity. Look for blocky crystalsblack pyroxene and glassy crystals of yellowish green olivine.

After a day of hiking and beach time, we are off to the Luau!

Day 4: Monday, March 7th, 2022 – Kona to Hilo: South Point, Mahana Beach (Green Sand Beach), and Punalu'u Beach (Black Sand Beach)



7:00 AM: You are on your own for breakfast
8:30 AM: Load up the vans and depart Kona for the South Point
10:00 AM: South Point Cliffs
11:00 AM: Mahana Beach (Green Sand Beach) and Lunch. It is about a 1 hr hike to the beach, hopefully we can drive to it but we'll see, it is worth the hike.
2:00 PM: Punalu'u Beach (Black Sand Beach). Pretty cool to see but likely a quick stop.
4:00 PM: Arrive at the hotel in Hilo: SCP Hilo Hotel
126 Banyan Way
Hilo, HI, 96720, United States
(808) 935-0821

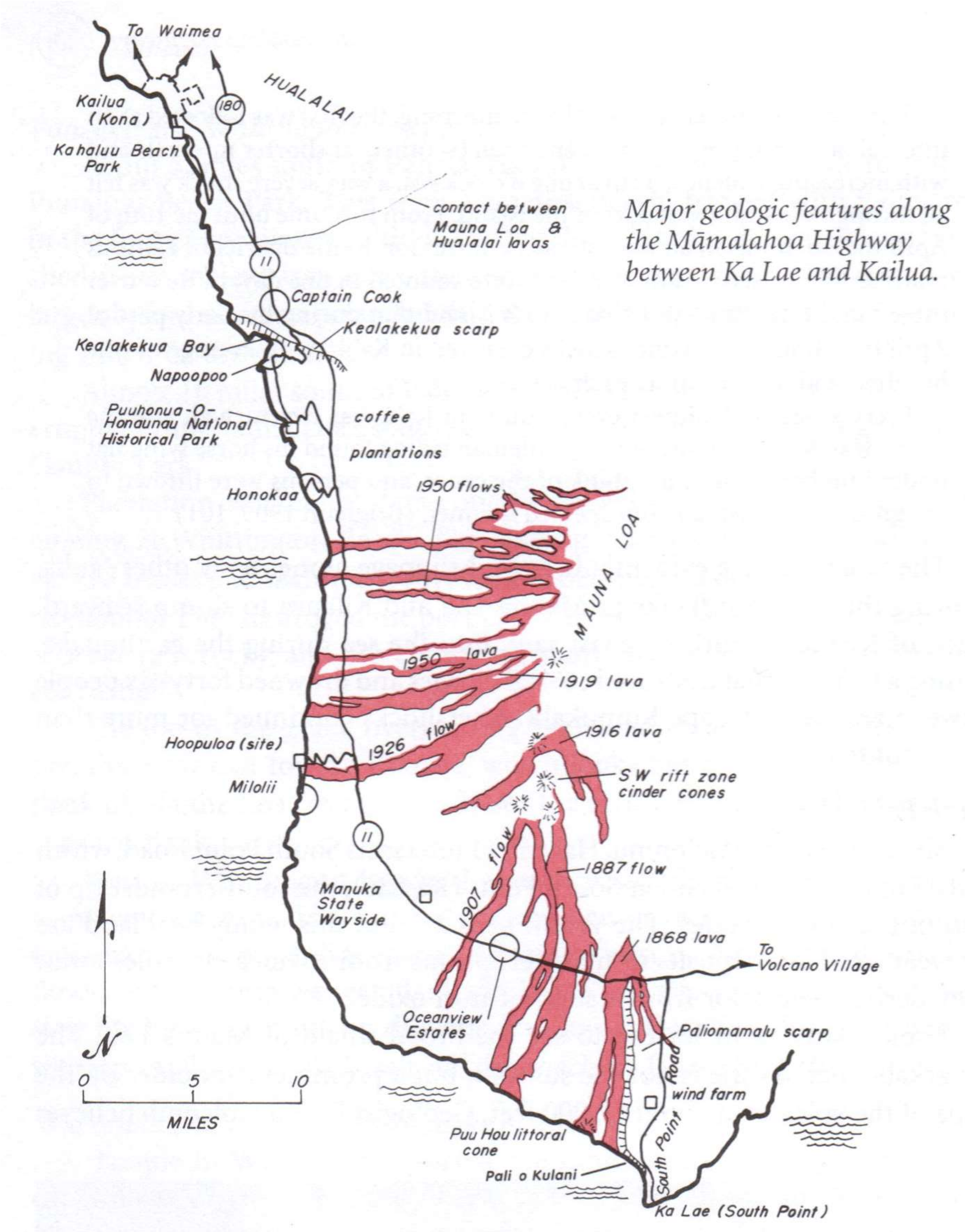


Figure 29 - The major geologic features during the drive from Kona south to Ka Lae (South Point). (Hazlett and Hyndman, 1996)

STOP 4.1: *South Point Cliffs*

This is the southernmost tip of land in the United States. Yellow soils around this windy headland are the weathered ash deposits of many eruptions from Kilauea, 40 miles away. They derive their color from a stain of iron oxide. Look inland from Ka Lae to the broad shield of Mauna Loa. The remarkably flat skyline is not the summit, but a prominent shoulder on the slope of the volcano at about 12,000 ft. Geologist Robin Holcomb believes this shoulder could have formed when a former caldera of Mauna Loa, much larger than Moko'aweoweo caldera, was filled to overflowing with lava. The young flows then built the modern summit, leaving a break in the slope that marks the edge of the old caldera. Moko'aweoweo formed later, around 600 years ago.

STOP 4.2: *Mahana Beach (Green Sand Beach).*

One of South Point's most famous scenic spots is Mahana Beach, also called Green Sands Beach because it has a distinctive golden green color (Figure 91). "The grains of green sand are olivine (or call it peridot if you wish although not much of the sand is truly of gem quality), a common mineral in much of the Hawaiian basalt, and as the basalt undergoes weathering the olivine becomes concentrated on this beach due partly to its high specific gravity." (They are apparent as green flecks in the raw lava stones used to build the columns and walls of the Jagger Museum at Kilauea's Volcano National Park.) As lava reached the coast, erosional forces, and the specific gravity of the stones, perhaps are responsible for the accumulation of such a large quantity of the granules that produced the green sand beach.

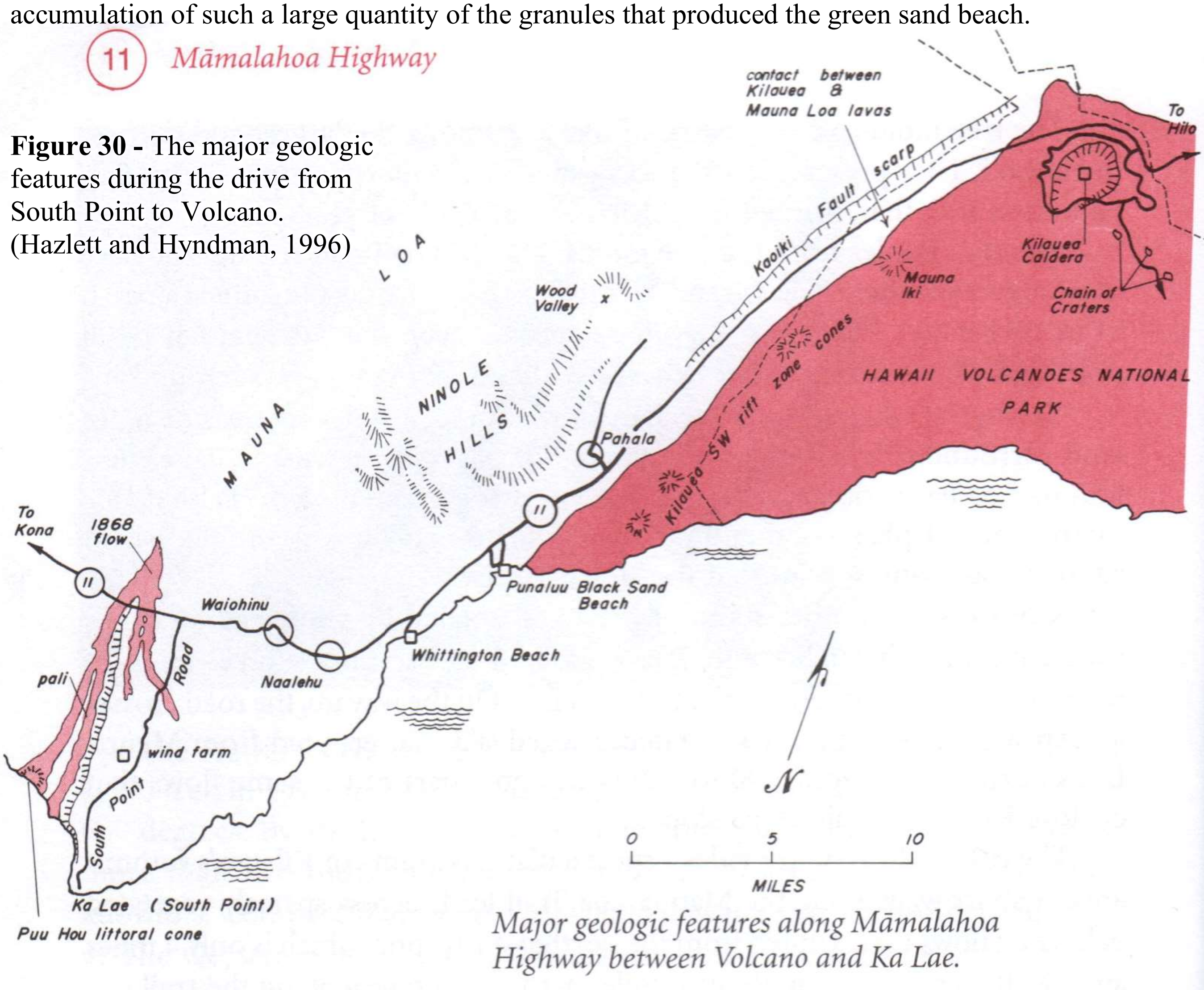


Figure 30 - The major geologic features during the drive from South Point to Volcano. (Hazlett and Hyndman, 1996)

STOP 4.3: *Punalu'u Beach (Black Sand Beach)*

Punaluu Beach is the most famous, most visited and easiest to access black sand beach on the Big Island. A trip to this stunning place requires about an hour drive from Hilo. Located in the far off Kau District, Punaluu Beach is located just of Highway 11, between the towns of Na'alehu and Pahala (approximately 4 .5 miles from either town). There are two access roads with well-marked signs for Punaluu Black Sand Beach/Sea Mountain Resort, so if you miss one turn, there will be another coming up in less than a mile.

Punaluu Beach is a popular site and you will not have it to yourself. With this said, you can be one of the few souls here if you come early in the day. This is the best time to avoid the crowds while getting to see the other main attraction at Punaluu...the Honu (sea turtles). The sand here is truly black. Not gray or salt and pepper, but a deep, pure jet black. The blue Pacific Ocean breaking on the black sand is an amazing sight.

The sand can get hot, since it is usually sunny in the Kau District. If so, there are plenty of beautiful, swaying coconut palms under which to spread your towel. Jumping into the ocean is a matter of taste. The water is typically pretty chilly, since the bottom of the bay has many fresh-water springs pumping cold water into it. Also, the water can be very rough. So, if you think a dip will be refreshing, you are probably correct, but beware of the surf. If there is no one else in the ocean, it is safest to refrain from going in yourself.

When the sea is calm, there is always the opportunity to swim or snorkel with the turtles. This is one of their favorite spots and early in the day there can be many of them paddling around, or sprinkled along the shore, resting after a seaweed breakfast. Photograph these beautiful and gentle creatures to your heart's content, but do not touch them. Turtles are an endangered species and it is illegal to touch or harass them in any way as they maintain legal representation.

Figure 31 - Sea turtle on Punalu'u Beach (uncredited web photo).

Day 5: Tuesday, March 8th, 2022 – Hilo: Volcanoes National Park

7:30 AM: Depart from the hotel and drive to Volcanoes National Park
9:00 AM: Arrive at the Kilauea Overlook and meeting with Dr. Drew Downs (USGS)
10:30 AM: Steam vents and Sulphur Banks (Ha'akulamanu) – short hike
12:00 PM: Lunch at the Kilauea Overlook
1:00 PM: Hike the Kilauea Iki Trail
3:30 PM: Hike the Nahuka - Thurston Lava Tube
4:30 PM: Depart Volcanoes Natl. Park and Return to Hilo for Dinner

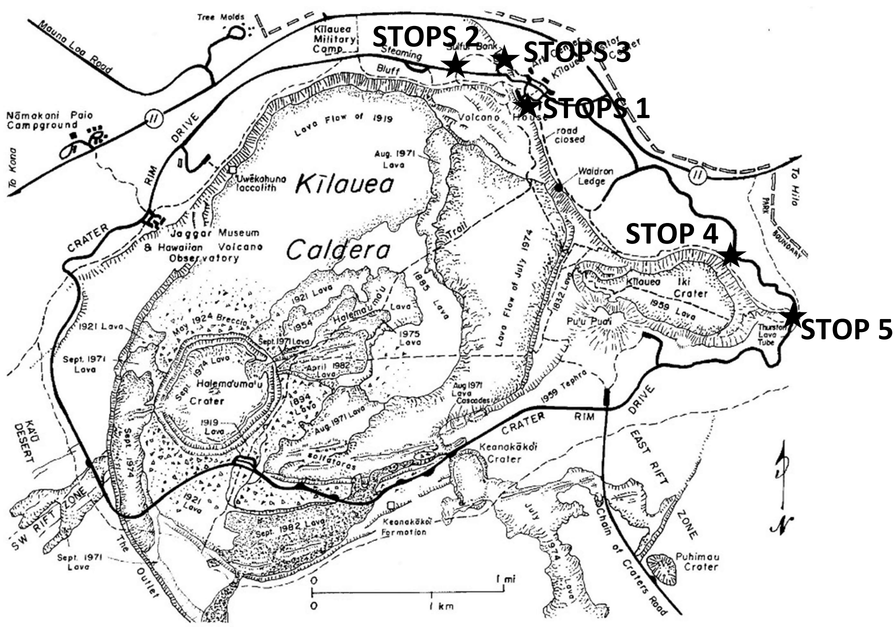


Figure 32 – Overview map of the Kilauea Crater Area (*see the larger version on the upcoming page*).

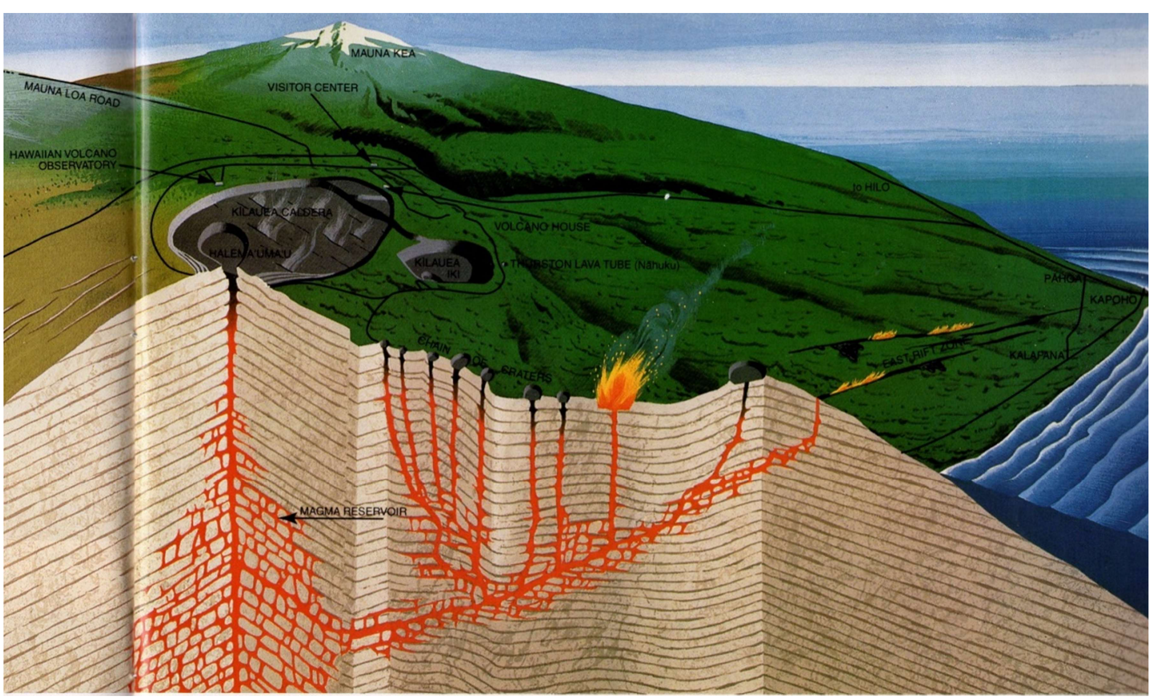


Figure 33 - Cross-section view of the Kilauea volcanic system (Babb, 1999).

BACKGROUND GEOLOGY

Kilauea Volcano and Hawaii Volcano National Park

Hawaii is perhaps the most famous shield volcano in the world and certainly the most visited. Starting in 1916, the Hawaii Volcano National Park which is located at Kilauea has drawn spectators from all over the world. Showing constant eruption beyond recorded history, surely it was noticed by at least a few inhabitants and voyeurs. Not the highest peak in Hawaii at 1,248 m (See Table 1), the activity at Kilauea has produced a plethora of volcanic features of great interest to students of geology. Kilauea is a broad shield-type volcano built upon the southeast slope of Mauna Loa, the "big mountain". The lavas of Mauna Loa lap against the northwestern margin of Kilauea (compare Figure 2 with Figures 34 and 35.) The summit of Kilauea is marked by an elongate caldera 4 km long by 3.2 km wide and 120 m deep along its western side. The caldera walls decrease to zero toward the south and within the caldera lies a circular crater known as Halema'uma'u (Figure 36), the site of magnificent basaltic volcanicity for the past century. Two rift zones extend southwestward and eastward from Kilauea caldera and these have localized flank eruptions. The eastern rift zone bends sharply extending 8 km southeastward from the caldera then bends extending east-northeastward toward Cape Kumukahi and onward toward the ocean floor.

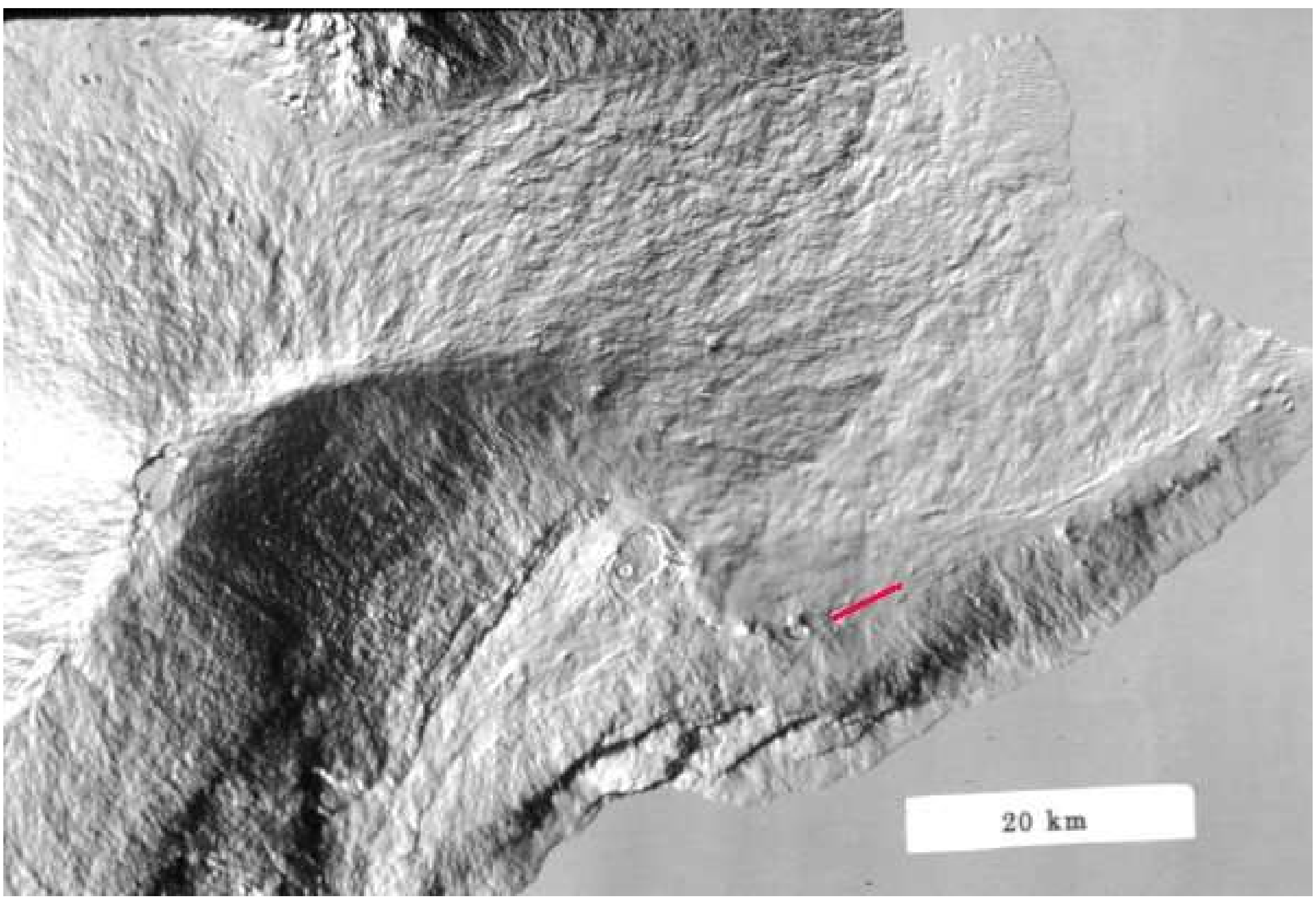


Figure 34 - Digital elevation map of Mauna Loa and Kilauea showing Kilauea's Summit. Note the oval-shaped collapse structure in the bottom center of the image, a huge caldera perched on the top of the summit. (From www.uhh.hawaii.edu/~kenhon/GEOL205/petrology/default.htm.)

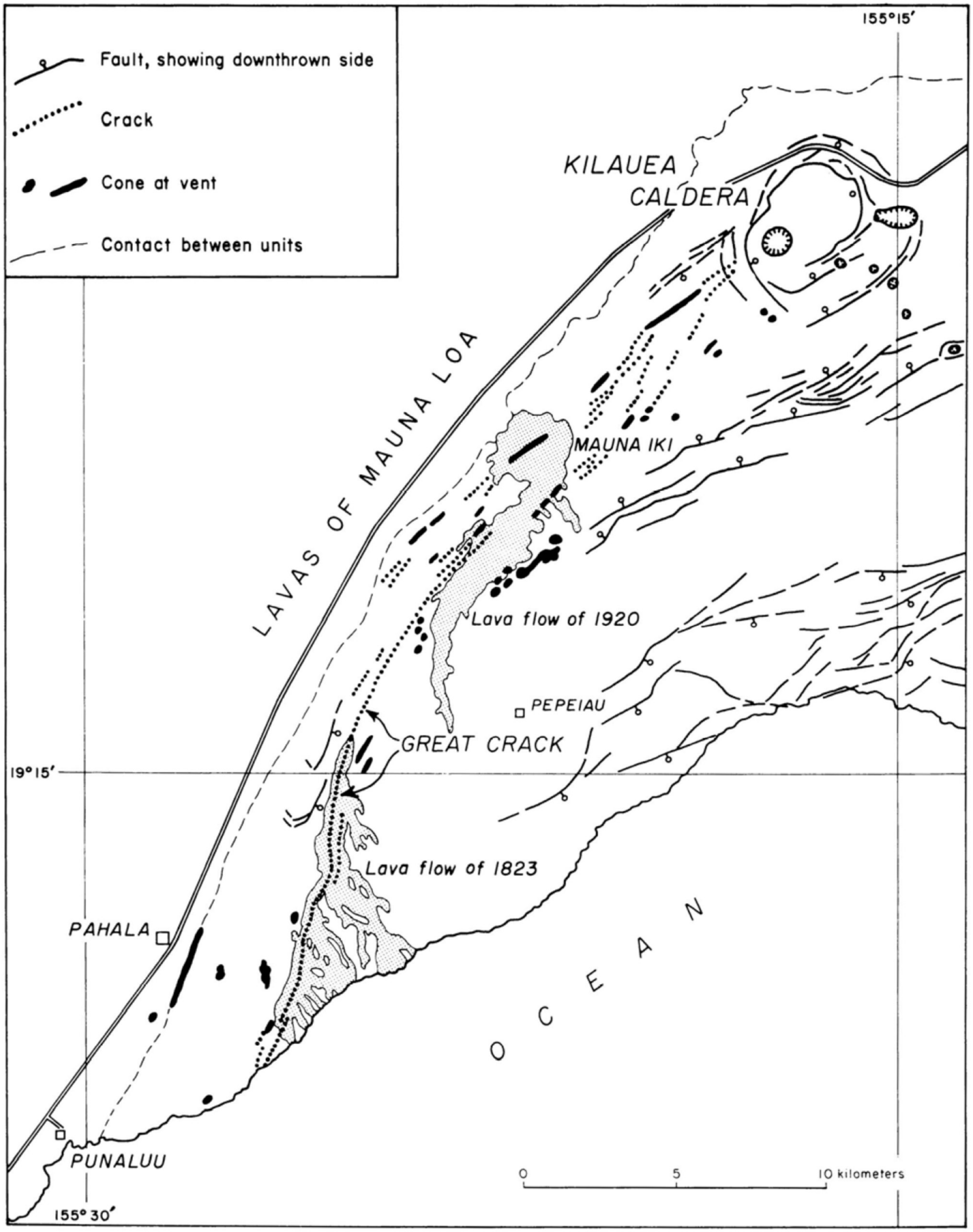


Figure 35 - Map of the western part of Kilauea volcano showing faults, fractures, and cones along the Southwest Rift Zone and the position of lava flows from 1823 and 1920. (From Macdonald and others, 1983, Fig. 3.12, p. 78.)

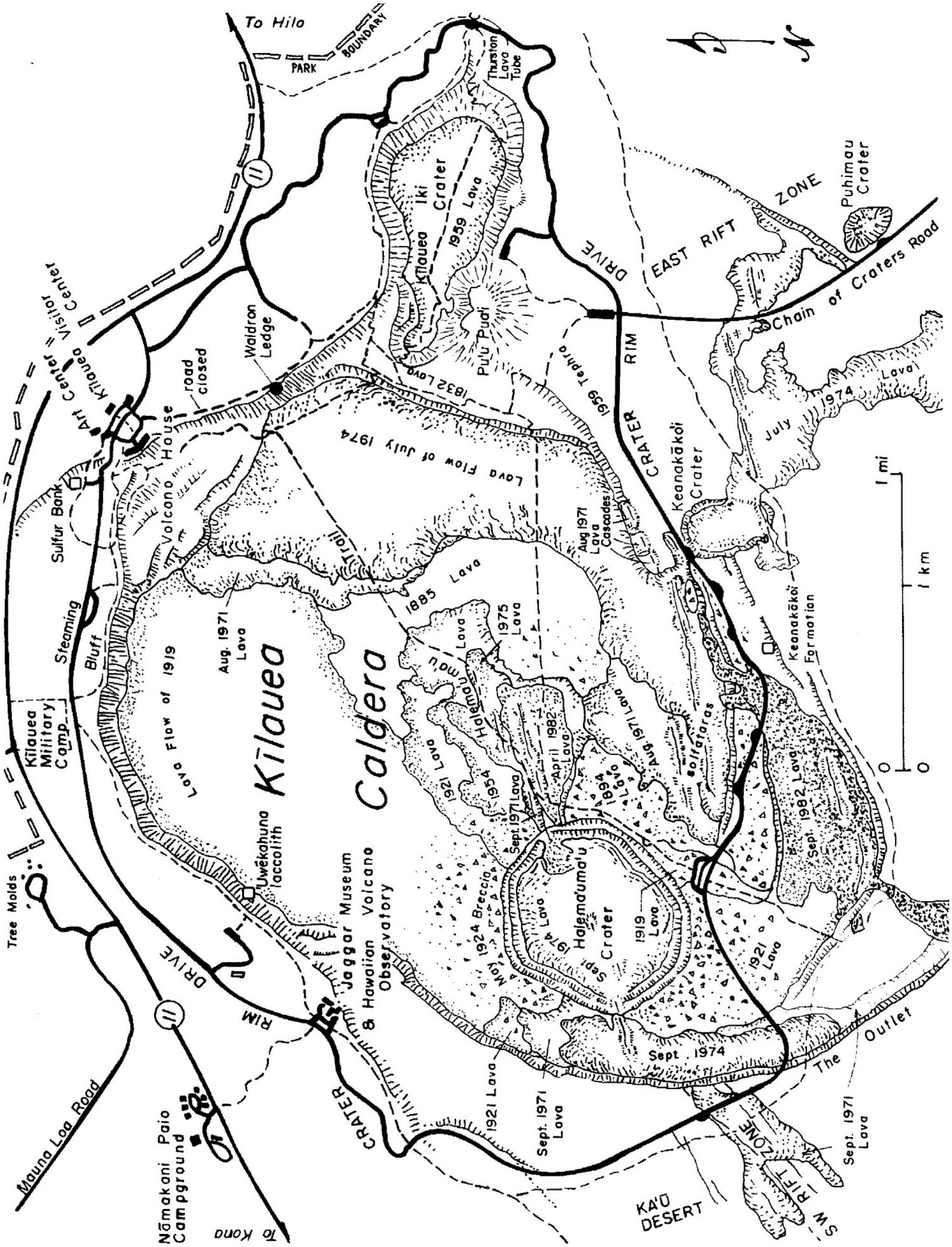


Figure 36 – Trails, roads, and geology, Kilauea summit area (Hazlett, 2002)

Thirteen pit craters are distributed along the rift within 16 km of the caldera (Figure 37). Eruption pairs have been suggested by many workers for both Mauna Loa and Kilauea with a summit eruption followed by a flank eruption but analysis by Klein (1982) indicates that the eruptions of Kilauea are random with little evidence for summit-flank pairing. Yet, eruption pairing can certainly be demonstrated for the 1954-55 and 1959-60 eruptions.

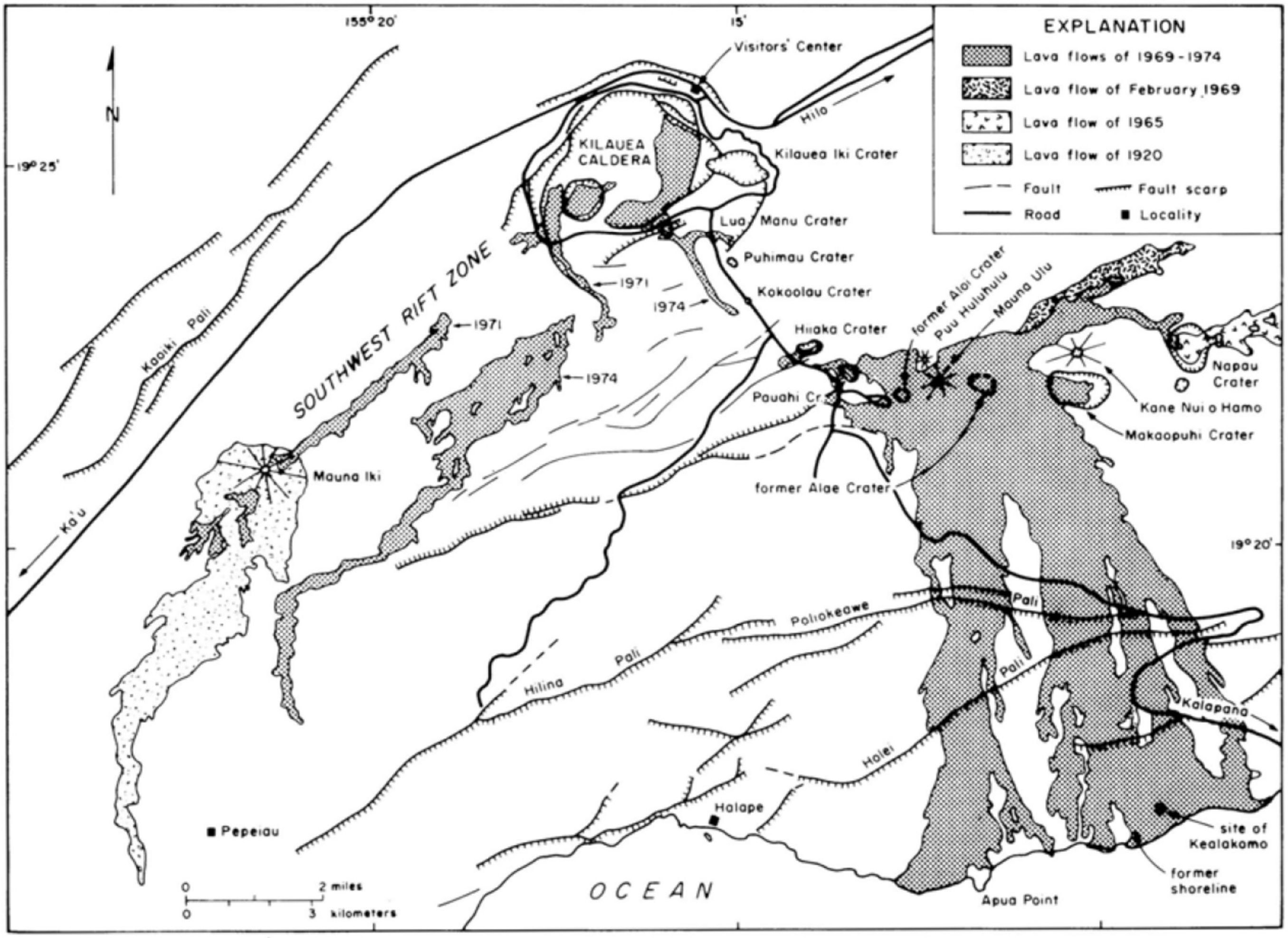


Figure 37 – Map of Kilauea caldera and the upper parts of the southwest and eastern rift zones of Kilauea Volcano and lava flows active since 1964. Aloi and Alae craters on the east rift zone have been buried by lava flows from Mauna Ulu, a small shield volcano active from 1969 to 1974. Lava from that vent entered the ocean at the south coast after cascading down the Poliokeawe and Holei palis, destroying the ancient Hawaiian city of Kealakomo. The Hilina, Poliokeawe, and Holei palis are fault scarps produced by a 600 m drop of landscape to the south. Halape sank about 4 m during the 29 November 1975 earthquake. (From Macdonald and others, 1983, p. 109, Fig. 3.29.)

Kilauea Caldera

Calderas are produced when a shallow magma chamber is evacuated and a void develops below a volcanic summit. A series of circular inward dipping ring fractures develop and coalesce and eventually the tip of the volcano can subside into the voided chamber leaving a caldera in its wake. Maps and sections across the Kilauea caldera (Figures 38-41) indicate major changes in a relatively short period of time geologically speaking. The multitude of thin flows that constitute Kilauea are clearly visible on the walls of the caldera. Pahoehoe flows predominate in the vicinity of the caldera but farther away from the caldera and the rifts aa becomes more abundant and near the coast aa flows predominate.

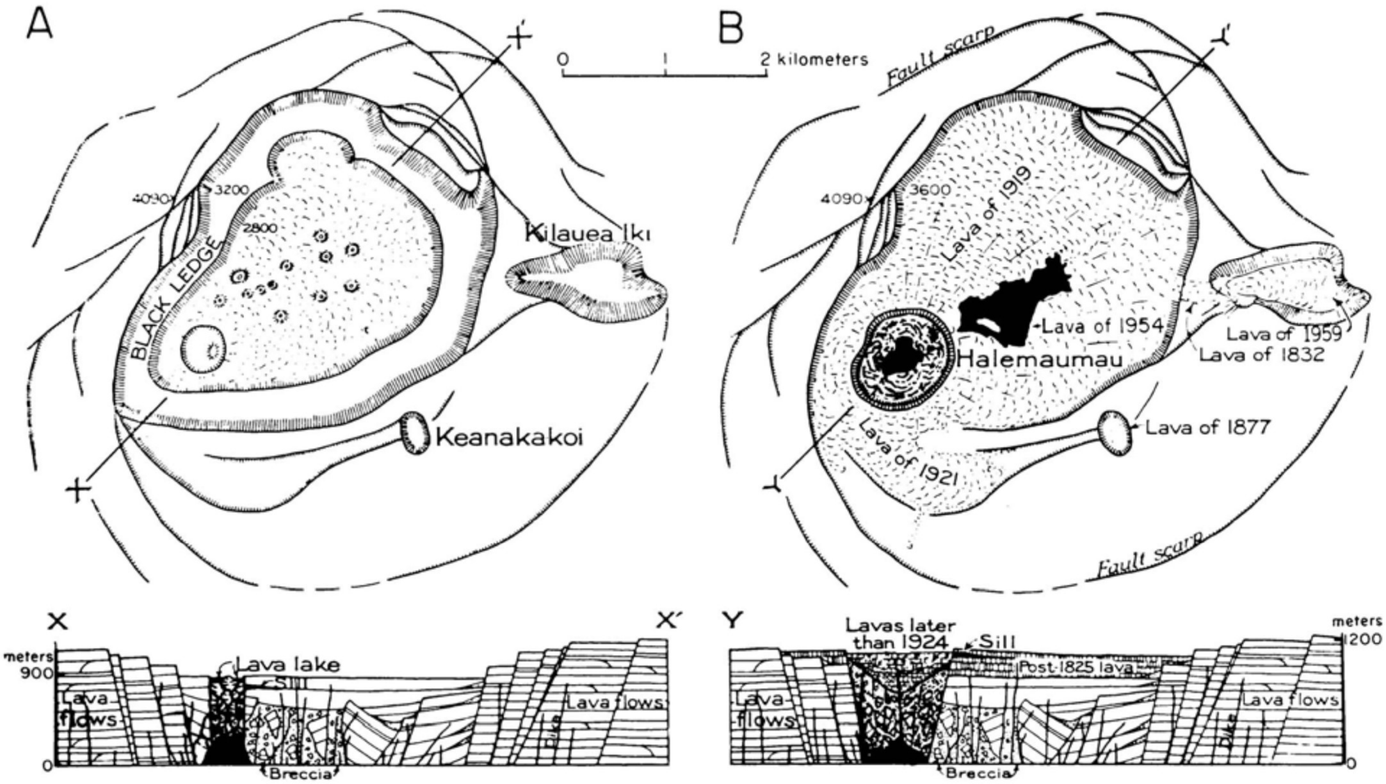


Figure 38 – Maps and sections of Kilauea caldera. A. in 1825 and B. in 1960. The large central pit that existed in 1825 had been filled in entirety before 1900. Structure beneath the caldera (sections) is interpretive. (From Macdonald and others, 1983, Fig 3.11, p. 76.)

