Chapter 6

ROAD LOG OF VOLCANIC ROCKS AND FEATURES OF PART OF OAHU*

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INTRODUCTION

This road log was especially prepared for International Association of Volcanology Hawaii Symposium. It concentrates on volcanic rocks and features of Oahu. The road log consists of two, one-day segments both starting at the University of Hawaii. The first segment examines the southeast portion of Oahu, describing the flanks and caldera of the Koolau Volcano and some of the vents and flows of the Honolulu post-erosional volcanic series. The second leg examines the western part of Oahu, the Waianae Volcano. The road log describes a trip through Kolekole Pass, which is on a military base. Permission from the U. S. Navy must be obtained prior to making the trip.

The able assistance of Glenn Bauer, Dave Grooms, Ed Malavassi, Mike Smith and Susie Vanderkuy in preparing this guidebook is gratefully acknowledged.

Leg 1

Introduction

This segment of the road log examines the southeast portion of Oahu following a clockwise pattern starting at the University of Hawaii. Stops planned include:

1. The Moiliili Quarry--a melilite nephelinite flow on the University of Hawaii lower campus.

2. Salt Lake Crater--a tuff cone with ultramafic and mafic nodules.

3. The Nuuanu Pali Lookout--a spectacular overview of the ancient caldera complex of the Koolau Volcano.

4. Roadcuts along H-3 near the Kaneohe Marine Corps Air Station--a dramatic cross-section of caldera breccia and dikes.

5. Makapuu Point--a good exposure of the dissected interior of the flanks of Koolau Volcano.

6. Hanauma Bay--a tuff cone complex with possible base surge deposits.

All mileages in this road log are in miles.

*Map in pocket at back of book accompanies this chapter.

Road Log

Start: The intersection of Dole Street and East-West Road on the Manoa campus of the University of Hawaii. Stop 1 can be reached easiest on foot. Vehicles can be parked on weekends in the parking lot behind (North) the Engineering Building. Return to the intersection. Proceed south across Dole Street between the dorms to stairway. Descend stairway. Note pegmatitic veins in the cliff face. Fresh samples can be obtained from the outcrops to the SE of the stairway on the far side of the football fields, below the circular dorms.

Stop 1. University of Hawaii Lower Campus

The University of Hawaii campus is underlain by a melilite nephelinite flow which originated from a vent on Sugar Loaf, the ridge north of the University. This flow appears to be very young, perhaps 10,000 to 20,000 years old (Macdonald and Abbott, 1970).* The Moiliili Quarry was excavated in the dense center of this approximately 12-m-thick a'a flow. The quarry is inactive and now houses the university athletic complex. The rock in the quarry walls is unusually coarse-grained for a lava flow and contains many pegmatitic veinlets. In hand specimen, the flow rock is greyish-brown in color and appears to lack phenocrysts. In thin section, microphenocrysts of olivine are present in a holocrystalline matrix of augite, nepheline, melilite and magnetite, with accessory apatite (Dunham, 1933). The pegmatitic veinlets consist of ragged augite, nepheline, melilite, apatite and magnetite grains. (See Table 1 in Chapter 1 for a chemical analysis.)

Cumulative Mileage

0.0 Return to vehicles. Proceed west (right) on Dole Street to University Avenue, the first cross street with a signal.

0.5 Left onto University Avenue. Move to right hand lane and turn

0.6 Right onto the Freeway (H-1) proceeding west toward Honolulu.

1.3 Punahou Street Overpass.

1.9 Punchbowl Crater. A tuff cone consisting of tan to brown palagonitic tuff which locally contains ultramafic nodules. A nephelinite flow is exposed on the south rim of the crater. Note the symmetrical shape of this cone compared to Diamond Head and Koko Crater.

2.9 Pali Highway turnoff (#61).

4.2 View of Waianae Range straight ahead.

4.9 Bishop Museum and Likelike Highway turnoff (#63 North) to right.

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*References cited in this chapter are the same as those of Chapter 1 by Garcia.

5.7 Kalihi melilite-nephelinite basalt flow, which contains ultramafic xenoliths and pegmatitic veinlets of nepheline, clinopyroxene, apatite and opaque minerals. The flow is approximately 16 m thick and originated near the summit of the Koolau Range.

6.6 Moanalua Gardens Park on right.

6.8 Exit Right at Airport-Tripler Hospital turnoff (Hwy. 66).

7.0 Turn Left onto Hwy 66 heading toward Airport.

7.1 Roadcuts on right expose outward-dipping tuffs of Salt Lake Crater.

7.4 Turn Right at signal onto Peltier Avenue.

7.5 Turn Right near top of hill at first right onto Ala Napunani.

7.6 Turn Left at first street onto Ala Ilima.

8.4 Turn Right at signal onto Ala Lilikoi.

8.7 Pink structure in distance is Tripler Military Hospital.

8.8 Turn Right onto deadend street just before elementary school. Park at the end of street. Walk along path to base of cliff.

Stop 2. Salt Lake Crater Tuff (see Chapter 3 by W. Leeman). The nephelinitic tuff contains rare ultramafic and mafic xenoliths, some of which are garnet-bearing. The tuff is palagonitic and up to 95 m thick. Locally, fossils of koa, palms and ohia trees have been recovered.

Retrace route to freeway (Hwy 78-H1)

10.9 Turn Right onto Hwy 78 heading toward Honolulu.

12.0 Kalihi flow and Middle Street overpass.

13.2 Profile of Punchbowl Crater straight ahead.

14.5 Turn Right off freeway onto Pali Highway (Hwy 61). Proceed Left (north) toward Kailua.

15.3 View of Nuuanu Valley straight ahead. Roadcuts to right of road expose thin-bedded lavas of the Koolau Volcano.

15.8 Crossing Nuuanu Stream. Underneath Highway bridge are excellent stream-cut exposures of the Nuuanu Valley post-erosional melilite-nephelinite flow from Makuhu cinder cone.

16.0 Philippine Consulate on right.

16.7 Summer residence of Queen Emma on right.

17.3 Nuuanu-Pali Road turnoff on right.

18.2 Outcrops of Nuuanu Valley post-erosional flows in roadcuts to right.

19.4 To the left is a cinder cone overgrown with vegetation. This cone, Makuku, was the source of the most recent post-erosional flow in Nuuanu Valley.

20.3 Turn Right onto turnoff for Pali Lookout and Nuuanu Pali State Park. Proceed to parking area and park.

Stop 3. The Pali Lookout presents a breathtaking view of the Pali (cliff) and the former caldera of the Koolau Volcano where the towns of Kaneohe (to the north) and Kailua (to the south) are now located. The hills in the distance straight ahead separating the two towns will be the site of the next stop. Nuuanu Valley is beheaded by a windward stream and the water drains from the leeward to the windward side. The Pali is not the result of faulting. Stearns and Vaksvik (1935) have shown that it was formed as a result of stream erosion. The location of the Pali is parallel to the boundary of the former caldera.

This area was formerly the highest part of the Koolau shield, perhaps once 1,900 m above sea level. This is within the zone of maximum rainfall. The Koolau volcano was deeply dissected at that time. As a result of this erosion and sinking of the island. the Koolau Range is now beneath this zone of maximum rainfall and is more slowly eroding.

This site is of historical interest. Kamehameha, in attempting to conquer all of the Hawaiian Islands, forced many Oahu warriors (estimates are as high as 300) off the cliff here killing them, ending any formal resistance to his attempt to unite the Hawaiian Islands. This was the last battle fought by the troops of Kamehameha. Walk down the old Pali Highway to the south of the lookout. In the cliff next to the road note numerous cross-sections of pahoehoe toes. 0.1 miles down old Pali Highway is a typical dike, 1 m thick, dipping 70^{o}. Another 0.05 down the road note the red basal breccia of the Pali nephelinite post-erosional flow, which mantles the Pali, dipping up to 40^{o}. The breccia contains fire fountain debris in layers alternating from coarse grained (up to 10 cm across) to fine grained (up to 3 cm across). Further down road, you will pass a stream valley which enters from the right. A palm tree is also located here. 150 feet from the stream the road narrows to six feet wide. At this point, the Pali basalt flow outcrops. Note the abundant ultramafic inclusions. Return to Pali lookout parking lot. Rejoin Pali Highway.