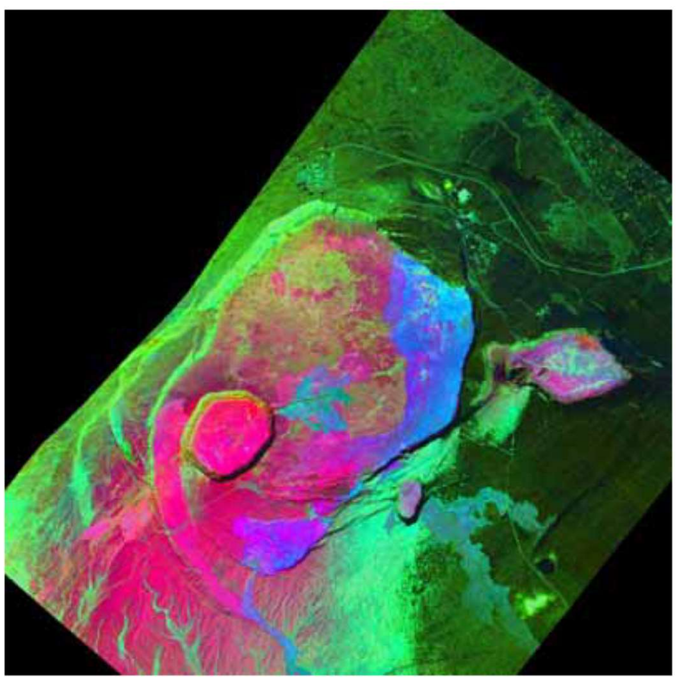


Figure 39 - False color satellite image showing the same general area as Figure 20.

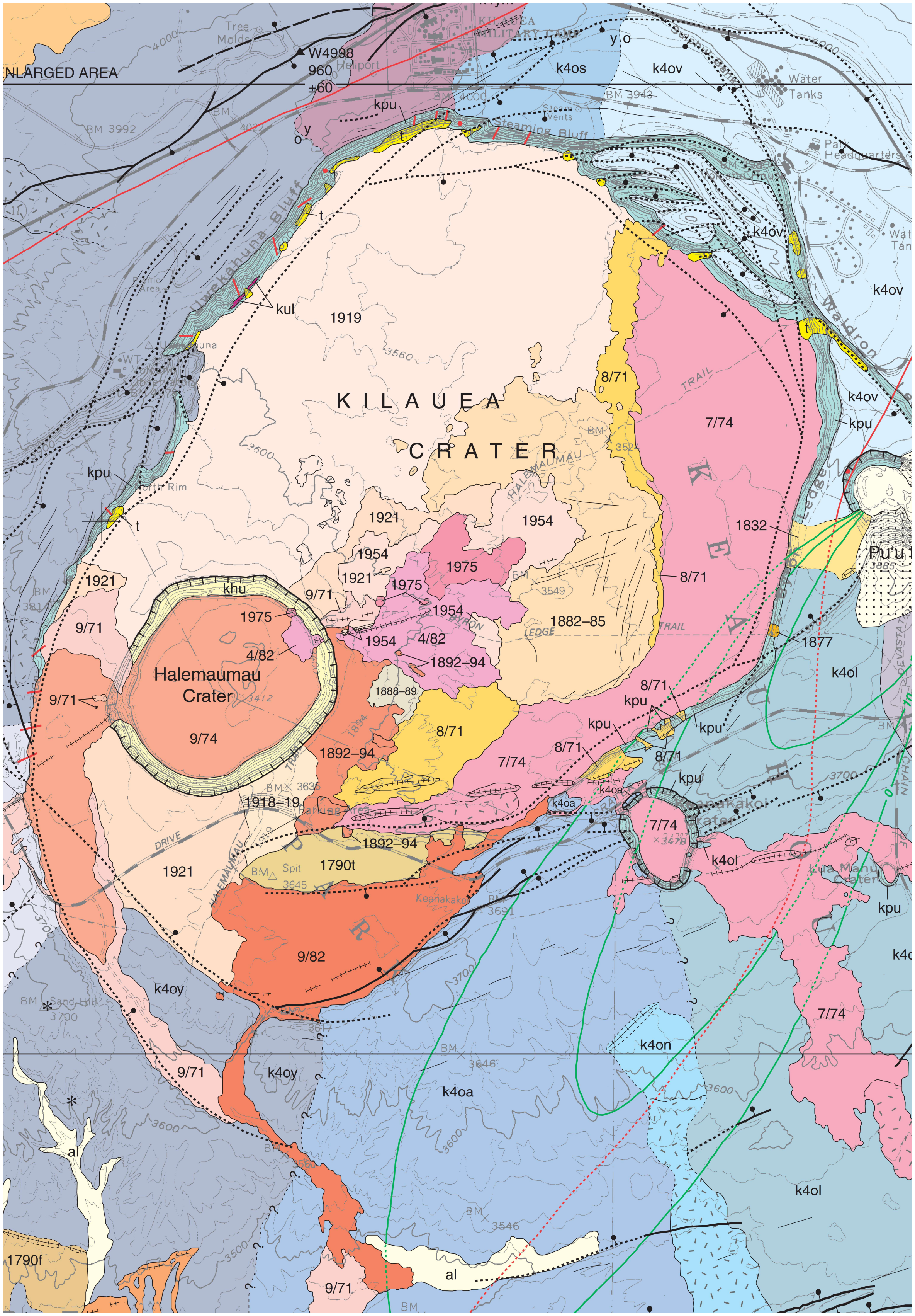


Figure 40 – Geological map, explanation, and section across Kilauea caldera (below). (From U. S. Geological Survey.) *continues on next page…*

KILAUEA CRATER, HAWAII 7½'
U.S.G.S. GEOLOGIC MAP GQ-667
EXPLANATION

MAUNA LOA

Prehistoric rock units

kl

Keamoku lava flows
kkl, *lobe of Kipuka Kulalio*
kkk, *lobe of Kipuka Kekake*
kl, *lower lobes*

pk

Lava of Kipuka Pakekake

llm

Lower lava of Mauna Loa

llk

Lower lavas of Kilauea
Darker shade indicates mappable aa flows

KILAUEA

hu

Historic lava
Chiefly consists of products of eruptions between 1823 and 1880

sl

Spatter and lava cones

bu

Basalt of Uwekahuna laccolith
Location: Uwekahuna Bluff on northwest wall of Kilauea caldera

ua

Uwekahuna Ash
Location: base of northwest wall of Kilauea caldera

QUATERNARY

SYMBOLS

Contact
Dashed where approximately located; dotted where concealed

Fault
Dashed where approximately located, dotted where concealed. Ball on downthrown side

Crack

Lava channel

Position of edge of Halemaumau before explosive eruption of 1924

Areas of sulfur deposition in 1966

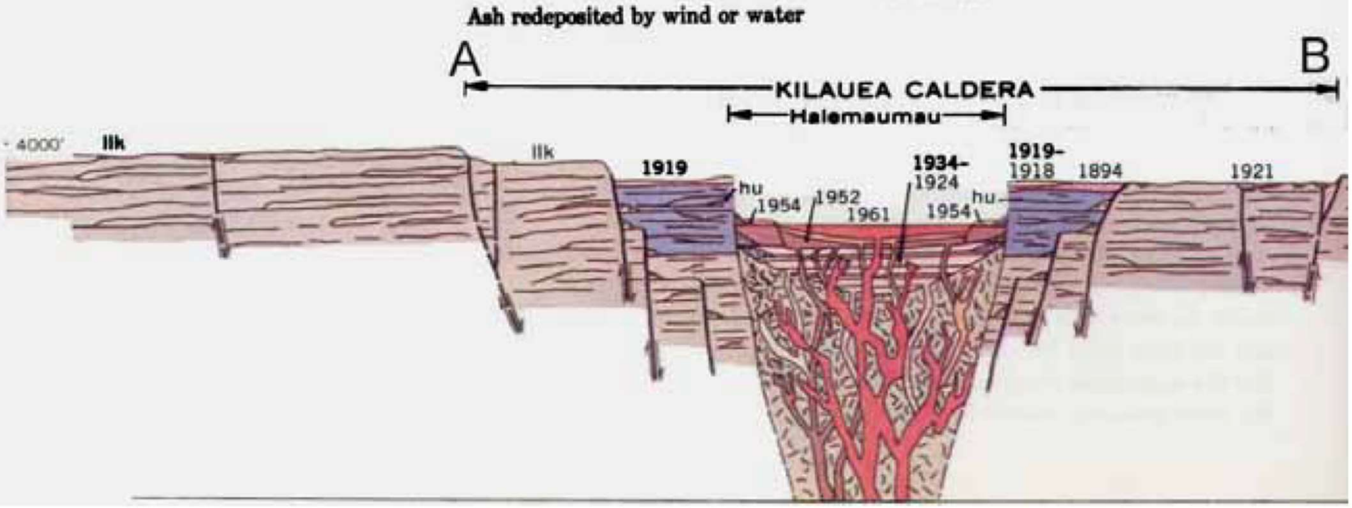
Landslide

Ash redeposited by wind or water

1 5 20

Isopachs of ash and lapilli from Kilauea Iki eruption of 1959, beyond mapped deposits. Contours indicate thickness of 1, 5, and 20 inches (adapted from unpublished map by D. H. Richter)

Approximate outer limit of continuous ash blanket of Keanakakoi Formation of Wentworth (1938). On hachured side of line, thickness of thickest pockets exceeds about 5 feet. The Keanakakoi Formation lies beneath the historic lava flows in the area of the caldera



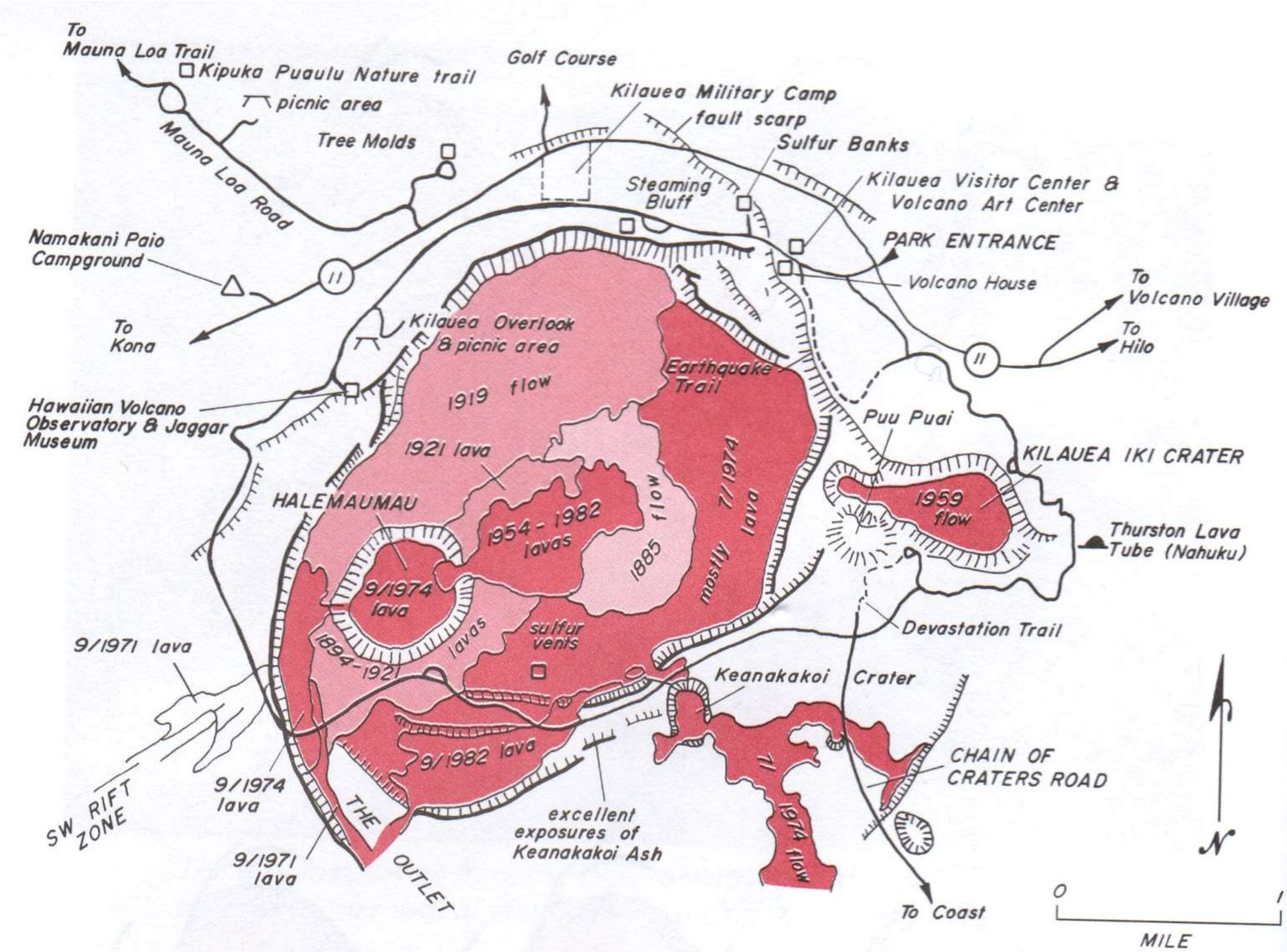


Figure 41 – Geological sketch map of Kilauea caldera and vicinity. (Hazlett & Hyndman, 1996, p. 70.)

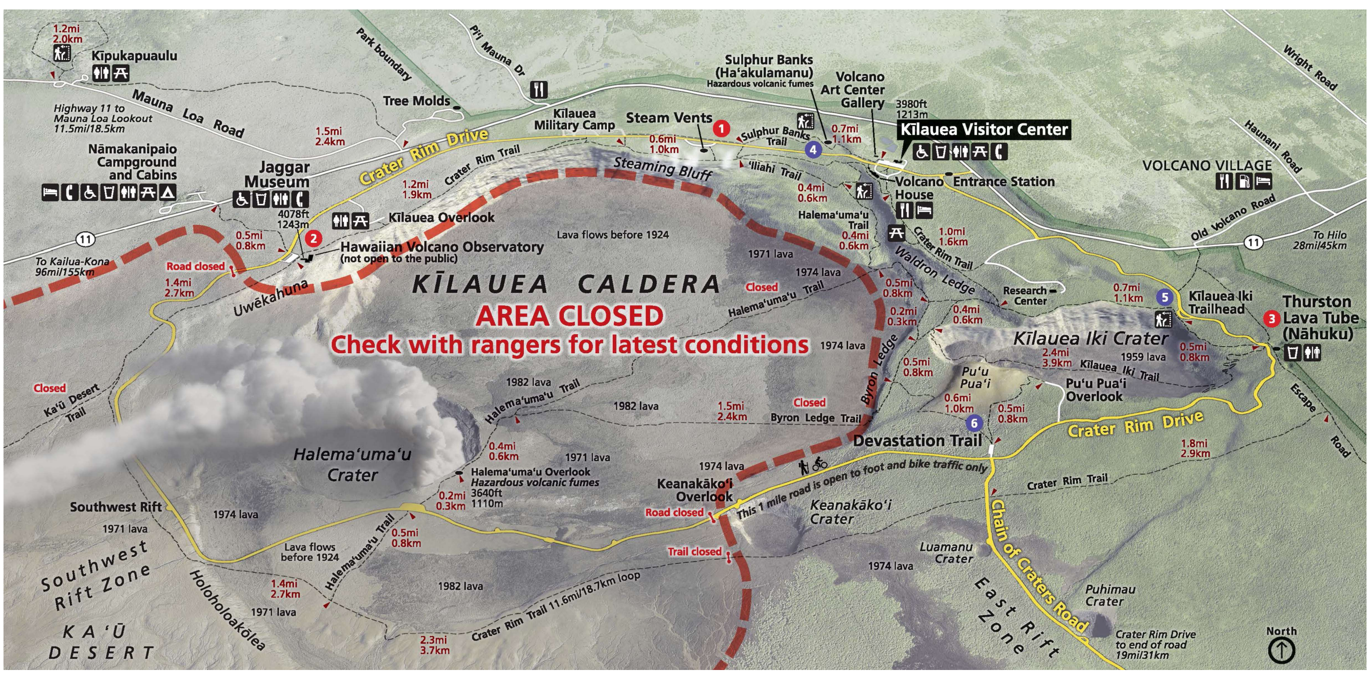


Figure 42 – National Park Kilauea Summit Map (From the Natl. Park Service, 2015)

Halema’uma’u Pit Crater

Halema’uma’u is the pit crater located inside Kilauea caldera, which is believed to be the house of the goddess, Pele. A pit crater and caldera are craters of different sizes as exemplified by Halema’uma’u pit crater inside Kilauea caldera. As you walk inside the caldera, you can smell and taste the gases released from the still active volcano. The main odoriferous gas is sulfur dioxide. Halema’uma’u is about 1440 m across and 640 m deep. It is sometimes called "The House of Everlasting Fire" because of an active lava lake within it for over a hundred years (Figure 43).

Figure 43 – A view of Halema’uma’u pit crater stolen from internet.

Halema’uma’u crater lies on the southwestern side of the main Kilauea caldera (See Figure 40). For the past century, Halema’uma’u has been the principal site of volcanic activity at Kilauea's summit. There has also been frequent activity along the Southeast Rift Zone (such as the presently active Pu'u 'O'o eruption, which started in 1983). The thin pahoehoe flows that built Kilauea can be seen in the walls of the caldera. As mentioned earlier, pahoehoe flows predominate in the caldera region because they are close to the vents in which they were issued. With the increasing distance from the caldera and rift zones, aa becomes more abundant, particularly nearer the coast. Clearly, significant volcanic activity has been recorded at Kilauea volcano (Figure 44).

From 1823 to 1924 Halema’uma’u was an active lava lake of molten lava. One could look into the crater and see the flowing liquid lava, which would sometimes overflow into the caldera. However, in 1924, the lava drained back into the crater, leaving it empty and lonely hearted but not for long. Quiescence resulted in a phreatic explosion (Figure 44) because the sudden draining of the lava lake caused cool ground water to enter the crater and be quickly heated. The mixing of the water and hot lava caused a high, explosive steam eruption, which threw out blocks of rocks and debris. Even though, the blocks were hot when they were thrown out of the crater, they were not new. The blocks were actually cooled magma of a previous eruption from the inner walls of the crater. One death resulted from this dangerous explosion – a photographer who had gotten a little to close was struck by a piece of falling debris and killed.

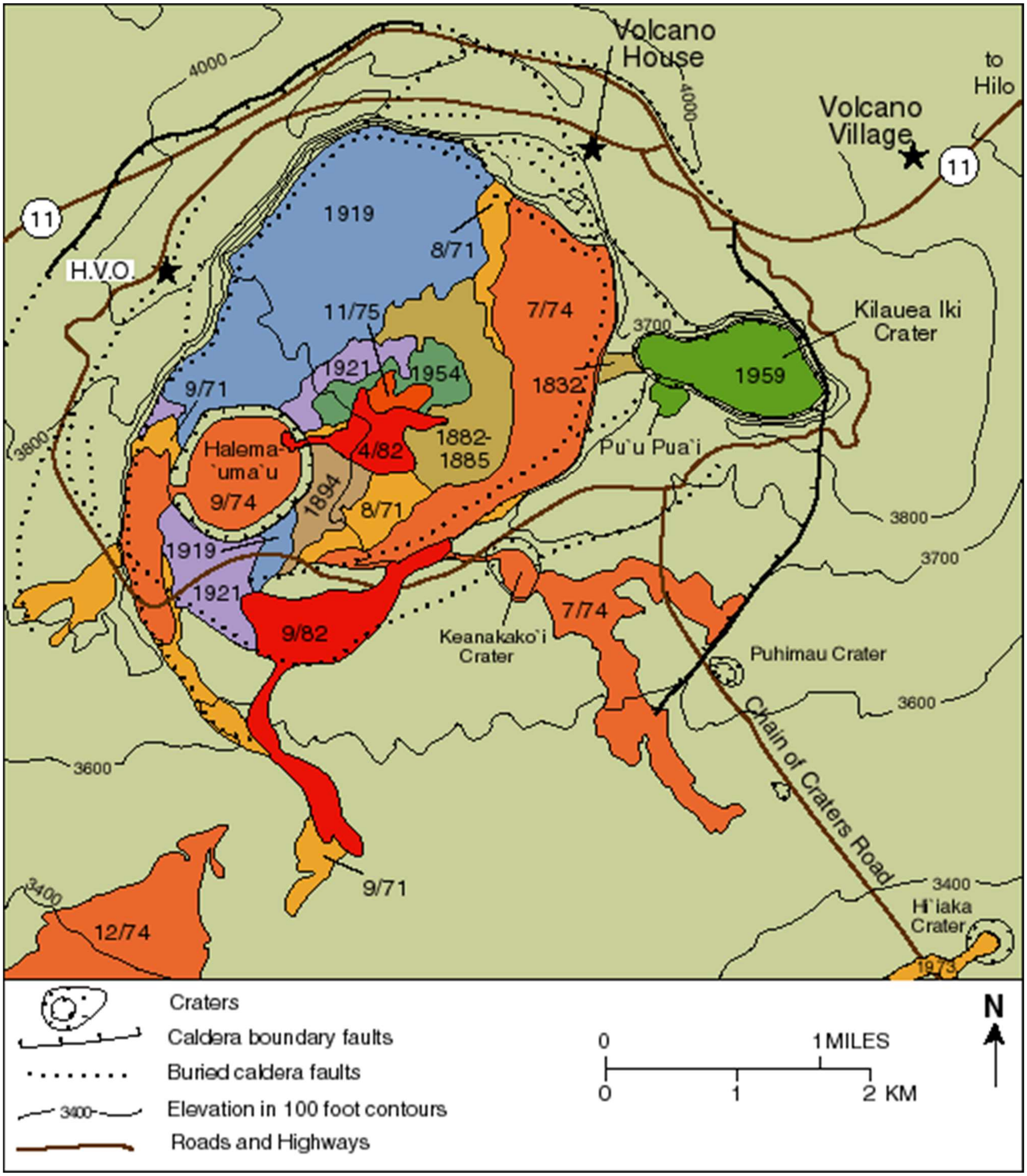


Figure 44 - Lava flows within the Kilauea caldera. (From https://hvo.wr.usgs.gov/kilauea/history/)

The Powerful Halema'uma'u Eruptions of 1924

Approximately 83 years ago, the final chapter of one of Kilauea's most alarming displays of volcanic power came to a close. Halema`uma`u, the fire pit nestled in Kilauea's summit caldera, ended a 10-day-long outburst of violent steam explosions on 24 May 1924. For nearly two decades prior to 1924 an immense lake of molten lava churned and bubbled at the bottom Halema`uma`u Crater. Travelers from across the world were drawn to the rim of Halema`uma`u to witness the spectacular array of volcanic pyrotechnics. In February 1924, however, a curious thing happened. A giant molten whirlpool formed on the lake's surface. Over two days' time, lava drained away like water in a bathtub, leaving behind a dully glowing pit 112 m (370 feet) deep and 520 m across (1,700 feet). Halema`uma`u remained in this ominously quiet state for almost two months.

In April 1924, attention was diverted from the unusual happenings at Halema`uma`u by an earthquake swarm that rattled the summit of Kilauea. The swarm migrated 45 km (28 miles) down the volcano's East Rift Zone to the eastern tip of the island near Kapoho. On April 22 and 23, Kapoho residents felt more then 200 earthquakes. Cracks opened, and a stretch of land 6.4 km (4 miles) long and 1.6 km (a mile) wide subsided. The area just north of Cape Kumukahi dropped 4 m (14 feet) and the sea washed inland a kilometer (half a mile) past the shoreline. Such swarms typically herald the start of an eruption, but no eruption came-or so it seemed. A few days later, attention again turned to Halema`uma`u. The floor of the pit began to sink rapidly. Incandescent slabs of rock peeled from the walls and crashed down into the pit. Hot ash and pebbles swirled out over the rim as the rocks hit bottom. Undaunted by ash storms that "stung like hail," some 400 visitors from a Thomas Cook steamship tour were thrilled by the awesome sight.

On the morning of May 11, a ranger from Hawaii National Park noticed several hot boulders on the rim of Halema`uma`u. Evidently, a small explosion had occurred in the pit overnight. The park superintendent, Thomas Boles, put up roadblocks 0.8 km (a half a mile) from the crater and ventured out to investigate with two other observers. Boles was within 3 m (10 feet) of rim when he heard a "thud" followed by a "prolonged whooosh." Thousands of redhot boulders shot up amidst a fury of black ash. The ash column rose 915 m (3000 feet) above the crater as the party ran for cover. Fortunately, all three made it back to their vehicle, sustaining only a few cuts and bruises. They found that a boulder weighing nearly 45 kg (100 pounds) had sailed over the vehicle during the explosion, landing more than 600 m (2,000') from the crater. Superintendent Boles pushed the roadblocks back 2.2 km (2 miles) from the crater. Similar events followed, with each explosion more intense than the last. At night, the white-hot rocks that were hurled from the crater looked like rockets trailing sparks.

The largest explosion occurred on May 18. With a resounding BOOM, an ash column shot up 6.5 km (4 miles) in the air while a hurricane-force rush of gas and ash spread across the caldera floor. To Superintendent Boles, the dark, mushrooming column "loomed up like a menacing genie from the Arabian Nights." Static electricity generated between ash particles produced streaks of blue lightning and condensed steam mixed with the ash to create a rainstorm of gray mud. A young man from a nearby sugar plantation had slipped past the road blocks set up by the Superintendent and was within 600 m (2,000') of the rim when the explosion occurred. He was hit by a boulder and severely burnt by the falling ash. Rescuers hurried in to the caldera when the explosion ended some 20 minutes later, but the unfortunate man died on the way to the hospital.

After the deadly blast of May 18, the explosions continued, but with waning intensity. When the dust finally settled on May 24, Kilauea caldera was littered with huge boulders. Rocks weighing as much as 8,000 kg (8 tons) were found 500 m (1,600') from the rim of Halema`uma`u. The pit itself was almost twice as wide as it had been and eight times deeper.

The cause of the 1924 explosions can be deduced from seismic and geodetic measurements made by HVO scientists before, during, and after the event. April's earthquakes warm indicates a massive draining of magma from Kilauea's summit reservoir into the East Rift Zone. The considerable ground cracking and subsidence in Kapoho suggests that magma moved out into the submarine portion of the rift where it very likely fed an eruption on the ocean floor. The summit of the volcano sagged inward and cracked as the magma drained. Groundwater rushed through the developing crack system where it encountered incandescent rock at temperatures close to 980°C (1,800°F). The water flashed violently to steam at the sudden encounter, releasing sufficient power to excavate over a thousand-million kilograms (a million tons) of rock. HVO scientists estimate that approximately 400 million cubic meters (520 million cubic yards) of magma shuttled down the east rift zone conduit in 1924. That's enough magma to fill 265,000 Olympic swimming pools!

Source: http://hvo.wr.usgs.gov/volcanowatch/1998/98_05_21.html

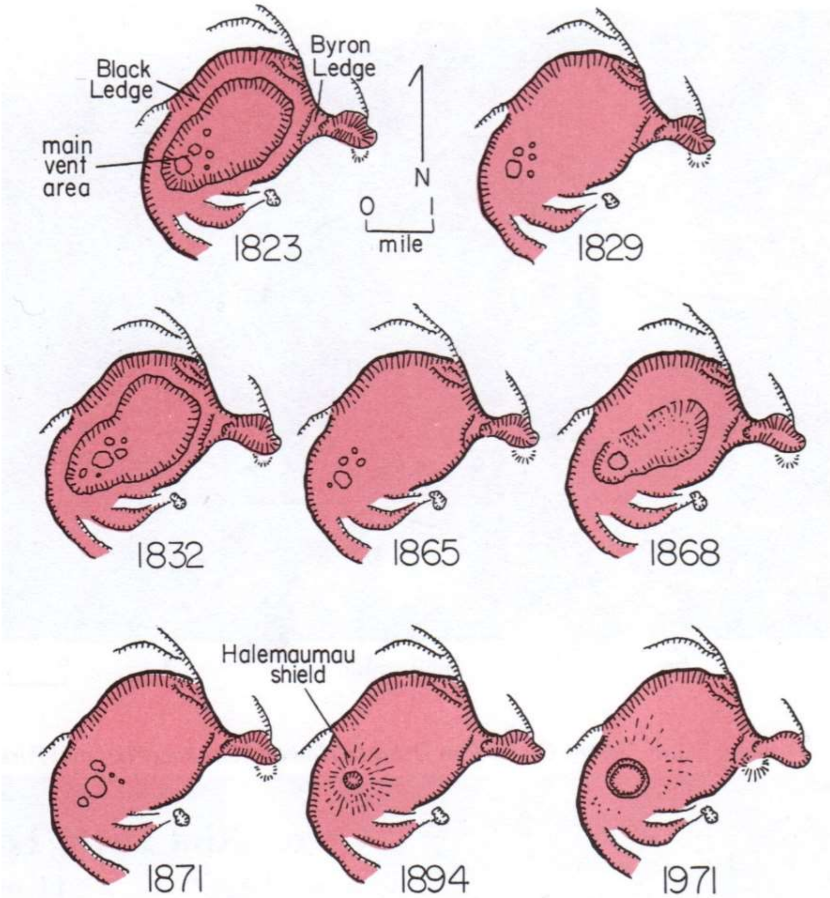


Figure 45 – The changing shape of Kilauea caldera since 1823 (From Hazlett and Hyndman, 1996, p. 69.)

STOP 5.1: *Kilauea Overlook and Meeting with USGS Geologist*

The Kilauea Overlook is located on the left side of the road, approximately 0.7 miles from Steaming Bluffs. The road sign indicates that this a picnic area. Which it is, but it is also a splendid overlook of the Kilauea Caldera and Halema'uma'u Crater. The view here is similar to that found at the Jaggar Museum (the Museum was 2018 due to instability on the slope on which it stands).

The view of Kilauea caldera from this overlook is spectacular. The caldera (a very large crater formed by collapse) is about 2 miles wide and more than 3 miles long. The highest point on the caldera's edge is near Kilauea Overlook. Halema'uma'u, the main pit crater within Kilauea caldera, is very visible from this point.

We will meet a geologist from the USGS here and they will talk about the recent eruption.

STOP 5.2: *Steam vents and Sulphur Banks (Ha'akulamanu)*

At the summit of Kīlauea, two of the most popular sights involve different substances rising up from cracks in the earth. At Wahinekapu (Steaming Bluff), you can feel hot water vapor as it billows from the ground in steam vents. This striking phenomenon is created as ground water seeps down to rocks heated by magma deep underground. The rocks are so hot that it vaporizes the water, returning it to the surface as steam.

A short distance away, at Ha'akulamanu (Sulphur Banks), volcanic gases seep out of the ground, along with ground water steam. These fumes can be amazingly hot. In 1922, scientists drilled two holes to measure underground heat in the area. Temperature measurements remained constant at 205° F (96° C) down to 50 feet (15 m), the maximum depth drilled. Fumes emitted here include sulfur dioxide (SO2), which smells like a struck match, and hydrogen sulfide (H_2S), the gas that smells like rotten eggs. These two gases react chemically to produce pure sulfur, a yellow mineral known to Hawaiians as kūkaepele, the waste of Pele.

The following trail guide is from Hazlett, 2002

Approximately two miles (3 km) walking, moderately strenuous in places. Allow about 1.5 hours walking time.

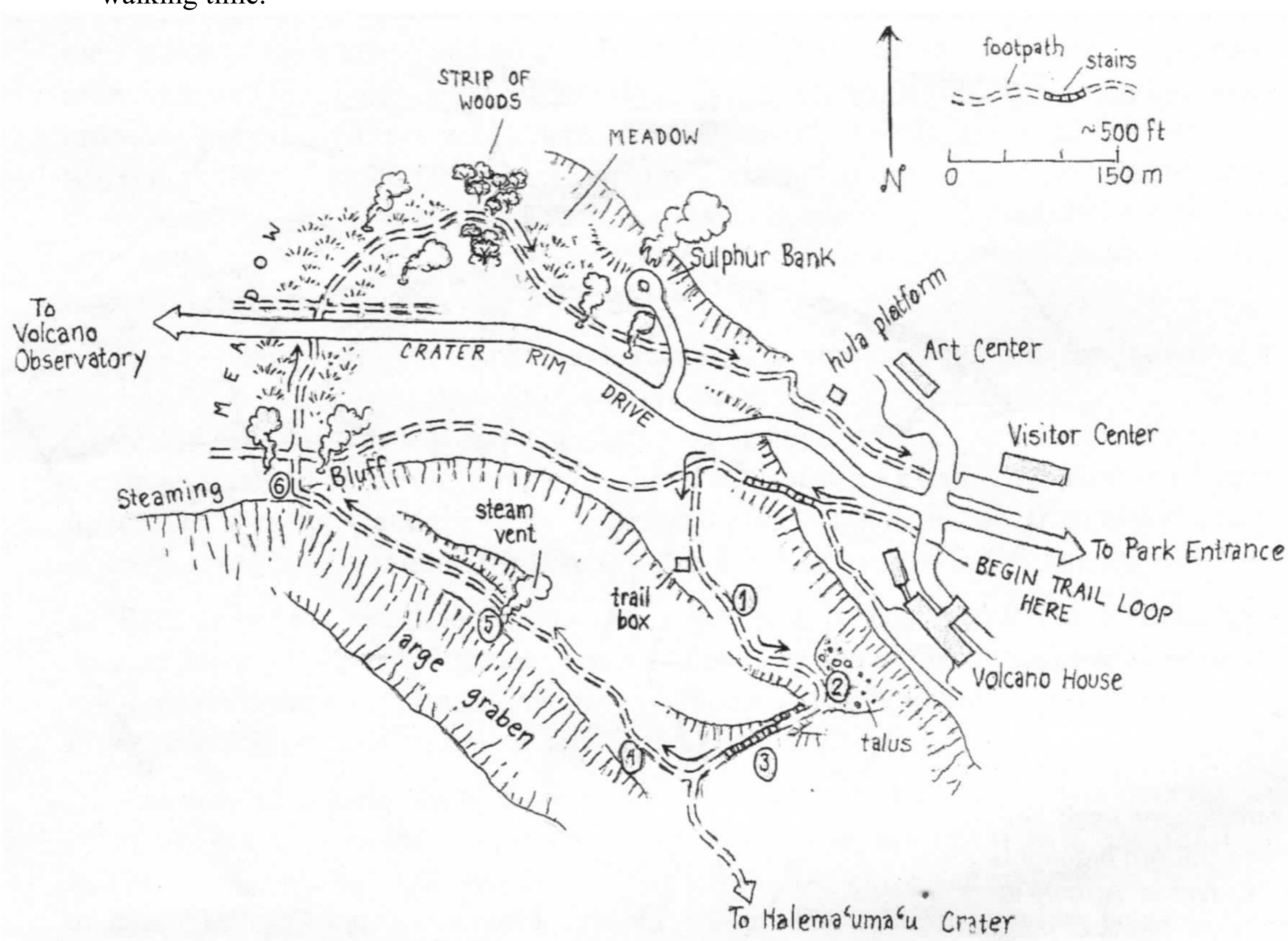


Figure 46 – Map of the Sandalwood-Sulphur Bank Trail Loop, see descriptions of stops below (From Hazlett, 2002, Figure 16, p. 66)

Sandalwood-Sulphur Bank Loop Trail (Figure 46) –

The northern end of Kilauea Caldera, beneath the Volcano House Hotel, did not collapse as deeply as the portions of the caldera. Densely forested bocks of faulted lava form an irregular step-like topography from just beneath the rim down to the present caldera floor, where young lava flows have lapped up around the base of this terrain. The fault-block landscape exhibits excellent examples of horsts and grabens.

The itinerary described below takes hikers part way down the caldera floor through this intensely faulted landscape, then back up to the caldera rim at Wahinekapu (Steaming Bluff). To return to the Visitor Center from Wahinekapu, take Sulphur Bank Trail past Ha'akulamanu solfatara. Numbers on Figure 46 correspond to the location of features described below. Some features may be more difficult to locate in the field than others, but all should, with care, be located. To begin, cross the street at the entrance to the Volcano House Parking Area, follow the asphalt path to the right, and descend the stone stairs following the Halema'uma'u Trail. At the trail intersection shortly past the foot of the stairs, bear left.

STOP 1 (Figure 46): In this area, shortly past the Halema'uma'u Trail Guide box, the path cuts through 3-4 foot (1 meter) high embankments of weathered volcanic ash. These deposits are fallout most likely from the 1790 pyroclastic eruption. They are much thinner than Keanakako'I Ash deposit of probably equivalent age on the southern rim of the caldera perhapsdue to directed venting and/or winds.

STOP 2: The trail takes a sharp turn to the right at the base of the caldera fault scarp beneath Volcano House. The scarp here is approximately 200 feet (60 m) high. At this point, you are standing within a small graben. After turning sharply, the trail passes through a slot in a raised block of densely vegetated lava and begins descending into a much deeper graben on the other side.