20.9 Heading east toward Kailua-Kaneohe.

21.0 Pass through tunnels.

22.3 View of Olomana Peak from the scenic lookout.

23.1 Junction with Kamehameha Highway. Continue straight. Note numerous dikes cutting caldera breccia in roadcut.

24.0 Caldera breccia in roadcuts intensely altered by chemical weathering.

24.2 Kailua Drive-In and Quarry Road to left.

25.0 Castle Junction. Continue straight.

25.5 Ulu Po Heiau--Hawaiian religious shrine on left.

26.0 Roadcut of Koolau Range basalts.

26.4 Main intersection in Kailua Town (Oneawa Street). Continue straight.

27.0 Road T's. Turn Left onto Kalaheo.

28.9 Intersection and Aikahi Shopping Center. Continue straight.

29.8 H-3 Freeway Overpass.

30.0 Turn Left onto H-3.

30.5 Scenic turnout overlooking Kailua Bay.

31.2 Stop 4. Caldera Breccia and Dikes.

Pull off road to right and park on grass. The roadcuts were made several years ago as part of the ill-fated H-3 trans-Koolau Highway. These roadcuts provide the best exposure of the caldera breccia and its dikes. The origin of the breccia is problematic. It is massive, consisting of angular fragments of a variety of rocks which resemble flows and dikes of the caldera-filling complex. The breccia is up to 165 m thick and is cut by numerous dikes. It may represent mudflows that covered the floor of the Koolau caldera (Macdonald and Abbott, 1970). Almost all of the dikes are oriented parallel, dipping 80-90°. But a few dikes are low-angle (20-40°), dipping toward the center of the ancient caldera. These low-angle dikes are also common near Castle Junction. Macdonald and Abbott (1970) suggest that these dikes are cone sheets.

Rejoin the H-3 highway. The highway abruptly ends after passing over Kalaheo Road and turns sharply 180°. Exit to the Right joining Hwy 630 heading East (right).

32.6 At traffic signal, turn Right onto Oneawa Street.

32.7 Cross canal.

34.0 Turn Right at main intersection in Kailua Town onto Kailua Road heading toward the Pali.

34.9 Heiau on right.

35.3 Turn Left at Castle Junction heading toward Waimanalo.

35.9 Olomana Peak to right.

36.2 More deeply weathered caldera breccia.

36.8 Junction with Keolu Road.

38.0 Olomana Golf Course to left.

39.6 Bellows Air Force Base entrance to left.

40.8 Waimanalo Post Office to left.

41.7 View of Manana Island, a cone of palagonitic tuff built around two vents, each marked with a crater. A bench, locally up to more than 45 m wide, is almost 2 m above present sea level. This bench is thought to have been cut when sea level was higher, perhaps during the most recent interglacial period.

42.6 View of Makapuu Lighthouse straight ahead.

43.5 Entrance to Sea Life Park.

43.8 Entrance to Makapuu Beach Park.

44.2 Pull off into turnout to Left and park.

Stop 5. Makapuu Point

In addition to providing a spectacular view of most of windward Oahu, this point is an excellent place to view the dissected interior of the flanks of the Koolau Volcano. The pali above Makapuu Beach and the pali of Makapuu Point show the hundreds of 1-m-thick flows that built the Koolau Volcano. It is too dangerous to walk along the road and view the flows. Instead, walk toward the Lighthouse (east). There are two observation caves built into the cliff about 100 feet from the road. Near the entrance of the cave further from the road is a fresh oceanite flow. Ascend the hill following the poorly marked trail. Half-way up the hill is a peculiar exposure of medium grained, light gray rock, with very well-developed flow layering. The attitude of the layering bends from near horizontal at the base of the exposure to overturned at the margins near the top of the exposure. This may be a filled lava tube.

If you climb to the top of the hill, you will obtain a view of Molokai and Lanai (on clear days) to the SE and Koko Crater and Koko Head to the SW.

The islands of the coast of Makapuu Beach and the lava flow underlying Sea Life Park and exposed along Makapuu Beach were erupted from the Koko Rift, which extends to the southwest through Koko Crater to Koko Head. This rift consists of at least 11 vents (see Fig. 1).

Rejoin the Highway heading south toward Koko Crater.

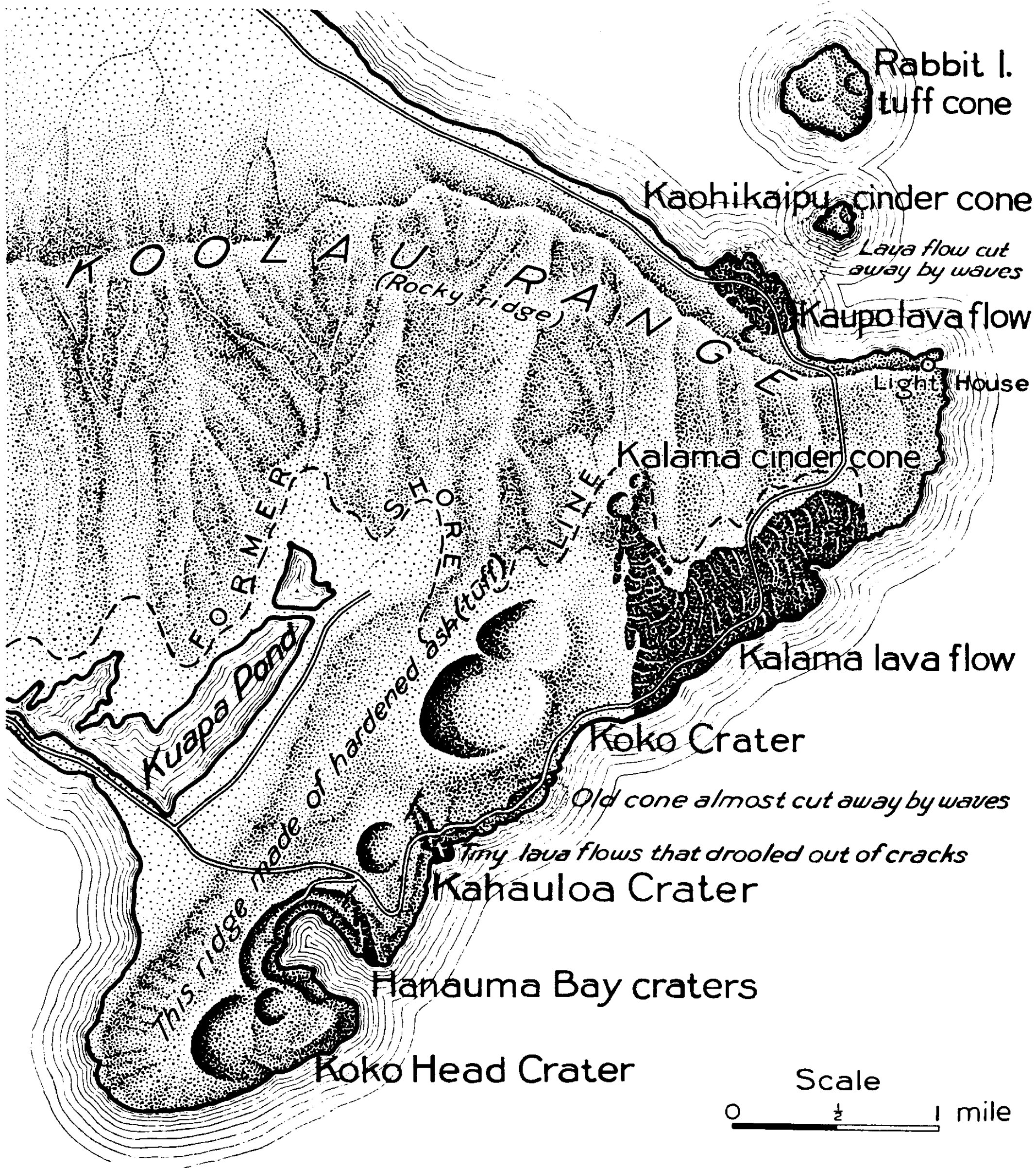

Figure 1. Koko Head area of eastern Oahu, showing Koko Rift and associated vents (from Stearns, 1939).