STOP 3: Descending farther through the fault terrain, its horst and graben topography can be well discerned from this section of trail. The massive blocks of lava next to the trail probably are derived from one or more aa flows. The lava is highly vesicular in places. No large phenocrysts may be easily seen with the unaided eye. Phenocryst-poor lava is common at Kilauea's summit, since eruptions tend to be fed from the upper, crystal-poor portion of the summit magma reservoir. The exploration party of the 1841 Wilkes Expedition that named Waldron Ledge scrambled through this faulted landscape to the caldera floor, which was much deeper then.

STOP 4: A few dozen yards (meters) past the trail intersection, an excellent view opens up of the largest horst and graben in the fault block terrain. As the trail ascends, note that the graben pinches out toward the caldera wall.

STOP 5: Approaching the caldera rim, the Sandalwood Trail passes the first of many steam vents to be encountered in this area. If the day is sunny you might not actually see any steam at first but only feel warm, moist air rising from the earth to either side of the trail. You are nearing Wahinekapu, the Steaming Bluff, which is described below. Note to the right of the trail a very large ground crack or small graben continuing upslope from the vent area.

STOP 6: Good views of the eastern caldera, Kilauea Iki, and Pu'u Pua'i pyroclastic cone come to view as reach the rim of Wahinekapu. Crossing a stone bridge across a large ground crack, you'll encounter several large, steaming cracks at the edge of the bluff. Continue forward along the Sulphur Bank Trail

The Sulphur Bank Trail crosses the highway and loops back through meadow and woods to the Visitor Center, passing numerous steam vents along the way. Be careful not to approach any of these openings very closely, as algae combined with moisture and soft, weathered earth makes the edges of the vents very slick. People have been killed around some of these openings through venturing to close.

Beautiful crystals of pure, fresh sulphur encrust surfaces near the entrance of the parking circle, next to the trail at Ha'akulamanu solfatara (Sulphur Bank). The solfatara has formed in a fractured monoclinal rise of ash-covered lava at the base of a 70-foot-high (20 m) high fault scarp. Similarly warped crustal blocks lie at the foot of the Koa'e fault scarp along Hilina Pali Road and are intimately associated with normal fault development in this region. The fault-related fracturing in the down-dropped block served as a conduit for the magmatic gases and steam feeding the solfatara. Past the solfatara, the trail ascends a ramp of warped and fault-bounded crust to the level of the nearby Visitor Center.

Ha'akulamanu (Sulphur Bank)

Ha'akulamanu, a solfatara field along the base of one of the ring fault escarpments forming the northern edge of Kilauea caldera, has been active throughout the past 180 years and probably for a long time before that. This site was known as the 'North Sulphur Bank' in the 19^{th} century, in relation to a similar feature ("South Sulphur Bank") southeast of Halema'uma'u Crate, which has since been mostly covered with lava. Visitors in the 19^{th} century used this site as a health spa and sauna. Early Hawaiians came here for cleansing rituals before then. Common encrusting minerals are native sulphur, gypsum, opal, and earthy hematite. A chemical oxidation/reduction reaction between SO_2 and H_2S gas is responsible for the formation of the pale yellow, native sulphur subliminates found at the solfatara here and at Halema'uma'u. The absence of thermal springs and geysers is due to the highly porous soil and fractured bedrock, which prevent formation of a shallow water table.

University of Hawaii and U.S. Geological Survey scientists, among others, have studied effluent from two gas wells near the parking area. Intermittent sampling at this site showed that the ratio of helium to carbon dioxide decreased prior to and during three eruptive sequences over a two-year period (Thomas, 1979). Continuous gas monitoring at the Sulphur Bank well showed that the helium concentration decreased abruptly prior to the onset of the Pu'u 'O'o-Kupaianaha eruption (Friedman and Reimer, 1987). The chemistry of condensates and the effects of mercury in Sulphur Bank emissions on local vegetation have also been studied (Barnard and others, 1990; Davies and Notcutt, 1996)

Minerals at Haʻakulamanu

Given enough time, water can dissolve rock. Adding heat and acid to water speeds up the process. At Haʻakulamanu (Sulphur Banks), all three ingredients— heat, water, and acid—are plentiful. As hot water vapor and acidic gases rise to the surface, they "cook" the pre-existing rock. This reaction causes chemical and textural changes in the minerals that make up the rock. Scientists call this process hydrothermal alteration, derived from the Greek words for water (hydro) and heat (therme).

STOP 5.3: *Volcano House and Lunch*

Volcano House is the name of a series of historic hotels built at the edge of the Kīlauea volcano, within the grounds of Hawai'i Volcanoes National Park on the Island of Hawai'i. The original 1877 building is listed on the National Register of Historic Places and now houses the Volcano Art Center. The hotel in use today was built in 1941 and expanded in 1961. In ancient Hawaii the volcano was the place to make offerings to the fire goddess Pele. Archeological evidence shows activity for hundreds of years, including gathering of volcanic glass to use as cutting tools. Only a few rare eruptions such as the one in 1790 are explosive, and the northeast rim provides a relatively safe vantage point. The prevailing northeast trade winds and higher elevation cause poisonous gasses and lava to flow in the other direction.

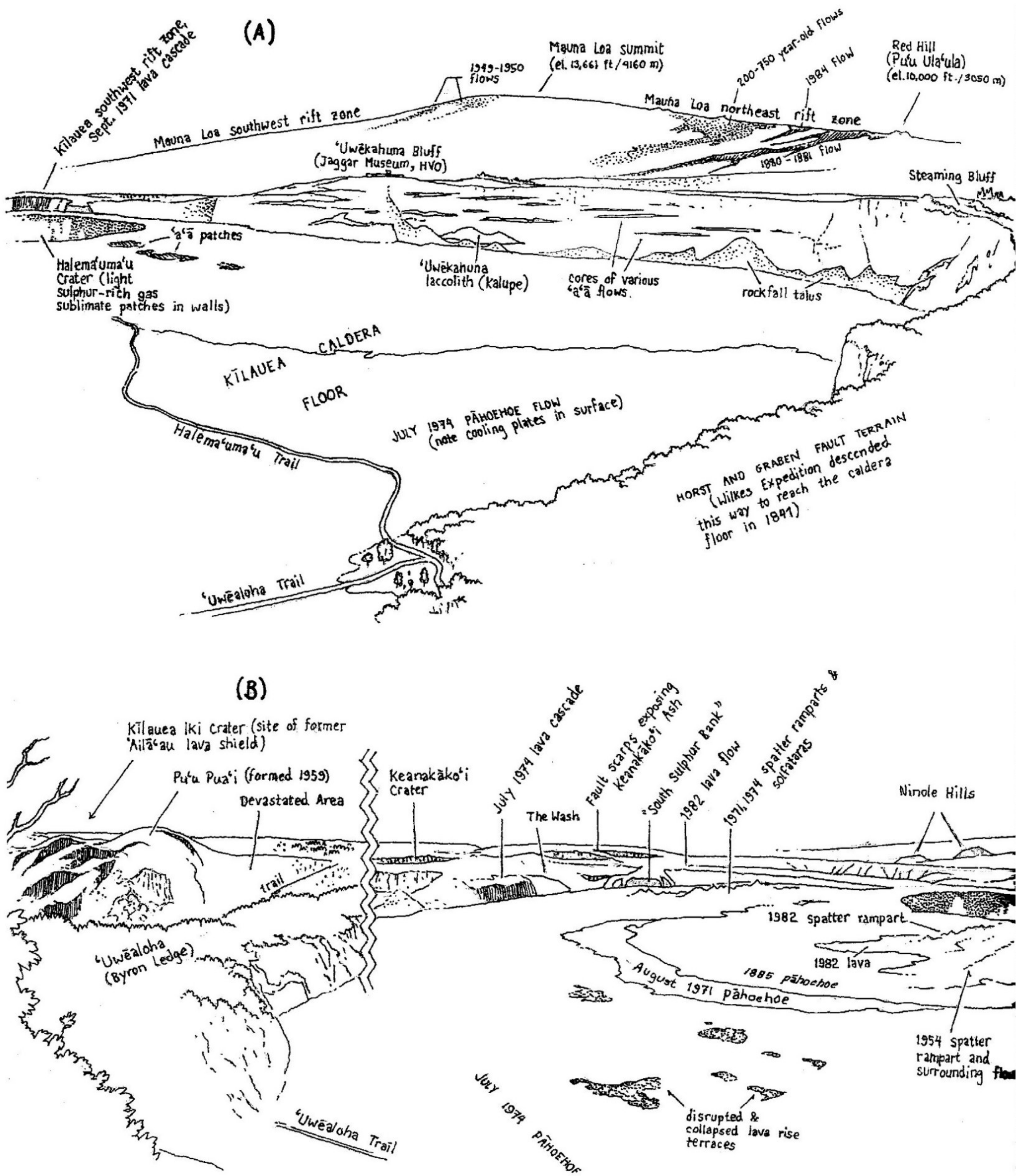


Figure 47 – Panoramas of Kilauea caldera viewed from Waldron Ledge/Volcano House rim. (a) View Looking west; (b) View looking southwest. (From Hazlett and Hyndman, 1996, p. 62.)

STOP 5.4: *Kilauea Iki Trail*

Here are the hike details: **Start/End:** Kīlauea Iki Overlook on Crater Rim Drive

Walking distance: 4 miles (6.4 km) (Estimated time: 2–3 hours)

Elevation: 3,874 feet (1,180 m) above sea level

Descent/Ascent: 400 feet (122 m) with steps and switchbacks, equivalent to climbing down and up a 40-story building

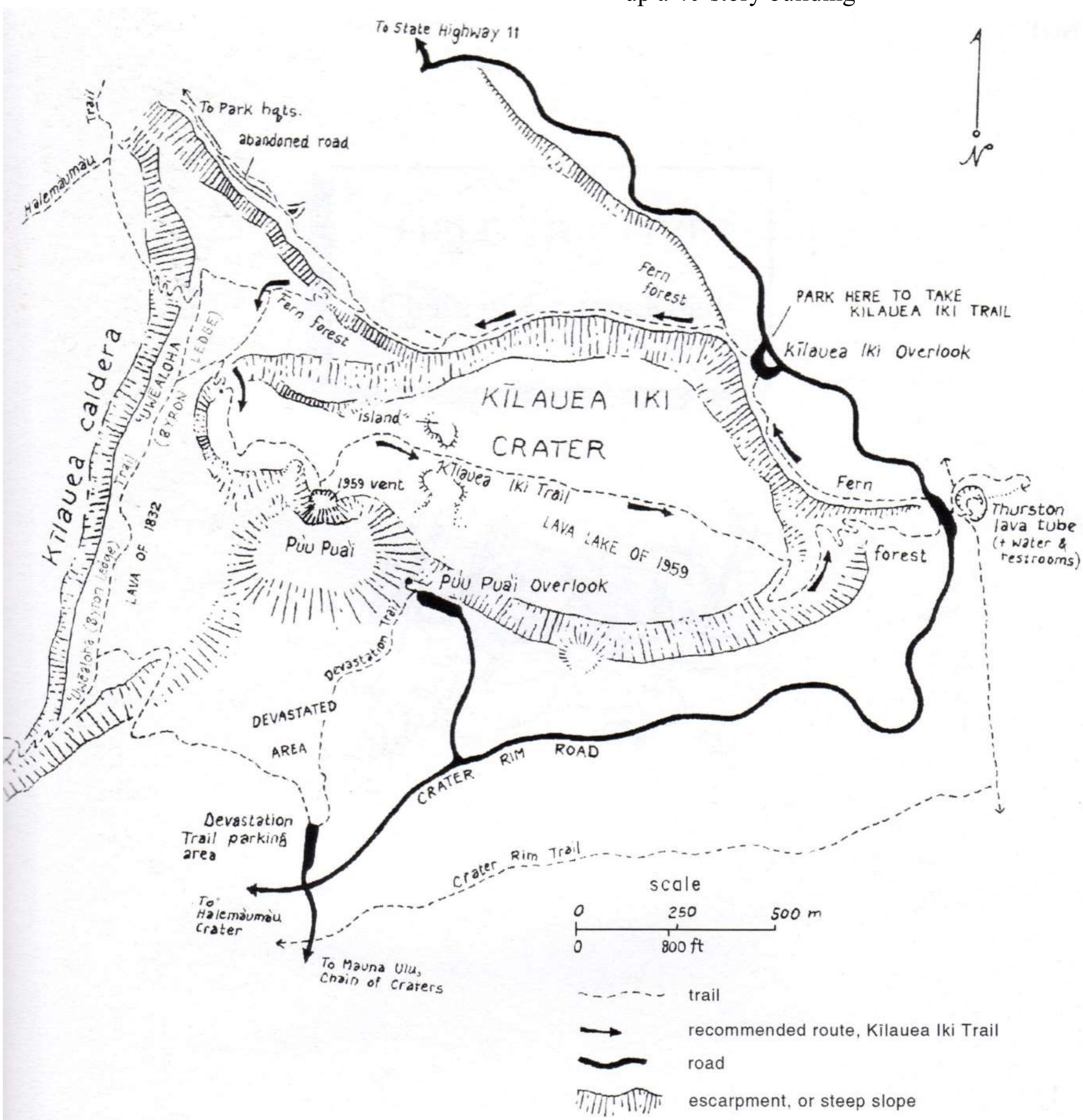


Figure 48 – Kilauea Iki Trail and Vicinity. (From Hazlett, 2002, p. 93.)

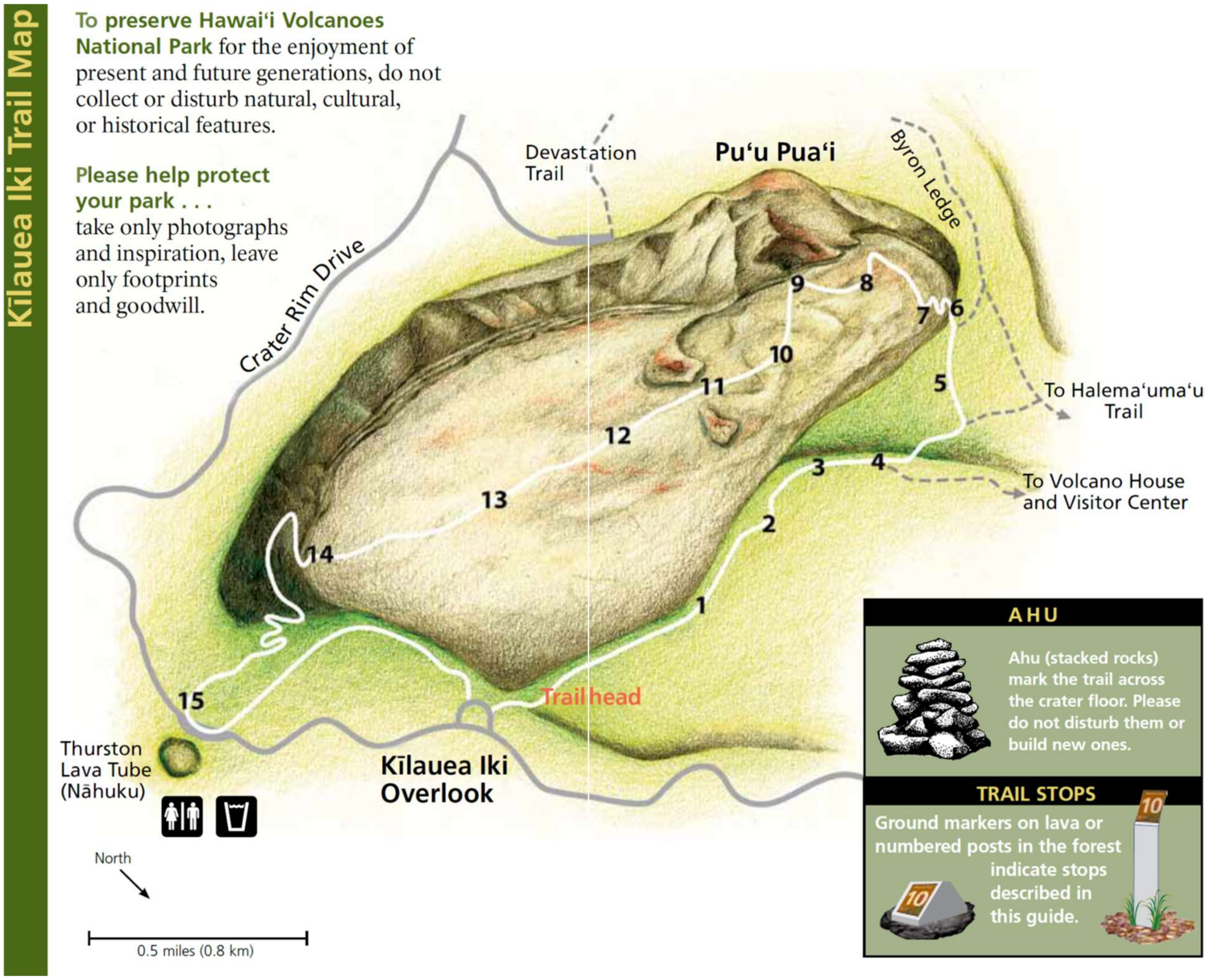
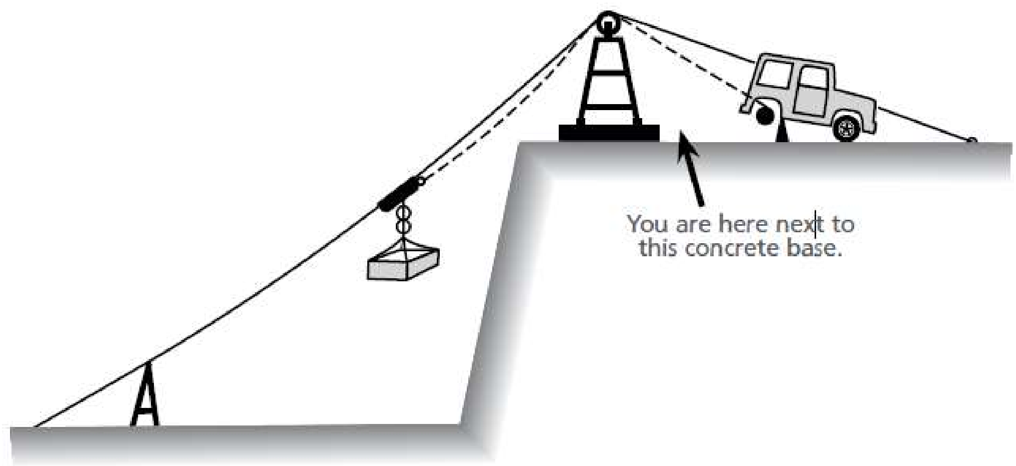


Figure 49: *The following stops correspond to the Figure above for the Kilauea Iki Trail: Written by Janet Babb, edited by Jane Takahashi, USGS Produced by the Interpretive Planning and Media Development Branch Hawai'i Volcanoes National Park*

Stop 1: The eruption began when a curtain of lava burst from a half-mile (0.8 km) long fissure, or crack, in the crater wall directly across from you. Within a day, multiple vents along the fissure consolidated into one main vent (an opening through which lava erupts). Over the next five weeks, fountains of lava gushed from the vent in 17 separate episodes. Molten rock flooded the crater, creating a lake of lava that rose halfway up the crater walls, burying the initial fissure.

Look at the hill on the opposite crater wall: This cinder-and-spatter cone, Pu'u Pua'i (gushing hill), did not exist prior to 1959. The reddish-brown cavity at the base of this cone was the main vent from which lava erupted. Imagine lava shooting five times higher than Pu'u Pua'i is tall. Three days before the eruption ended, lava surged 1,900 feet (580 m) above the vent—a record for the highest fountain ever measured in Hawai'i.

Stop 2: This concrete platform was the foundation of a trolley system used in research projects after the eruption. The lava lake at Kīlauea Iki provided a rare opportunity to study how molten rock cools and solidifies. By drilling into the lake's solidified crust, scientists acquired data to help them understand processes within deep, inaccessible magma reservoirs—like the one beneath Kīlauea's summit.



An old Jeep powered the trolley system. Workers suspended a steel cable from a tripod on the crater rim to an A-frame on the crater floor. Rope wrapped around a spool on the rear axle of the Jeep moved the trolley along the cable, transporting heavy equipment into and out of the crater. This ingenious system succeeded but almost certainly would not be approved under today's stricter safety standards.

Stop 3: *"The high crater rim . . . was drenched in glowing spatter during the night when an avalanche of cone debris deflected the jetting fountain across the lake."* D.H. Richter, USGS*

When you put your thumb across the end of a gushing hose, water doesn't stop flowing— it spurts out in different directions. Similarly, when slabs of rock blocked Kīlauea Iki's gushing vent, lava fountains were deflected.

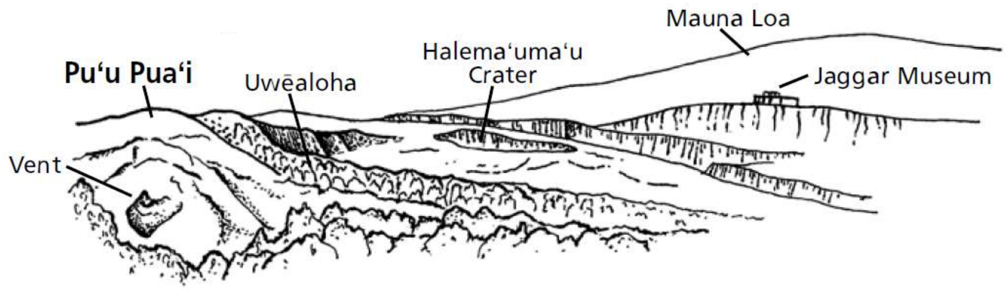
During one eruptive episode, spatter (blobs of molten rock) up to three feet (one meter) in diameter shot across the crater and landed where you are standing. Fortunately, no spectators were at this often-crowded vantage point that night.

The bombardment lasted only 20 minutes, but in that short time, Pele lived up to another of her names: Kawahine'aila'au, woman who eats trees. Spatter completely denuded the forest here. Most of the plants you see today sprouted from seeds that colonized the molten rock after it cooled.

Stop 4: *"Pumice from the fountain continued to fall like black rain . . . accumulating rapidly on the rim of the crater . . . where a new cinder cone was beginning to grow." D.H. Richter, USGS**

Pause here to enjoy a magnificent view of Pu'u Pua'i. With each high fountain, fragments of frothy lava (cinder) and blobs of molten rock (spatter) piled up on the crater rim, forming this cinder-and-spatter cone.

Caution: Rocky slope ahead. The trail cuts through a section of large boulders shaken loose from cliffs during powerful earthquakes in 1975 and 1983 (magnitude 7.2 and 6.8, respectively).



Uwēaloha (Byron Ledge), a tree-covered ridge, separates Kīlauea Iki Crater from Kīlauea summit caldera. On the floor of this large depression, you can see Halema‘uma‘u Crater, home of the volcano goddess Pele. Jaggar Museum and the Hawaiian Volcano Observatory are perched on the caldera rim. Mauna Loa, the islands most massive volcano, is visible from here on clear days.

Stop 5: Spared by the 1959 eruption, this forest has been subjected to other destructive forces—non-native plants and animals.

Downwind from high lava fountains, forests suffered tremendous damage. Trees were stripped of leaves and branches—or completely buried—by falling cinder. Prevailing trade winds blew most of the cinder away from here, sparing this forest from the eruption. Protecting it from invasive flora and fauna has required human intervention.

Stop 6: Prior to 1959, you would be looking into a forest-covered crater 800 feet (244 m) deep, twice the present depth. The black rock that forms the crater floor is actually the surface of the lava lake that flooded Kīlauea Iki. Don’t worry about walking across the crater—the lake is now solid.

Stop to look for slump scars on Pu‘u Pua‘i: As you make your way into the crater, look for grooves cut into the side of the cinder- and-spatter cone. How did they get there? Read on.

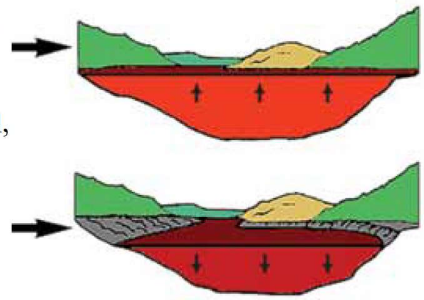
Cinder and spatter rapidly accumulated to form Pu‘u Pua‘i (gushing hill). Perched precariously on the crater rim, oversteepened slabs of congealed spatter occasionally broke loose and slid down the cone, exposing its yellow-hot interior. Pulled by gravity, the slabs scraped and scratched groove marks in semimolten rock beneath the cone’s cooling surface.

Stop 7: You are standing on a rocky ledge known as a “bathtub ring.” In geologic terms, it’s called a lava subsidence terrace.

When the lava lake grew higher than the vent, fountains stopped erupting. Molten lava drained back into the vent, dragging pieces of the lake’s crust with it. Lava often poured back into the vent four times faster than it was erupted, generating a noisy whirlpool of red-hot, liquid lava and black slabs of solid rock.

Lush forests survived above the lake's high lava mark.

As the lake partially drained, its surface dropped nearly 50 feet (15 m), leaving behind a crusty lava "bathtub ring" to indicate its highest level.



Can you see glassy green crystals of olivine in the rocks here?: Hawaiian lava contains the mineral olivine, which forms deep green crystals. Enjoy looking at the olivine crystals, but remember to leave them in place.

Stop 8: With temperatures up to 2,200˚ F (1,217˚ C), Kīlauea Iki erupted the hottest lava ever measured on the volcano.

Throughout the eruption, Hawaiian Volcano Observatory scientists entered the crater daily, but never without a clear line of retreat to escape from deadly fumes and blistering cinders. They risked scorched gloves and charred boots to measure temperatures and collect samples of gas and lava to help them better understand the inner workings of Kīlauea Volcano.

"We were continually broiled by radiant heat from the fountain and flows and were bathed in strong, at times choking, sulfur dioxide fumes . . ." D.H. Richter, USGS*

You are walking through rough, unstable rock that looks like the jumbled ʻaʻā lava you see elsewhere in the park. But this rock is not ʻaʻā. It formed when welded spatter (blobs of molten lava fused together) broke apart as it slid down the cone, rolling and tumbling into coarse, jagged pieces of rock. Watch your step on the uneven trail.

Stop 9: You are standing at the lip of the main vent. Fallen rocks cover the actual opening through which lava erupted 17 times.

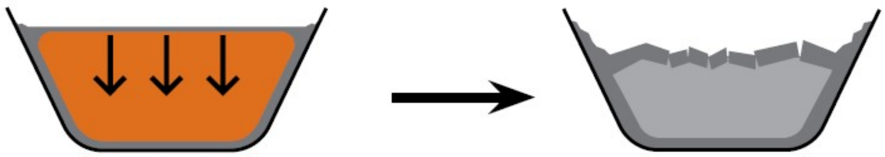
Each episode of the eruption played out differently. Some went on for days while others lasted only hours. Molten rock sometimes poured from the vent in a rolling boil. At other times lava burst skyward to form towering fountains in a matter of seconds.

". . . incandescent clots of gas-inflated lava glow bright orange as they spurt skyward . . . then darken rapidly through tones of red to steely gray as they plummet back to the earth." D.H. Richter, USGS*

Every episode ended with lava draining back into the vent. The rock beneath your feet—slabs of the lake's crust—stacked up as lava drained from the crater. These brittle layers broke and pulled apart as they slumped into the vent, creating the dangerous cracks and unstable rock layers in front of you. The rocks here weigh less than you might expect because they contain numerous holes left by gas bubbles in the frothy lava. If you pick up a rock, watch out for its razor-sharp edges, and be sure to leave it where you found it.

Note the variety of colors in rocks around the vent: In a process similar to the way water rusts a nail, volcanic gases oxidize iron-rich minerals in lava, creating shades of red, purple and brown in the rocks.

Stop 10: Fractures in the crater floor widen (or close) as the lava lake continues to slowly cool and subside.



When molten lava drained back into the vent, the lake's crust collapsed 50 feet (15 m) or more. As it dropped into deeper parts of the crater, the rigid crust buckled and cracked, creating the uneven rocky ridges you see here. Today, the crater floor continues to subside about 3/4 inch (2 cm) per year as the hot interior of the lava lake slowly cools and contracts.

Stop 11: *"Under the continued rain of pumice and cinder, the cone was growing rapidly . . . and becoming very unstable."* D.H. Richter, USGS*

Raised terraces flanking the trail probably formed when huge blocks of Pu'u Pua'i slid into the lava lake. Slowly rafted away from the base of the cone by gushing lava, these "floating islands" came to rest here. Each time the lake level rose, they were covered by molten lava. When lava drained back into the vent, the blocks were again exposed as terraces standing above the surrounding lake surface.
You often see steam rising from the terraces and cracks in the crater floor. Steam forms when rainwater percolates down to hot rock below the surface and vaporizes. Steaming cracks attract visitors on cold, windy days, but beware! The steam is scalding hot.

Did you notice chalky white streaks on the black rock?: These white deposits form when dissolved minerals, primarily calcium sulfates and silica, are carried to the surface by steam.

Stop 12: The lava fountains at Kīlauea Iki were impressive, but the real story of this eruption was the rapidly rising lava lake.

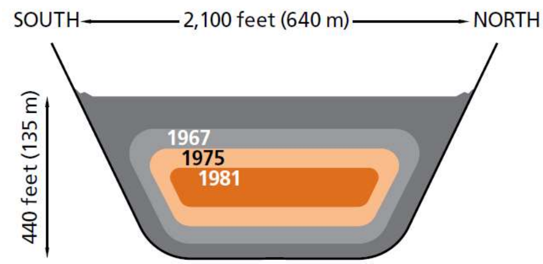
With no outlet from the crater, lava flooded Kīlauea Iki. During the first episode alone, 68 million tons of lava poured into the crater, creating a lake several hundred feet deep. By the time the eruption ended on December 20, another 18 million tons of lava were added to the crater, increasing the lake depth to over 400 feet (120 m). The enormous weight of this lava lake is 235 times heavier than the Empire State Building.

". . . a dark crust formed rapidly on the glowing lava, and incandescence was restricted to the ever-changing pattern of cracks that crisscrossed the [lake's] surface." D.H. Richter, USGS*

The lake's surface quickly cooled to form a thin black crust that readily broke into plates 10 –20 feet (3– 6 m) across. Cracks between the plates were quickly filled by less dense molten lava rising from beneath the crust. As frothy orange-hot lava oozed over the rigid plates, they were "swallowed" into the lake. This process of "crustal overturning" moved across the entire lake in a matter of minutes. It occurred many times during the eruption and for almost a week after it ceased. You are walking on a surface created by the final overturn of the lake.

Stop 13: Based on cooling rates measured through repeated drilling projects, scientists believe the lava lake was solid by the mid-1990s.
Scientists first drilled into the lava lake at Kīlauea Iki four months after the eruption ended. Drilling stopped abruptly at a depth of only nine feet (2.7 m), when red-hot lava oozed up the borehole. With each passing year, the crust grew thicker.

As the lava cooled from outside to inside, zones of molten rock within the lake decreased in size. By 1988, the last time scientists drilled into the lake, only traces of melt remained at depths of 240–330 feet (73–100 m). Although the lake is now entirely solid, it's still hot inside.



Cross section of lava lake
(vertical exaggeration 2:1)

The 1988 drilling project revealed a surprising discovery: The lava lake at Kīlauea Iki is deeper than originally projected. The old crater floor apparently subsided into the underlying magma reservoir. No collapse was observed during the eruption, so the crater floor must have gradually "floated down" as molten rock erupted from the reservoir. The lava lake is now estimated to be 440 feet (135 m) deep. Drill holes are still visible 175 feet (50 m) to the left of this stop. You can step off the trail for a closer look, but approach boreholes with care. Many of them emit scalding steam.

Stop 14: *"The fountain blasting through fluid lava . . . generated large waves . . . which traveled the short distance across the lake to the opposite shore where they broke like waves on a beach."* D.H. Richter, USGS*
As you climb back up the "bathtub ring," turn around and gaze across Kīlauea Iki. Picture this crater as it was in November 1959—a rolling lake of molten rock, with waves of incandescent lava washing up this ledge.

Envision high lava fountains illuminating the night sky and Pu‘u Pua‘i growing larger as cinder and spatter rain down on the crater rim. Imagine the searing heat and thundering roar of lava bursting from the vent. Think about future eruptions and how Kīlauea Iki may look a century from now. As Pele creates new land, her sister Hi‘iakaikapoliopele brings life to the barren lava. Note how ‘ōhi‘a and other plants are revegetating the lava. Windblown seeds take root in cracks where moisture and nutrients collect. Given enough time, trees and shrubs will again create a forest like the one buried beneath this lake of lava.

Stop 15: Explore a lava tube where molten rock flowed around 500 years ago. It's just across the road. If you have time, walk through Thurston Lava Tube (Nāhuku) before returning to your car. As you walk along the path to this cave-like feature, listen and look for native birds in the rain forest.

STOP 5.5: *Nahuka - Thurston Lava Tube*

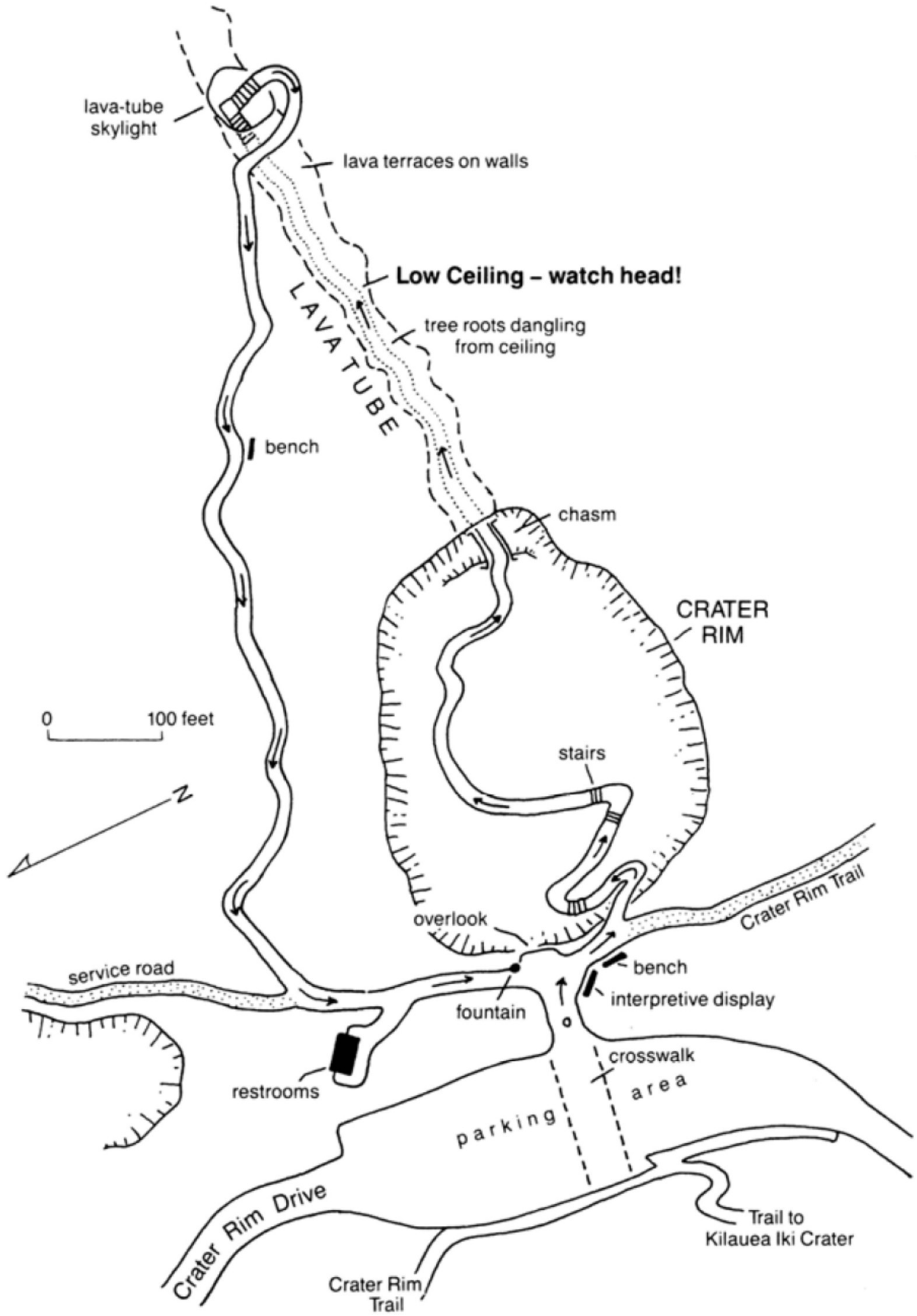


Figure 50 – Map of Thurston lava tube. (From Decker, Decker, and Hazlett, 1997, p. 19.)

Discovered in 1913 by **Lorrin Thurston**, a newspaper publisher of the Honolulu Advertiser who played an instrumental role in creating the park, the Thurston lava tube formed about 350-500 years ago. At that time a large vent, called the Ai-laau shield, was erupting pahoehoe lava on the east side of Kilauea's summit. Lava from this vent buried the entire north flank of Kilauea, all the way to the ocean. After the eruption ceased, the summit of the vent collapsed to produce the Kilauea Iki pit crater.

Additional collapse adjacent to the Kilauea Iki pit crater produced two other small craters. Access to the lava tube is through one of these small pit craters. The trail descends along the wall of the crater then across its floor (Figure 50). The 20-minute walk at Thurston Lava Tube will give you a close-up look at a Hawaiian rainforest and the lava tube. Be careful, the trail can be slippery when wet.