44.7 View of Koko Crater, which consists of two tuff cones.

45.3 Entrance to Hawaii Kai Golf Course. In building this golf course, Kalama cinder cone was removed.

46.6 Entrance to Sandy Beach.

47.2 Blow Hole parking lot--Note erosional unconformity in roadcut to right. All the tuff layers for the next 1.0 miles originated from Koko Crater.

48.1 Lanai Lookout parking lot. Note thin lava flow to right. Fisher (1977) noted numerous U-shaped channels and anti-dune deposits in the cliffs below the parking lot. He interpreted them as being related to base surge eruptions from Kahauloa Crater.

48.3 Koko Head Shooting Range in Kahauloa Crater, Molokai and Lanai Islands should be visible offshore.

48.8 Turn Left onto Hanauma Bay turnoff. Park in the lot.

Stop 6. Hanauma Bay

Walk to the edge of the parking lot overlooking Hanauma Bay. The bay is known for the abundance of colorful tropical fishes and its clear water. All wildlife, plantlife and yes, even rocks are protected in the Koko Head City Park. You must obtain permission from the City Parks Office before removing anything from the Park. Hanauma Bay is part of Koko Head, which is the southwestern portion of the Koko Rift. Koko Head is a tuff cone complex consisting of at least four vents, perhaps as many as six (Fig. 1.)

Hanauma Bay is a nested tuff cone formed by phreatomagmatic eruptions. The outer rim of the bay forms a depositional anticline. A depositional syncline separates the outer rim from the inner rim. A conspicuous angular conformity marks the boundary of the tuffs from the outer rim crater and the tuffs from the inner rim. The tuffs at Hanauma Bay are palagonitic, but remnant olivine and pyroxene grains are common. Accidental fragments of coralline material and Koolau Range basalts are common in the tuffs. Locally, these accidental fragments and blocks of juvenile material fell into soft ash deposits, creating bomb sags. Low-angle cross bedding and U-shaped channels are common near the angular conformity. These may be the result of base surge deposits. Three alkalic olivine basalt flows are present at Hanauma. One flow outcrops in the SE corner of the bay halfway up the wall. Another flowed into the north side of the bay. A third lava flowed down the depositional syncline on the north side of the bay.

49.4 Return to main highway. Turn Left toward Honolulu and Diamond Head, which is in the distance. A small posterosional shield volcano, Kaimuki Dome, separates the Koolau Range from Diamond Head (see Fig. 2).

50.2 Lunalilo Home Road. Koko Marina Shopping Center.

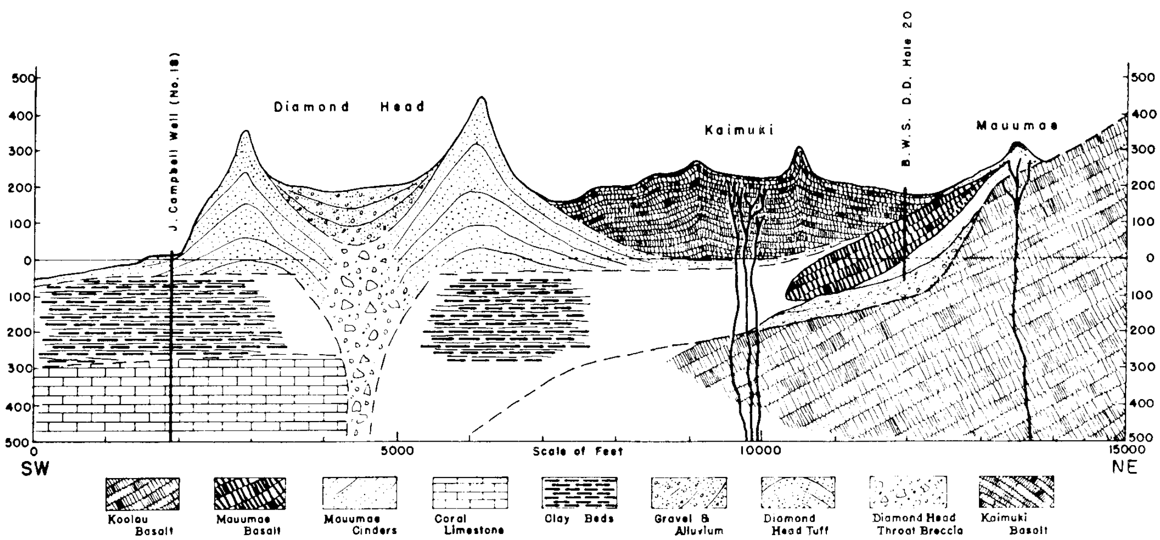

Figure 2. Geologic section, Diamond Head to Mauumae, Oahu, showing Kaimuki Dome (from Wentworth, 1951).