We will enter through a collapse crater and exit via a skylight. It is a relatively well-lit 400' trail followed by 1,100 feet of dark passage near the entrance. **Bring flashlights and gloves.** We will take the 0.3 mile loop trail and try to get permission to enter the darker part of the tube. By contrast the Kazumura Cave system is 50 miles long and may actually be a part of the same structure. Look for lava marks on cave walls and the lack of lavacicles the result of detailed work by lava tube bandits.

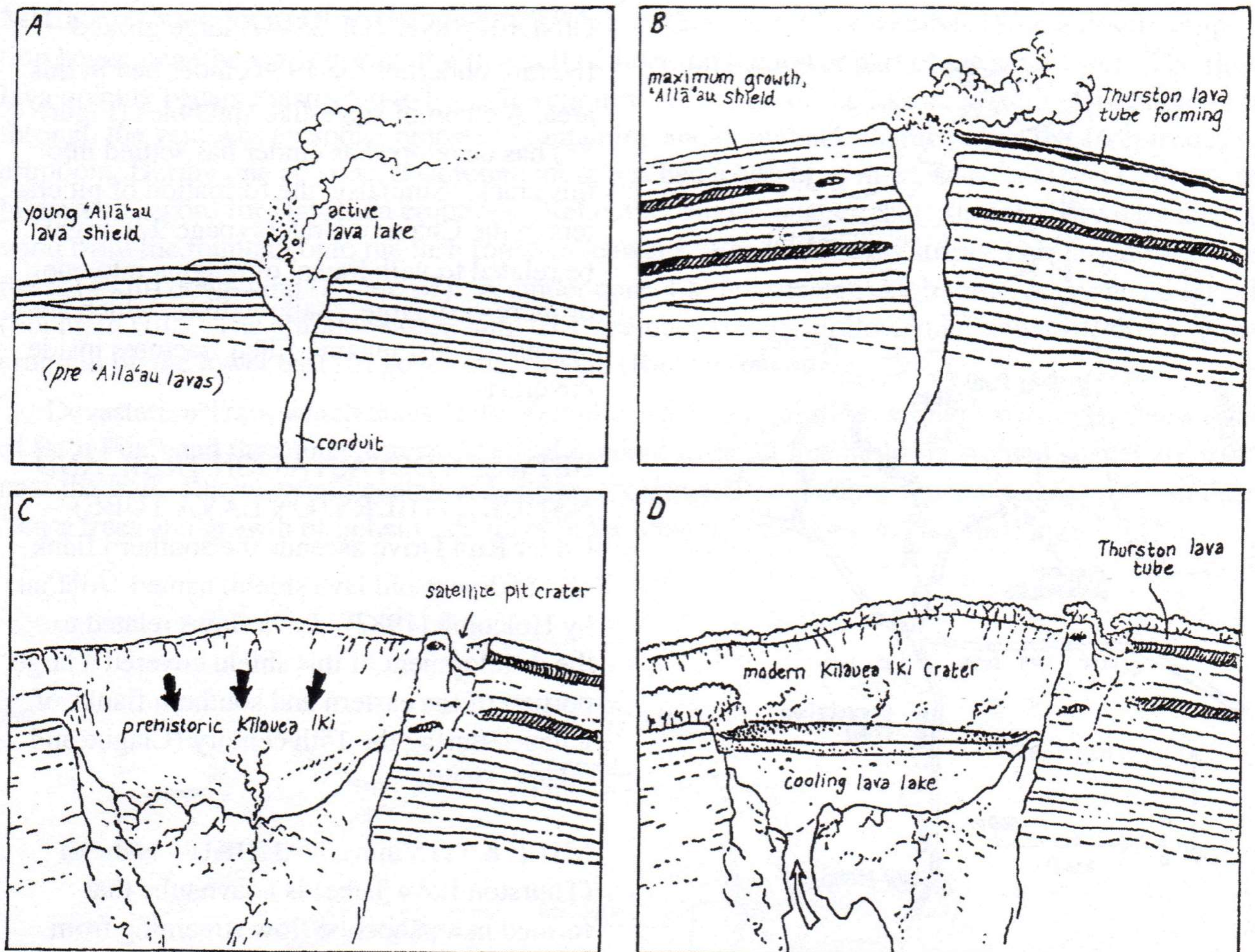
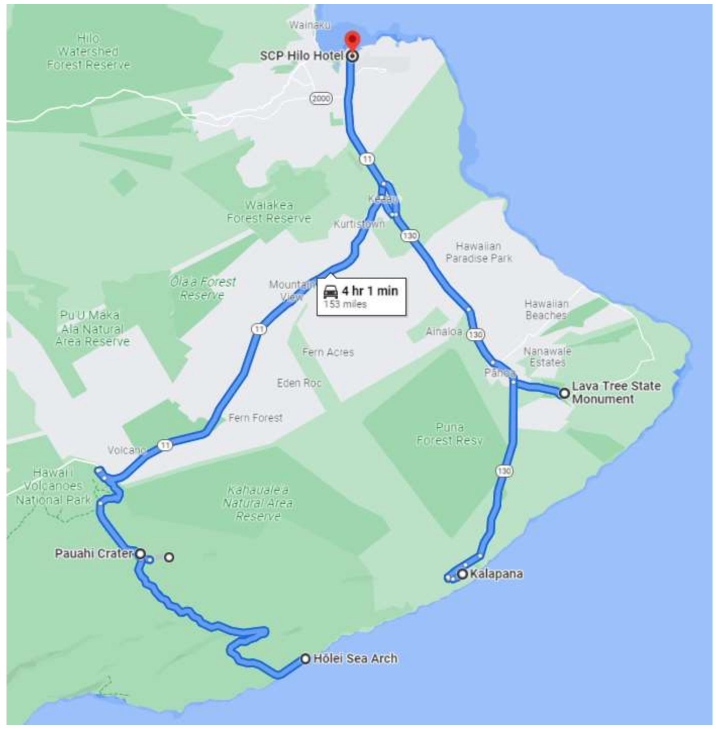


Figure 51 – Formation of Kilauea Iki Crater and Thurston lava tube. (From Hazlett, 2002, p. 90.)

When the eruption stopped the lava drained from the tube. The trail within the tube is 400 feet (120 m) long. The tube (Figure 50) extends beyond the main trail before pinching off (permission to visit this part of the tube must be granted at park headquarters prior to entry). The tube is named for **Lorrin Thurston**, a newspaper publisher that played an instrumental role in creating the park. Thurston lava tube is also called by its Hawaiian name, **Nahuku**, which refers to the small protuberances on the walls of the tube. Similar to conditions in Nassau County, aggressive alien species are changing ecosystems in much of Hawaii. To protect native habitats within the park, rangers are removing alien species and building fences to keep out feral pigs. Pigs disturb the native plants, which helps to introduce alien plant species, and spread disease, such as avian malaria.

Day 6: Wednesday, March 9th, 2022 – Hilo: Volcanoes National Park

7:30 AM: Depart from the hotel and drive to Volcanoes National Park
8:45 AM: Overview at Pauahi Crater
9:30 AM: Hike the Mauna Ula trail
11:00 AM: Drive a bit of the Chain of Craters Road
12:00 PM: Lunch at the end of the Road
2:00 PM: Drive to Lava Tree State Monument
3:00 PM: Hike from Kalapana to the lava viewing point (hopefully!!!)
8:00 PM: Return to the car and drive back to Hilo for a late dinner



STOP 6.1: *Pauahi Crater*

Pauahi Crater (meaning "burning house") is located approximately 3 miles along Chain of Craters Road and is one of its more impressive features (Figure 51). This depression is 2,000 feet long (610 m) and about 300 feet deep (90 m) with 2300 mm annual precipitation. Three eruptions have occurred near Pauahi Crater in historical time. The first was in May 1973, when a fissure erupted briefly on the floor of the crater. The November 1973 eruption lasted a total of 31 days (10 November to 09 December) but most of the activity was during the first 10 hours of the first day. Two fissures opened in Pauahi Crater within minutes of each other, and lava began to pool in both the east and west pits of the crater. The crater consists of three separate pit craters. Two make a figure-8 that is 1,650 feet long and 360 feet deep. Lava flowed from the bottom of the crater in 1973 and 1979 and in 1975 the 7.2 M (Kalapana) earthquake and 6.6M quake (Ka'oiki) of 1983 created landslide rubble at the bottom of the crater. The latest eruption from crater floor was during the 1979 eruption when lava whirlpools where observed here.

The lava not only flowed in from the fissures but also erupted from the crater itself and created a huge lava lake at the bottom of the crater. A set of en echelon fissures extended from just west of the crater, across the crater floor, and east of the crater almost to Pu'u Huluhulu, a total distance of about 2 miles (3 km). The November 1979 eruption lasted only 1 day and was preceded by swarm of small earthquakes started abruptly on 15 November. During the peak of the swarm, as many as 20 earthquakes per hour shook the ground beneath the Pauahi Crater area. As with many of the other craters, Pauahi Crater holds religious significance to the Hawaiians. Often you will see Ti leaf wrapped packages, fruit, leis or other gifts sitting near the edge of the crater. These are gifts to the crater and the gods and should not be disturbed.

Sources: http://www.brainygeography.com/features/HI.crater/pauahicrater.html and http://www.volcanolive.com/pauahi.html

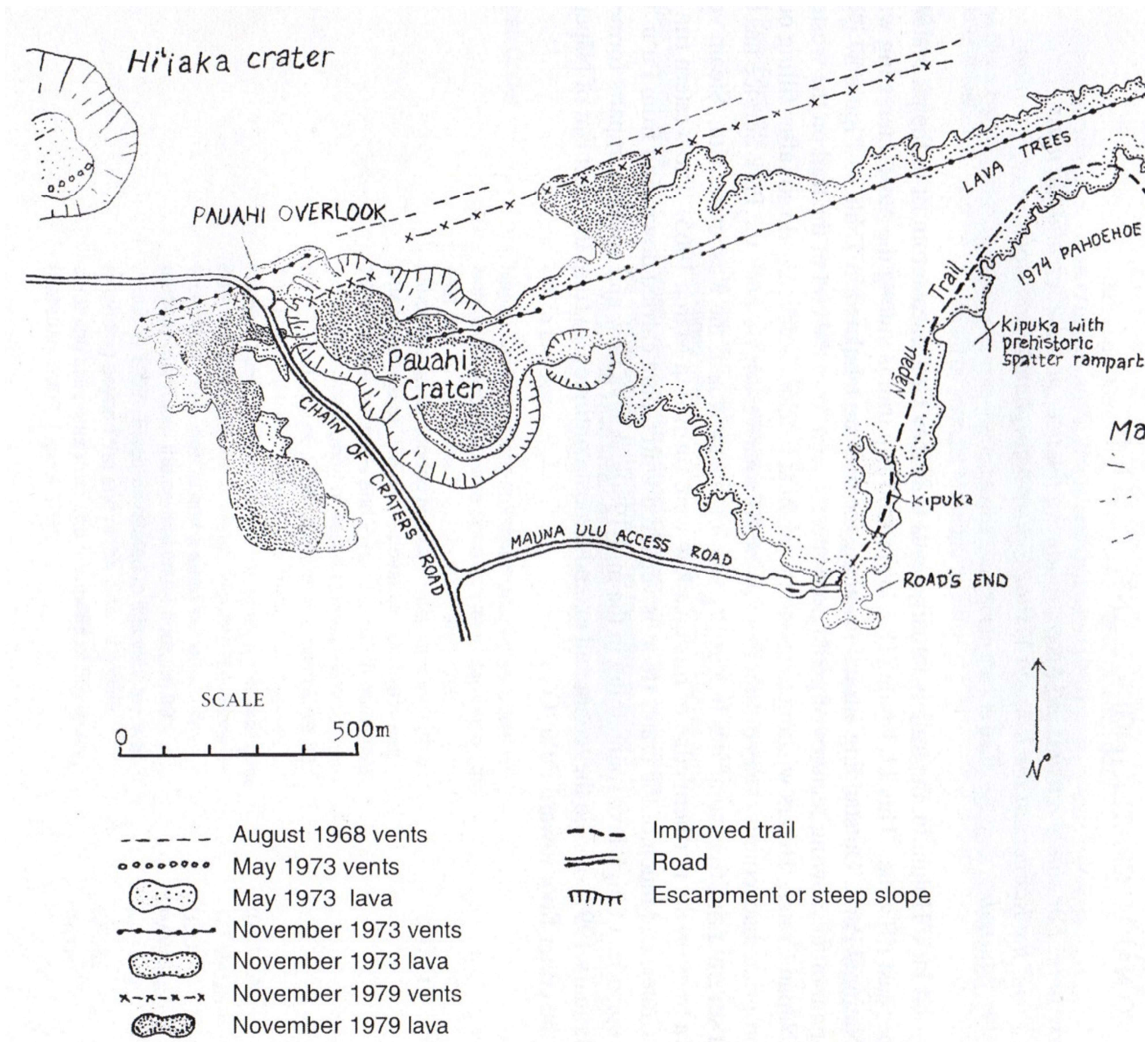


Figure 52 – Location map showing Pauahi Crater and vicinity. (From Hazlett, 2002, Fig. 35, p. 105.)

STOP 6.2: *Mauna Ula Trail*

HIKE DETAILS *Start/End:* Mauna Ulu Parking Lot
Walking Distance: 2.5 miles (4 km) round trip
Estimated Walking Time: 2–3 hours round trip
Descent/Ascent: 210 feet (64 m)
Protect Fragile Formations: Surface patterns and delicate lava trees are made from fragile rock. Reduce your impact. Do not touch these formations.

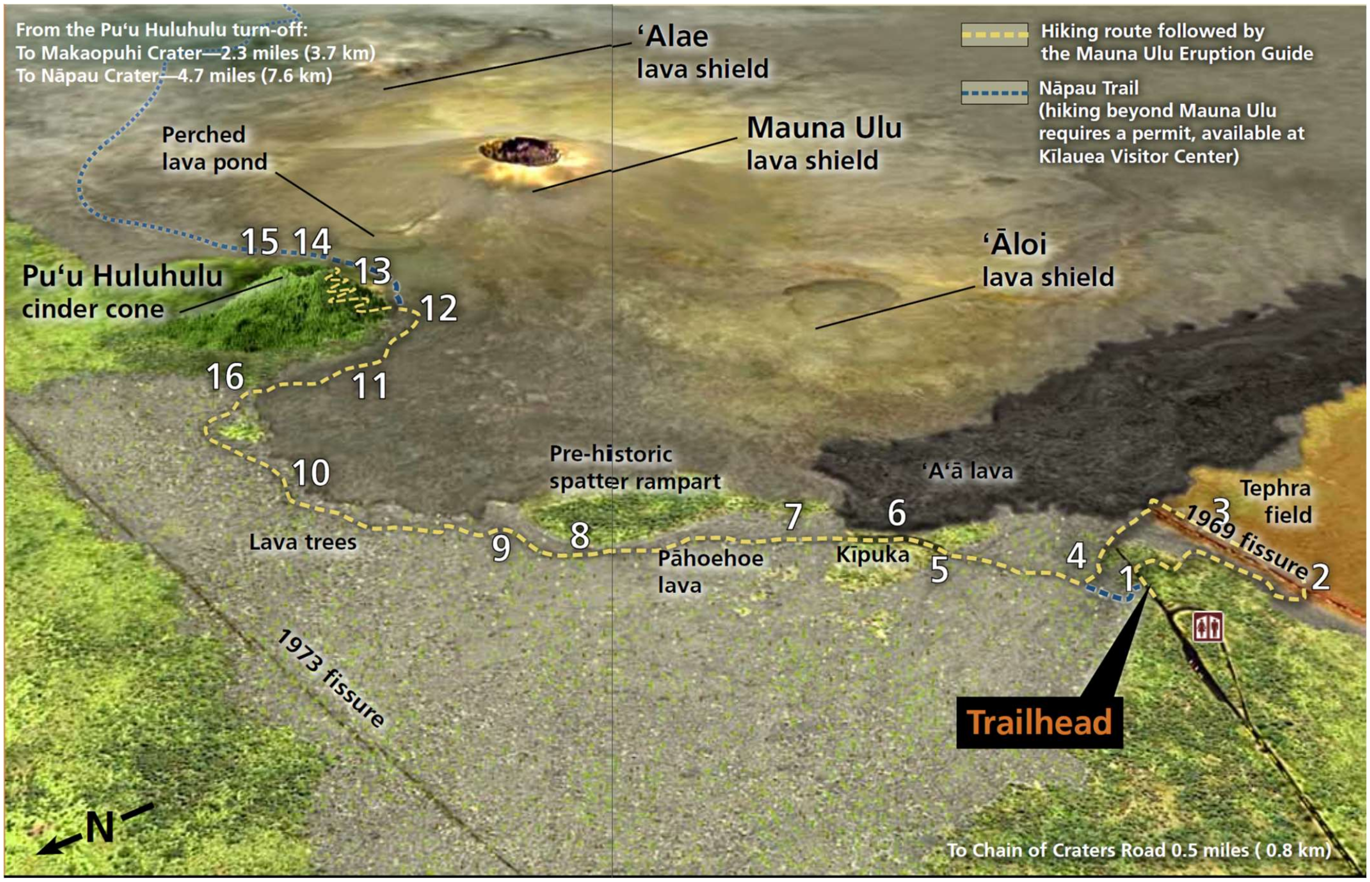


Figure 53 – Features along the Mauna Ula Trail. (From Ashley and Robinson, 2010, Mauna Ula Eruption Guide, p. 4-5.)

Before the current activity on Kilauea's east rift zone, the most long-lived rift eruption was that of Mauna Ulu (Figures 53 and 54), which began 25 years ago, on May 24, 1969. This eruption lasted until July 24, 1974. There were two main parts of the Mauna Ulu eruption, separated by a hiatus between October 1971 and February 1972. The first half of the eruption lasted roughly 2.5 years and produced an estimated 185 million cubic meters of lava (about 240 million cubic yards). The second half of the eruption lasted another 2.5 years and produced an additional 160 million cubic meters of lava. The lavas erupted between 1969 and 1974 from Mauna Ulu, and closely associated vents covered 17.6 square miles and added about 230 acres of new land to Hawaii.

The eruption at Mauna Ulu began on May 24, 1969, and, like the eruption of Pu'u 'O'o, the earliest part was characterized by episodes of high fountaining until December 1969, with fountains reaching heights of nearly 1,800 feet. The next stage of the eruption was passive effusion of lava from a new fissure just west of Mauna Ulu, then a new fissure just east of Mauna Ulu near Alae Crater. This quiet, effusive phase of the eruption was similar to that which took place at Kupaianaha from July 1986 to February 1992. The main differences are that Kupaianaha was located farther away from Pu'u 'O'o than the Alae fissure was from Mauna Ulu, and that this phase of the current eruption lasted much longer.

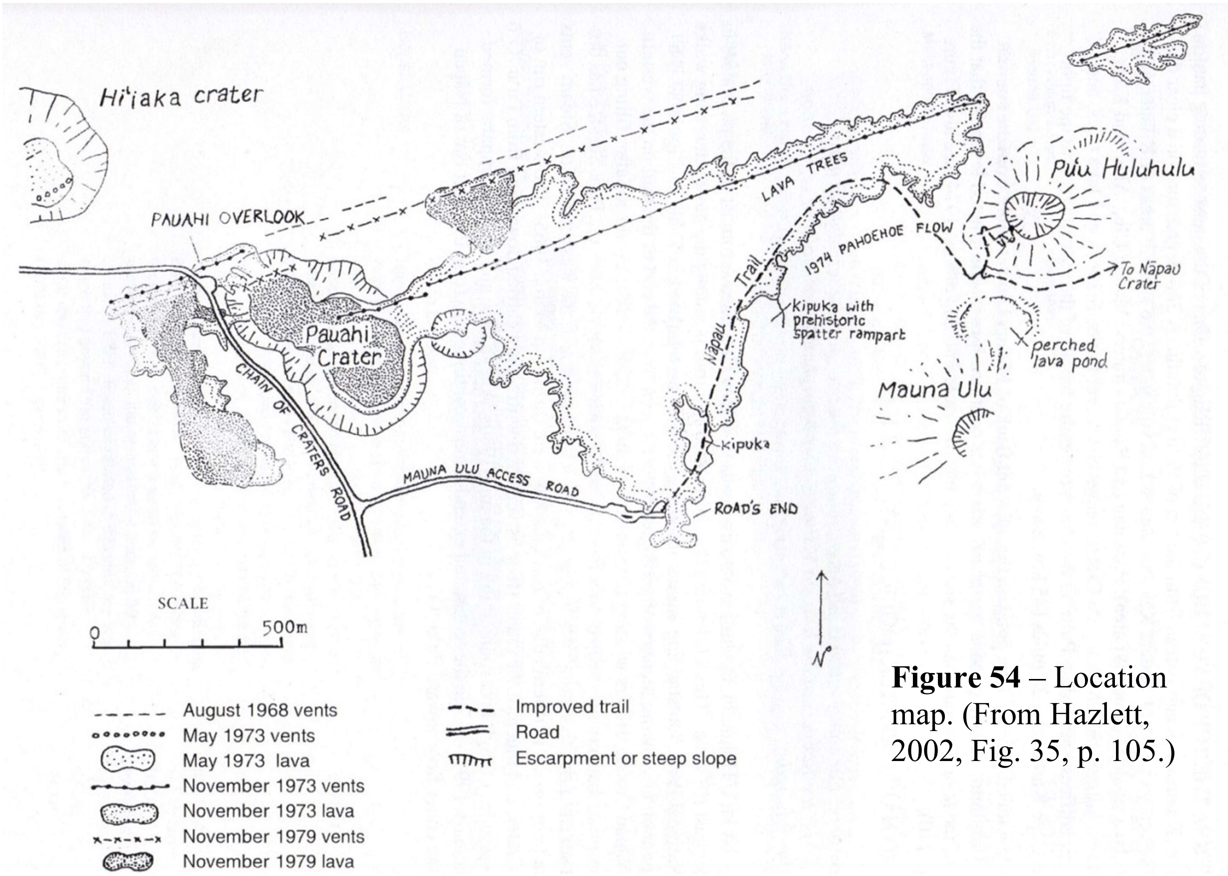


Figure 54 – Location map. (From Hazlett, 2002, Fig. 35, p. 105.)

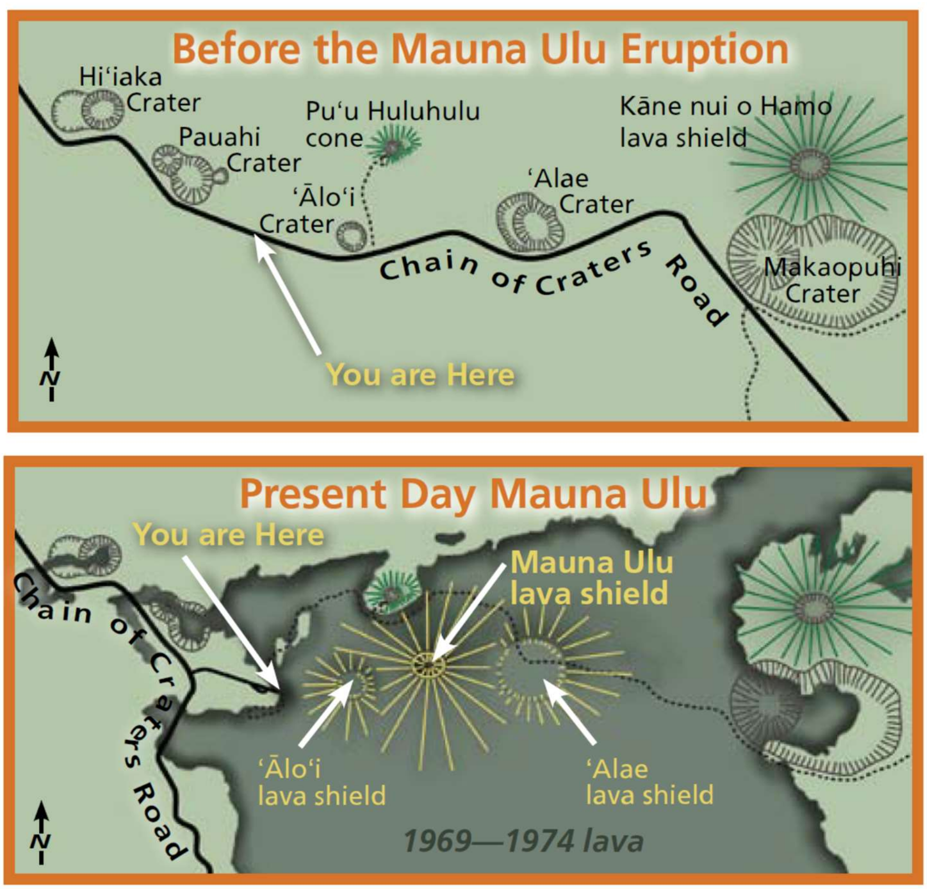


Figure 55 – Change to the regions from the 1969-1974 eruptions. (From Ashley and Robinson, 2010, Mauna Ula Eruption Guide, p. 4-5.)

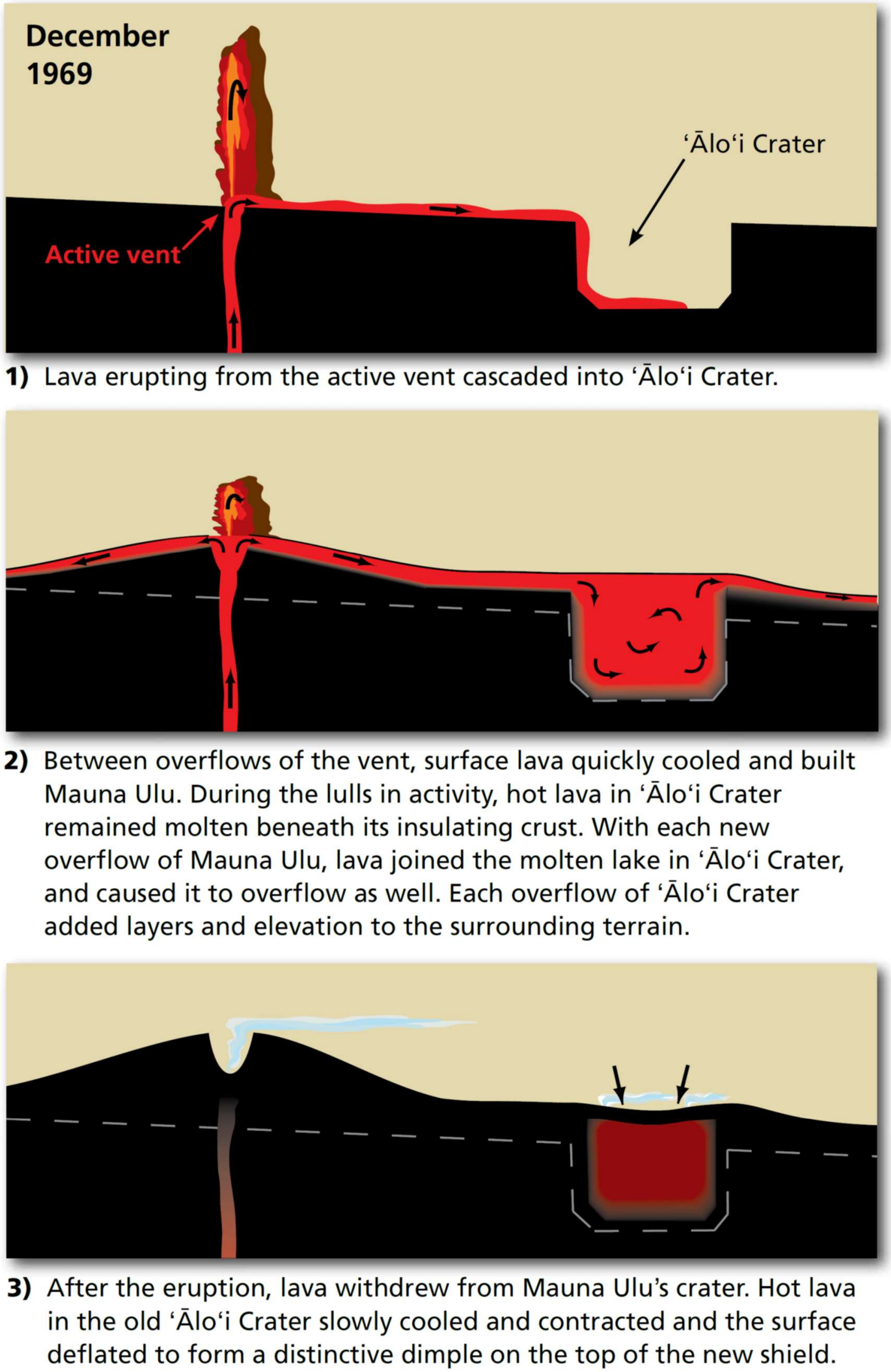


Figure 56 – The relationship of Mauna Ula and ʻAloʼi craters. (From Ashley and Robinson, 2010, Mauna Ula Eruption Guide, p. 11.)

Starting in June 1971, the surface of the lava pond inside Mauna Ulu began to drop, and the summit area of Kilauea simultaneously began to inflate (uplift) as additional magma entered the summit magma reservoir. A brief eruption took place inside the summit caldera just east of Halema'uma'u during August 1971, and another took place inside the caldera and along the southwest rift zone in late September 1971. By October 15, lava could no longer be seen inside Mauna Ulu Crater, and the first part of the Mauna Ulu eruption was over. However, magma continued to enter the volcano, as seen by rapid inflation of the summit region. No eruptions took place for 3.5 months, but by February 3, 1972, lava quietly reentered the Mauna Ulu Crater and the second half of the eruption was under way.

During the 1972-1974 part of the eruption, activity was confined to Mauna Ulu and a satellitic shield at the former site of Alae Crater, except for two fissure eruptions along the upper east rift zone - - one near Pauahi Crater in May 1973 and the other near Pauahi and Hi'iaka Craters in November and December 1973. An eruption in the uppermost east rift zone near Keanakako'i Crater and within the summit caldera from July 19 to 22 marked the end of the Mauna Ulu eruption, but not the end of activity

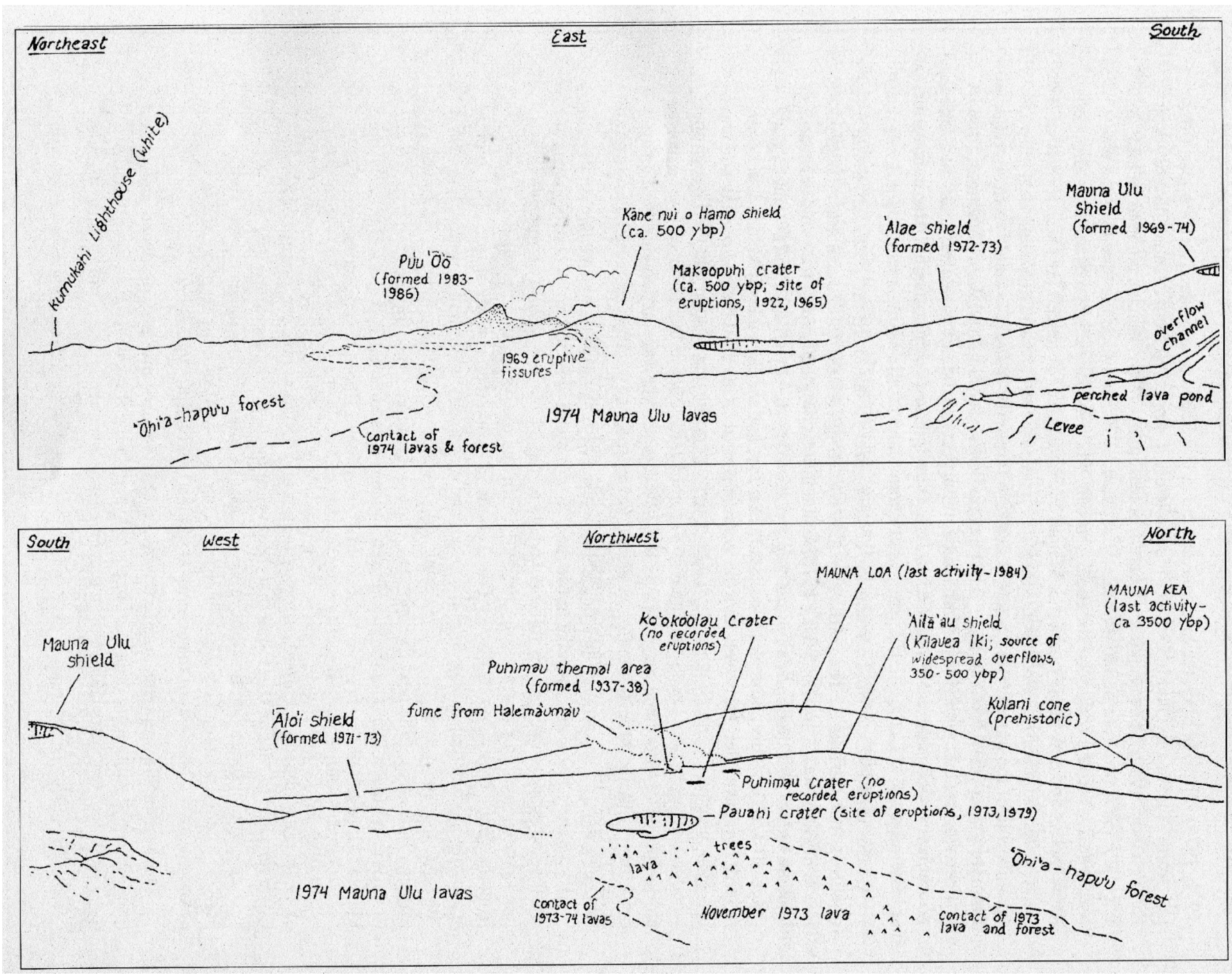


Figure 57 – Panorama from Pu'u Huluhulu (From Hazlett, 2002, Fig. 36, p. 110.)

at Kilauea, since there followed a second summit eruption in September and a large southwest rift eruption that started on the last day of 1974. After each of these eruptions, the summit of Kilauea again inflated as magma continued to arrive and swell the magma reservoir beneath the summit. The summit deflated catastrophically during a magnitude-7.2 earthquake that occurred on November 29, 1975. This earthquake moved the south flank seaward and created a large underground volume in which additional magma arriving from below could be stored. Eruptive activity did not resume on Kilauea until 1977.

The Mauna Ulu eruption is important because it is our best (and only!) previous example of a long-lived rift eruption. The sequence of events that occurred at Mauna Ulu provides us with some insight into how the current eruption may eventually end. The current eruption is the most long-lived rift eruption on Kilauea in historic time; it began on January 3, 1983 and is now in its twelfth year of nearly continuous activity. Several major phases of the eruptive activity, starting with an initial period lasting from the start of the eruption until July 1986, characterized by periodic high-fountaining events built the Pu'u 'O'o cinder and spatter cone.

This phase of activity was followed by development of a new vent, Kupaianaha, located several miles down drift from Pu'u 'O'o, which passively issued tube-fed pahoehoe flows from July 1986 until February 1992. These flows covered a large area, including the village of Kalapana, and entered the sea for several years. Since late 1991, five additional vents have formed, with the last four located on the south and west flanks of the Pu'u 'O'o cone. The first was a fissure eruption between Kupaianaha and Pu'u 'O'o. The currently active vents have erupted primarily tube-fed pahoehoe flows that have entered the ocean nearly continuously since November 1992. During the nearly 11.4 years of the current eruption, approximately 1 cubic kilometer of lava has erupted, about 34 square miles of land has been covered by lava, and about 500 acres of new land have been added to Hawaii.

There are similarities between events at Mauna Ulu and those at Pu'u 'O'o-Kupaianaha. Each eruption began with a period of high fountains, and each evolved into a passive, effusive eruption. The first half of the Mauna Ulu eruption ended following a decrease in eruptive output and a decrease in the level of the lava pond in Mauna Ulu, despite the continued addition of magma into the summit reservoir. When Kupaianaha shut down in 1992, the lava volume also decreased slowly over time, and the summit of Kupaianaha collapsed (indicating a withdrawal of magma and drop in the magma level under the crusted-over vent), despite the continued addition of magma into the summit reservoir. In addition to the inflation seen at the summit, the lava pond inside Pu'u 'O'o rose. The shutdown at Kupaianaha after slightly more than nine years of eruptive activity may be similar to the end of the first half of the Mauna Ulu eruption that lasted 2.5 years.

Based on the events at Mauna Ulu and at Kupaianaha, we suspect that the end of activity at Pu'u 'O'o will be heralded by a steady decline in lava output coupled with a lowering of the lava pond. However, we also expect the summit to reinflate with magma as the activity at Pu'u 'O'o wanes. Such pressurization of the summit region could result in eruptive outbreaks further up the east rift zone from Pu'u 'O'o, at Kilauea's summit, in the southwest rift zone, or in any combination of these locations. Eruptions occurred at all three places as Mauna Ulu activity waned in 1974. However, at the present time, we see no signs suggesting that the current eruption is slowing down.

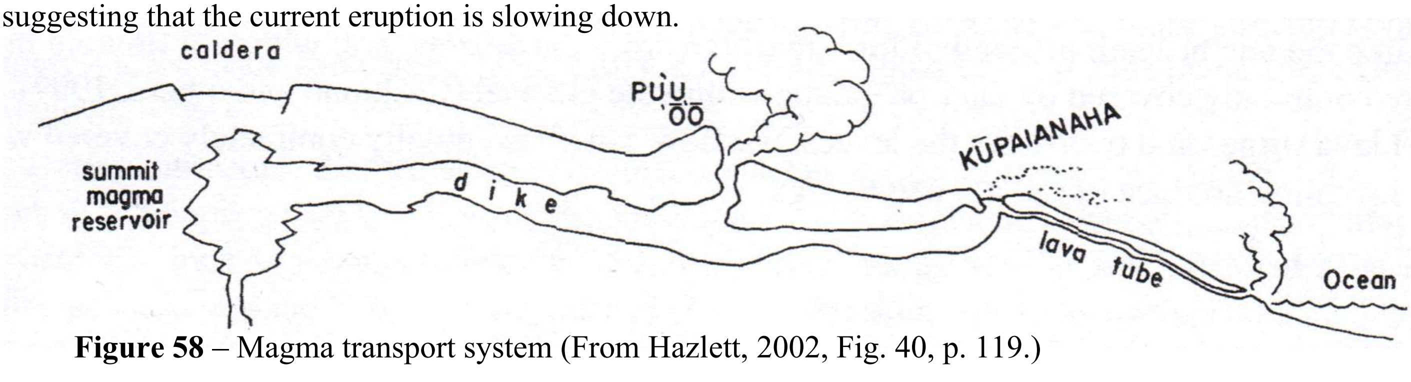


Figure 58 – Magma transport system (From Hazlett, 2002, Fig. 40, p. 119.)