52.6 Niu Valley Shopping Center. Lavas exposed in cliffs from here to the University are part of the Koolau Volcano.

54.1 Aina Haina Shopping Center.

56.0 View of Kaimuki Dome, which is about 65 m thick.

57.4 View of Palolo Valley to right. Like many of the large valleys on the Honolulu side of the Koolau Range, it has a nearly flat, wide base and steep sides. The original valley cut into the Koolau Range was v-shaped. Coarse grained alluvium, coralline limestone and posterosional basalts have filled in the valley, giving it a flat, wide bottom.

57.7 Alkalic olivine basalt outcrops from Kaimuki Dome.

58.5 Kapiolani Boulevard Exit.
University of Hawaii Exit.
End of Leg 1.

Leg 2 - Waianae Range

Introduction

Several stops and a major section of this leg of the Oahu Geologic Fieldtrip are on private property or military property. It is very difficult for private citizens to gain access to Kolekole Pass because it is on the U. S. Navy Lualualei Ordnance Storage Base. Contact the base for permission. The Mauna Kuwhale rhyolite can be seen only on private land. Contact the Seventh Day Adventist's Camp-Waianae caretaker (see phone book). Plagioclase-phyric basalts are common in the Waianae Range. The locality visited on this trip is on private property. Contact First Hawaiian Bank-Property Management section for access to their employees' retreat.

Before starting this trip, read the introduction to the geology of Oahu on the Waianae Range, the chapter on the Mauna Kuwhale rhyolite by Glenn Bauer and the chapter on Lualualei Valley by John Sinton.

Cumulative Mileage

0.0 Intersection of University Avenue and Dole Street. Proceed south on University Avenue in right lane.

0.1 Turn Right onto H-1 Freeway.

3.9 View of Waianae Range

4.8 Likelike Highway turnoff.

7.2 Salt Lake Crater tuffs on left; Koolau Range lavas on right.

8.4 View of Aloha Stadium and Pearl Harbor. Pearl Harbor is essentially a complex of drowned river valleys. At the end of volcanism of Koolau Volcano, a slight embayment existed on southern Oahu. As the island sank, perhaps 400 m or more, a broad bay developed with a barrier reef at its mouth (similar to Kaneohe Bay today). Sediment filled in the bay as quickly as the island sank, so that the bay was never very deep. A water well located 190 m inland from Ewa Beach hit coral reefs to depths of 250 m. The well continued in limy muds to a depth of 310 m where lava was eventually reached. The sinking of the island was not uniform or uninterrupted. Several unconformities were found in cores from the Ewa Beach well and in another well drilled 3.2 km farther inland. These unconformities may be related to glacial periods. Each loch of Pearl Harbor is a drowned valley.

9.4 Stay in Right lanes and follow signs for H-1 and Pearl City.

10.8 View of Mt. Kaala, the highest point on Oahu at approximately 1283 m. The flat, swampy summit of Mt. Kaala is a remnant of the upper surface of the Waianae Shield Volcano.

12.6 Two cinder cones are prominent features on the skyline along the southern flank of the Waianae Range. They are part of the last eruptions which formed the Waianae Shield.

14.6 Turn Right onto H-2 toward Wahiawa.

20.0 Mililani turnoff.

21.7 Turn Right on Wheeler Air Force Base turnoff.

22.2 Turn Right at stop sign.

22.3 Turn Right onto Hwy 99 heading north.

23.0 Entrance to Wheeler Air Force Base to left. Continue straight.

23.5 Turn Left following signs for Schofield Barracks.

24.0 Turn Left--Schofield Field Barracks main gate.

Due to access limitations and a change in the trip route no mileages were determined for Schofield Barracks. Continue straight on Macomb Road. At "T" intersection

Turn Right onto Heard Avenue.