STOP 6.3: *Drive along Chain of Craters Road*

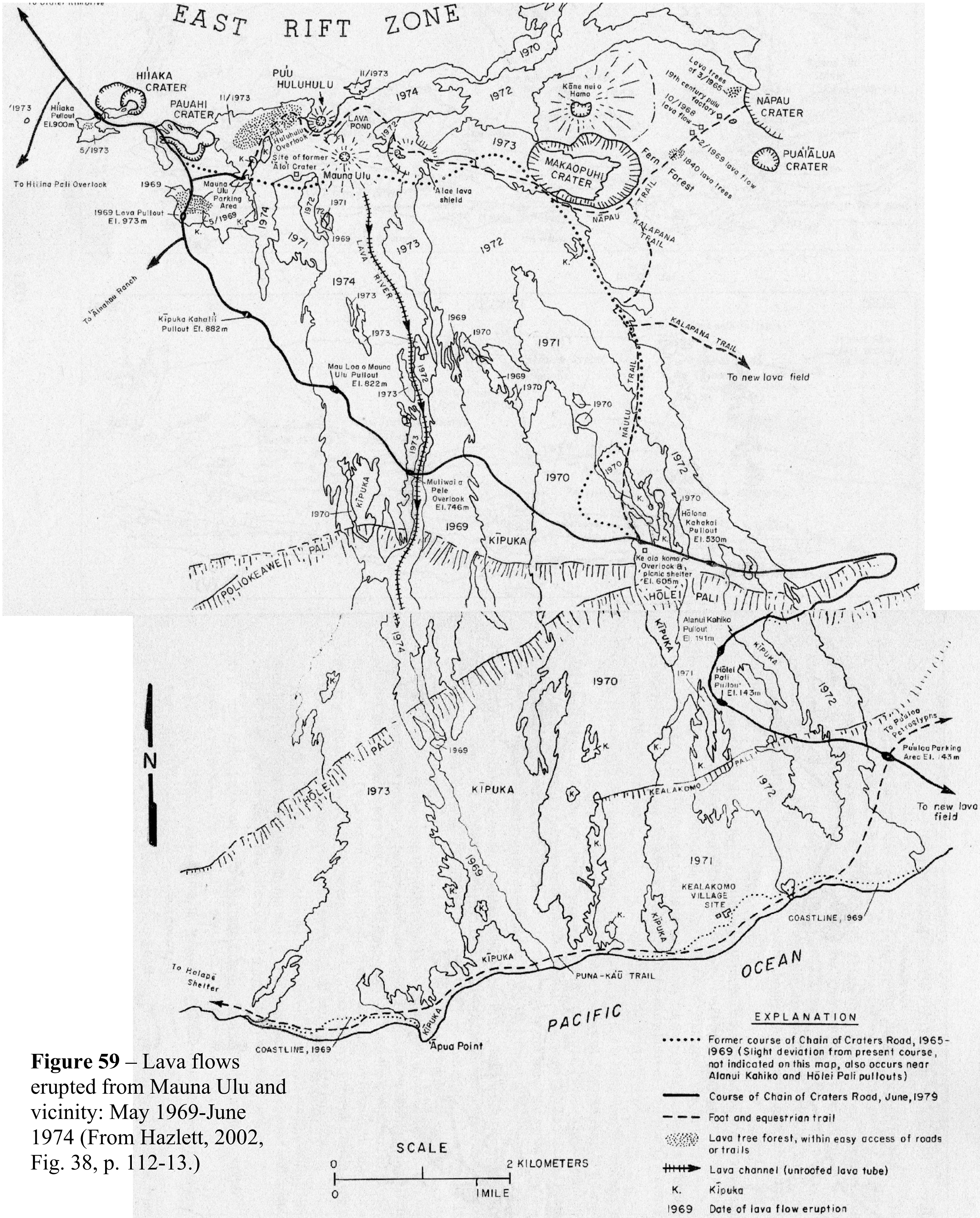


Figure 59 – Lava flows erupted from Mauna Ulu and vicinity: May 1969-June 1974 (From Hazlett, 2002, Fig. 38, p. 112-13.)

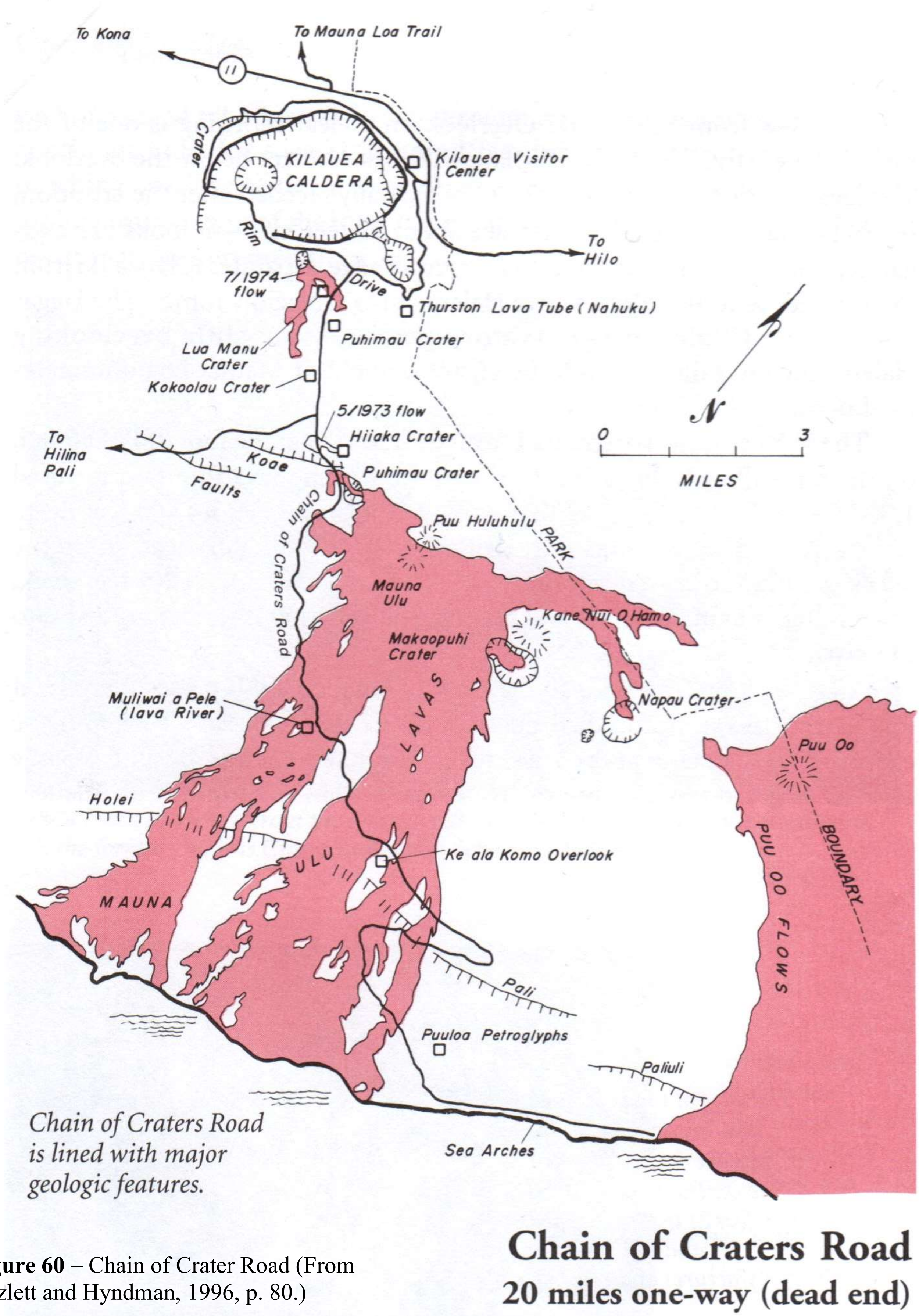


Figure 60 – Chain of Crater Road (From Hazlett and Hyndman, 1996, p. 80.)

Chain of Craters Road (formerly Cockett's Trail) was dedicated on April 15, 1928. Built at a cost of $148,000, it ended at the rim of Makaopuhi Crater. Chain of Craters Road to the coast (to Kalapana) from Makaopuhi was opened in 1965, and then partly buried in 1969 at the start of the Mauna Ulu eruption. Post Mauna Ulu eruption, Chain of Craters Road was realigned and reopened in June 1979.

The coastal region of the park was home to a number of villages; Kamoamoa, Lae ʻApuki, Kealakomo and others. Numerous trails, home sites, heiau (temple), petroglyphs and agricultural sites attest to the complex uses of this area over the centuries since first human settlement. During the 13th Century, Hawaiʻi's first luakini heiau (a temple designated for human sacrifices) was built by Priest Paʻao. Wahaʻula (red mouth) Heiau was consecrated to the God Kū and remained in use till 1819 after King Kamehameha died. This and tens of thousands of other archeological sites have been buried under lava since 1969.

Since 1986, lava has flowed repeatedly over Chain of Craters Road/Highway 130. The Park's acreage has been increased by hundreds of acres and nearly 9 miles (14.5 km) of road have been inundated by the flows. In June 1989, Wahaʻula Visitor Center and associated buildings were burnt and covered by lava. The Wahaʻula Heiau was surrounded by lava more than once and finally buried entirely in August 1997. The Kamoamoa village site, heiau, campground, picnic area, and black sand beach were covered by lava in November 1992.

In 2003, flows covered Chain of Craters road just past the Hōlei Sea Arch. When conditions permit, a drive down to the "End of the Road" offers visitors an opportunity to view excellent examples of the slow advance of lava across the coastal plain. These flows are characteristic of pāhoehoe on relatively flat terrain at a great distance from its vent.

Presently, the Chain of Craters Road is 18.8 miles (30.3 km) to the end of the road with an elevation change of about 3,700 ft. (1,127.8 meters). Chain of Craters Road begins off of Crater Rim Drive, 3.3 miles or 5.3 kilometers south of Kīlauea Visitor Center.

No food, water, or fuel is available along the Chain of Craters Road. Vault-type toilets are available at Mauna Ulu parking area (3.5 miles from the Crater Rim Drive junction) and at the end of Chain of Craters Road.

June 27 Lava Flow and its effect on Chain of Craters Road

A lava flow emerged from Kīlauea Volcano's Pu'u' Ō'ō vent in the remote East Rift Zone on June 27, 2014 and is slowly advancing towards the town of Pāhoa and threatens to cover the community's two main access routes. To sustain access in and out of the area, the NPS is working in cooperation with the State of Hawai'i, Hawai'i County, and the Federal Highway Administration to construct an emergency access route between the park and Kalapana along the previously lava-covered portion of the old Chain of Craters Kalapana road.

Source: https://www.nps.gov/havo/planyourvisit/ccr_tour.htm

STOP 6.4: *Lava Tree State Park*

The Lava Tree State Park is in the Nanawale Forest Reserve of the lower Puna district. The park is an excellent way to see both native Hawaiian plants as well as the fascinating lava trees themselves. To get to there take Highway 130 towards the town of Pāhoa. Drive past Pahoa lava from the 1290-1470 AD eruption from the Kilauea east rift zone. Pass the first intersection that takes you into Pāhoa and at the next intersection (the intersection with a traffic light) make a left onto Pāhoa-Kapoho Road (this is also Highway 132). Follow this road for about 3 miles until you see the park on your left (Figure 60). The park is open 24 hours a day, year round. There is no cost to visit the park, aside from the airfare to get to there.

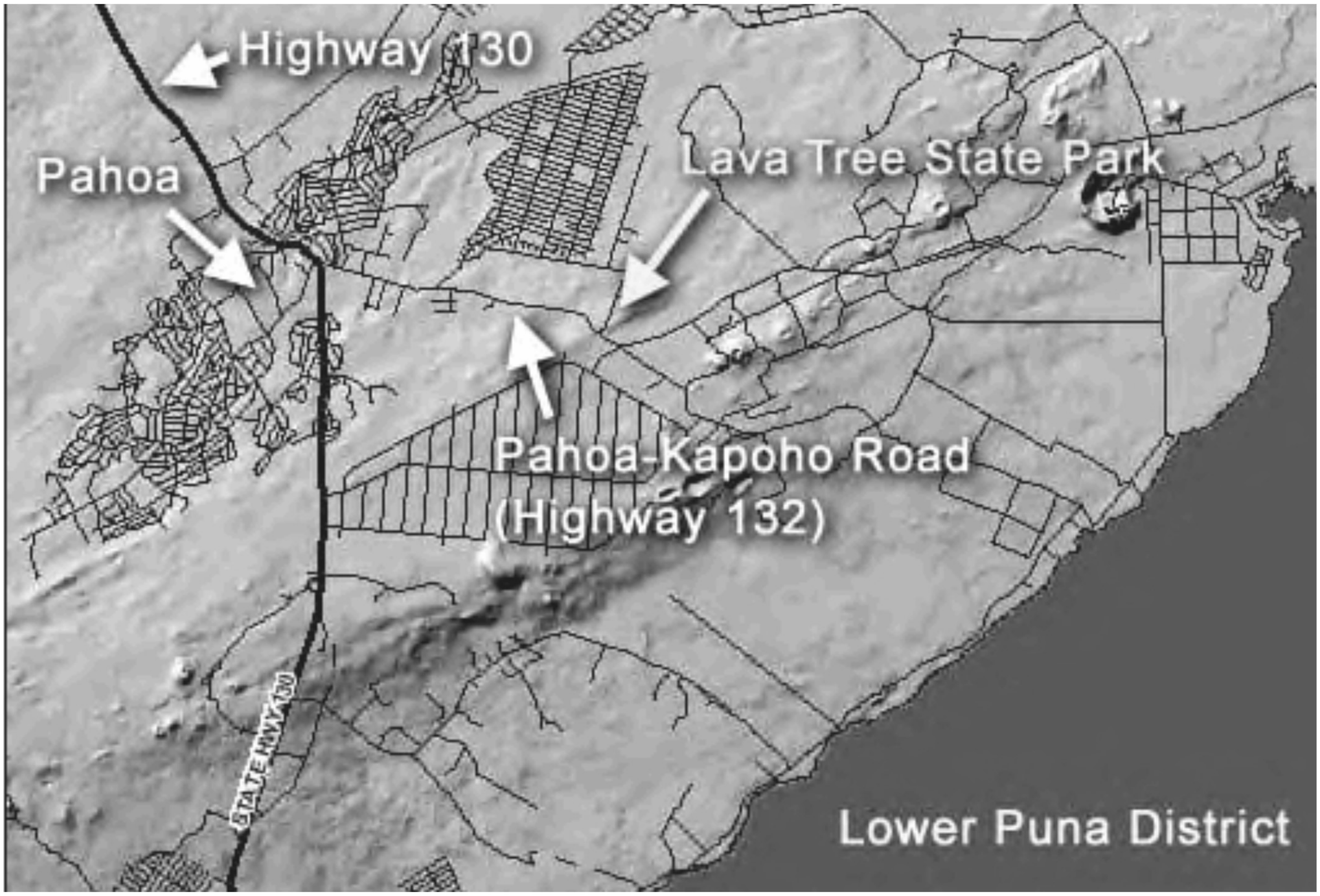


Figure 61 – Location map showing Lava Tree State Park. (From Unknown Internet Source.)

Lava Tree State Park consists of 17.1 acres of native plants, trees and many lava tree molds - most of which are still standing. A small paved trail takes the visitor around the park and is easy walking for adults and children. There are many dangerous, deep fissures, many hidden by vegetation. Another (even better but less accessible) example of lava trees can be found in the Hawaii Volcanoes National Park. The lava trees were formed during the 1790 pahoehoe flow from fissure flow of Kilauea but most of the lava drained back into fissures. Seams and lava-coated fractures, seams, and vents are drain back directional indicators. Later, Albizzea trees were planted in 1925. Here, lateritic soils are infertile but the plants thrive on leaf litter nutrients.

Lava trees are made when molten lava coats trees in one of two ways. First, a fissure can open that sprays fountains of lava into the air. The falling lava coats trees and burns the insides out leaving a lava mold around the tree. The second way for lava trees to form is molten lava flow filling an area and then draining - leaving the rock trees behind. The Lava Tree State Park is an example of this second method of formation.

In 1790 the East Rift of the Kilauea volcano opened up and issued a huge pahoehoe lava flow. This lava flow entered a wet 'Ōhi'a tree forest and filled it to a depth of over 11 feet in molten lava. When the liquid lava, at 2000° F, came in contact with the cool wet trees the lava touching the trees began to cool. At the same time, the tremendous heat consumed the tree leaving a perfect mold where the tree once grew. The mold is so perfect that you can still see the imprint of the bark in the lava rock itself (Figure 62).

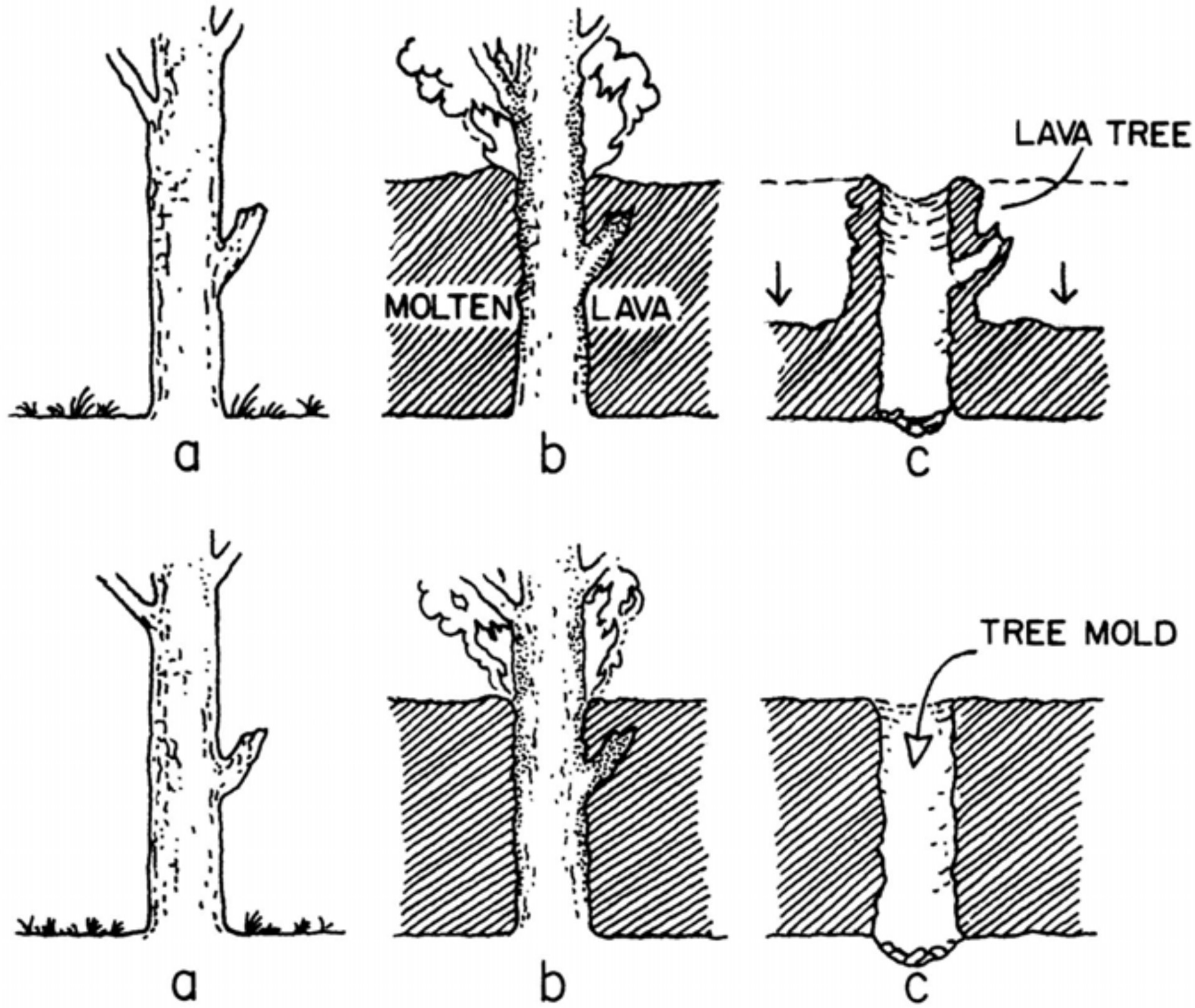


Figure 62 – Diagrams illustrating the method of formation of lava trees and lava tree molds. (From Hazlett and Hyndman, 1996, p. 31.)

Soon after filling the area with lava a nearby fissure opened in the ground allowing all the lava in the area to drain back into the earth. Because the lava surrounding the trees had already cooled due to the temperature of the trees, the lava molds did not drain but remained as monuments to the trees that once stood in the same spot.

STOP 6.5: *Hike from Kalapana to the lava viewing point*

Kalapana is a town on the island of Hawaii that was completely destroyed and partly buried by the eruptive flow of lava from Kilauea volcano in 1990 (Figure 63). A nearby housing subdivision, Royal Gardens, was also largely destroyed, though some of its structures remain untouched to the present day. The lava flow that destroyed Kalapana erupted from the southeast rift zone of Kilauea. Along with the destruction of Kalapana were those of the nearby town of Kaimu and Kaimu Bay, both of which now lie buried beneath more than 50 feet of lava. The lava flow also created a new coastline. Kalapana is now considered a ghost town. Although most access to the town has been cut off, there is currently a bed and breakfast running, and a few people still live there. These people mostly get in and out by 4-wheel drive vehicles.

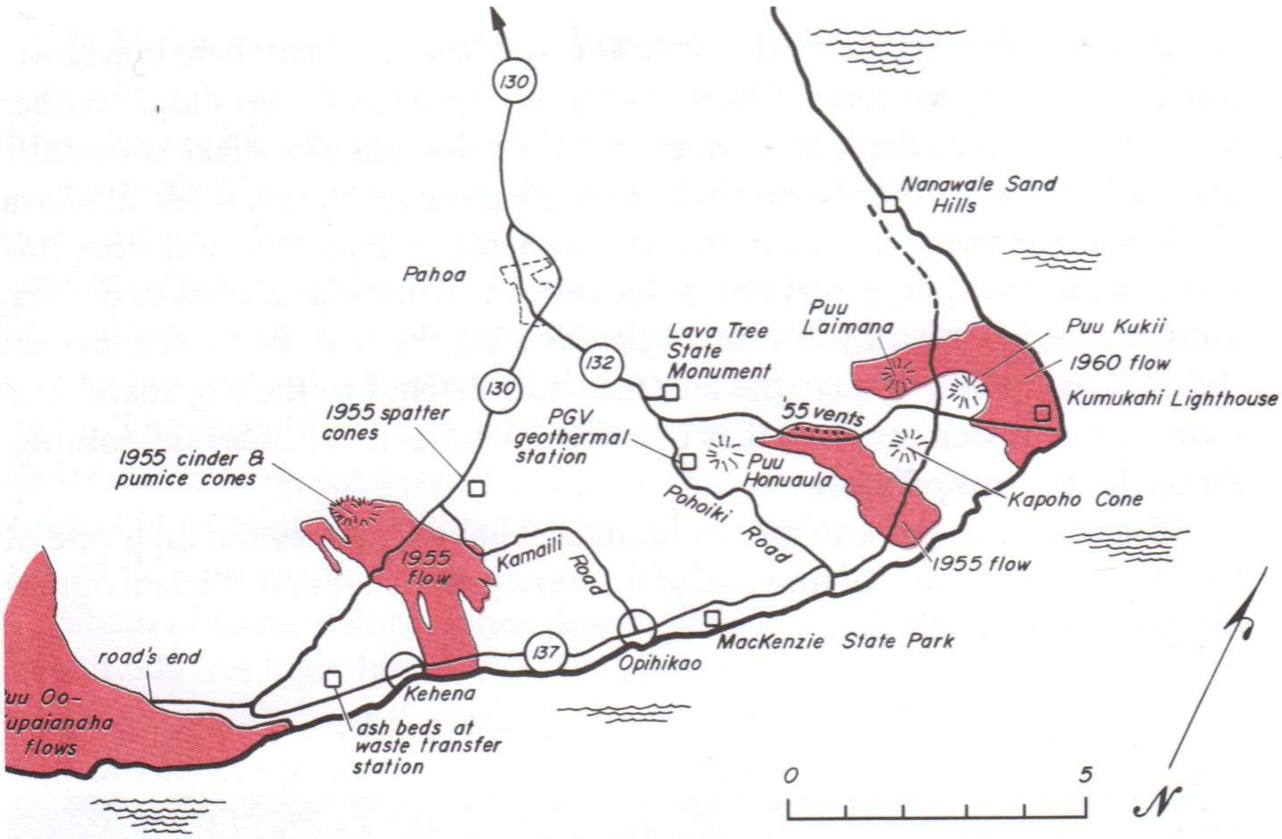


Figure 63 – Major geologic features in the lower east rift zone of Kilauea (From Hazlett and Hyndman, 1996, p. 88.).

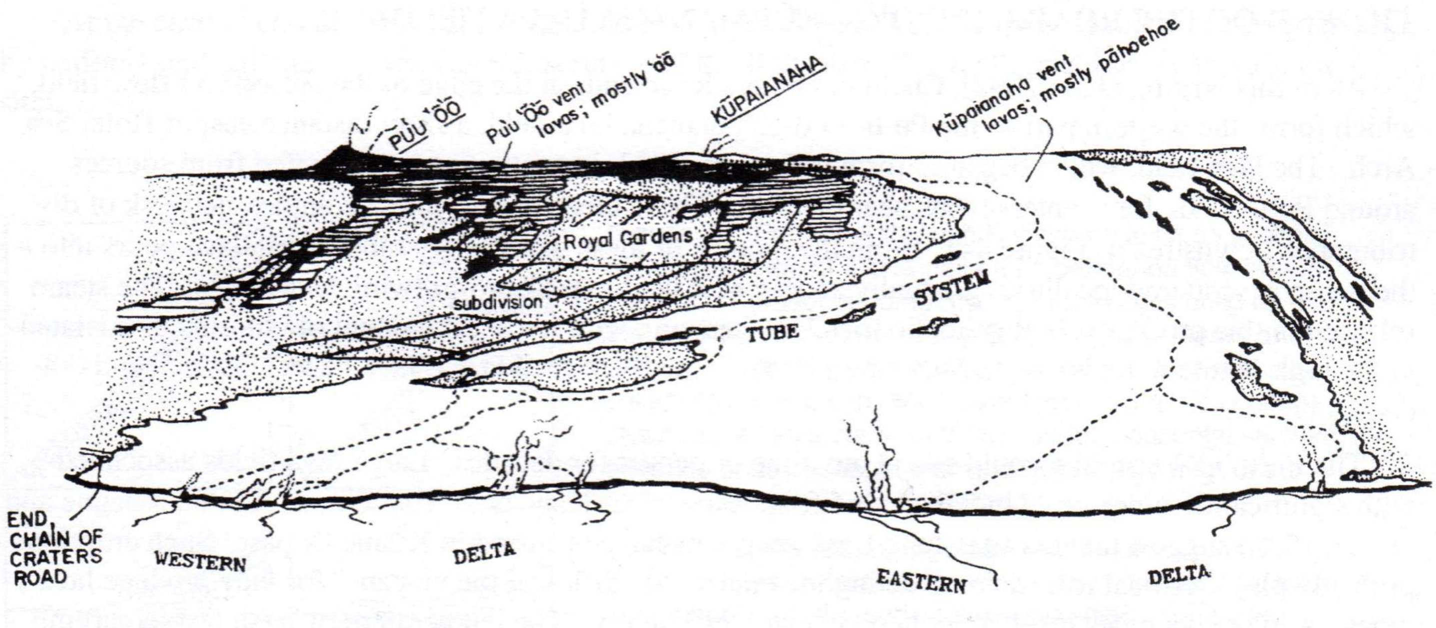


Figure 64 – Oblique aerial view of the Kupaianaha lava field in 1990-1992, looking inland from above the ocean toward the crest of the east rift zone, which forms the horizon. The dashed lines represent the path of the lava tube system. Note that a single master tube leading from Kupaianaha separates into distributary tubes down slope. From the surface, the path of the tube system could be traced by connecting scattered plumes of bluish fume rising from skylights. By night the skylights appeared as points of orange light in the slope of the pali (From Hazlett, 2002, Fig. 44, p. 127.).

The following is from https://pubs.usgs.gov/fs/2000/fs152-00/

The current eruption of Kilauea Volcano began in 1983 with spectacular lava fountaining at a new vent, named Pu‘u ‘O‘o, high on the volcano's east rift zone. Although surface flows have been common in this eruption, most of the lava from the vent travels concealed in lava tubes until it reaches the ocean.

When lava moves through the landscape and into the ocean, we see how the Hawaiian Islands are built. The experience of witnessing rock in its bright molten state and watching land being formed has fascinated and inspired everyone who has been lucky enough to see it. Seeing lava for the first time is captivating and often lures the viewer closer, but it is also beguiling and dangerous.

When hot lava enters the water, it bursts into pieces, building new land at the ocean edge from the fragmental material. This pile of rubble is then covered with a veneer of lava flows, forming a "bench" that gives a false impression of solid ground.

Without experience drawn from years of watching the behavior of this volcano, the casual visitor cannot know all the hazards and may easily underestimate them. Unfortunately, warning signs cannot always be posted near hazardous areas. This is because the positions of lava flows and lava tubes change frequently.

The information in this pamphlet has been gathered from the experiences of Earth scientists working on Kilauea. Heeding its lessons can help you safely enjoy your visit.

What are the Volcanic Hazards Facing you?

- Bench collapse can kill
- Tephra jets & littoral fountains hurl hot lava
- Steam blasts toss rocks
- Acid fumes and glass particles can irritate eyes and lungs
- Scalding waves burn

Plus, be prepared for personal hazards such as:

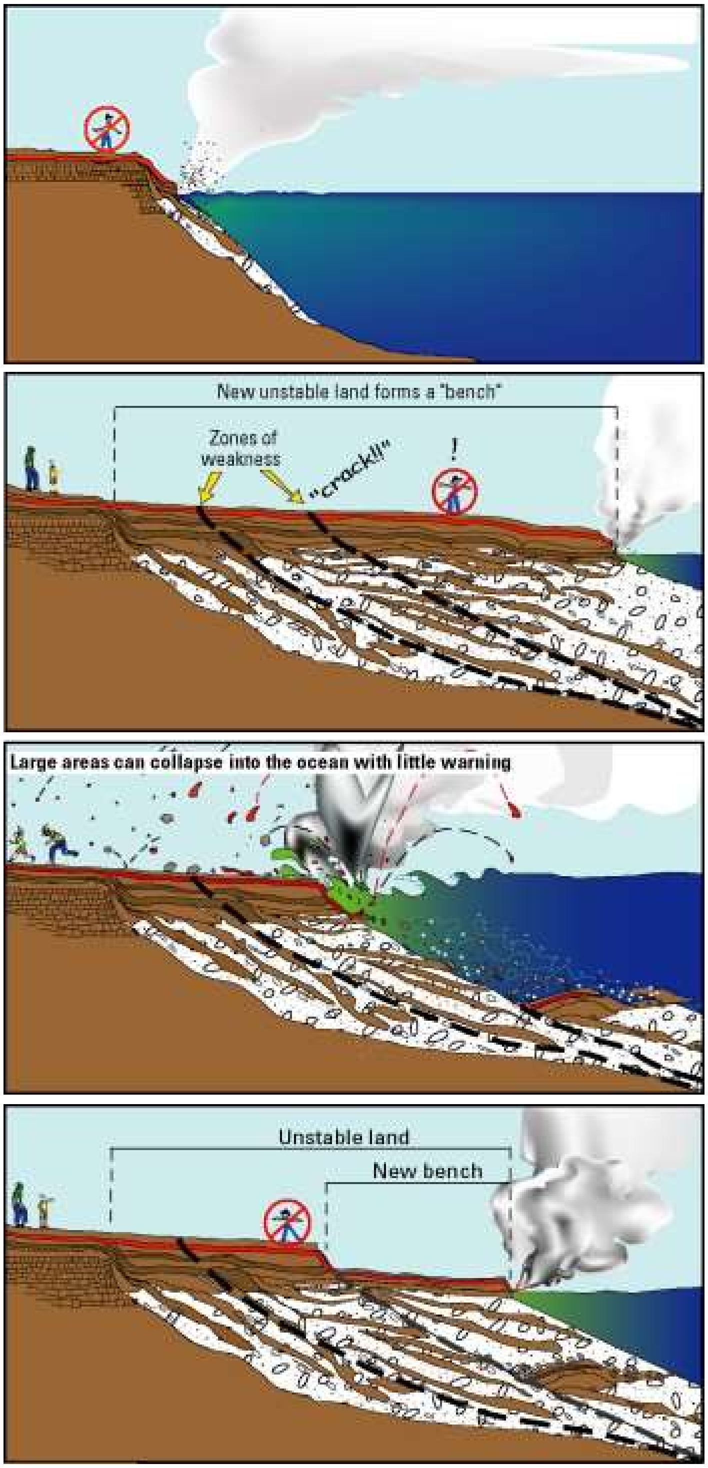
- Dehydration
- Heat stroke
- Sunburn & sunstroke
- Sprains & abrasions
- Getting lost in the dark

Recommendations:

- Do not stand near the steep cliffs. This land breaks off frequently, and you can't climb up from the ocean if you fall in.
- Do not go on the beach. Bench collapses have killed people.
- Do not go near the water.
- Move inland quickly if you hear unusual noises.

New Land, Shoreline Collapse, and Explosions

Figure 65: *Formation of bench and unstable land*



An area of new, unstable land, commonly called a "bench", forms where the lava enters the ocean. Although most activity consists of sluggish submarine flows and mild spattering, sudden landslides can cause the bench to collapse and trigger violent explosions that throw lava and rocks 300 feet (100 m) inland.

This lava covered bench looks solid from above but can collapse unexpectedly. Be alert to cracking or booming sounds.

Such collapse can trigger a series of strong explosions that blasts lava spatter and large rocks and send waves of scalding water onshore.

This lava covered bench looks solid from above but can collapse unexpectedly. Be alert to cracking or booming sounds.

What is a tephra jet?

When waves splash the open steam of lava, they "explode" in a cloud of steam, hot water, and tephra (molten spatter, tiny glass fragments, and long glass filaments known as "Pele's hair") called a "tephra jet."

A tephra jet is the most common type of explosion a visitor is likely to witness when an active lava tube opens to the sea.

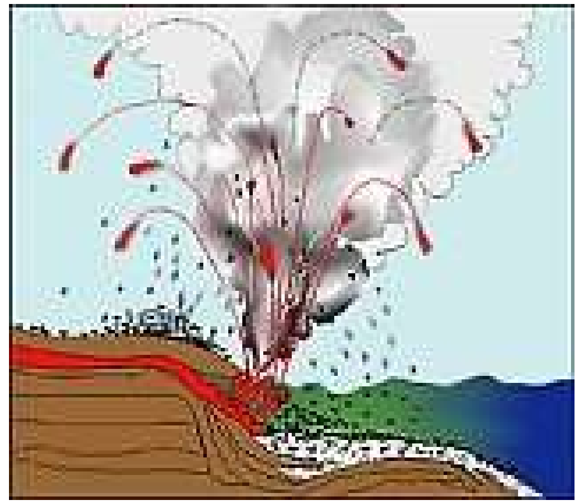


Figure 66: Tephra jet

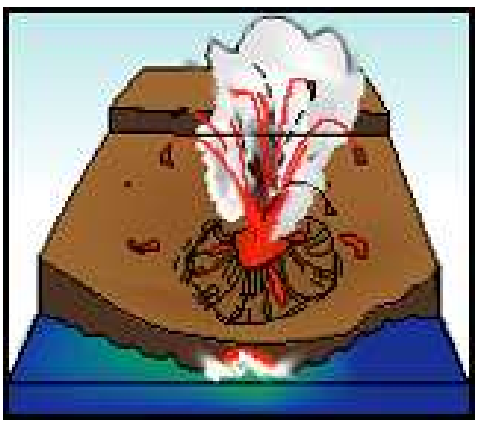


Figure 67: Littoral Fountain

A **littoral fountain** (left) produces bursts if molten lava and steam from a lava tube at or below sea level. As water enters the 2,120°F (1,160°C) lava tube, it immediately flashes to steam. The resulting explosions of molten lava, bombs, and small tephra pieces can reach higher than 300 feet (100 m) and builds a steep cone on the bench.

What causes the explosions?

Collapse of a bench exposes hot, newly solidified lava flows to sea water. The water heats to steam and can trigger a type of explosion called a steam blast. Visitors standing anywhere near a bench or on cliffs from a previous bench collapse can be hit by flying rocks.

April 1993: A person on the bench died when it suddenly collapsed. Twelve people who were near the bench needed medical attention after **being hit by flying debris.**

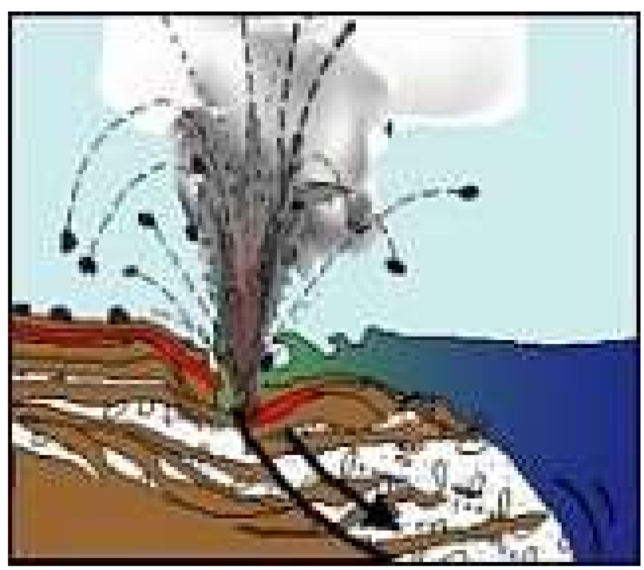


Figure 68: Coastal volcanic explosions

Is the water hot near ocean entry sites of lava?

In 1994, two people standing near the water's edge at an ocean entry site of lava were caught off guard by a sudden wave. They were severely scalded and had to be hospitalized.

When hot lava touches the ocean, it evaporates some water, forming an impressive steam plume, and heats the surface water to temperatures capable of causing third-degree burns. Visitors should stay away from the water near the bench, because unexpected waves from natural tides or high surf, as well as from sudden bench collapses, can splash hot water onto shore!

Why are steam plumes considered a hazard?

Avoid walking under plumes of "laze" (lava haze) formed when hot lava makes seawater boil and vaporize. Chloride in the sea salt combines with hydrogen in the water to form hydrochloric acid in the plumes. Clouds of laze produce "acid rain," which can fall on people and land along the coast during onshore winds. The rain, with a pH between 1.5 and 3.5 (pure water has a neutral pH of 7), has the corrosive property of battery acid. The plume cloud also contains tiny glass fragments that can irritate the eyes and, in rare cases, cause permanent damage.
Avoid walking under steam plumes!

Figure 69: Onshore winds can blow the steam plume from lava entering the ocean into the path of hikers, creating a whiteout. This plume hides deep cracks in the middle ground of the photograph.

What is a "whiteout"?

Onshore winds can blow steam plumes onto the land, causing visibility to be limited. This can be disorienting and could cause you to walk into risky areas. Move away from a whiteout when the winds shift. Heavy rain can also produce dense fog that limits visibility.

What is "vog" and who is at risk breathing it?

"Vog" (volcanic smog) is the visible haze that forms when irritating sulfur dioxide and other volcanic gases combine and interact chemically with oxygen, moisture, dust, and sunlight. Kilauea emits about 2,000 tons of sulfur dioxide each day during eruption, now mainly from the still-open vent at Pu‘u ‘O‘o.

Trade winds commonly disperse the volcano's gases, so that the concentration is not generally hazardous. However, sulfur dioxide fumes can be concentrated near ground cracks along and down-wind from lava tubes.

Concentrated sulfur dioxide fumes put all people at risk, but particularly those persons with breathing problems (such as asthma and chronic obstructive pulmonary disease) and heart difficulties, pregnant women, infants, and young children. If sulfur-fume concentrations begin to cause you physical distress, you should leave the area.

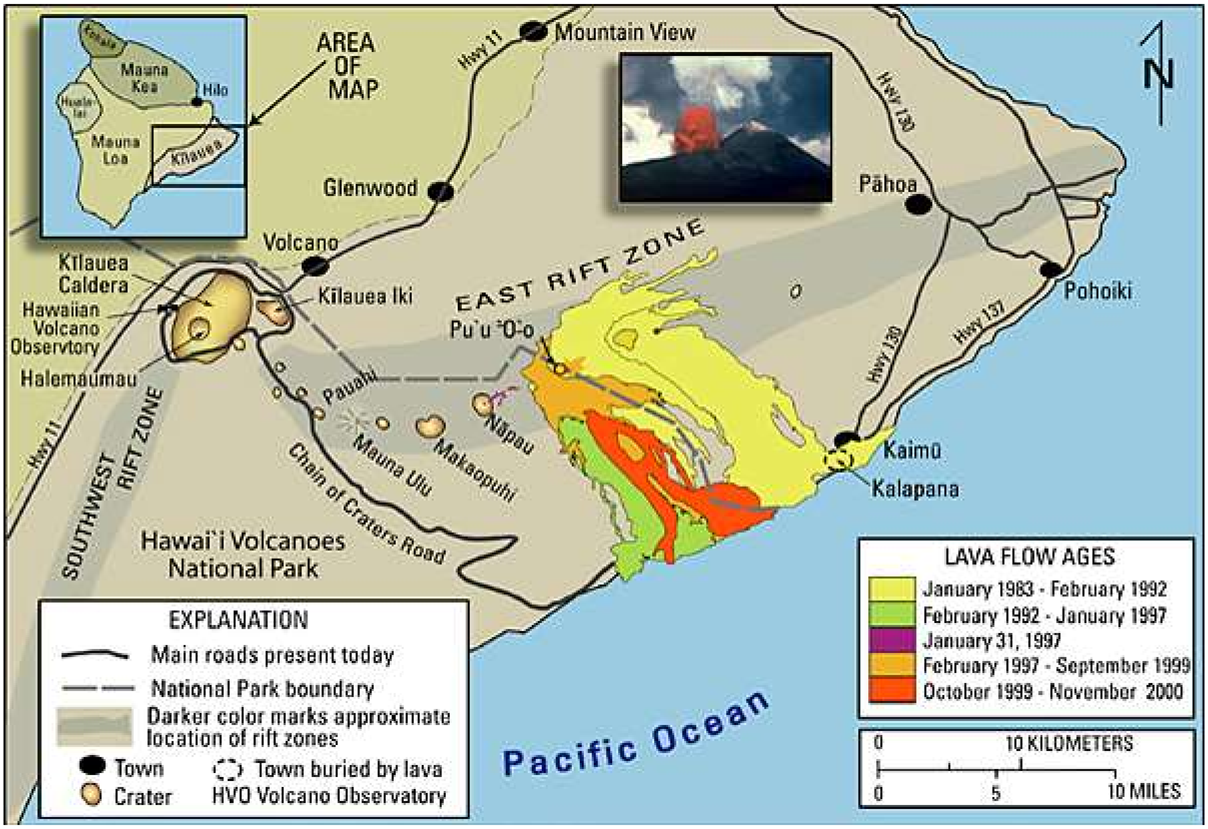


Figure 70: The current eruption of Kilauea, which began in 1983 at Pu‘u ‘O‘o on the volcano's eastrift zone, has covered many square miles with lava flows and added new land along the Island of Hawai'i's south coast. Insert shows a 1986 high-fountaining event at Pu‘u ‘O‘o. Such fountaining built a cone 835 ft (255 m) high, but the cone has lost much of its to because of collapses since 1986.

Stay Alert, Stay Alive. Plan Ahead Before Going to the Lava Flows.

Figure 71: Typical irregular surface of pahoehoe. Red glowing areas in the foreground show that this flow is still active.

How long does it take to walk there?

The hummocky surfaces of pahoehoe lava flows are unlike anything most people have walked on. Because of their surface irregularities, you should allow twice the time you think the walk might take. If a ranger tells you it is 3 miles (5 km) to the flows, consider it the equivalent of walking 5 to 6 miles (8-10 km) on a smoother surface. (Also, don't forget that the return trip always seems twice as long!)

I am only going for a few hours. Why do I need a flashlight?

Many people who walk out just for a day hike get caught in the dark. This can happen because (1) they didn't estimate their speed properly, (2) they were engrossed in the scenery and didn't pay attention to the time, or (3) darkness falls more quickly near the equator than in temperate locales; when the sun sets, there is less than an hour of twilight left.

WHAT IS A SKYLIGHT?

Figure 72: A scientist from the Hawaiian Volcano Observatory probes into a lava tube through a "skylight" near the coast. Lava in the tube has a temperature of about 2,120°F (1,160°C). The steam plume in the background is created where lava from this tube reaches the ocean.

Large volumes of lava commonly travel in lava tubes beneath the congealed surface of recent flows. "Skylights" form when the roof of a lava tube collapses, revealing the molten lava flowing beneath. It is important to stand well back from these holes, which form where the roof of the tube is thin and unstable.

What do I need to take with me when I visit the lava-flow field?

Shown below are the items that the National Park advises taking when visiting the lava-flow field. They are arranged from the essential ("very important") items at the top to recommended items at the bottom.

No services are available at the end of Chain of Craters Road. Purchase any needed items before you drive to this area.

Isn't some of this equipment unnecessary?

Most injuries are not directly due to the eruption. Intense sunlight and high temperatures can lead to dehydration, heat exhaustion, or sunstroke. Take sunscreen and a hat and drink more water than you think you need. Air temperatures near lava flows can exceed 120°F (49°C), depending on cloud cover and wind conditions. At higher elevations, wind and rain can chill you and lead to hypothermia (low body temperature).

Injuries from falling are common. It is easy to break through a thin, overhanging crust of lava or trip on a crack and fall on the abrasive, glassy surface. U.S. Geological Survey (USGS) scientists always wear long pants, sturdy boots, and sometimes gloves when working near the flows-never shorts and slippers!

Day 7: Thursday, March 10th, 2022 – Free Day in Hilo: Helicopters and Boats

??? AM: Today will be a "Free Day". Some may choose to take a Helicopter ride around the volcano, others may choose to take a boat ride out to where the lava is entering the ocean. AND others may choose to hang out in town to do the shops. We'll play this by ear as we see how the trip plays out.

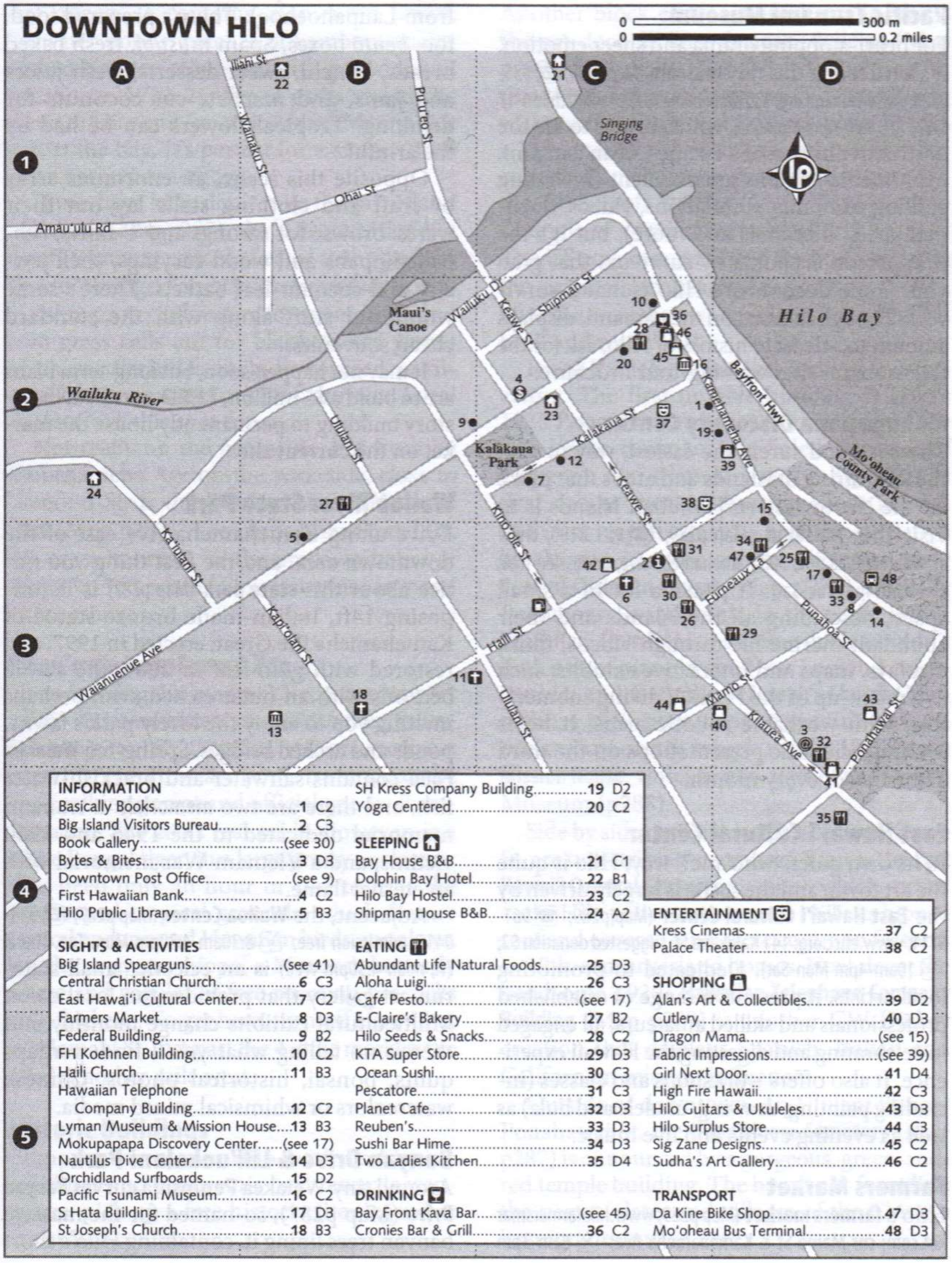
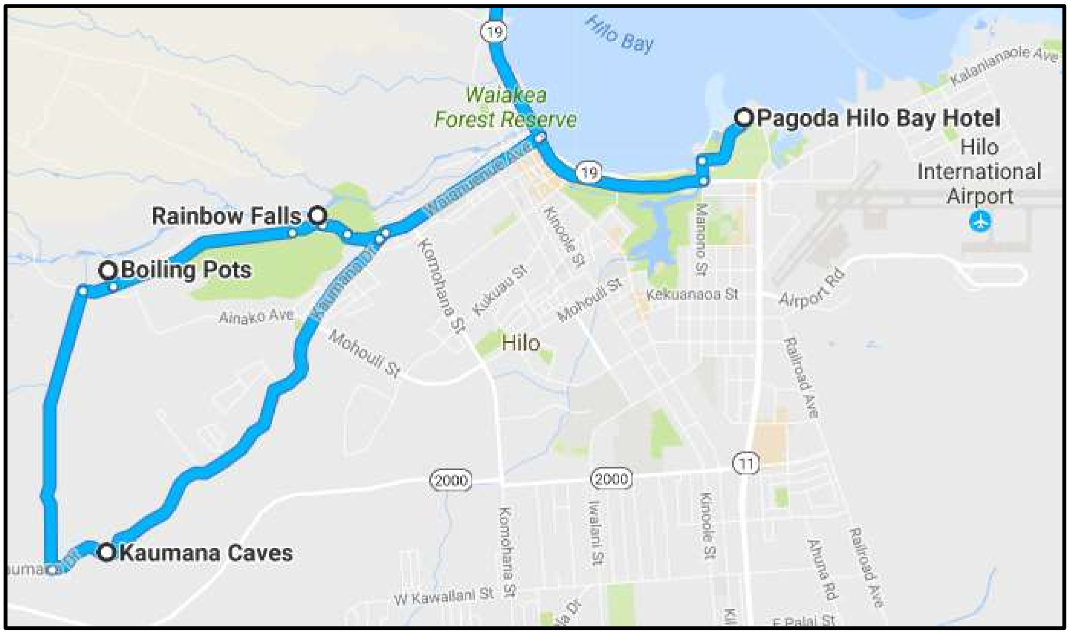


Figure 73 – Map of Hilo (From Lonely Planet Guidebook, 2009, p. 289).

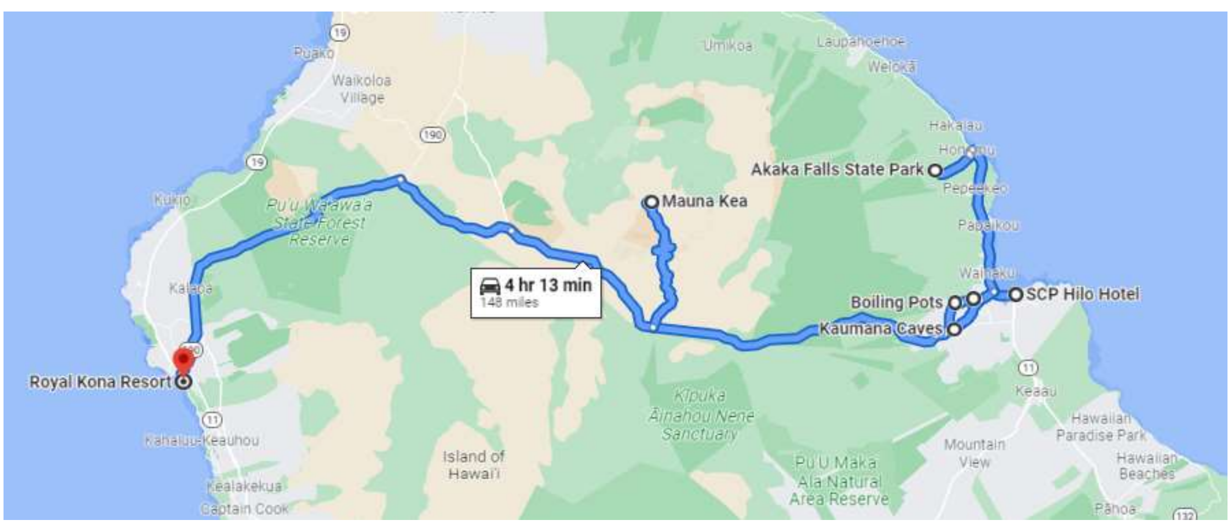
Day 8: Friday, March 11th, 2022 – Hilo to Kona: Rainforests, Waterfalls, Lava Tubes, and Observatory



8:00 AM: Pack up all your stuff, load up the vans
8:45 AM: Kaumana Cave Lava Tube
9:30 AM: Boiling Pots
10:30 AM: Rainbow Falls
11:00 AM: Akaka Falls
12:00 PM: Lunch
1:00 PM: Drive Saddle Road to Kona
3:00 PM: Arrive in Kona and check into the hotel

Royal Kona Resort
75-5852 Alii Dr.
Kailua-Kona, HI 96740

5:00 PM: If we can get a tour of the Keck Observatory on the top of Mauna Kea, we'll try to do this this evening.



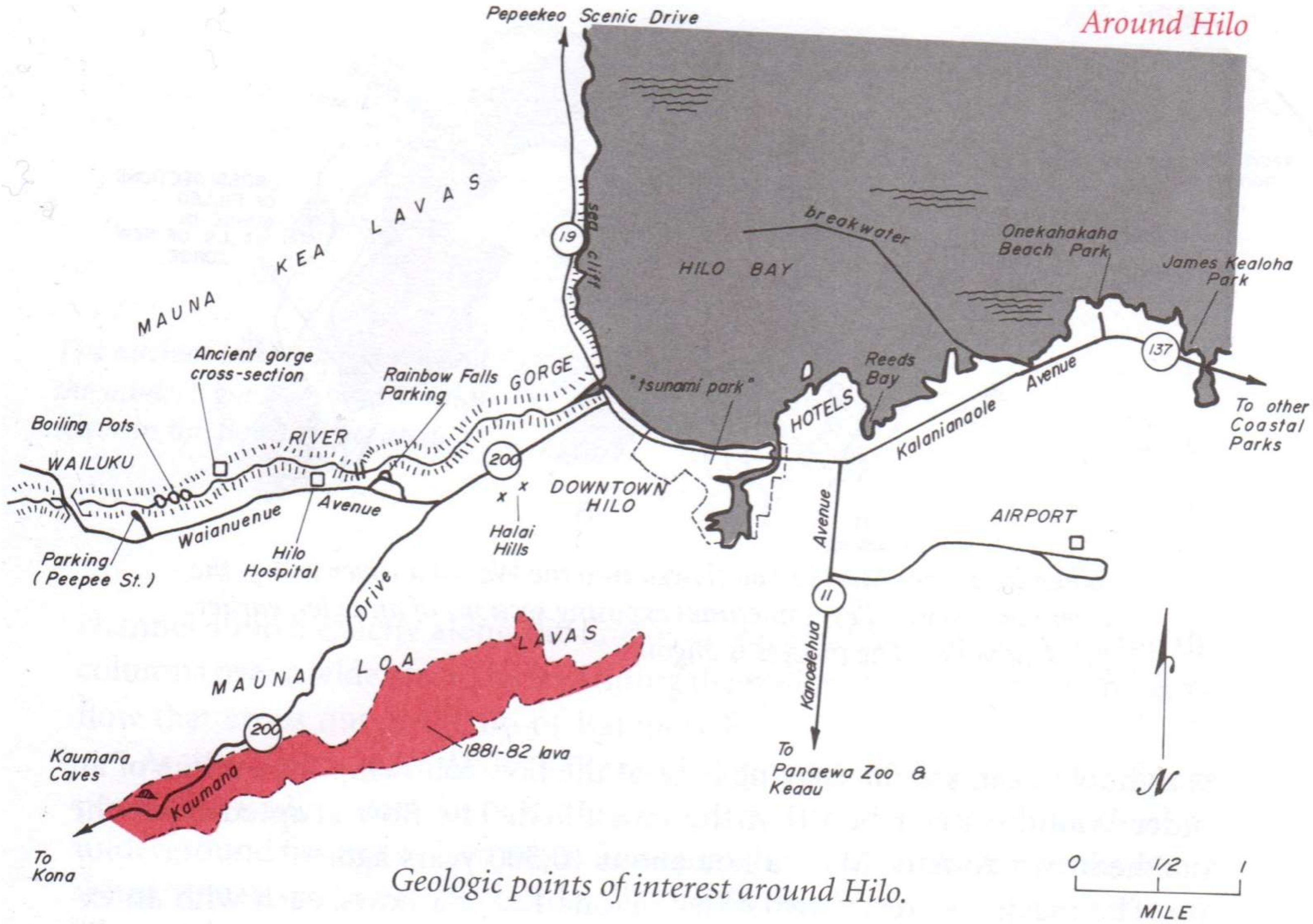


Figure 74 – Geologic points of interest around Hilo (From Hazlett and Hyndman, 1996, p. 57.).

STOP 8.1: *Kaumana Cave Lava Tube*

The Kaumana Caves, part of a 25-mile-long lava tube located on Hawaii's Big Island, are the centerpiece of a small park maintained by the County of Hawaii. Set on a hilltop above Hilo, near the 4-mile marker along Kaumana Drive (often called Saddle Road by the locals), the cave's entrance – actually a skylight formed when part of the lava tube collapsed – is open to curious visitors who want to explore the inside.

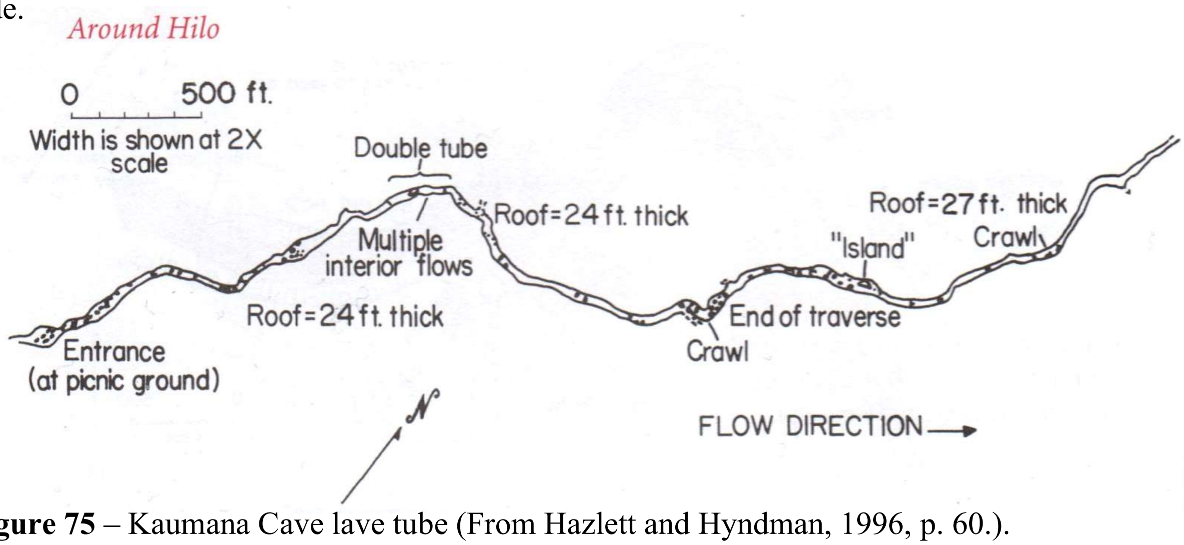


Figure 75 – Kaumana Cave lave tube (From Hazlett and Hyndman, 1996, p. 60.).

Formation

The Kaumana lava tube was formed by lava flow from Hawaii's Mauna Loa in 1881. The eruption of the giant volcano actually occurred on Nov. 5, 1880, but the lava continued its slow approach on Hilo through the first few months of 1881. By late June, it was within 5 miles of the town and began picking up speed. Legend has it that Hawaii's Princess Ruth, sent from Honolulu, is responsible for saving the then-tiny village because she was carried into the hills in late July and took up a position in front of the lava, praying to Pele, the Hawaiian goddess of religion and fire, to spare the town. The flow began slowing, and finally stopped in early August, just 1.5 miles from Hilo Bay. The Kaumana lava tube was formed as the flow first descended the hills above Hilo and, after cooling, served as a major supply conduit for the lava that followed.

Environment

A concrete staircase leads down into the skylight that forms the entrance to the caves. The section of the caves open to the public stretches for approximately 2 miles. Many areas near the entrance are lit by sunlight, but the cave is damp, cool and often muddy, with lots of vines, ferns and roots hanging down from the entranceway and the ceiling. Visitors can observe a wide variety of lava formations, including some rock that is red because it cooled so fast during the 1881 flow that it retained its color. Admission to the cave is free, and the park grounds also include picnic tables, restrooms and ample space for parking.

Risks and Precautions

The farther you go inside the cave, the darker it becomes. Visitors who plan to explore the caves beyond the first 200 or 300 feet should bring drinking water and at least two powerful flashlights with extra batteries; they should wear long pants, closed-toe shoes, gloves and a long-sleeve shirt or jacket. Proceed with caution and always shine the flashlight ahead, because the lava can be slippery, especially after heavy rains, and the farther you go, low ceilings, ledges and outcroppings make it easy to bump your head or another body part. The height of the ceiling varies from 25 to 30 feet in areas near the entrance to less than 3 feet in some deeper sections. For experienced spelunkers, numerous offshoots are available for exploration, but those who plan to do so should also bring a hard hat with headlight. Do not explore deep parts of the lava tube during heavy rains, because some sections have been known to overflow during periods of flooding.

STOP 8.2: *Boiling Pots and Rainbow Falls*

Rainbow Falls and Boiling Pots are both located on the Wailuku River just a short drive from Hilo along Waianuenue Avenue (Figure 74). Rainbow Falls (Figure 76) was aptly named for the frequent magnificent rainbows in the waterfall's mist. This is especially splendid in the early morning, which we will keep in mind in planning our day. In the same area, Boiling Pots are named for the effects of swirling waters of the Wailuku River which was a path for aa flows from Mauna Loa's NE rift zone roughly 10.5 Ka. We will backtrack later back toward Route 200 and turn right on Route 200 to see the Kaumana cave.

The 80-foot high Rainbow Falls tumble down through lavas of Mauna Loa into a large natural pool flanked by wild ginger. Here, the Wailuku River discharge is more than 300 million gallons daily. Legend has it that the cave underneath the waterfall was the home of Hina, mother of the powerful demigod Maui and creator of the Hawaiian Islands. Legend also has it that it's best to view the falls between 9:00 and 10:00 a.m., when the sun rises above the mango trees. Mangos! – You know what that means - Break into the cooler and get the blender! Nearby the waterfalls you will find the Boiling Pots (Figure 77), a series of pools whose water roils and brews due to the geological processes that are still changing the face of Hawaii. During the rainy season the river churns through a succession of "pots," resembling a steaming

Jacuzzi. Some of the river water flows beneath a level of old lava, then suddenly bubbles up as if it were boiling. The "pots" are visible from the parking area but hiking down the trail to the water's edge is much more exciting. Just don't enter the water – too much excitement is no good! To the left of the Boiling Pots note Pe'e Pe'e Falls, a beautiful, five-spouted waterfall.

Figure 76 – View of Rainbow Falls. (Unknown Web Contribution.)

Figure 77 – View of the Boiling Pots. (Unknown Web Contributor.)

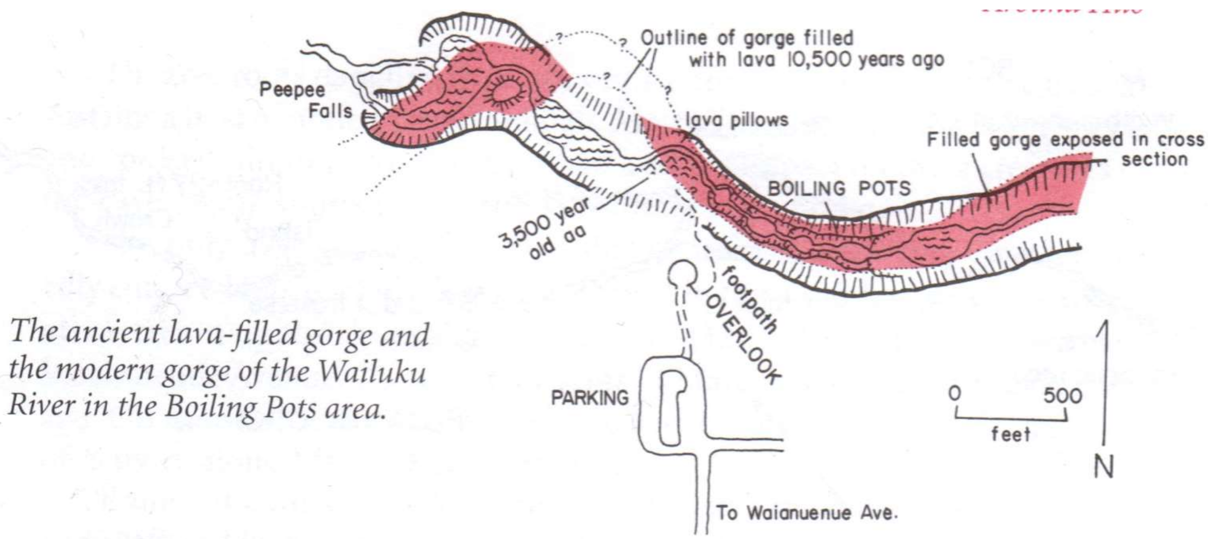


Figure 78 – Location map of the Boiling Pots area (From Hazlett and Hyndman, 1996, p. 59.).

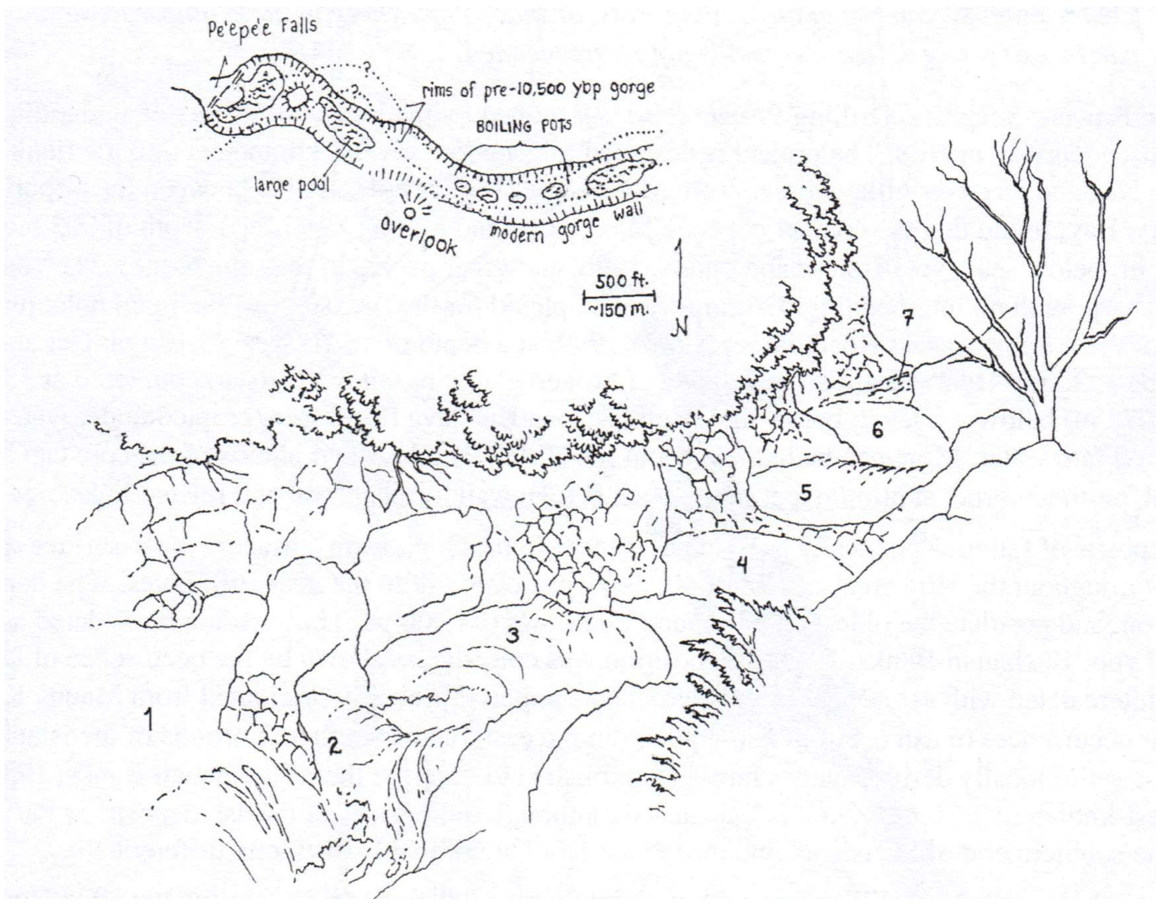


Figure 79 – The Boiling Pots, Wailuku River. The sketch shows the view looking downstream from the undeveloped path below the visitor overlook. Especially fine cooling joints in the 10,500-year old lava crop out around pools 4-6. Pool 4 often is separated from pool 5 by a ledge of jointed lava, draining into it through a subterranean chamber. The view downstream past the rapids at 7 reveals a spectacular view of a lava-filled paleogorge exposed in the modern riverbank. Getting into position to see this may be treacherous, however, owing to slippery wet rocks, mud, and vegetation (From Hazlett, 2002, Fig. 8, p. 37.).

Both the Rainbow Falls and Boiling Pots are controlled by past and present geologic forces. Boiling pots are steps of large, circular pools. Kind of like a series of potholes about 10 to 20 m in diameter (Figure 78). The first pool drops down into the second pool usually by a waterfall. All of the pools are in succession, flowing in route until they get to the ocean. They are developed between the shields of Mauna Loa and Mauna Kea at Humuula saddle, a natural channel for rain runoff from the southern and southeastern flanks of Mauna Kea. Because of the runoff, a shallow gorge developed along the edge of the Mauna Loa lava which was subsequently filled with a prehistoric lava flow. This flow, eroded by the present Wailuku River, formed the boiling pots. The cooling of the prehistoric flow made several distinct fracture zones including long skinny columnar joints with a hexagonal shape. The columnar joints are about 40 cm across with a height of 10 - 12 m.

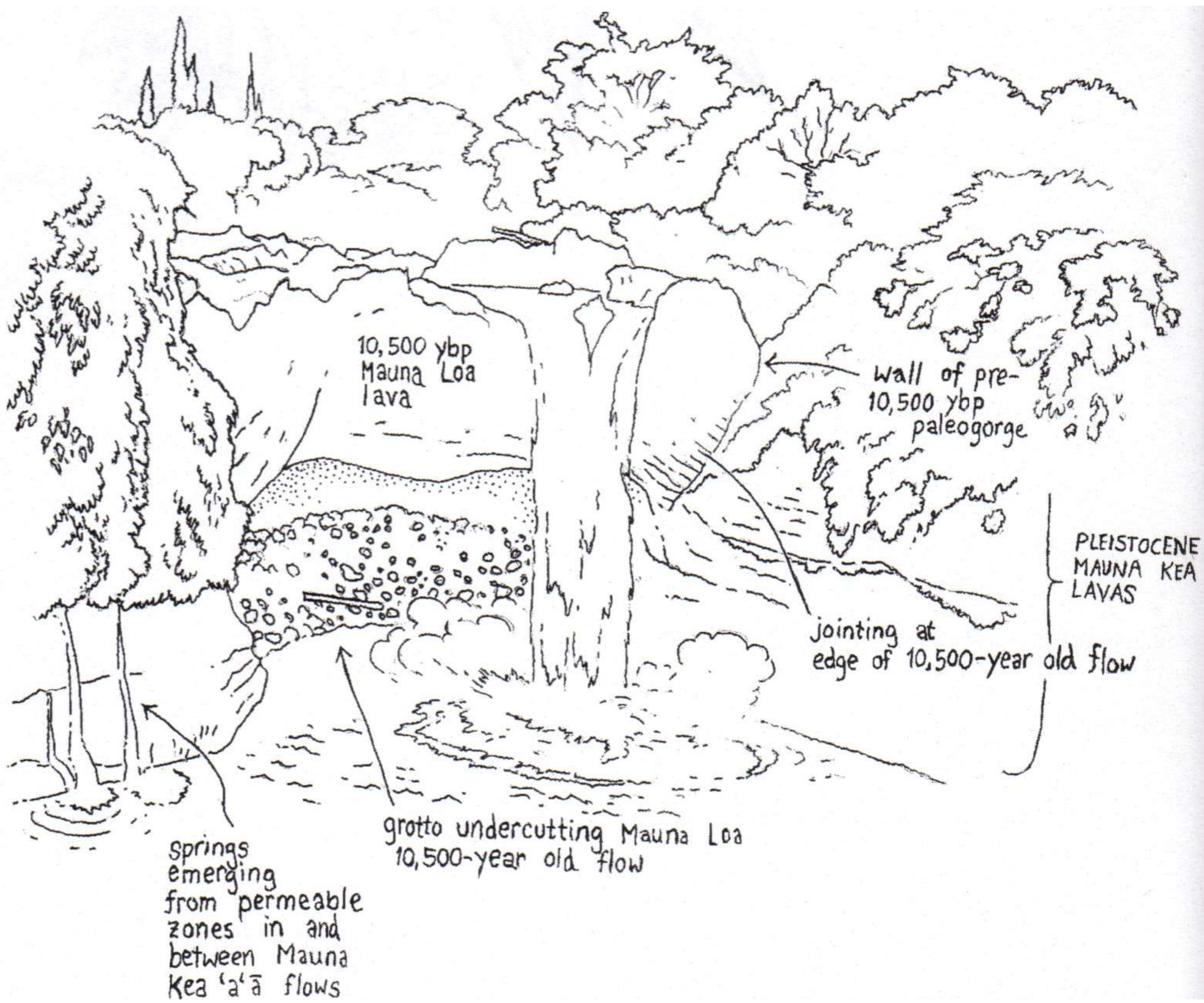


Figure 80 – Geologic features observable from the Rainbow Falls Overlook, Wailuku River, Hilo (From Hazlett, 2002, Fig. 7, p. 36.).