At intersection bear Right onto Trimble Road. Continue on Trimble Road to Carpenter Street (Solomon School) on SE corner of intersection.

Turn Left onto Carpenter Street. Continue to "T" intersection.

Turn Right onto Lyman Road

(Mileages restart at the edge of housing area)

0.0 Intersection of Kolekole Road and Lyman Road.

1.0 Stop Sign. Turn Left. Continue past stables.

3.0 Quarry; dikes exposed in walls. They are dipping at 40-45^{o}. A massive flow displays crude columnar jointing.

3.3 Guard Station. You must have a pass or permission to enter the U. S. Navy Base.

3.4 Observation Point. Pull into parking lot at Left and park.

Stop 1. Lualualei Valley-Waianae Caldera (see Chapter 4 by John Sinton). From the observation point at approximately 500-m elevation you can see the main mass of Waianae Volcano. The lavas dip gently outward from the caldera. In the roadcut across from the observation point is a well-exposed aphanitic dike cross cutting a plagioclase-phyric dike. Just to the west is a low peak where tens of dikes are exposed. This was probably part of a rift system.

For the next 1.6 miles is an area of abundant dikes and a coarse grained breccia.

4.9 Massive, thick, caldera-filling lavas.

10.1 Exit. U. S. Navy Lualualei Base.

11.2 Kaiser Cement Plant. Coralline material from higher stands of the sea (+25 ft. and +90 ft.) are processed here.

12.8 Turn Right onto Farrington Hwy at "T" intersection.

14.4 Along the ocean side of the road is a raised coral reef platform (+5 ft. stand of sea).

17.2 At 11 o'clock ahead note the transition from upper member to middle member of the Waianae Volcanic Series. This is based on the change of dip from gentle (5^{o}) to flat.

17.9 Turn Right onto Waianae Valley Road.

20.6 Bear to Right at intersection.

20.7 Turn Left onto dirt road to Seventh Day Adventist's camp. Drive to far side of camp and park near last cabin.

Stop 2. Mauna Kuwhale Rhyodacite (see chapter 5 by Glenn Bauer)
Climb hill behind the cabin. The basal part of the hill is basalt which is cut by many dikes. The upper 65 m of the hill is rhyodacite. Across the narrow hill behind the dairy farm is another, thicker outcrop of the rhyodacite.

24.2 Return to Farrington Road. Turn Right.

27.6 Makaha surfing beach.

29.5 Turn Right onto road leading to First Hawaiian Bank's employee recreation center. You must have permission to enter the center. There is a guard at the gate.

Park in upper level parking lot.

Stop 3. Plagioclase-Phyric Basalt
Walk the jeep trail that leads from SE portion of parking lot between cabins. Follow road uphill to water tower. In the cuts in the hillside behind the tower is a thick, plagioclase-phyric basalt. Some plagioclase grains are 1-4 cm long. Plagioclase-phyric basalts are much more common in the Waianae Range than in the Koolau Range. They are most common at the boundary between tholeiitic and alkalic lavas.

Return to cars and Farrington Hwy. Turn Right.

30.9 Makua Cave. About 150 m long and 15 m high at entrance. Numerous dikes are exposed in the cliff next to the cave. They are part of one of the main rift complexes of Waianae Volcano.

31.3 Coralline beach deposits from +25 ft. stand of the sea.

33.1 Kaena Point tracking station road to right.
Yokohama Beach on Left. (Lunch stop).

End of road log.

Retrace route following Farrington Highway to Honolulu around the southern flank of the Waianae Range.

Acknowledgments--Material in this road log was extensively borrowed from:

Macdonald, G. A. and Abbott, A. T., 1970. Volcanoes in the Sea. University of Hawaii Press, Honolulu.
Stearns, H. T., 1939. Geologic map and guide of the island of Oahu. Hawaii Div. of Hydrography, Bull. 2.
Wentworth, C. K., 1951. Geology and groundwater resources of the Honolulu-Pearl Harbor area Oahu, Hawaii. Honolulu Board of Water Supply.