STOP 8.3: *Akaka Falls*

Heading north out of Hilo on Highway 11 leads you onto the Hamakua Coast (Figure 81). Between the 14 and 15 mile markers is the junction with Highway 220, which takes you directly to Akaka Falls State Park. A sign is posted just prior to the junction, indicating this destination. The park is approximately 5 miles from your turn, at the end of the road. The drive will provide some of the most spectacular views of Mauna Kea to be found on the windward side of Hawaii. On a clear day, you will see 4 or 5 of the world-class astronomical observatories that sit at the top of Hawaii's tallest volcano, gleaming white and somehow otherworldly amidst the stark grey and brown of the peak's barren summit.

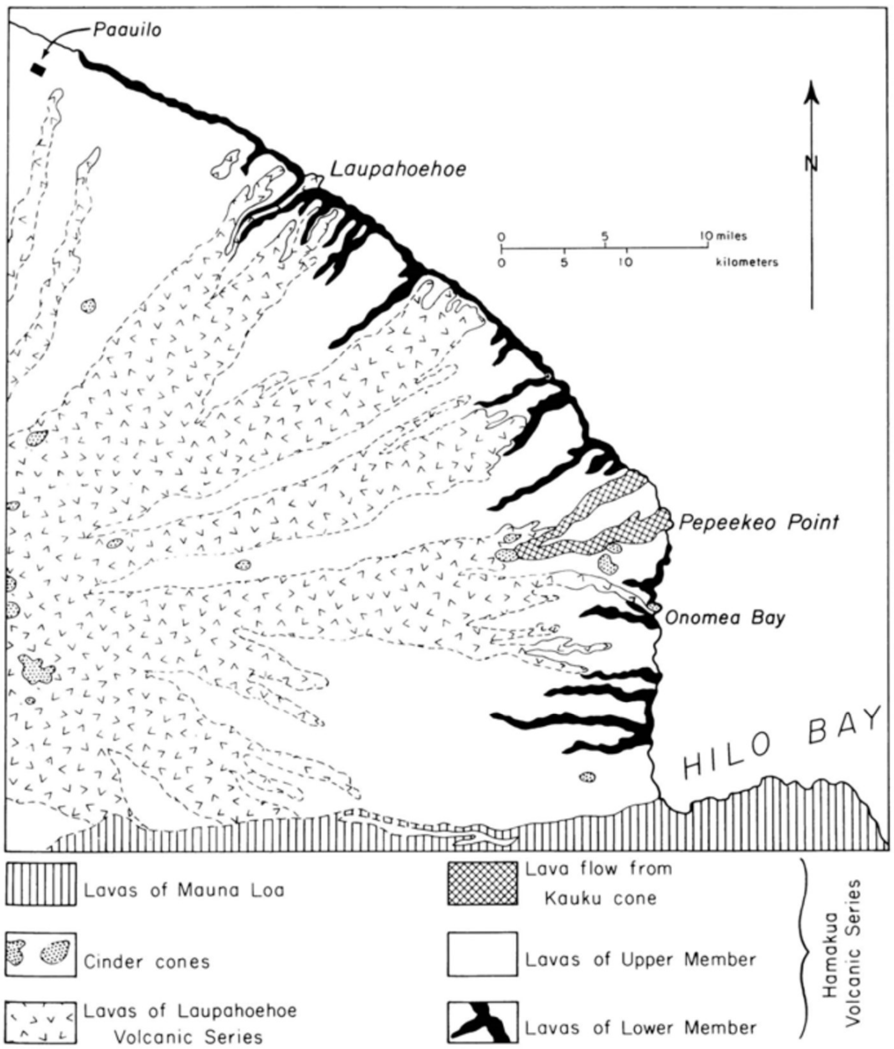


Figure 81 – Geology north of Hilo Bay. (From Macdonald and others, 1983.)

An easily navigated loop trail less than 1 mile begins at the small parking lot. A sign at the trail head provides the distance to Kahuna and Akaka Falls (Figure 82), as well as to a third water fall, which is an unexpected treat, since the park name gives no indication of additional water features. The trail is paved but has many steps, both up and down, along its length and a misstep will easily bring you to your knees on some rough lava rock. Your entire course is taken under towering bamboo, banyan trees, giant heleconia, banana, and ginger. Dizzying sights surround you in every direction.

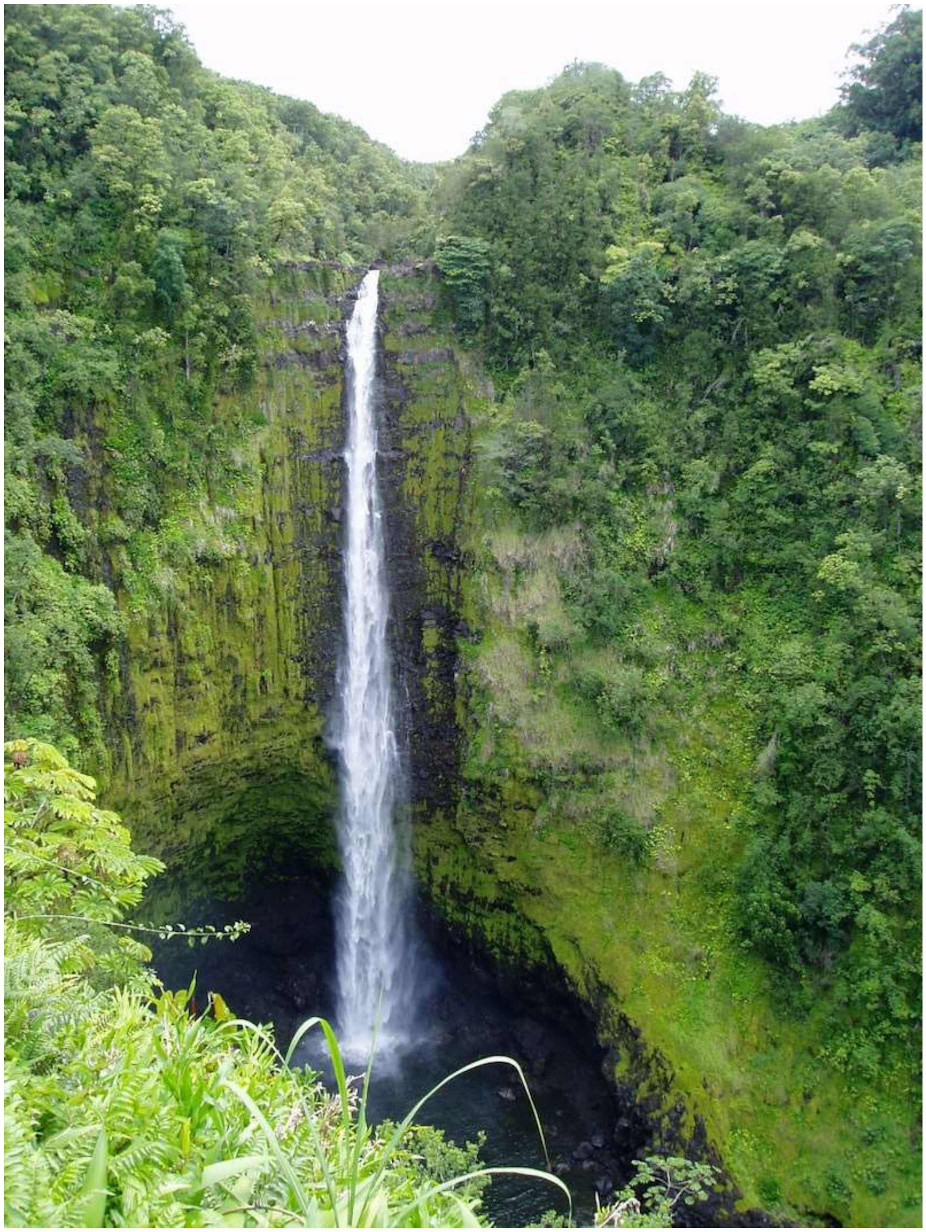


Figure 82 – View of Akaka Falls showing stacked lavas and a plunge pool. (Unknown Web Contributor.)

By keeping to your right, you arrive first at Kahuna Falls, a 440-foot water fall that slides down the mountain across the ravine ahead of you, rather than tumbling down in a sheer drop. This fall is pretty but is partially hidden by the lush foliage and the deep channel it has carved for itself over the eons. Keep in mind this is not what you came to see. Continue the loop, which now climbs up the steepest section of the trail. This portion appears daunting, but lasts for no more than 100 feet before you reach the top. Once at the top of the incline, you will hear Akaka Falls before you see it and, with luck, you'll catch a cooling breeze from the ocean.

A few steps farther along and the trail begins to descend. Views of the fall appear through the trees and shortly you are at the viewing area. The fall is now directly in front of you, glorious in its sheer cliffs. It falls, straight and narrow for 420 feet from the lip of basalt, hitting bottom in a green, fern-filled grotto with a blaze of rainbows reflecting in the spray. The Hawaiian word akaka means to split and the falls breach a steep normal fault and cascades downward through Mauna Kea aa flows with a capping of lateritic ash. A large circular plunge pool adorns the base of the falls.

While neither the highest nor most voluminous fall on the Big Island, Akaka Falls is certainly the easiest to access. The loop trail can be completed in no more than one half hour, though lingering at the viewing area to marvel at this virtually drive-up wonder of nature and cool off after the ups and downs of your walk can add as much time to the trip as you like. The drive back down to Honomu town provides some awesome ocean views. The Pacific is spread out before you in 3 directions and reminds you that you are indeed driving on an island. This fact, seemingly self-evident, is easy to forget since the island is so large. The view will bring you back to the reality of your location.

Source: http://hawaii.kulshan.com/Hawaii/Hawaii_County/The_Big_Island/Honomu/Outdoors/Akaka_Falls_State_Park.htm

STOP 8.4: *Mauna Kea Observatory*

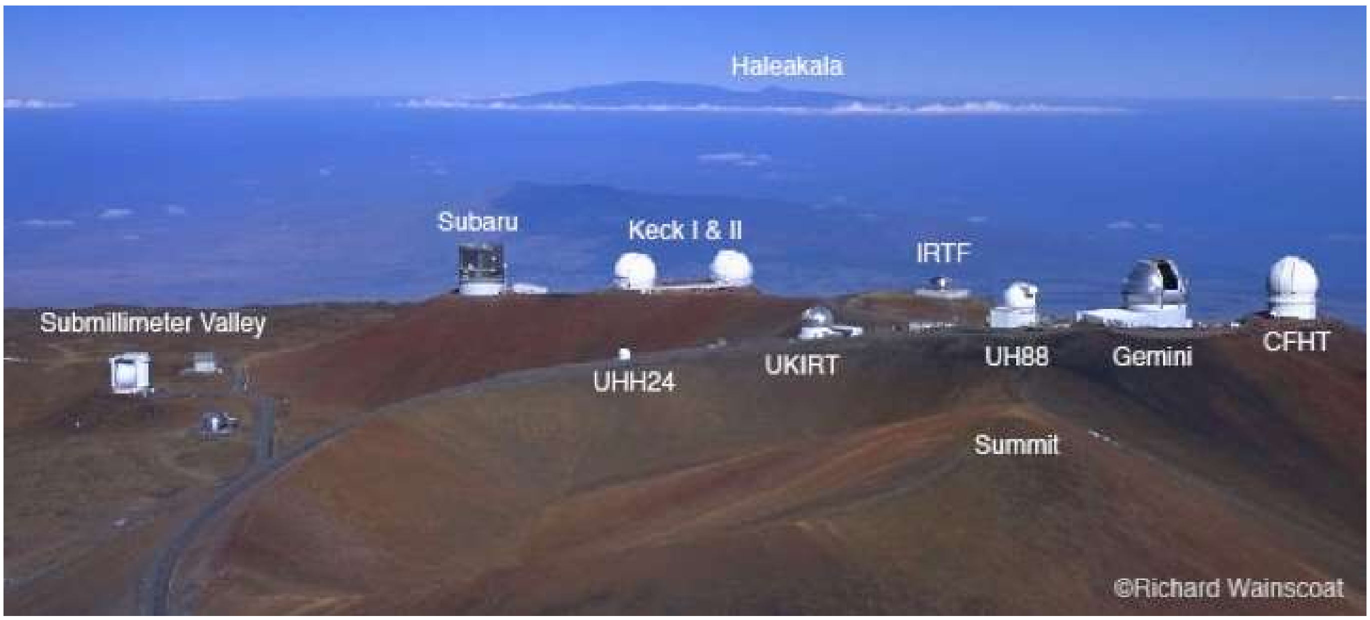


Figure 83 – View of the telescope array on top of Mauna Kea

Mauna Kea

Mauna Kea is a dormant volcano in the Hawaiian Islands, one of five volcanic peaks that together form the island of Hawaii. It is the tallest mountain in the world when measured from base to peak, its base being some 19,678 feet (5998 m) under the surface of the Pacific Ocean, which would bring its total height to 33,474 feet (10,203 m). In Hawaiian, Mauna Kea means "white mountain", a reference to the fact that it is regularly snow- or frost-capped during the northern hemisphere winter. Its highest point, Pu'u Wekiu (one of numerous cinder cones on the summit), is the highest point in the state of Hawaii at 13,796 feet (4,205 m).

Tall cinder cones atop the summit of Mauna Kea and lava flows that underlie its steep upper flanks (Figure 66) have built the volcano a scant 35 m higher than nearby Mauna Loa (4,170 m). Mauna Kea, like Hawaii's other older volcanoes, Hualalai and Kohala, has evolved beyond the shield-building stage, as indicated by (1) the very low eruption rates compared to Mauna Loa and Kilauea; (2) the absence of a summit caldera and elongated fissure vents that radiate its summit; (3) steeper and more irregular topography (for example, the upper flanks of Mauna Kea are twice as steep as those of Mauna Loa – Figure 67); and (4) different chemical compositions of the lava.

These changes in part reflect a low rate magma supply that causes the continuously active summit reservoir and rift zones of the shield stage to give way to small isolated batches of magma that rise episodically into the volcano, erupt briefly, and soon solidify. They also reflect greater viscosity and volatile content of the lava, which result in thick flows that steepen the edifice and explosive eruptions that build large cinder cones (Figure 69). After hundreds of thousands of years of building itself up by volcanic activity, the mountain's height is slowly decreasing as its massive weight depresses the Pacific seafloor.

Glaciers on Mauna Kea

Although snow and ice occur now mostly in the period from November through March, Mauna Kea had permanent (year-round) ice caps during the Pleistocene ice ages (Woodcock et al., 1970). Most people don't think about snow or glaciers in Hawaii, but geologists have long recognized deposits formed by glaciers on Mauna Kea during recent ice ages (Figure 84). The latest work indicates that deposits of three glacial episodes since 150,000 to 200,000 years ago are preserved on the volcano. Glacial moraines on the volcano formed about 70,000 years ago and from approximately 40,000 to 13,000 years ago. If glacial deposits were formed on Mauna Loa, they have long since been buried by younger lava flows.

Even today, snow falls on both Mauna Kea and Mauna Loa. Both volcanoes are so high that snow falls during winter months, perhaps accumulating to a few meters depth. The seasonal snow cover on the steep slopes of Mauna Kea is easier to see from coastal areas than on the gentle, rounded slopes of Mauna Loa, whose summit cannot be seen from sea level.

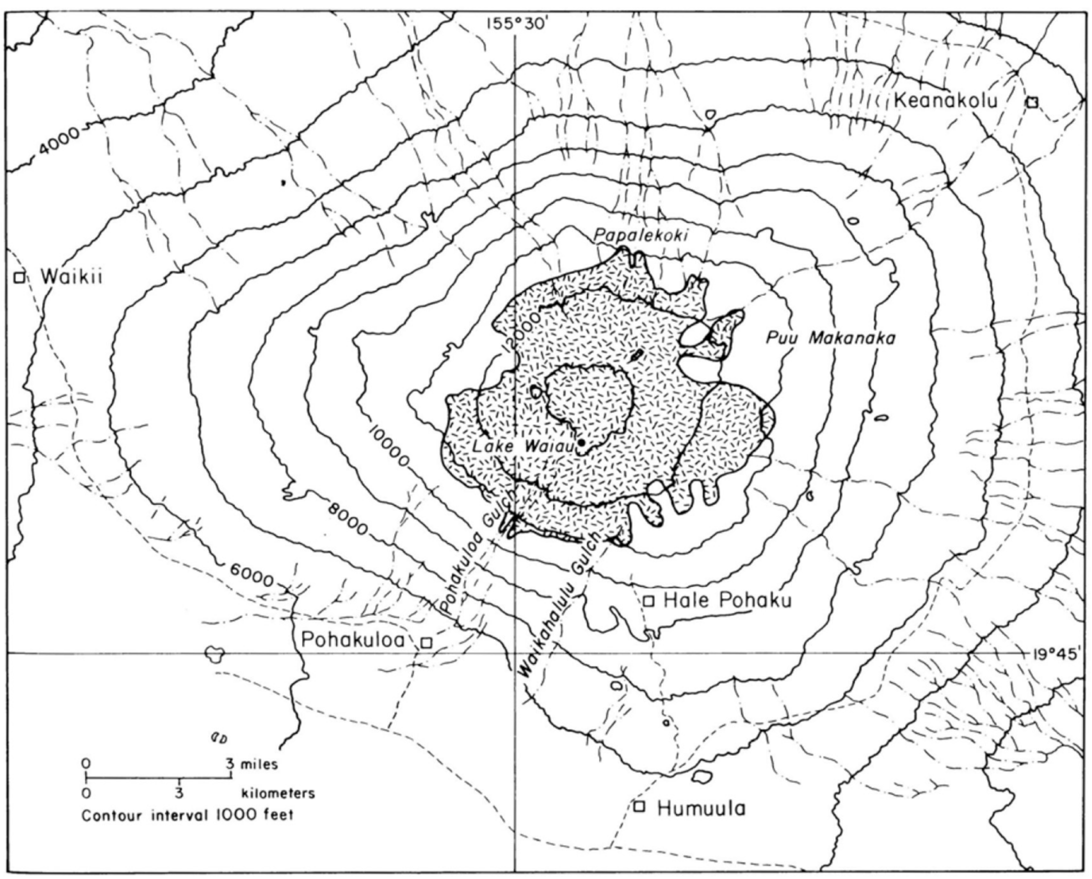


Figure 84: Map of Mauna Kea showing extent of ice cap that occupied the summit during Pleistocene. (From Macdonald and others, 1983, Fig. 13.3, p. 257.)

Will Mauna Kea Ever Erupt Again?

Mauna Kea is presently a dormant volcano, having last erupted about 4,500 years ago. However, Mauna Kea is likely to erupt again. Its quiescent periods between eruptions are long compared to those of the active volcanoes Hualalai (which erupts every few hundred years), Mauna Loa (which erupts every few years to a few tens of years) and Kilauea (which erupts every few years). A swarm of earthquakes beneath Mauna Kea might signal that an eruption could occur within a short time, but such swarms do not always result in an eruption. Sensitive astronomical telescopes on top of Mauna Kea would, as a by product of their stargazing, detect minute ground tilts possibly foretelling a future eruption.

Most Recent Eruption(s)

At least 7 separate vents erupted between about 6,000 and 4,000 years ago. The oldest dated rocks are 237,000 ± 31,000 years before present but the estimated age of Mauna Kea is almost 1 Ma. The volcano is in the post-shield stage a transition that occurred before about 200,000 to 250,000 years ago.

Sources: http://en.wikipedia.org/wiki/Mauna_Kea; http://hvo.wr.usgs.gov/volcanoes/maunakea/

Day 9: Saturday, March 12th, 2022 – Kona: Free Day and Fly out that evening

??? AM: Wake up whenever you want. Today is a free day. I suggest snorkeling, surfing, renting scooter, shopping in Kona.

6:00 PM: Last group dinner with everyone!

10:20 PM: Board flight (Alaska Airlines Flight 880) from Kailua/Kona (KOA) to Seattle (SEA).

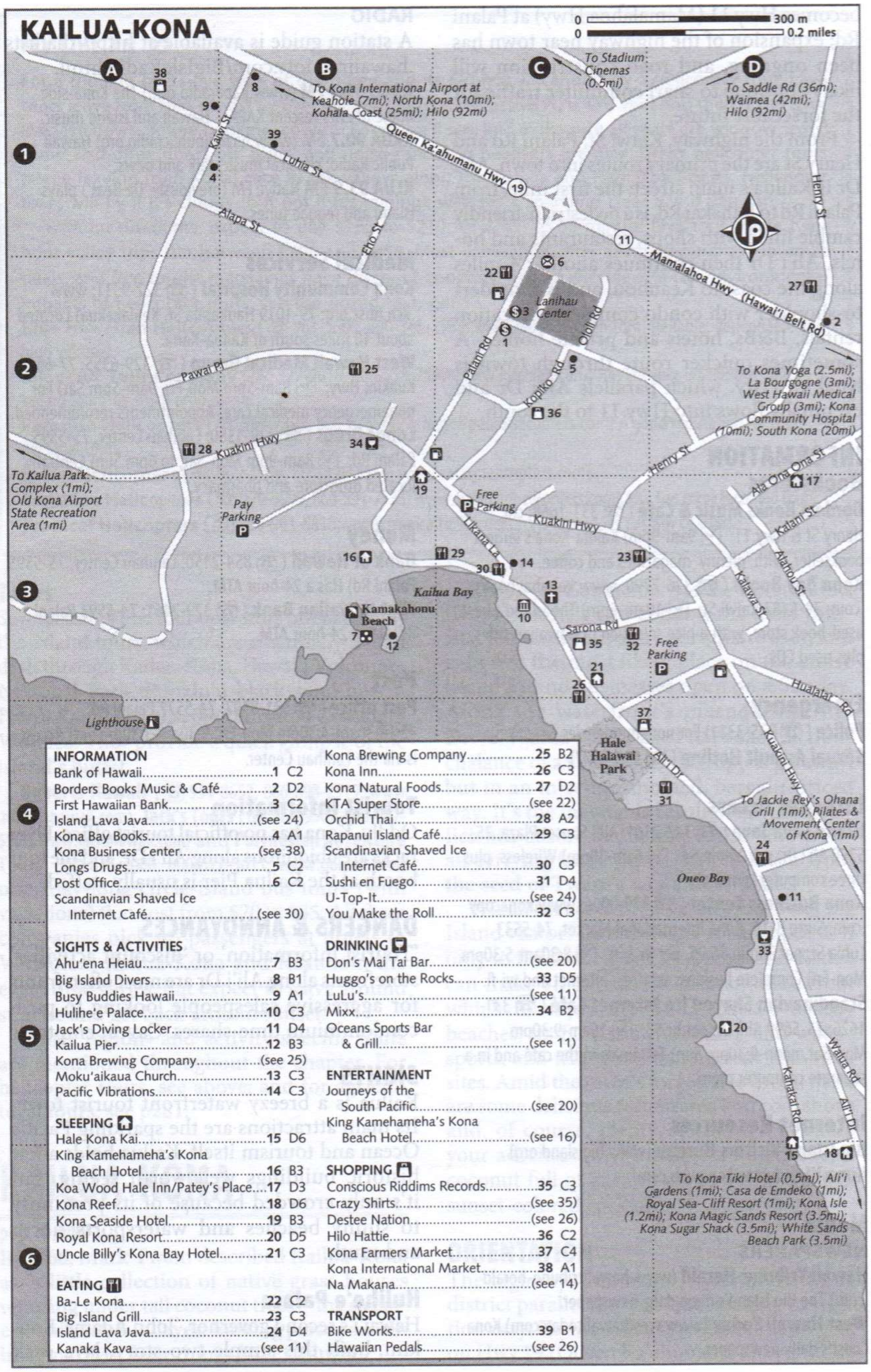


Figure 85 – Map of Kailua-Kona (From Lonely Planet Guidebook, 2009, p. 216).

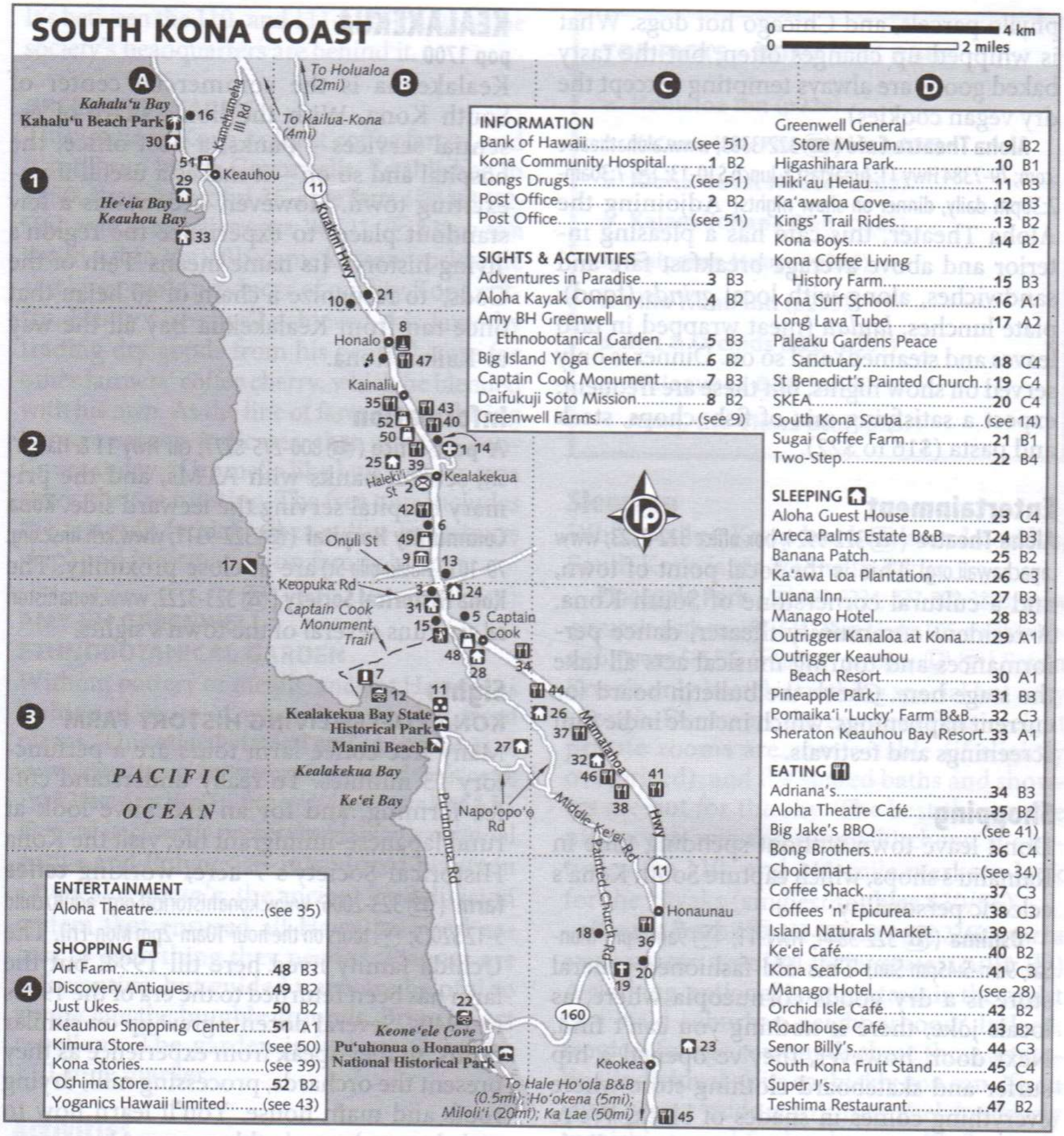


Figure 86 – Map of the South Kona Coast (From Lonely Planet Guidebook, 2009, p. 231).

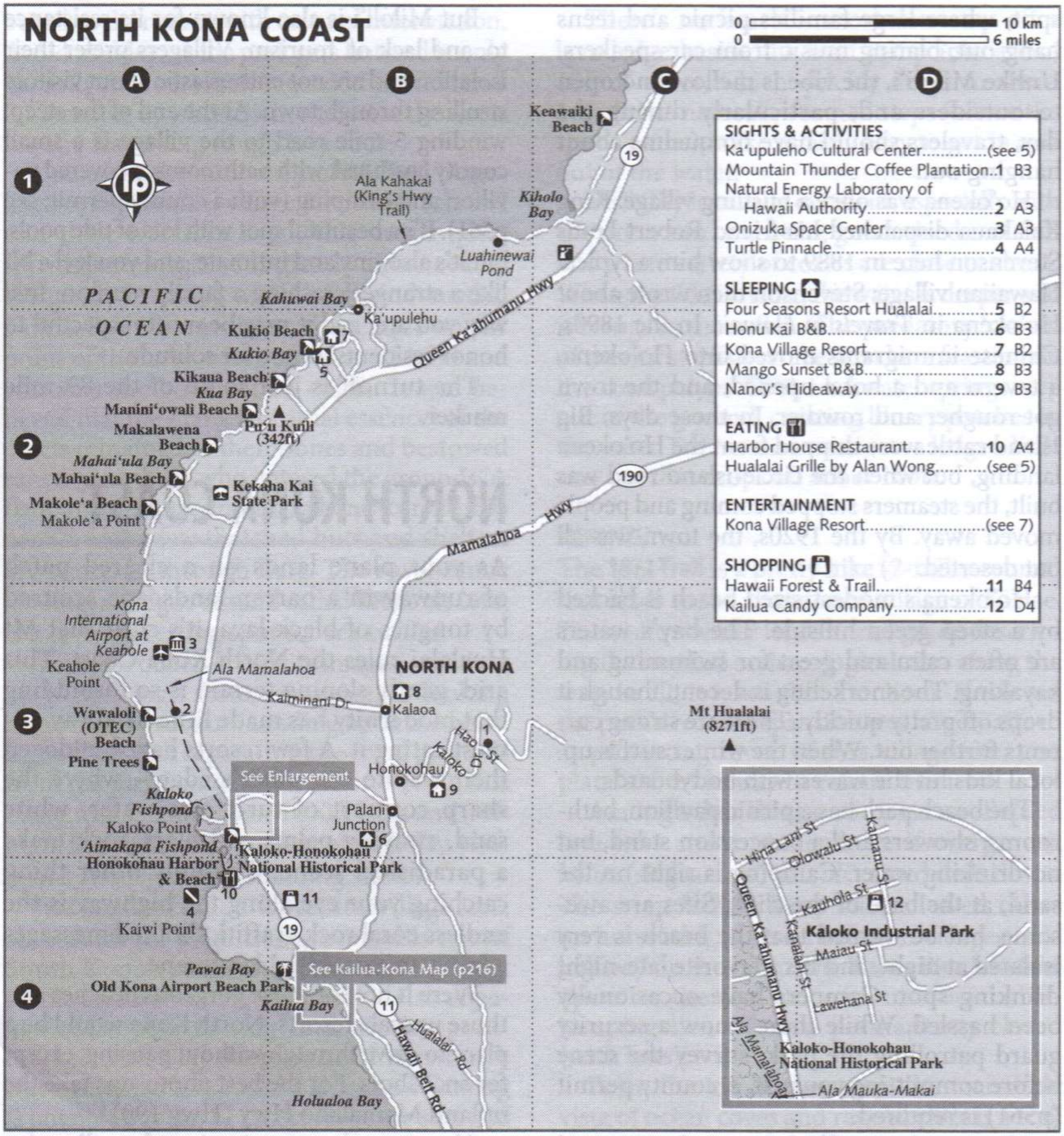


Figure 87 – Map of the North Kona Coast (From Lonely Planet Guidebook, 2009, p. 242).

Day 10: Sunday, March 13th, 2022 – Fly back to DC

7:15 AM: Arrive in Seattle (Alaska Airlines)

8:30 AM: Depart from Seattle (Alaska Airlines Flight 004) to Washington, DC-Reagan (DCA)

4:30 PM: Arrive in Washington, DC- Reagan (DCA)

GLOSSARY OF VOLCANIC AND GEOLOGIC TERMS

Aa: Hawaiian word used to describe a lava flow whose surface is broken into rough angular fragments.

Accessory: A mineral whose presence in a rock is not essential to the proper classification of the rock.

Accidental: Pyroclastic rocks that are formed from fragments of non-volcanic rocks or from volcanic rocks not related to the erupting volcano.

Accretionary Lava Ball: A rounded mass, ranging in diameter from a few centimeters to several meters, [carried] on the surface of a lava flow (e.g., 'a'a) or on cinder-cone slopes [and formed] by the molding of viscous lava around a core of already solidified lava.

Acid: A descriptive term applied to igneous rocks with more than 60% silica (SiO2).

Active Volcano: A volcano that is erupting. Also, a volcano that is not presently erupting, but that has erupted within historical time and is considered likely to do so in the future.

Agglutinate: A pyroclastic deposit consisting of an accumulation of originally plastic ejecta and formed by the coherence of the fragments upon solidification.

Alkalic: Rocks which contain above average amounts of sodium and/or potassium for the group of rocks for which it belongs. For example, the basalts of the capping stage of Hawaiian volcanoes are alkalic. They contain more sodium and/or potassium than the shield-building basalts that make the bulk of the volcano.

Andesite: Volcanic rock (or lava) characteristically medium dark in color and containing 54 to 62 percent silica and moderate amounts of iron and magnesium.

Ash: Fine particles of pulverized rock blown from an explosion vent. Measuring less than 1/10 inch in diameter, ash may be either solid or molten when first erupted. By far the most common variety is vitric ash (glassy particles formed by gas bubbles bursting through liquid magma).

Ashfall (Airfall): Volcanic ash that has fallen through the air from an eruption cloud. A deposit so formed is usually well sorted and layered.

Ash Flow: A turbulent mixture of gas and rock fragments, most of which are ash-sized particles, ejected violently from a crater or fissure. The mass of pyroclastics is normally of very high temperature and moves rapidly down the slopes or even along a level surface.

Asthenosphere: The shell within the earth, some tens of kilometers below the surface and of undefined thickness, which is a shell of weakness where plastic movements take place to permit pressure adjustments.

Aquifer: A body of rock that contains significant quantities of water that can be tapped by wells or springs.

Avalanche: A large mass of material or mixtures of material falling or sliding rapidly under the force of gravity. Avalanches often are classified by their content, such as snow, ice, soil, or rock avalanches. A mixture of these materials is a debris avalanche.

Basalt: Volcanic rock (or lava) that characteristically is dark in color, contains 45% to 54% silica, and generally is rich in iron and magnesium.

Basement: The undifferentiated rocks that underlie the rocks of interest in an area.

Basic: A descriptive term applied to igneous rocks (basalt and gabbro) with silica (SiO2) between 44% and 52%.

Bench: The unstable, newly-formed front of a lava delta.

Blister: A swelling of the crust of a lava flow formed by the puffing-up of gas or vapor beneath the flow. Blisters are about 1 meter in diameter and hollow.

Block: Angular chunk of solid rock ejected during an eruption.

Bomb: Fragment of molten or semi-molten rock, 2 1/2 inches to many feet in diameter, which is blown out during an eruption. Because of their plastic condition, bombs are often modified in shape during their flight or upon impact.

Caldera: The Spanish word for cauldron, a basin-shaped volcanic depression; by definition, at least a mile in diameter. Such large depressions are typically formed by the subsidence of volcanoes. Crater Lake occupies the best-known caldera in the Cascades.

Capping Stage: Refers to a stage in the evolution of a typical Hawaiian volcano during which alkalic, basalt, and related rocks build a steeply, sloping cap on the main shield of the volcano. Eruptions are less frequent, but more explosive. The summit caldera may be buried.

Central Vent: A central vent is an opening at the Earth's surface of a volcanic conduit of cylindrical or pipe-like form.

Central Volcano: A volcano constructed by the ejection of debris and lava flows from a central point, forming a more or less symmetrical volcano.

Cinder Cone: A volcanic cone built entirely of loose fragmented material (pyroclastics)

Cirque: A steep-walled horseshoe-shaped recess high on a mountain that is formed by glacial erosion.

Cleavage: The breaking of a mineral along crystallographic weak lattice planes that reflect weaknesses in a crystal structure.

Composite Volcano: A steep volcanic cone built by both lava flows and pyroclastic eruptions.

Compound Volcano: A volcano that consists of a complex of two or more vents, or a volcano that has an associated volcanic dome, either in its crater or on its flanks. Examples are Vesuvius and Mont Pelee.

Compression Waves: Earthquake waves that move like a slinky. As the wave moves to the left, for example, it expands and compresses in the same direction as it moves.

Conduit: A passage followed by magma in a volcano.

Continental Crust: Solid, outer layers of the earth, including the rocks of the continents.

Continental Drift: The theory that horizontal movement of the earth's surface causes slow, relative movements of the continents toward or away from one another.

Country Rocks: The rock intruded by and surrounding an igneous intrusion.

Crater: A steep-sided, usually circular depression formed by either explosion or collapse at a volcanic vent.

Craton: A part of the earth's crust that has attained stability and has been little deformed for a prolonged period.

Curtain of Fire: A row of coalescing lava fountains along a fissure; a typical feature of a Hawaiian-type eruption.

Dacite: Volcanic rock (or lava) that characteristically is light in color and contains 62% to 69% silica and moderate a mounts of sodium and potassium.

Debris Avalanche: A rapid and unusually sudden sliding or flowage of unsorted masses of rock and other material. As applied to the major avalanche involved in the eruption of Mount St. Helens, a rapid mass movement that included fragmented cold and hot volcanic rock, water, snow, glacier ice, trees, and some hot pyroclastic material. Most of the May 18, 1980 deposits in the upper valley of the North Fork Toutle River and in the vicinity of Spirit Lake are from the debris avalanche.

Debris Flow: A mixture of water-saturated rock debris that flows downslope under the force of gravity (also called lahar or mudflow).

Detachment Plane: The surface along which a landslide disconnects from its original position.

Diatreme: A breccia filled volcanic pipe that was formed by a gaseous explosion.

Dike: A sheet-like body of igneous rock that cuts across layering or contacts in the rock into which it intrudes.

Dome: A steep-sided mass of viscous (doughy) lava extruded from a volcanic vent (often circular in plane view) and spiny, rounded, or flat on top. Its surface is often rough and blocky as a result of fragmentation of the cooler, outer crust during growth of the dome.

Dormant Volcano: Literally, "sleeping." The term is used to describe a volcano which is presently inactive but which may erupt again. Most of the major Cascade volcanoes are believed to be dormant rather than extinct.

Drainage Basin: The area of land drained by a river system.

Ejecta: Material that is thrown out by a volcano, including pyroclastic material (tephra) and lava bombs.

En Echelon: Set of geologic features that are in an overlapping or a staggered arrangement (e.g., faults). Each is relatively short, but collectively they form a linear zone in which the strike of the individual features is oblique to that of the zone as a whole.

Episode: An episode is a volcanic event that is distinguished by its duration or style.

Eruption: The process by which solid, liquid, and gaseous materials are ejected into the earth's atmosphere and onto the earth's surface by volcanic activity. Eruptions range from the quiet overflow of liquid rock to the tremendously violent expulsion of pyroclastics.

Eruption Cloud: The column of gases, ash, and larger rock fragments rising from a crater or other vent. If it is of sufficient volume and velocity, this gaseous column may reach many miles into the stratosphere, where high winds will carry it long distances.

Eruptive Vent: The opening through which volcanic material is emitted.

Evacuate: Temporarily move people away from possible danger.

Extinct Volcano: A volcano that is not presently erupting and is not likely to do so for a very long time in the future.

Extrusion: The emission of magmatic material at the earth's surface. Also, the structure or form produced by the process (e.g., a lava flow, volcanic dome, or certain pyroclastic rocks).

Fault: A crack or fracture in the earth's surface. Movement along the fault can cause earthquakes or--in the process of mountain-building--can release underlying magma and permit it to rise to the surface.

Fault Scarp A steep slope or cliff formed directly by movement along a fault and representing the exposed surface of the fault before modification by erosion and weathering.

Felsic: An igneous rock having abundant light-colored minerals.

Fire fountain: See also: lava fountain.

Fissures: Elongated fractures or cracks on the slopes of a volcano. Fissure eruptions typically produce liquid flows, but pyroclastics may also be ejected.

Flank Eruption: An eruption from the side of a volcano (in contrast to a summit eruption.)

Fluvial: Produced by the action of flowing water.

Formation: A body of rock identified by lithic characteristics and stratigraphic position and is map able at the earth's surface or traceable in the subsurface.

Fracture: The manner of breaking due to intense folding or faulting.

Fumarole: A vent or opening through which issue steam, hydrogen sulfide, or other gases. The craters of many dormant volcanoes contain active fumaroles.

Geothermal Energy: Energy derived from the internal heat of the earth.

Geothermal Power: Power generated by using the heat energy of the earth.

Graben: An elongate crustal block that is relatively depressed (down dropped) between two fault systems.

Guyot: A type of seamount that has a platform top. Named for a nineteenth-century Swiss-American geologist.

Hardness: The resistance of a mineral to scratching.

Harmonic Tremor: A continuous release of seismic energy typically associated with the underground movement of magma. It contrasts distinctly with the sudden release and rapid decrease of seismic energy associated with the more common type of earthquake caused by slippage along a fault.

Heat transfer: Movement of heat from one place to another.

Heterolithologic: Material is made up of a heterogeneous mix of different rock types. Instead of being composed on one rock type, it is composed of fragments of many different rocks.

Holocene: The time period from 10,000 years ago to the present. Also, the rocks and deposits of that age.

Horizontal Blast: An explosive eruption in which the resultant cloud of hot ash and other material moves laterally rather than upward.

Horst: A block of the earth's crust, generally long compared to its width that has been uplifted along faults relative to the rocks on either side.

Hot Spot: A volcanic center, 60 to 120 miles (100 to 200 km) across and persistent for at least a few tens of million of years, that is thought to be the surface expression of a persistent rising plume of hot mantle material. Hot spots are not linked to arcs and may not be associated with ocean ridges.

Hot-spot Volcanoes: Volcanoes related to a persistent heat source in the mantle.

Hyaloclastite: A deposit formed by the flowing or intrusion of lava or magma into water, ice, or water-saturated sediment and its consequent granulation or shattering into small angular fragments.

Hydrothermal Reservoir: An underground zone of porous rock containing hot water.

Hypabyssal: A relatively shallow intrusive consisting of magma or the resulting solidified rock.

Hypocenter: The place on a buried fault where an earthquake occurs.

Ignimbrite: The rock formed by the widespread deposition and consolidation of ash flows and nuees ardentes. The term was originally applied only to densely welded deposits but now includes non-welded deposits.

Intensity: A measure of the effects of an earthquake at a particular place. Intensity depends not only on the magnitude of the earthquake, but also on the distance from the epicenter and the local geology.

Intermediate: A descriptive term applied to igneous rocks that are transitional between basic and acidic with silica (SiO2) between 54% and 65%.

Intrusion: The process of emplacement of magma in pre-existing rock.

Intrusive: A term that refers to igneous rock mass formed at depth within surrounding rock.

Joint: A surface of fracture in a rock.

Juvenile: Pyroclastic material derived directly from magma reaching the surface. Also a term used to describe CM's approach to teaching Geology and life in general.

Kipuka: An area surrounded by a lava flow.

Laccolith: A body of igneous rocks with a flat bottom and domed top. It is parallel to the layers above and below it.

Lahar: A torrential flow of water-saturated volcanic debris down the slope of a volcano in response to gravity. A type of mudflow.

Landsat: A series of unmanned satellites orbiting at about 706 km (438 miles) above the surface of the earth. The satellites carry cameras similar to video cameras and take images or pictures showing features as small as 30 m or 80 m wide, depending on which camera is used.

Lapilli: Literally, "little stones." Round to angular rock fragments, measuring 1/10 inch to 2 1/2 inches in diameter, which may be ejected in either a solid or a molten state.

Lava: Magma which has reached the surface through a volcanic eruption. The term is most commonly applied to streams of liquid rock that flow from a crater or fissure. It also refers to cooled and solidified rock.

Lava Dome: Mass of lava, created by many individual flows, that has built a dome-shaped pile of lava.

Lava Flow: An outpouring of lava onto the land surface from a vent or fissure. Also, a solidified tongue like or sheet-like body formed by outpouring lava.

Lava Fountain: A rhythmic vertical fountain like eruption of lava.

Lava Lake (Pond): A lake of molten lava, usually basaltic, contained in a vent, crater, or broad depression of a shield volcano.

Lava Shields: A shield volcano made of basaltic lava.

Lava Tube: A tunnel formed when the surface of a lava flow cools and solidifies while the still-molten interior flows through and drains away.

Limu O Pele (Pele Seaweed): Delicate, translucent sheets of spatter filled with tiny glass bubbles.

Lithic: Of or pertaining to stone.

Lithosphere: The rigid crust and uppermost mantle of the earth. Thickness is on the order of 60 miles (100 km). Stronger than the underlying asthenosphere.

Luster: The reflection of light from the surface of a mineral.

Maar: A volcanic crater that is produced by an explosion in an area of low relief, is generally more or less circular, and often contains a lake, pond, or marsh.

Mafic: An igneous composed chiefly of one or more dark-colored minerals.

Magma: Molten rock beneath the surface of the earth.

Magma Chamber: The subterranean cavity containing the gas-rich liquid magma which feeds a volcano.

Magmatic: Pertaining to magma.

Magnitude: A numerical expression of the amount of energy released by an earthquake, determined by measuring earthquake waves on standardized recording instruments (seismographs.) The number scale for magnitudes is logarithmic rather than arithmetic. Therefore, deflections on a seismograph for a magnitude 5 earthquake, for example, are 10 times greater than those for a magnitude 4 earthquake, 100 times greater than for a magnitude 3 earthquake, and so on. Energy release is roughly 27 times greater for each successive Richter scale increase.

Mantle: The zone of the earth below the crust and above the core.

Matrix: The solid matter in which a fossil or crystal is embedded. Also, a binding substance (e.g., cement in concrete).

Miocene: An epoch in Earth's history from about 24 to 5 million years ago. Also refers to the rocks that formed in that epoch.

Moho: Also called the Mohorovicic discontinuity. The surface or discontinuity that separates the crust from the mantle. The Moho is at a depth of 5-10 km beneath the ocean floor and about 35 km below the continents (but down to 60 km below mountains). Named for Andrija Mohorovicic, a Croatian seismologist and wild blender aficionado.

Monogenetic: A volcano built by a single eruption.

Mudflow: A flowage of water-saturated earth material possessing a high degree of fluidity during movement. A less-saturated flowing mass is often called a debris flow. A mudflow originating on the flank of a volcano is properly called a lahar.

Myth: A fictional story to explain the origin of some person, place, or thing. Also a useful term to describe CM’s technical publications.

Nuees Ardentes: A French term applied to a highly heated mass of gas-charged ash which is expelled with explosive force and moves hurricane speed down the mountainside.

Obsidian: A black or dark-colored volcanic glass usually composed of rhyolite.

Oceanic Crust: The earth's crust where it underlies oceans.

Pahoehoe: A Hawaiian term for lava with a smooth, billowy, or ropy surface.

Pali: Hawaiian word for steep hills or cliffs.

Pele Hair: A natural spun glass formed by blowing-out during quiet fountaining of fluid lava, cascading lava falls, or turbulent flows, sometimes in association with Pele tears. A single strand, with a diameter of less than half a millimeter, may be as long as two meters.

Pele Tears: Small, solidified drops of volcanic glass behind which trail pendants of Pele hair. They may be tear-shaped, spherical, or nearly cylindrical.

Peralkaline: Igneous rocks in which the molecular proportion of aluminum oxide is less than that of sodium and potassium oxides combined.

Phenocryst: A conspicuous, usually large, crystal embedded in porphyritic igneous rock.

Phreatic Eruption (Explosion): An explosive volcanic eruption caused when water and heated volcanic rocks interact to produce a violent expulsion of steam and pulverized rocks. Magma is not involved.

Phreatomagmatic: An explosive volcanic eruption that results from the interaction of surface or subsurface water and magma.

Pillow lava: Interconnected, sack-like bodies of lava formed underwater.

Pipe: A vertical conduit through the Earth's crust below a volcano, through which magmatic materials have passed. Commonly filled with volcanic breccia and fragments of older rock.

Pit Crater: A crater formed by sinking in of the surface, not primarily a vent for lava.

Plastic: Capable of being molded into any form, which is retained.

Plate Tectonics: The theory that the earth's crust is broken into about 10 fragments (plates,) which move in relation to one another, shifting continents, forming new ocean crust, and stimulating volcanic eruptions.

Pleistocene: An epoch in Earth history from about 2-5 million years to 10,000 years ago. Also refers to the rocks and sediment deposited in that epoch.

Plinian Eruption: An explosive eruption in which a steady, turbulent stream of fragmented magma and magmatic gases is released at a high velocity from a vent. Large volumes of tephra and tall eruption columns are characteristic.

Plug: Solidified lava that fills the conduit of a volcano. It is usually more resistant to erosion than the material making up the surrounding cone, and may remain standing as a solitary pinnacle when the rest of the original structure has eroded away.

Plug Dome: The steep-sided, rounded mound formed when viscous lava wells up into a crater and is too stiff to flow away. It piles up as a dome-shaped mass, often completely filling the vent from which it emerged.

Pluton: A large igneous intrusion formed at great depth in the crust.

Polygenetic: Originating in various ways or from various sources.

Precambrian: All geologic time from the beginning of Earth history to 570 million years ago. Also refers to the rocks that formed in that epoch.

Pumice: Light-colored, frothy volcanic rock, usually of dacite or rhyolite composition, formed by the expansion of gas in erupting lava. Commonly seen as lumps or fragments of pea-size and larger, but can also occur abundantly as ash-sized particles.

Pyroclastic: Pertaining to fragmented (clastic) rock material formed by a volcanic explosion or ejection from a volcanic vent.

Pyroclastic Flow: Lateral flowage of a turbulent mixture of hot gases and unsorted pyroclastic material (volcanic fragments, crystals, ash, pumice, and glass shards) that can move at high speed (50 to 100 miles an hour.) The term also can refer to the deposit so formed.

Quaternary: The period of Earth's history from about 2 million years ago to the present; also, the rocks and deposits of that age.

Relief: The vertical difference between the summit of a mountain and the adjacent valley or plain.

Renewed Volcanism State: Refers to a state in the evolution of a typical Hawaiian volcano during which --after a long period of quiescence--lava and tephra erupt intermittently. Erosion and reef building continue.

Repose: The interval of time between volcanic eruptions.

Rhyodacite: An extrusive rock intermediate in composition between dacite and rhyolite.

Rhyolite: Volcanic rock (or lava) that characteristically is light in color, contains 69% silica or more, and is rich in potassium and sodium.

Ridge, Oceanic: A major submarine mountain range.

Rift System: The oceanic ridges formed where tectonic plates are separating and a new crust is being created; also, their on-land counterparts such as the East African Rift of Africa or Southwest Rift of Hawaii.

Rift Zone: A zone of volcanic features associated with underlying dikes. The location of the rift is marked by cracks, faults, and vents.

Ring of Fire: The regions of mountain-building earthquakes and volcanoes which surround the Pacific Ocean.

Scoria: A bomb-size (> 64 mm) pyroclast that is irregular in form and generally very vesicular. It is usually heavier, darker, and more crystalline than pumice.

Seafloor Spreading: The mechanism by which new seafloor crust is created at oceanic ridges and slowly spreads away as plates are separating.

Seamount: A submarine volcano.

Seismograph: An instrument that records seismic waves; that is, vibrations of the earth.

Seismologist: Scientists who study earthquake waves and what they tell us about the inside of the Earth.

Seismometer: An instrument that measures motion of the ground caused by earthquake waves.

Shearing: The motion of surfaces sliding past one another.

Shear Waves: Earthquake waves that move up and down as the wave itself moves. For example, to the left.

Shield Volcano: A gently sloping volcano in the shape of a flattened dome and built almost exclusively of lava flows.

Shoshonite: A trachyandesite composed of olivine and augite phenocrysts in a groundmass of labradorite with alkali feldspar rims, olivine, augite, a small amount of leucite, and some dark-colored glass. Its name is derived from the Shoshone River, Wyoming and given by Iddings in 1895.

Silica: A chemical combination of silicon and oxygen.

Sill: A tabular body of intrusive igneous rock, parallel to the layering of the rocks into which it intrudes.

Skylight: An opening formed by a collapse in the roof of a lava tube.

Solfatara: A type of fumarole, the gases of which are characteristically sulfurous.

Spatter Cone: A low, steep-sided cone of spatter built up on a fissure or vent. It is usually of basaltic material.

Spatter Rampart: A ridge of congealed pyroclastic material (usually basaltic) built up on a fissure or vent.

Specific Gravity: The density of a mineral divided by the density of water.

Spines: Horn-like projections formed upon a lava dome.

Stalactite: A cone shaped deposit of minerals hanging from the roof of a cavern.

Stratigraphic: The study of rock strata, especially of their distribution, deposition, and age.

Stratovolcano: A volcano composed of both lava flows and pyroclastic material.

Streak: The color of a mineral in the powdered form.

Strike-Slip Fault: A nearly vertical fault with side-slipping displacement.

Strombolian Eruption: A type of volcanic eruption characterized by jetting of clots or fountains of fluid basaltic lava from a central crater.

Subduction Zone: The zone of convergence of two tectonic plates, one of which usually overrides the other.

Surge: A ring-shaped cloud of gas and suspended solid debris that moves radially outward at high velocity as a density flow from the base of a vertical eruption column accompanying a volcanic eruption or crater formation.

Talus: A slope formed at the base of a steeper slope, made of fallen and disintegrated materials.

Tephra: Materials of all types and sizes that are erupted from a crater or volcanic vent and deposited from the air.

Tephrochronology: The collection, preparation, petrographic description, and approximate dating of tephra.

Tilt: The angle between the slope of a part of a volcano and some reference. The reference may be the slope of the volcano at some previous time.

Trachyandesite: An extrusive rock intermediate in composition between trachyte and andesite.

Trachybasalt: An extrusive rock intermediate in composition between trachyte and basalt.

Trachyte: A group of fine-grained, generally porphyritic, extrusive igneous rocks having alkali feldspar and minor mafic minerals as the main components, and possibly a small amount of sodic plagioclase.

Tremor: Low amplitude, continuous earthquake activity often associated with magma movement.

Tsunami: A great sea wave produced by a submarine earthquake, volcanic eruption, or large landslide.

Tuff: Rock formed of pyroclastic material.

Tuff Cone: A type of volcanic cone formed by the interaction of basaltic magma and water. Smaller and steeper than a tuff ring.

Tuff Ring: A wide, low-rimmed, well-bedded accumulation of hyaloclastic debris built around a volcanic vent located in a lake, coastal zone, marsh, or area of abundant ground water.

Tumulus: A doming or small mound on the crest of a lava flow caused by pressure due to the difference in the rate of flow between the cooler crust and the more fluid lava below.

Ultramafic: Igneous rocks made mostly of the mafic minerals hypersthene, augite, and/or olivine.

Unconformity: A substantial break or gap in the geologic record where a rock unit is overlain by another that is not next in stratigraphic succession, such as an interruption in continuity of a depositional sequence of sedimentary rocks or a break between eroded igneous rocks and younger sedimentary strata. It results from a change that caused deposition to cease for a considerable time, and it normally implies uplift and erosion with loss of the previous formed record.

Vent: The opening at the earth's surface through which volcanic materials issue forth.

Vesicle: A small air pocket or cavity formed in volcanic rock during solidification.

Viscosity: A measure of resistance to flow in a liquid (water has low viscosity while honey has a higher viscosity.)

Volcano: A vent in the surface of the Earth through which magma and associated gases and ash erupt; also, the form or structure (usually conical) that is produced by the ejected material.

Volcanic Arc: A generally curved linear belt of volcanoes above a subduction zone, and the volcanic and plutonic rocks formed there.

Volcanic Complex: A persistent volcanic vent area that has built a complex combination of volcanic landforms.

Volcanic Cone: A mound of loose material that was ejected ballistically.

Volcanic Neck: A massive pillar of rock more resistant to erosion than the lavas and pyroclastic rocks of a volcanic cone.

Vulcan: Roman god of fire and the forge after whom volcanoes are named.

Vulcanian: A type of eruption consisting of the explosive ejection of incandescent fragments of new viscous lava, usually on the form of blocks.

Water Table: The surface between where the pore space in rock is filled with water and where the pore space in rock is filled with air.

Xenocrysts: A crystal that resembles a phenocryst in igneous rock, but is a foreign to the body of rock in which it occurs.

Xenoliths: A foreign inclusion in an igneous rock.

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BUDGET INFORMATION

(as of 02/10/22)

Total Cost of the Trip: ……………………………………………………………$37,811.92

Cost per person for the trip (10 students)………………………………….………$1,000
Cost per person for the trip (3 faculty)…………………………………….……....$1,500
Cost per person for the trip (2 non-UPJ spouse)……………………………..……..$2,400
Contribution from Student Activities: ……………………………………………$19,000

<u>Breakdown</u>

1.	Airfare – Alaskan Air		$ 19.176.60
2.	Rental Vehicles – Seattle (Enterprise)		$ 297.80
	Rental Vehicles – Hawaii (Enterprise)		$ 3,501.60
	Gas Budget		$ 600.00
3.	Lodging		
	a.	Seattle – 1 night Rodeway Inn	$ 446.54
	b.	Kona – 2 nights at Royal Kona Hotel	$ 4,481.30
	c.	Hilo – 4 nights at SCP Hilo Hotel	$ 4,427.12
	d.	Kona – 1 night at Royal Kona Hotel	$ 2,240.65
4.	Miscellaneous		
	a.	Guidebook (to be paid to the UPJ print shop)	$ 300.00

Payments to be made during the trip

1.	Luau – King Kamehameha Hotel	$ 2,340.31
2.	Money for Group Meals	$ 489

BOOKING RECEIPTS

AIRFARE

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Flight	Departs	Arrives	Class	Traveler(s)	Seat(s)
Alaska Alaska 003 Boeing 737-800 (Winglets)	Washington,DC-Reagan National (DCA) Fri, Mar 4 8:40 pm	Seattle(SEA) Fri, Mar 4 5:35 pm	S (Coach)	Holly Garrett Alexander Kijowski Courtney Roxby Nicholas Scelsi Aleya Schreckengost Olivia Weaver Cian Williamson Rea Ryan Kerrigan Jessica Miller Stephen Lindberg Marilyn Lindberg Teresa Mcconnell Delaney D Amato Ava Freed Elliott Finney	26C 26D 26E 26F 25A 25B 25C 27A 27B 27C 27D 27E 27F 26A 26B
Alaska Alaska 807 Boeing 737-900 (Winglets)	Seattle (SEA) Sat, Mar 5 5:55 pm	Kailua/Kona (KOA) Sat, Mar 5 10:15 pm	S (Coach)	Holly Garrett Alexander Kijowski Courtney Roxby Nicholas Scelsi Aleya Schreckengost Olivia Weaver Cian Williamson Rea Ryan Kerrigan Jessica Miller Stephen Lindberg Marilyn Lindberg Teresa Mcconnell Delaney D Amato Ava Freed Elliott Finney	28E 28F 27A 27B 27C 27D 27E 29A 29B 29C 29D 29E 29F 28C 28D
Alaska Alaska 880 Boeing 737-900	Kailua/Kona (KOA) Sat, Mar 12 10:20 pm	Seattle (SEA) Sun, Mar 13 7:15 am	N (Coach)	Holly Garrett Alexander Kijowski Courtney Roxby	28E 28F 27A

(Winglets)				Nicholas Scelsi Aleya Schreckengost Olivia Weaver Cian Williamson Rea Ryan Kerrigan Jessica Miller Stephen Lindberg Marilyn Lindberg Teresa Mcconnell Delaney D Amato Ava Freed Elliott Finney	27B 27C 27D 27E 29A 29B 29C 29D 29E 29F 28C 28D
Alaska 4 Boeing 737-800 (Winglets)	Seattle (SEA) Sun, Mar 13 8:30 am	Washington, DC-Reagan National (DCA) Sun, Mar 13 4:30 pm	V (Coach)	Holly Garrett Alexander Kijowski Courtney Roxby Nicholas Scelsi Aleya Schreckengost Olivia Weaver Cian Williamson Rea Ryan Kerrigan Jessica Miller Stephen Lindberg Marilyn Lindberg Teresa Mcconnell Delaney D Amato Ava Freed Elliott Finney	26C 26D 26E 26F 25A 25B 25C 27A 27B 27C 27D 27E 27F 26A 26B

HOTELS

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Hotels.com confirmation number	9183418579966
Check-in	Friday, March 4, 2022 (2 PM-4 AM local time)
Check-out	Saturday, March 5, 2022 (Before 11:00 AM local time)
Your stay	1 night, 6 rooms
Cancellation policy	See details below in "Room details"
Total price	**$446.54** Including taxes and fees See full payment details below

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Check-in	Saturday, March 5, 2022 (4:00 PM-anytime local time)
Check-out	Monday, March 7, 2022 (Before 11 AM local time)
Your stay	2 nights, 6 rooms
Cancellation policy	See details below in "Room details"
Total to be charged by the hotel in their local currency	**$3,953.64** Including taxes and fees See full payment details below

SCP Hilo Hotel
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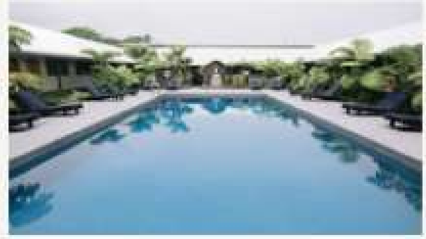
US
+18089350821



Need to make a change? Don't worry, it's quick and easy to amend or cancel your booking online. Manage your booking

Hotels.com confirmation number	9178422374817
Check-in	Monday, March 7, 2022 (4 PM-anytime local time)
Check-out	Tuesday, March 8, 2022 (Before 11:00 AM local time)
Your stay	1 night, 6 rooms
Cancellation policy	See details below in "Room details"
Total price	**$1,217.87** Including taxes and fees See full payment details below

SCP Hilo Hotel
126 Banyan Way
Hilo
96720
HI
US
+18089350821

Need to make a change? Don't worry, it's quick and easy to amend or cancel your booking online. Manage your booking

Hotels.com confirmation number	9183418200273
Check-in	Tuesday, March 8, 2022 (4 PM-anytime local time)
Check-out	Friday, March 11, 2022 (Before 11:00 AM local time)
Your stay	3 nights, 6 rooms
Cancellation policy	See details below in "Room details"
Total price	**$3,449.25** Including taxes and fees See full payment details below

Royal Kona Resort
75-5852 Alii Dr
Kailua-Kona
96740
HI
US
+18083293111

Need to make a change? Don't worry, it's quick and easy to amend or cancel your booking online. Manage your booking

Hotels.com confirmation number	9183419924259
Check-in	Friday, March 11, 2022 (4:00 PM-anytime local time)
Check-out	Saturday, March 12, 2022 (Before 11 AM local time)
Your stay	1 night, 6 rooms
Cancellation policy	See details below in "Room details"
Total to be charged by the hotel in their local currency	**$2,321.70** Including taxes and fees See full payment details below

VEHICLE RENTALS

enterprise

Your Reservation is Confirmed.

Thanks for choosing Enterprise! You reserved a Midsize SUV vehicle on March 4, 2022 at SEA TAC INTL ARPT.

Your confirmation number is: 1082853172

Itinerary

PICK UP

Fri, March 4, 2022
9:00 PM
SEA TAC INTL ARPT (SEA)

3150 S 160TH ST STE 508
SUITE 508
SEATAC WA 98188-2698 USA
(833) 329-8464
Fri 6:00 AM-11:59 PM

Hours subject to change. Please call to verify.

Follow these directions to get to the counter

ENTERPRISE IS LOCATED IN THE CONSOLIDATED RENTAL CAR FACILITY AT SEA-TAC AIRPORT. UPON ARRIVAL AT SEA-TAC AIRPORT, PROCEED TO THE BAGGAGE CLAIM LEVEL & PICK UP YOUR CHECKED BAGS. EXIT THE SLIDING GLASS DOORS NEAR CAROUSEL #1 OR #15 AND WALK TO ONE OF THE TWO DESIGNATED RENTAL CAR SHUTTLE BUS STOPS. SHUTTLE BUSES DEPART FREQUENTLY FOR THE RENTAL CAR FACILITY. UPON ARRIVAL TO THE FACILITY, PLEASE PROCEED TO THE ENTERPRISE COUNTER TO OBTAIN YOUR RENTAL AGREEMENT AND VEHICLE KEYS. . SELF-SERVICE KIOSKS AT THIS LOCATION CAN MAKE YOUR RENTAL TRANSACTION QUICK AND EASY.

RETURN

1

Sat, March 5, 2022
4:00 PM
SEA TAC INTL ARPT (SEA)

Vehicle

Midsize SUV

Nissan Rogue or similar
Automatic

enterprise

Your Reservation is Confirmed.

Thanks for choosing Enterprise! You reserved a Midsize SUV vehicle on March 4, 2022 at SEA TAC INTL ARPT.

Your confirmation number is: 1082853240

Itinerary

PICK UP

Fri, March 4, 2022

9:00 PM

SEA TAC INTL ARPT (SEA)

3150 S 160TH ST STE 508

SUITE 508

SEATAC WA 98188-2698 USA

(833) 329-8464

Fri 6:00 AM-11:59 PM

Hours subject to change. Please call to verify.

Follow these directions to get to the counter

ENTERPRISE IS LOCATED IN THE CONSOLIDATED RENTAL CAR FACILITY AT SEA-TAC AIRPORT. UPON ARRIVAL AT SEA-TAC AIRPORT, PROCEED TO THE BAGGAGE CLAIM LEVEL & PICK UP YOUR CHECKED BAGS. EXIT THE SLIDING GLASS DOORS NEAR CAROUSEL #1 OR #15 AND WALK TO ONE OF THE TWO DESIGNATED RENTAL CAR SHUTTLE BUS STOPS. SHUTTLE BUSES DEPART FREQUENTLY FOR THE RENTAL CAR FACILITY. UPON ARRIVAL TO THE FACILITY, PLEASE PROCEED TO THE ENTERPRISE COUNTER TO OBTAIN YOUR RENTAL AGREEMENT AND VEHICLE KEYS. . SELF-SERVICE KIOSKS AT THIS LOCATION CAN MAKE YOUR RENTAL TRANSACTION QUICK AND EASY.

RETURN

Sat, March 5, 2022

4:00 PM

SEA TAC INTL ARPT (SEA)

Vehicle

Midsize SUV

Nissan Rogue or similar

Automatic

enterprise

Your Reservation is Confirmed.

Thanks for choosing Enterprise! You reserved a Midsize SUV vehicle on March 4, 2022 at SEA TAC INTL ARPT.

Your confirmation number is: 1082853301

Itinerary

PICK UP

Fri, March 4, 2022
9:00 PM
SEA TAC INTL ARPT (SEA)

3150 S 160TH ST STE 508
SUITE 508
SEATAC WA 98188-2698 USA
(833) 329-8464
Fri 6:00 AM-11:59 PM
Hours subject to change. Please call to verify.

Follow these directions to get to the counter

ENTERPRISE IS LOCATED IN THE CONSOLIDATED RENTAL CAR FACILITY AT SEA-TAC AIRPORT. UPON ARRIVAL AT SEA-TAC AIRPORT, PROCEED TO THE BAGGAGE CLAIM LEVEL & PICK UP YOUR CHECKED BAGS. EXIT THE SLIDING GLASS DOORS NEAR CAROUSEL #1 OR #15 AND WALK TO ONE OF THE TWO DESIGNATED RENTAL CAR SHUTTLE BUS STOPS. SHUTTLE BUSES DEPART FREQUENTLY FOR THE RENTAL CAR FACILITY. UPON ARRIVAL TO THE FACILITY, PLEASE PROCEED TO THE ENTERPRISE COUNTER TO OBTAIN YOUR RENTAL AGREEMENT AND VEHICLE KEYS. . SELF-SERVICE KIOSKS AT THIS LOCATION CAN MAKE YOUR RENTAL TRANSACTION QUICK AND EASY.

RETURN

1

Sat, March 5, 2022
4:00 PM
SEA TAC INTL ARPT (SEA)

Vehicle

Midsize SUV

Nissan Rogue or similar
Automatic

Your Reservation is Confirmed.

Thanks for choosing Enterprise! You reserved a Standard SUV vehicle on March 5, 2022 at KONA INTL ARPT.

Your confirmation number is: 1081723340

Itinerary

PICK UP

Sat, March 5, 2022
10:45 PM
KONA INTL ARPT (KOA)
73 107 AULEPE STREET
73-200 KUPIPI ST
KAILUA KONA HI 96740-2645 USA
(844) 914-1549
Sat 6:00 AM-11:00 PM
Hours subject to change. Please call to verify.

Follow these directions to get to the counter

Due to current events, your rental will be serviced by the Alamo Rent-A-Car brand in Kona. Upon arrival, proceed to the shuttle bus pick up area located outside of baggage claim. Board the Enterprise or Alamo bus to proceed to the counter and obtain your rental agreement.

RETURN

Sat, March 12, 2022
10:00 PM

KONA INTL ARPT (KOA)

Vehicle
Standard SUV
Ford Edge or similar
Automatic

enterprise

Your Reservation is Confirmed.

Thanks for choosing Enterprise! You reserved a Standard SUV vehicle on March 5, 2022 at KONA INTL ARPT.

Your confirmation number is: 1081723383

Itinerary

PICK UP

Sat, March 5, 2022
10:45 PM
KONA INTL ARPT (KOA)

73 107 AULEPE STREET
73-200 KUPIPI ST
KAILUA KONA HI 96740-2645 USA
(844) 914-1549
Sat 6:00 AM-11:00 PM
Hours subject to change. Please call to verify.

Follow these directions to get to the counter

Due to current events, your rental will be serviced by the Alamo Rent-A-Car brand in Kona. Upon arrival, proceed to the shuttle bus pick up area located outside of baggage claim. Board the Enterprise or Alamo bus to proceed to the counter and obtain your rental agreement.

RETURN

Sat, March 12, 2022
10:00 PM

1

KONA INTL ARPT (KOA)

Vehicle

Standard SUV
Ford Edge or similar
Automatic

enterprise

Your Reservation is Confirmed.

Thanks for choosing Enterprise! You reserved a Standard SUV vehicle on March 5, 2022 at KONA INTL ARPT.

Your confirmation number is: 1081723405

Itinerary

PICK UP

Sat, March 5, 2022
10:45 PM

KONA INTL ARPT (KOA)

73 107 AULEPE STREET
73-200 KUPIPI ST
KAILUA KONA HI 96740-2645 USA
(844) 914-1549
Sat 6:00 AM-11:00 PM
Hours subject to change. Please call to verify.

Follow these directions to get to the counter

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RETURN

Sat, March 12, 2022
10:00 PM

KONA INTL ARPT (KOA)

Vehicle

Standard SUV
Ford Edge or similar
Automatic

LUAU

Kerrigan, Ryan

From:	admin@islandbreezeluau.com
Sent:	Monday, December 13, 2021 2:41 PM
To:	Kerrigan, Ryan
Cc:	reservations@ibphawaii.com
Subject:	www.islandbreezeluau.com Order 9617 Voucher

Thank you for your order from www.islandbreezeluau.com. This email is your tickets. If you are not able to print these tickets, please check in with your name at the luau.

Your order voucher number is 3001-9617

866-482-9775

Order Details

Important Notice: Many activity providers, restaurants and other businesses in Hawaii will require a mask while frequenting their buildings, during check-ins, and during close interactions with staff. It would be best to travel with personal use masks for your own use. As of April 20th a mask is required to enter a business. This mandate currently does not have an end date.

Item# 3001-9617-1	**Confirmation # 7220586 (Reserved by Ryan Kerrigan)**		
Activity ID	**Quantity**	**Activity Description**	**Information**
1	15	Island Breeze Luau - Per Adult (13 yrs+)	Activity Date : 3/6/2022 Participant Names and Ages : UPJ Geology Select Your Big Island Hotel : Royal Kona Resort Notes :

Island Breeze Productions
808-326-4969
Where and When
Check-in is at 5:30 pm.
Festivities end at approximately 8:00 pm.
Check in is at the entrance to the luau grounds.
The Island Breeze Luau is held on the historic grounds of the King Kamehameha's Kona Beach Hotel, which is located adjacent to the pier at Kailua Bay, on Palani Road in Kailua-Kona.
View Map
Parking is available at King Kamehameha's Kona Beach Hotel. Validation is given at the luau. Self-parking is free with validation (parking validations are subject to change without notice).

Restrictions : There are no specific restrictions for this activity.
What to wear or bring : Casual dress. Bring your ID for alcoholic drinks.
Guests do NOT need a printed copy of the voucher.

PREVIOUS SPRING BREAK GROUPS

SPRING BREAK 2020 – ICELAND
Cancelled two days before departure…

SPRING BREAK 2019 – ECUADOR
Picture taken in front of ash flow from Mount Chimborazo
L-R: Jen Hlivko, Kyle Molnar, Ryan Kerrigan, Jessica Miller, Abby Wess, Alex Hockensmith, Susan Ma, Kyle Sarver, Jake Marsh, Tyler Newell, and Kim Waltermire

SPRING BREAK 2018 – SCOTLAND
Picture taken in front of Edinburgh Castle
L-R: Ryan Kerrigan, Jessica Miller, Terry McConnell, Steve Lindberg, Marilyn Lindberg, Sam Louderback, Jake Marsh, Lauren Raysich, Kim Waltermire, and Katie Roxby
Not Pictured: Bill McConnell

SPRING BREAK 2017 – HAWAII
Picture taken at the rim of Mauna Ulu in Volcanoes National Park
L-R: Jacob Williamson-Rea, Tyler Norris, Kris Miller, Allie Marra, Luke Layton, Matt Leger, Katie Roxby, and Ryan Kerrigan

SPRING BREAK 2016 – ICELAND
Picture taken on columnar joints at Reynisfjara Beach, Iceland
Top Row: Tyler Norris, Lorin Simboli, Allie Marra, Luke Layton; *Bottom Row:* Catie Bert, Matt Leger; *Not Pictured:* Ryan Kerrigan, Terry McConnell, and Steve Lindberg

SPRING BREAK 2015 – NORTH CAROLINA
Picture taken at Ray Mine Pegmatite mine, Spruce Pine, NC
Left to Right: Kris Miller, Luke Layton, Leah Marko, Andrew Barchowsky, Matt Gerber, and Ryan Kerrigan

NOTES: