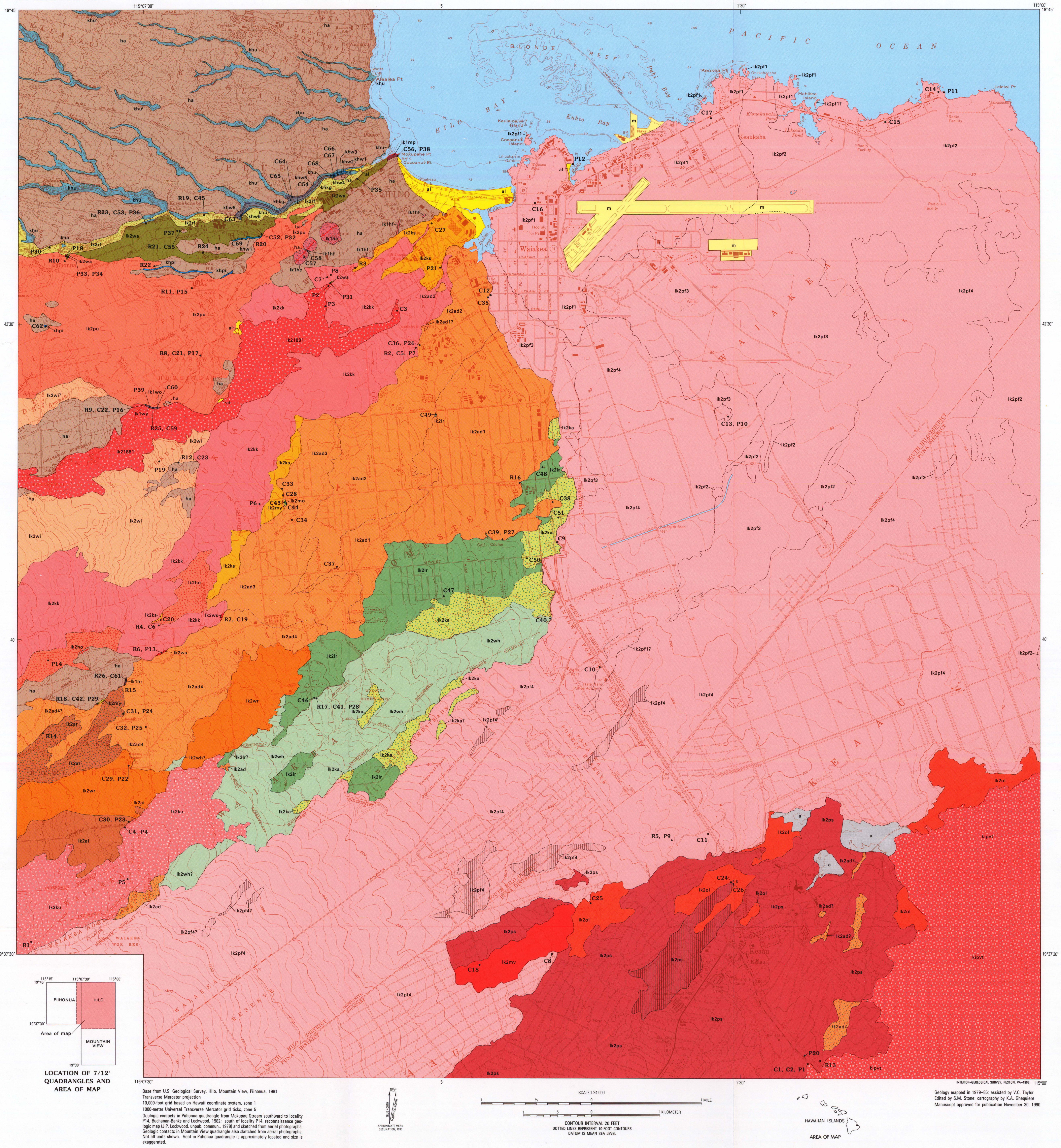
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

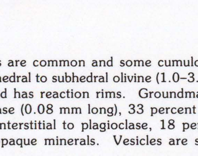
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I-2274
Explanatory pamphlet accompanies map



Base from U.S. Geological Survey, Hilo, Mountain View, Piihonua, 1981
Transverse Mercator projection
10,000-foot grid based on Hawaii coordinate system, zone 1
1000-meter Universal Transverse Mercator grid ticks, zone 5
Geologic contacts in Piihonua quadrangle from Mokupau Stream southward to locality P14, Buchanan-Banks and Lockwood, 1982; south of locality P14, reconnaissance geologic map (J.P. Lockwood, unpub. commun., 1979) and sketched from aerial photographs. Geologic contacts in Mountain View quadrangle also sketched from aerial photographs. Not all units shown. Vent in Piihonua quadrangle is approximately located and size is exaggerated.

APPROXIMATE MEAN DECLINATION, 1993

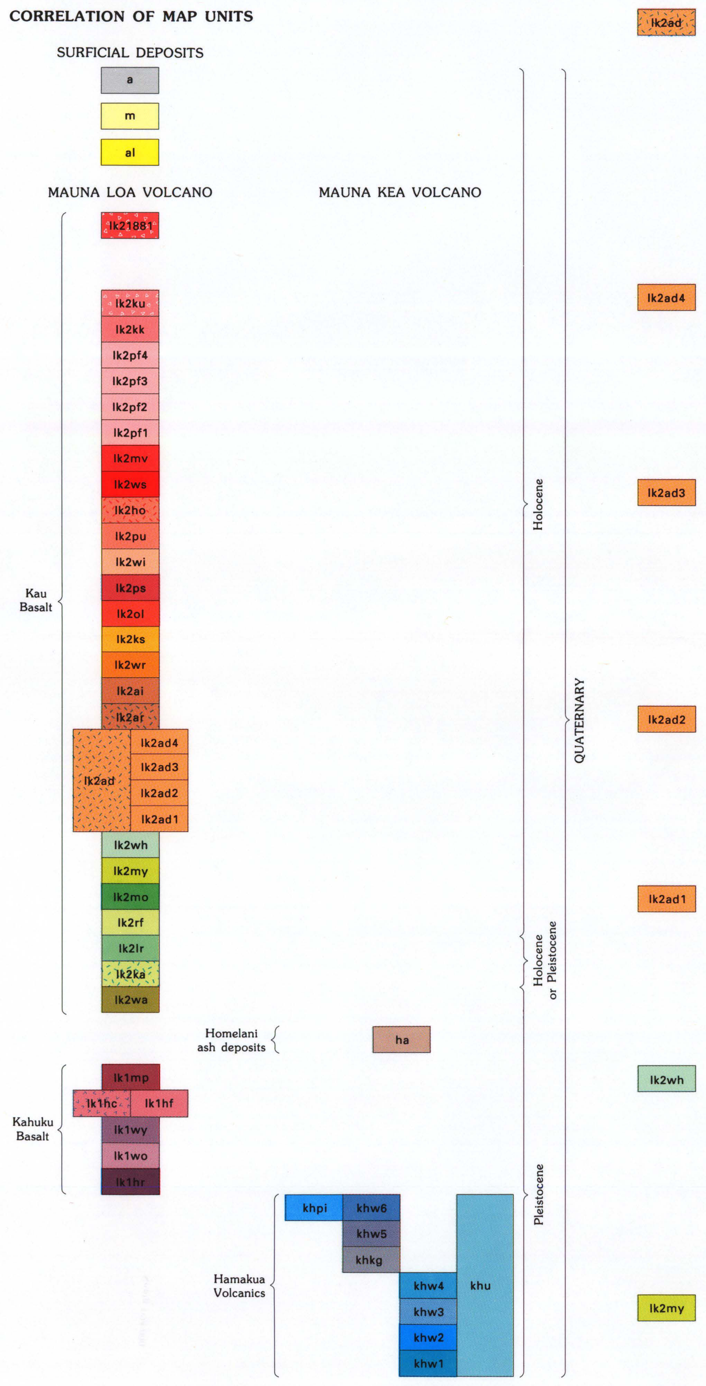
SCALE 1:24 000
1 ½ 0 1 MILE
1 .5 0 1 KILOMETER
CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL



INTERIOR–GEOLOGICAL SURVEY, RESTON, VA–1993

Geology mapped in 1979–85; assisted by V.C. Taylor
Edited by S.M. Stone; cartography by K.A. Ghequiere
Manuscript approved for publication November 30, 1990

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

[Unless otherwise noted, the following observations apply to all units. In all thin sections, olivine is euhedral and its alteration product, around rims and in fractures, is iddingsite; plagioclase is lath shaped, normally zoned, and shows albite and albite-Carlsbad twinning, and composition is given when determined; orthopyroxene is generally hypersthene; and clinopyroxene is generally augite. Microphenocrysts are commonly smaller than 0.05 mm across. Groundmass content is calculated on a vesicle-free basis. In thin sections of rocks from Kilauea and Mauna Loa, groundmass is typically hypocrystalline, contains devitrified glass heavily dusted with opaque minerals, and constitutes 89 to 98 percent of section. In thin sections of rocks from Mauna Kea, groundmass is generally holocrystalline, has an intergranular texture, and constitutes 88 to 95 percent of section. In outcrop, pahoehoe flows are tube fed, have spherical to subspherical vesicles, and are moderately vesicular (10–30 percent), whereas aa flows are dense, have irregularly shaped vesicles, and are slightly vesicular (<10 percent)]

SURFICIAL DEPOSITS

a **Artificial deposit (Holocene)**—Mud and rock slurry from washing of sugarcane that was bulldozed and then harvested by crane; slurry distributed by canal system from Puna Sugar Company Mill near Keaau to make young lava flows arable. Not shown where underlying rock can be identified

m **Modified land (Holocene)**—Large areas of land surface greatly modified for large engineered structures and docking facilities

al **Alluvial deposits (Holocene)**—Chiefly unconsolidated sand along coast and pebble- to cobble-size gravel in streams

KILAUEA VOLCANO

Puna Basalt (Holocene)—Composed of tholeiitic basalt. Consists of:

kipvt **Pahoehoe flow of Old Volcano Trail**—Medium- to dark-gray basalt characterized by about 8 percent subhedral to anhedral olivine microphenocrysts in hyaline groundmass having hyalophitic texture and by fresh, black, surface glass. Groundmass consists of about 36 percent glass; 29 percent mafic minerals, probably olivine; and 27 percent plagioclase (An60), some in stellate form.

Unit, typically about 1 to 2 m thick, covers 4-km² area in southeast corner of quadrangle. Slight differences in plagioclase abundance in different outcrops suggest possibility of two flows, but outcrops and possible contacts are obscured by slurry of mud and rocks. Radiocarbon age of 0.26±0.07 ka was obtained on charcoal from beneath unit (table 1, Sample No. W3881); however age is believed to be between about 0.35 to 0.50 ka (Holcomb, 1987, fig 12.12). Chemical analyses (table 2, Map Nos. C1 and C2, C1 overlies C2); paleomagnetic data (table 3, Map No. P1)

MAUNA LOA VOLCANO

Kau Basalt (Holocene and Pleistocene)—Composed of medium- to dark-gray tholeiitic basalt. Consists of:

lk21881 **Pahoehoe flow of 1880–81 eruption (Holocene)**—Basalt characterized by about 2 percent olivine and 1 percent orthopyroxene phenocrysts in hyaline groundmass having hyalophitic texture and by fresh, black, surface glass. Olivine is subhedral to rounded, has reaction rims, and contains rounded inclusions of glass-rich groundmass as well as euhedral opaque minerals, probably chrome spinel. Orthopyroxene is more subhedral, elongate, and smaller than olivine. Groundmass consists of 40 percent subhedral plagioclase (An55; 0.2 mm long), 30 percent mafic minerals, and 26 percent vitric glass. Vesicles range from spherical (1–2 mm across) at surface, to flattened (0.5–1 cm long) in flow interior.

Historic eruption of November 1880 to August 1881 from fissure vents at about 10,400-ft elevation on the northeast rift zone (Macdonald, 1949, p. 61; Lockwood, 1990, fig. 4) initially produced aa but in early December began to erupt pahoehoe (Baldwin, 1953). Eruption lasted 280 days (Wright, 1971, table 1), and flow eventually reached northwestern part of quadrangle covering about 3.2 km². Unit is generally about 1 m thick near margins but reaches thicknesses of 2 to 2.5 m where it crosses Komohana Street. In Piihonua quadrangle, lava tubes that once channeled the flow are commonly several meters high (Greeley, 1974). Smaller distributary tubes transport subsurface water into more populated area of Hilo, sometimes causing flooding. Chemical analysis (table 2, Map No. C3); paleomagnetic data (table 3, Map Nos. P2 and P3; Coe and others, 1978, table 6)

lk2ku **Pahoehoe flow of Kulaloa Road (Holocene)**—Basalt characterized by about 5 percent clinopyroxene and 2 percent olivine microphenocrysts, and 4 percent phenocrysts and microphenocrysts of plagioclase in groundmass having intersertal texture. Fresh glass present on surfaces undisturbed by human activity. Clinopyroxene and olivine are generally tabular and euhedral to subhedral. Plagioclase (An64; 2 mm long) is euhedral to strongly resorbed. Groundmass consists of 38 percent glass, 29 percent mafic minerals, 22 percent plagioclase, and less than 1 percent olivine as an accessory mineral.

Unit has average thickness of about 1 m and covers about 1.3 km² in southwest corner of quadrangle, south of Ainaola Drive. Locally overlies ash deposit 10 to 15 cm thick. Radiocarbon age of 0.57 ±0.06 ka was obtained on charcoal from beneath unit (table 1, Map No. R1). Source vent is believed to be at about 4,600-ft elevation on northeast rift zone (J.P. Lockwood, oral commun., 1986). Chemical analysis (table 2, Map No. C4); paleomagnetic data (table 3, Map Nos. P4 and P5)

lk2kk **Pahoehoe flow of Kukuau ahupuaa (Holocene)**—Basalt characterized by less than 1 percent each olivine phenocrysts, plagioclase phenocrysts and microphenocrysts, and pyroxene microphenocrysts in groundmass having hyalophitic texture. Patches of fairly well preserved glass are present on surfaces undisturbed by human activity. Sparse, scattered olivine and pyroxene crystals are euhedral to subhedral; pyroxene also found as glomerocrysts. Plagioclase (An60; 1 mm long) is generally subhedral. Groundmass consists of 43 percent glass, 31 percent pyroxene, 24 percent plagioclase, and less than 0.5 percent olivine. Numerous vesicles (38 percent; 0.5–2 mm across) are present.

Unit originated from vents near 9,000-ft elevation on northeast rift zone (J.P. Lockwood, oral commun., 1986). Generally 1 to 1.5 m thick but locally as much as 2 m thick. Flow covers about 10 km² in northwestern part of quadrangle and overlies unit lk2ws, another young pahoehoe flow. Because of similarities in morphology, mineral content, and age, may include some unit lk2ws as mapped. Flow contains lava tubes that carry subsurface water into populated area of Hilo causing flooding, especially where unit overlies impervious aa flow (Lockwood and Buchanan-Banks, 1981). Average radiocarbon age is about 1.18 ka (table 1, Map Nos. R2–R4). Chemical analyses (table 2, Map Nos. C5–C7); paleomagnetic data (table 3, Map Nos. P6–P8)

Olivine-bearing to picritic flows of Panaewa Forest Reserve (Holocene)—Mapped as four flow units mainly on basis of morphology and mineral abundance. Mapping complicated by bulldozing of large areas for agricultural and construction projects; where undisturbed, flows are covered by thick jungle. Thus, few mappable contacts could be identified. Following thin-section descriptions from each flow unit emphasize mineral distinctions between units; however, in outcrop, flow units are difficult to distinguish. Divided into:

lk2pf4 **Flow unit 4**—Aa characterized by 24 percent olivine and 4 percent plagioclase phenocrysts and about 2 percent clinopyroxene microphenocrysts in groundmass having pilotaxitic texture. Olivine (as large as 0.6 mm across) is euhedral to rounded and resorbed, displaying incipient alteration along some fractures and cleavages. Plagioclase (An64; 0.5–1.6 mm long) is subhedral, blocky to lath shaped; some grains show weak oscillatory zoning toward rims; glomerocrysts are common, and some cumulocrysts with olivine are present. Clinopyroxene (0.03–0.04 mm long) is subhedral to anhedral. Groundmass (69 percent) consists of 29 percent plagioclase (0.05 mm long); 24 percent mafic minerals, mostly clinopyroxene; and 16 percent equant to bladed opaque minerals. Vesicles (15 percent) are rounded to subrounded.

Unit, containing minor pahoehoe phases, erupted from near 5,200-ft elevation on northeast rift zone (J.P. Lockwood, oral commun., 1986). Unit has prominent scarps as much as 4 m high, but base is rarely exposed. Toward distal end, scarps are subdued making contact with underlying flows difficult to determine. Unit covers about 75 km² from southwest corner to east-northeastern part of quadrangle covering flow paths of three older units. In south face of quarry near paleomagnetic sample locality P10 (see map), unit apparently overlies flow unit 3. Age is 1.47±0.05 ka (table 1, Map No. R5). Chemical analyses (table 2, Map Nos. C8–C11); paleomagnetic data (table 3, Map No. P9)

lk2pf3 **Flow unit 3**—Light-gray flinty aa characterized by about 5 percent plagioclase and less than 1 percent olivine and clinopyroxene phenocrysts in groundmass having intersertal to granular texture. Plagioclase (An62; 0.5 mm long) is blocky to lath shaped and displays some weak oscillatory and patchy zoning; some crystals contain cavities; glomerocrysts are common and some cumulocrysts with olivine are present. Euhedral to subhedral olivine (1.0–3.0 mm long) is partially resorbed and has reaction rims. Groundmass consists of 39 percent plagioclase (0.08 mm long), 33 percent mafic minerals (0.02 mm long) interstitial to plagioclase, 18 percent glass, and about 5 percent opaque minerals. Vesicles are spherical to subspherical.

Well exposed in quarries just south of General Lyman Field east of Hawaii Highway 11 where unit is as much as 10 m thick. Distinct horizontal jointing increases upward from about 1 m near base to a few centimeters at top of outcrop; vertical jointing is less frequent. In quarry near paleomagnetic sample locality P10 (see map), upper 3 to 4 m of flow is pahoehoe that may have resulted from local ponding; intraflow rubble is present in lower part of unit. In same quarry, unit overlies pahoehoe that is probably flow unit 1. Flow covers about 13 km². Chemical analyses (table 2, Map Nos. C12 and C13); paleomagnetic data (table 3, Map No. P10)

lk2pf2 **Flow unit 2**—Pahoehoe characterized by about 12 percent olivine, 11 percent plagioclase, and 4 percent clinopyroxene phenocrysts in fine-grained groundmass having intergranular to intersertal texture. Olivine (2.0–6.0 mm long) is partially resorbed and has reaction rims. Plagioclase (An62; 0.5–1.5 mm long) is mostly blocky to subhedral and commonly found as glomerocrysts. Some cumulocrysts with clinopyroxene are present. Groundmass (74 percent) consists of intergrowths of 33 percent glass; 23 percent mafic minerals, dominantly clinopyroxene; and 18 percent plagioclase. Vesicles are usually subspherical, but some are cylindrical.

Unit covers about 8 km². Chemical analyses (table 2, Map Nos. C14 and C15); paleomagnetic data (table 3, Map No. P11)

lk2pf1 **Flow unit 1**—Pahoehoe characterized by about 3 percent plagioclase and 2 percent olivine phenocrysts and less than 1 percent clinopyroxene microphenocrysts in fine-grained groundmass having hyalophitic texture and by small patches of poorly preserved surface glass. Plagioclase (An64; 0.5–1.2 mm long) is euhedral to subhedral, blocky to lath shaped, and displays some weak oscillatory zoning, particularly near rims; glomerocrysts are common and cumulocrysts with olivine are found occasionally. Olivine is euhedral to subhedral and has reaction rims. Groundmass consists of 38 percent blocky mafic grains, 30 percent interstitial glass heavily dusted with mafic minerals, and 29 percent plagioclase. Spherical vesicles (32 percent) are numerous.

Unit covers about 8 km² forming north-central coastline. Drill core obtained near Naval Reserve Electronic Facility establishes minimum thickness of 7.6 m. Chemical analyses (table 2, Map Nos. C16 and C17); paleomagnetic data (table 3, Map No. P12)

lk2mv **Aa flow at south boundary with Mountain View quadrangle (Holocene)**—Basalt characterized by about 5 percent olivine and 4 percent plagioclase phenocrysts and rare microphenocrysts of clinopyroxene(?) in very fine grained groundmass having microgranular texture. Blocky olivine (2.0–3.0 mm long) generally having reaction rims, and plagioclase (An 60; 3.0 mm long) are commonly found as cumulocrysts. Plagioclase occasionally shows oscillatory zoning from core to rim. Groundmass (average grain length 0.7 mm) consists of 41 percent blocky mafic minerals, 35 percent plagioclase, and 15 percent blocky opaque minerals. Vesicles (12 percent) are irregularly shaped.

Unit, generally about 3 m thick, covers about 0.5 km² near south-central Hilo quadrangle boundary. Surface expression subdued because of prolonged use for sugarcane cultivation. Underlain by unit lk2ps and overlain by unit lk2pf4, constraining its age between about 5.2 and 1.5 ka. Chemical analysis (table 2, Map No. C18)

lk2ws **Pahoehoe flow of Waiakea Stream (Holocene)**—Basalt characterized by 2 percent each of olivine and clinopyroxene phenocrysts and less than 1 percent each of plagioclase and orthopyroxene, usually as microphenocrysts but some as phenocrysts, in groundmass having intergranular texture. Olivine has spinel inclusions and some crystal cavities filled with devitrified glass. Rare phenocrysts of plagioclase (An68; 0.5 mm long) and orthopyroxene (0.6 mm long) are subhedral. Groundmass (glassier than groundmass of unit lk2kk) consists of 60 percent opaque minerals, 20 percent blocky to acicular plagioclase, 14 percent euhedral to anhedral clinopyroxene, and less than 0.5 percent each of orthopyroxene and olivine.

Unit less than 1 m thick at margins; crops out in Waiakea Stream north of Hoaka Road in southwestern Hilo quadrangle. Overlies thin ash deposit about 0.3 m thick and another older pahoehoe that is too small to show at map scale. Overlain by stream deposits and vegetation, which obscure any surface glass that might be preserved; also overlain by unit lk2kk and may be included within some areas mapped as unit lk2kk. Average radiocarbon age is 1.6±0.15 ka (table 1, Map Nos. R6 and R7). Chemical analysis (table 2, Map No. C19); paleomagnetic data (table 3, Map No. P13)

lk2ho **Aa flow near Hoaka Road (Holocene)**—Light- to medium-gray basalt characterized by 10 percent plagioclase, 6 percent clinopyroxene, and a few olivine phenocrysts in very fine grained groundmass having intergranular texture. Plagioclase (An57; 0.2–0.4 mm long) is subhedral and forms occasional cumulocrysts with clinopyroxene and olivine. Groundmass (84 percent; average grain size 0.01 mm) consists of 46 percent mafic minerals, mostly clinopyroxene; 22 percent plagioclase (0.05–0.06 mm long); and 16 percent opaque minerals. Vesicles are serrate to rounded.

Unit generally about 1 to 2 m thick and has reddish-brown rubble at top; covers more than 1 km² near west-central edge of Hilo quadrangle. Overlies units lk2ks and lk2ad and underlies unit lk2kk, constraining its age between about 9.0 and 1.2 ka. Paleomagnetic direction of remanent magnetization is similar to unit lk2pf4, whose radiocarbon age is about 1.5 ka. Also, Macdonald and Eaton (1964, p. 157) reported average radiocarbon age of 2.0±0.25 ka from cinder quarry in Piihonua quadrangle where spatter and younger lavas of the Kau Basalt overlie Pahala ash. Unit crops out near this cinder quarry, and the radiocarbon ages may provide a maximum age for unit. Chemical analysis (table 2, Map No. C20); paleomagnetic data (table 3, Map No. P14)

lk2pu **Pahoehoe flow of Punahoa ahupuaa (Holocene)**—Light- to medium-gray basalt characterized by about 4 percent olivine and rare plagioclase microphenocrysts in groundmass having hyalophitic texture. Surface glass is generally poorly preserved but bottom glass is well preserved. Groundmass consists of 34 percent plagioclase, 32 percent anhedral mafic minerals, 30 percent interstitial glass, and less than 1 percent opaque minerals. Abundant vesicles (46 percent) have generally smooth interiors, although some surface vesicles have slightly diktytaxitic texture that increases downward in flow.

Covers about 3.5 km² in northwestern part of Hilo quadrangle. Several units of this flow, which have a combined thickness of about 4 m, are well exposed north of Waianuenue Avenue in north-trending canal west of and parallel to Akolea Road, Piihonua quadrangle (Map No. P18). Numerous lava tubes provide pathways for large volumes of subsurface water, supplying over 90 percent of spring-derived drinking water for Hilo (Hawaii County Board of Water Supply, 1971; Lockwood and Buchanan-Banks, 1981). For part of its length, south boundary of flow coincides with north bank of Waipahoehoe Stream, where flow locally overlies ash deposits that are 4 m thick. Along north boundary, flow locally overlies lava flows from Mauna Kea Volcano. Average radiocarbon age is about 3.48 ka (table 1, Map Nos. R8–R11). Chemical analyses (table 2, Map Nos. C21 and C22); paleomagnetic data (table 3, Map Nos. P15–P18)

lk2wi **Pahoehoe flow of Wilder Road (Holocene)**—Basalt characterized by about 2 percent olivine phenocrysts in groundmass having hyalophitic texture. Surface glass is rare and poorly preserved. Sparse, blocky olivine (0.2 mm long) has spinel inclusions and is euhedral to subhedral. Groundmass consists of about 52 percent glass, some of which is clear; 21 percent anhedral mafic minerals, probably clinopyroxene; 18 percent plagioclase (An69); and 7 percent olivine. Abundant vesicles (46 percent; 1–2 mm across) have shiney, smooth interiors.

Unit, about 0.5 to 1 m thick; covers about 1.0 km² at west-central edge of quadrangle, where it overlies ash deposits that have exposed thickness of 2 m. Age is 4.41±0.12 ka (table 1, Map No. R12). Chemical analysis (table 2, Map No. C23); paleomagnetic data (table 3, Map No. P19)

lk2ps **Picritic aa and pahoehoe flow of Puna Sugar fields (Holocene)**—Basalt characterized by 31 percent olivine phenocrysts and 7 percent plagioclase phenocrysts and microphenocrysts in groundmass having hyalophitic to intersertal texture. Olivine (1.0–2.0 mm across) is euhedral to subhedral and some phenocrysts are embayed. Euhedral to subhedral plagioclase (An74; 0.7–1.5 mm long) shows broad oscillatory zoning, where some zones are rich in wormlike glass inclusions; pericline twinning is also present; cumulocrysts with olivine (1 cm long) found deep in flow. Groundmass (62 percent) consists of 22 percent glass, 21 percent mafic minerals, 15 percent plagioclase, and 4 percent olivine. Vesicles (15 percent) have glass-rich halos.

Unit is primarily aa, about 3 m thick, but contains some pahoehoe phases; covers about 11 km² along south boundary of quadrangle near Keaau. Surface expression subdued due to weathering, thin ash cover, and use for sugarcane cultivation for more than 30 yr. Age is 5.25±0.10 ka (table 1, Map No. R13). Chemical analysis (table 2, Map No. C24); paleomagnetic data (table 3, Map No. P20)

lk2ol **Aa flow of Olaa Plantation (Holocene)**—Basalt characterized by about 4 percent olivine phenocrysts, 3 percent plagioclase phenocrysts and microphenocrysts, 2 percent gabbroic inclusions, and rare subhedral pyroxene phenocrysts in groundmass having hyalophitic to intersertal texture. Olivine (1.0 mm long) has rounded corners and thin reaction rims; occasionally found as glomerocrysts as large as 1 cm in diameter and as gabbroic inclusions deep in flow where some are as much as several centimeters across. Plagioclase (An68; 0.5 mm long) is resorbed, commonly has glass inclusions, and shows some weak oscillatory zoning. Groundmass consists of 43 percent mafic minerals, probably mostly clinopyroxene; 32 percent plagioclase; 14 percent glass; and 3 percent opaque minerals.

Unit, containing minor local pahoehoe, is generally about 4 m thick; exposed in isolated patches totaling about 6 km² in south-central part of quadrangle near Keaau. Overlain by unit lk2ps. Chemical analyses (table 2, Map Nos. C25 and C26)

lk2ks **Aa flow of Kinoole Street (Holocene)**—Basalt characterized by 5 percent olivine and 3 percent plagioclase phenocrysts and microphenocrysts in groundmass having hyalophitic to granular texture. Olivine (1.0–2.0 mm long), which has spinel inclusions, is dominantly euhedral to subhedral and has reaction rims; subhedral to anhedral grains are partially resorbed. Plagioclase (An68; 1.0 mm long) tends to be blocky to lath shaped and frequently found as glomerocrysts or as cumulocrysts (1–2 mm across) with olivine. Groundmass consists of 39 percent plagioclase; 32 percent mafic minerals, including some pyroxene and olivine(?); and 21 percent euhedral opaque minerals. Vesicles (17 percent) are regular to serrate in shape.

Generally about 1 to 2 m thick and contains loose yellow-orange rubble; crops out discontinuously over a 1.6-km² area from west-central part of Hilo quadrangle to Hilo Bay. Overlies unit lk2ad and in turn underlies units lk2ho and lk2kk, constraining its age between about 9.0 and 1.2 ka. Chemical analyses (table 2, Map Nos. C27 and C28); paleomagnetic data (table 3, Map No. P21)

lk2wr **Aa flow of Waikahe Road (Holocene)**—Medium-gray to reddish-gray basalt characterized by 7 percent plagioclase and 3 percent olivine phenocrysts and 4 percent clinopyroxene microphenocrysts in groundmass having microcrystalline texture. Plagioclase (An69; 0.25–0.5 mm long) is blocky to lath shaped; some grains show weak oscillatory zoning; a few grains are partially resorbed and have a sievelike texture; some forms cumulocrysts with minor olivine or clinopyroxene, or both. Olivine (2.0 mm long) has reaction rims, is partially resorbed, and is found as scattered glomerocrysts. Clinopyroxene (0.4 mm long) is euhedral to subhedral. Groundmass (86 percent) consists of 38 percent glass; 22 percent mafic minerals, probably mostly clinopyroxene; 19 percent plagioclase; and 7 percent opaque minerals.

Unit has loose reddish-brown clinker. Generally about 4 to 5 m thick and crops out over 2.5-km² area in southwestern part of map area. Overlies unit lk2ar and, in turn, underlies unit lk2ku, but paleomagnetic declination indicates unit is no younger than about 4.5 ka (D.E. Champion, oral commun., 1986). Chemical analysis (table 2, Map No. C29); paleomagnetic data (table 3, Map No. P22)

lk2ai **Pahoehoe flow of Ainaola Drive**—Basalt characterized by less than 1 percent each of olivine (0.5–1.0 mm long) and plagioclase phenocrysts in groundmass having intersertal texture. Euhedral plagioclase (An60; 0.5–1.3 mm long) is blocky, has resorbed rims, and displays oscillatory zoning. Groundmass (73 percent) consists of 44 percent pyroxene, 31 percent glass, 23 percent plagioclase, and about 1 percent olivine.

Unit crops out mainly in southeastern part of Piihonua quadrangle, but also underlies unit lk2ku and thin ash deposit in southwestern part of Hilo quadrangle. Chemical analysis (table 2, Map No. C30); paleomagnetic data (table 3, Map No. P23)

lk2ar **Aa flow of Alawaena Road**—Basalt characterized by about 18 percent olivine and 12 percent plagioclase phenocrysts in holocrystalline groundmass having microcrystalline texture and by dusky-red indurated upper rubble. Olivine (0.5–2.2 mm long) is euhedral to subhedral, is slightly altered along fractures; some found as cognate inclusions with plagioclase (An60). Euhedral plagioclase (An57; 0.35 mm long) is blocky; some displays oscillatory zoning. Groundmass (66 percent) consists of about 39 percent opaque minerals, 20 percent plagioclase, and 7 percent interstitial mafic minerals. Vesicles (12 percent) are both rounded and irregularly shaped.

Unit crops out in southeastern corner of Piihonua quadrangle; overlies unit lk2my. Radiocarbon age is 8.03±0.07 (table 1, Map No. R14). Chemical analysis (table 2, Map No. C31); paleomagnetic data (table 3, Map No. P24)

lk2ad **Olivine-bearing to picritic aa flows of Ainaola Drive (Holocene)**—Picritic aa, generally 4 to 5 m thick, locally interbedded with minor olivine pahoehoe that has distinctive frothy texture and abundant vesicles; pahoehoe occasionally found as surface unit. Olivine phenocrysts compose 14 to 29 percent of rock; plagioclase is rare in hand specimens. Unit has loose yellowish-brown clinker. Crops out over 15-km² area from southwestern to northwest-central part of map area and near Keaau beneath unit lk2ol. Locally overlies ash deposit 20 to 25 cm thick and is locally overlain by thin ash deposit.

Primarily mapped as four flow units mainly on basis of topographic expression and photogeologic interpretation. Units cannot easily be distinguished in field because small differences in mineralogy between hand specimens taken from each unit fall within range of variability found within a single unit. In thin section, however, flow units show significant differences in content of orthopyroxene phenocrysts and glomerocrysts. Divided into:

lk2ad4 **Flow unit 4**—Basalt characterized by about 29 percent olivine phenocrysts and 0.3 percent opaque microphenocrysts in groundmass having granular texture. Euhedral to subhedral olivine (1–2 mm long) has reaction rims and minor opaque inclusions, some of which are resorbed. Groundmass (71 percent) consists of 25 percent plagioclase (0.5 mm long), 40 percent anhedral granular mafic minerals, and 6 percent well-formed opaque laths. Vesicles (12 percent) are subspherical and have irregular edges.

Unit forms prominent channel that crosses Malaai Road in southwestern part of quadrangle. Covers about 3.8 km². Age is 9.02±0.13 ka (table 1, map no. R15). Chemical analysis (table 2, Map No. C32); paleomagnetic data (table 3, Map No. P25)

lk2ad3 **Flow unit 3**—Basalt characterized by about 14 percent olivine phenocrysts in groundmass having intersertal texture. Many euhedral to subhedral olivine phenocrysts contain opaque, round, generally centrally located glass inclusions; some olivine is embayed. Orthopyroxene microphenocrysts are rare. Few cumulocrysts (6.5–9.5 mm across) present have an ophitic texture, some contain plagioclase laths (An66), and more rarely olivine. Groundmass (86 percent) consists of 39 percent glass, 24 percent clinopyroxene, and 23 percent plagioclase. Vesicles are both rounded and elongate.

Unit has more subdued topography than flow unit 4 because it was used for sugarcane cultivation from late 1800s to mid-1900s (Kelly and others, 1981, fig. 25); covers 2.8-km² area. Chemical analyses (table 2, Map Nos. C33 and C34)

lk2ad2 **Flow unit 2**— Basalt characterized by 20 percent olivine phenocrysts in groundmass having intergranular texture. Generally unaltered olivine occasionally shows slight resorption and contains a few euhedral opaque minerals. Groundmass (80 percent) consists of 31 percent plagioclase (0.01–0.02 mm long), 28 percent opaque minerals and glass, and 21 percent mafic minerals. Vesicles (26 percent) are generally elongate.

Crops out along south end of Komohana Street, and to northeast underlies University of Hawaii campus; covers about 4.3 km². Chemical analyses (table 2, Map Nos. C35–C37); paleomagnetic data (table 3, Map No. P26)

lk2ad1 **Flow unit 1**—Basalt characterized by 18 percent olivine phenocrysts, 1 percent plagioclase microphenocrysts, and rare euhedral opaque minerals in groundmass having intergranular texture. Olivine is slightly resorbed. Groundmass (80 percent) consists of 37 percent mafic minerals; 28 percent plagioclase (0.3 mm long), containing opaque olivine inclusions; and 16 percent opaque minerals. Vesicles (19 percent) are irregularly shaped.

Crops out from Haihai Street northeastward to Kilauea Avenue; covers about 4.4 km². Age is 9.02±0.12 ka (table 1, Map No. R16). Chemical analyses (table 2, Map Nos. C38 and C39); paleomagnetic data (table 3, Map No. P27)

lk2wh **Pahoehoe flow of Waiakea Homesteads (Holocene)**—Basalt characterized by 21 percent plagioclase (An58; 0.2 mm long) and 2 percent olivine phenocrysts in groundmass having hyalophitic texture. Some olivine (0.6–1.0 mm long) grains are skeletal. Groundmass (77 percent) consists of 43 percent glass; 22 percent subhedral to anhedral pyroxene, occasionally in stellate form alone or with plagioclase; and 12 percent subhedral to anhedral olivine. Numerous vesicles (39 percent) are usually spherical, but some are flattened and irregular in shape; walls are slightly diktytaxitic.

Unit is as much as 2.5 to 3 m thick and covers about 6.0 km² in southwestern part of quadrangle. Overlies and is separated from unit lk2lr by ash deposit about 0.3 m thick. Age is 9.78±0.14 ka (table 1, Map No. R17). Chemical analyses (table 2, Map Nos. C40 and C41); paleomagnetic data (table 3, Map No. P28)

lk2my **Younger pahoehoe flow near Makani Circle (Holocene)**—Basalt characterized by about 5 percent olivine phenocrysts in crystal-rich groundmass having hyalophitic texture. Olivine (0.4–0.8 mm long) is subhedral to embayed and shows alteration along fractures and cleavages; some found as glomerocrysts and as cumulocrysts with adhered groundmass plagioclase; some is partly skeletal. Groundmass consists of about 41 percent glass; 23 percent plagioclase (An69; 0.1–0.2 mm long), some of which is blocky; 18 percent pyroxene, and 13 percent olivine. Vesicles (1–2.5 mm across), many surrounded by glass halos, are spherical to subrounded and have smooth to diktytaxitic walls.

Unit, about 0.5 m thick, exposed beneath unit lk2ad3 in roadcut for new housing subdivision west of Waiakea Stream, where stream crosses West Kawailani Street. Size of outcrop exaggerated on map. Overlies thin, 2- to 5-cm thick red-baked ash deposit and unit lk2mo. Radiocarbon age of 10.3±0.07 ka (table 1, Map No. R18) was obtained on unit in Piihonua quadrangle, where 1-m thick unit underlies a thin ash and overlies an ash deposit nearly 1 m thick. Chemical analyses (table 2, Map Nos. C42 and C43); paleomagnetic data (table 3, Map No. P29)

lk2mo **Older pahoehoe flow near Makani Circle (Holocene)**—Light- to medium-gray basalt characterized by about 2 percent generally subhedral olivine (0.4–0.6 mm across) microphenocrysts in groundmass having hyalophitic to intersertal texture. Groundmass consists of about 50 percent glass, 23 percent pyroxene, 17 percent plagioclase (An72; 0.1 mm long), and 8 percent olivine. Abundant vesicles (47 percent; 1.2–1.9 mm across), some having glass halos, are subrounded to irregularly shaped and have smooth to diktytaxitic walls.

Unit, having less than 0.5-m thickness exposed, underlies unit lk2my. Size of outcrop exaggerated on map. Chemical analysis (table 2, Map No. C44)

lk2rf **Aa flow of Rainbow Falls (Holocene)**—Vitric basalt characterized by about 4 percent olivine, 1 percent clinopyroxene, and about 0.5 percent plagioclase and orthopyroxene phenocrysts in holocrystalline groundmass having intersertal texture. Olivine (2.0–3.0 mm long) is euhedral to anhedral, has reaction rims, and contains some spinel inclusions; anhedral crystals are commonly resorbed; some found in cumulocrysts with pyroxene, but more often found in glomerocrysts as large as 1.5 to 2 cm across, but more commonly 1 to 1.5 cm across. Some orthopyroxene is rimmed by clinopyroxene. Plagioclase (1–3 mm long) has poorly developed albite twinning. Groundmass consists of 55 percent fine plagioclase microlites; 29 percent mafic minerals, mostly clinopyroxene; and 11 percent glass, mostly as halos around rare vesicles.

Unit generally 4 to 5 m thick. Crops out in northwestern part of map area covering about 0.5 km² in and along south bank of Wailuku River; is uppermost flow forming Rainbow Falls. Near mouth of river forms prominent outcrop locally known as Maui's Canoe, which probably resulted from emptying of aa channel through gravity flow. Locally overlies ash deposit 15 to 20 cm thick. Age is 10.61±0.15 ka (table 1, Map No. R19). Chemical analysis (table 2, Map No. C45); paleomagnetic data (table 3, Map No. P30)

lk2lr **Pahoehoe flow of Laula Road (Holocene or Pleistocene)**—Light- to medium-gray basalt characterized by about 15 percent euhedral to subhedral olivine phenocrysts and microphenocrysts, less than 5 percent clinopyroxene dominantly as microphenocrysts, and less than 0.5 percent plagioclase microphenocrysts in groundmass having coarsely intergranular texture. Olivine (0.8–2.5 mm long) is slightly altered along some fractures and contains spinel inclusions; some olivine shows twinning and some kink banding. Groundmass (81 percent) consists of about 37 percent glass, 28 percent mafic minerals dominated by clinopyroxene ranging from microlites through blocky to anhedral crystals, and 16 percent plagioclase. Spherical to subspherical vesicles (0.3–2.4 mm across) are rimmed with devitrified glass microlites.

Thin sections from different outcrops show significant differences: groundmass texture varies from fine to coarse grained and olivine and olivine-pyroxene ratios vary; differences suggest that more than one unit is included within mapped flow. Unit, commonly 2 to 2.5 m thick, crops out as isolated patches over area of 3.6 km² in southwestern to central part of Hilo quadrangle. Overlain by unit lk2wh; hence, age is greater than about 9.8 ka, but no maximum age has been determined. Chemical analyses (table 2, Map Nos. C46–C49)

lk2ka **Picritic aa flow near Kilauea Avenue (Holocene or Pleistocene)**—Light- to medium-gray basalt characterized by about 42 percent olivine and 4 percent euhedral to subhedral clinopyroxene (0.5–0.7 mm long) as phenocrysts and microphenocrysts and less than 1 percent each of plagioclase and subhedral opaque microphenocrysts (0.2–0.3 mm long) in groundmass having intergranular texture. Euhedral to subhedral olivine (1.5–2.5 mm long) has cubic to irregular chrome spinel inclusions; some grains are embayed, and some have fine reaction rims and alteration along fractures; a few cumulocrysts with plagioclase (as much as 1.5 cm across) found in pahoehoe phase, fewer in aa phase. Rare plagioclase microphenocrysts. Groundmass (54 percent) consists of about 24 percent anhedral mafic minerals, 8 percent euhedral to subhedral opaque minerals, and 22 percent interstitial plagioclase.

Unit generally has yellow to yellow-orange rubble and contains minor pahoehoe phases. Generally 1 to 1.5 m thick; exposed in subdued, isolated patches over about 1.5 km² in southwest quarter of Hilo quadrangle south and east of Haihai Street. Overlain by unit lk2wh; hence, age is greater than about 9.8 ka, but no maximum age has been determined. Chemical analyses (table 2, Map Nos. C50 and C51)

lk2wa **Pahoehoe flow of Waianuenue Avenue (Pleistocene)**—Light- to medium-gray basalt usually characterized by about 3 percent olivine microphenocrysts in groundmass having hyalophitic texture; however, some samples contain as much as 6 percent olivine microphenocrysts, while others contain amounts in between. Olivine (0.04–0.08 mm long) is anhedral to skeletal, blocky, and commonly has reaction rims. Groundmass consists of 35 percent glass, 24 percent clinopyroxene, 22 percent subhedral plagioclase (An71–73), and 16 percent olivine.

Unit generally 2 to 3 m thick, but in Wailuku River channel near west boundary of Hilo quadrangle a 5-m-thick section is exposed overlying 6 m of Homelani ash (Buchanan-Banks, 1983). Covers area of about 1.0 km² south of Wailuku River and is locally overlain by thin ash about 20 cm thick. Average radiocarbon age is about 14.2 ka (table 1, Map Nos. R20–R24). Chemical analyses (table 2, Map Nos. C52–C55); paleomagnetic data (table 3, Map Nos. P31–P37)

Kahuku Basalt (Pleistocene)—Composed of medium- to dark-gray tholeiitic basalt. Consists of:

lk1mp **Pahoehoe flow of Mokupane Point**—Basalt characterized by about 2 percent olivine and 0.5 percent plagioclase, mostly as microphenocrysts in groundmass having hyalophitic to intersertal texture. Olivine (0.4–0.7 mm long) is subhedral to anhedral, blocky to lath shaped, and has reaction rims. Sparse plagioclase (An68; 0.7 mm long) is present. Groundmass consists of 45 percent glass; 21 percent mafic minerals, mostly clinopyroxene; 19 percent plagioclase, frequently exhibiting stellate form; and 12 percent interstitial olivine, commonly altered. Vesicles (37 percent) are spherical to irregularly shaped and slightly flattened; they are 1 to 2 mm across in upper few centimeters of flow, but with increasing depth, vesicles decrease in abundance and enlarge to about 1 cm across.

A 0.5-m-thick outcrop is exposed only along south bank of Wailuku River at its mouth. Believed to be overlain upslope by unit lk2wa, but no contact was observed; thus, age is older than about 14.2 ka, but no maximum age has been determined. Chemical analysis (table 2, Map No. C56); paleomagnetic data (table 3, Map No. P38)

Cones and pahoehoe flows near Halai—Age of cones and flows lk1uh is estimated to be greater than about 14.2 ka because they are overlain by Homelani ash deposits (unit ha). Divided into:

lk1hc **Spatter-and-cinder cones**—Three cones trend northeastward in northwest part of Hilo quadrangle south of Wailuku River. Eruptive products vary from partially welded spatter and spatter-fed flows near cones to dense pahoehoe flows (unit lk1hf) eastward. Chemical analysis (table 2, Map No. C57)

lk1hf **Pahoehoe flows, undifferentiated**—Spatter-fed flows range from light- to dark-gray basalt characterized by about 38 percent olivine and 6 percent plagioclase phenocrysts and microphenocrysts, and many small microphenocrysts of opaque minerals (0.08–0.2 mm across). Abundant euhedral to subhedral olivine phenocrysts, which have spinel and glass inclusions, usually show minor reaction rims. Most plagioclase (An 71; 0.3–0.5 mm long) microphenocrysts are oriented along flow direction, as are olivine laths. Some plagioclase and clinopyroxene found as cumulocrysts (1.5 mm across). Groundmass (54 percent) consists of 25 percent mafic minerals, 17 percent pyroxene, and 12 percent opaque minerals; a small amount of unaltered glass is present. Variability in olivine and plagioclase content between samples suggests that more than one flow is present. Groundmass textures vary from intergranular to hyalophitic, and devitrified glass heavily dusted with opaque minerals is locally present. Vesicles vary from few to abundant, and small-sized ones (0.3 mm across) dominate; they are spherical to stretched parallel to flow banding.

Exposures are too limited to permit mapping of individual flows. Chemical analysis (table 2, Map No. C58)

lk1wy **Younger pahoehoe flow of Waipahoehoe Stream**—Basalt characterized by about 9 percent olivine phenocrysts and about 1 percent plagioclase microphenocrysts in groundmass having hyalophitic texture. Skeletal olivine (as much as 0.6 mm across) is euhedral to subhedral and occasionally found as glomerocrysts; some cumulocrysts with plagioclase (An 65; as much as 0.4 mm long) are present. Groundmass consists of 34 percent glass; 31 percent mafic minerals, probably composed of slightly more olivine than clinopyroxene; and 25 percent plagioclase. Vesicles are rounded but are commonly not spherical.

Crops out beneath unit lk2pu and thick ash deposit in Waipahoehoe Stream at west-central edge of Hilo quadrangle; overlies unit lk1wo. Outcrop exaggerated on map. Age is 23.84±0.60 ka (table 1, Map No. R25). Chemical analysis (table 2, Map No. C59); paleomagnetic data (table 3, Map No. P39)

lk1wo **Older pahoehoe flow of Waipahoehoe Stream**—Basalt characterized by about 6 percent phenocrysts and 1 percent microphenocrysts of olivine, and 3 percent plagioclase and 1 percent clinopyroxene microphenocrysts in groundmass having hyalophitic texture. Olivine (0.4–0.6 mm across) is lath shaped and euhedral to subhedral; some grains have suggestions of skeletal structure, and some have large opaque inclusions; alteration found in fractures and along edges of grains; microphenocrysts commonly found as stellate cumulocrysts with plagioclase and pyroxene. Some plagioclase microphenocrysts (An65; 0.2 mm long) are blocky. Groundmass consists of 38 percent glass, some of which is vitric; 22 percent mafic minerals, mostly clinopyroxene; 20 percent plagioclase laths; and 9 percent olivine. Some remnant glass heavily dusted with opaque minerals. Vesicles common (33 percent); vesicle walls range from smooth to diktytaxitic.

Crops out only in Waipahoehoe Stream; size of outcrop exaggerated on map. Underlies 0.3-m-thick ash deposit and unit lk1wy; thus, age of unit is greater than 23.84 ka. Oldest Mauna Loa flow recognized within Hilo quadrangle. Chemical analysis (table 2, Map No. C60)

lk1hr **Pahoehoe flow south of Hoaka Road**—Medium-gray basalt characterized by about 11 percent olivine and less than 1 percent plagioclase (An68; as much as 0.6 mm long) phenocrysts in groundmass having hyalophitic texture. Olivine (as much as 1 mm long) is skeletal and has multiple zones of resorption or inclusions. Groundmass consists of 33 percent glass; 23 percent plagioclase, some as stellate growths with mafic minerals; 20 percent olivine; and 12 percent clinopyroxene.

Unit, oldest Mauna Loa lava flow found during mapping, crops out in Waiakea Stream, Piihonua quadrangle, where it overlies ash deposit about 0.5 m thick and older pahoehoe flow, and underlies 1-m thick ash deposit. Size of outcrop exaggerated on map. Age is 24.24±0.50 ka (table 1, Map No. R26). Chemical analysis (table 2, Map No. C61)

MAUNA KEA VOLCANO

ha **Homelani ash deposits (Pleistocene)**—Originally composed of particles of volcanic glass and crystal fragments, but severe weathering, resulting from high average annual temperatures and abundant rainfall, has altered most original constituents (Bates, 1960; Wieczorek and others, 1982). From a distance, thick outcrops of ash appear generally orangish yellow, but on closer examination, are banded in colors varying from pale-yellowish orange through very dark grayish brown. Bands range in thickness from 1 cm to about 1 m.

Unit crops out over a 10-km² area, mostly on flanks of Mauna Kea; south of Wailuku River is locally overlain by lava flows from Mauna Loa. May include ash deposits of other volcanoes. Thickest ash deposit underlies unit lk2wa and is thus older than about 14.2 ka

Hamakua Volcanics (Pleistocene)—Composed of light- to medium-gray alkalic basalt. Unit underlies Homelani ash deposits; thus, age is older than about 14.2 ka. Consists of:

khpi **Aa flow of Puu Ioane**—Basalt characterized by about 6 percent plagioclase and 1 percent olivine as phenocrysts and microphenocrysts, and 6 percent brown clinopyroxene (0.09–0.3 mm long) microphenocrysts. Euhedral to subhedral plagioclase (An62; 0.2–0.6 mm long) is commonly skeletal and blocky and contains inclusions of brown glass; some displays oscillatory zoning; microphenocrysts found as subhedral laths. Olivine commonly has reaction rims and is similar in size to plagioclase. No pyroxene phenocrysts present in thin section, but observed in hand specimen, often as cumulocrysts with plagioclase. Groundmass consists of about 39 percent plagioclase (0.03–0.05 mm long), 26 percent pyroxene, and 23 percent subhedral opaque minerals. No vesicles are present.

Unit several meters thick and characterized by bands of dark weathered rock as much as 1 cm wide that are found randomly throughout exposures; uppermost few meters severely weathered, forming saprolite. Crops out in isolated patches in northwestern part of quadrangle. Well exposed near south end of canal west of and parallel to Akolea Road, Piihonua quadrangle (Map No. C62). Locally overlain by units lk2pu or ha, and occasionally by both. Some outcrops exaggerated on map. Chemical analysis (table 2, Map No. C62)

khw6 **Aa flow unit 6 of Wailuku River**—Very dark to medium-gray, flinty basalt characterized by about 12 percent plagioclase, 3 percent olivine, and less than 1 percent opaque minerals as microphenocrysts in trachytic groundmass having granular texture. Plagioclase (An65, rimmed with An36; 0.2–0.4 mm long) displays some oscillatory zoning. Olivine (0.2–1.0 mm long) is lath shaped; in hand specimen, occasionally found as cumulocrysts with pyroxene (4–5 mm across). Groundmass (83 percent) consists of 28 percent fine-grained plagioclase laths (0.02–0.08 mm long) aligned along flow direction and set in granular matrix of 34 percent mafic minerals, probably pyroxene, and 21 percent opaque minerals (0.01–0.02 mm long).

Unit contains distinctive dark bands of weathered rock about 1 cm wide. Lies beneath Rainbow Falls overlook under units lk2rf, lk2wa, and ha; stratigraphically overlies units khu and khw5. Size of outcrop exaggerated on map. Chemical analysis (table 2, Map No. C63)

khu **Aa and pahoehoe flows from Mauna Kea Volcano, undivided**—Numerous lava flows crop out beneath 6-m thick Homelani ash deposits (unit ha); some are interbedded with numbered flow units. Flows are exposed in Wailuku River and may also be exposed in deep drainages to north where precipitous embankments and heavy vegetation precluded mapping individual flow units

khw5 **Pahoehoe flow unit 5 of Wailuku River**—Basalt characterized by less than 0.5 percent olivine and 0.5 percent plagioclase phenocrysts. Subhedral olivine (0.3–0.7 mm long) is partially altered. Plagioclase (An55, rimmed with An38; 0.7–1.5 mm long), some blocky, found as cumulocrysts with olivine. Groundmass (99 percent) consists of about 50 percent strongly zoned plagioclase (An71); 28 percent brownish pyroxene; 14 percent anhedral, blocky to rod-shaped opaque minerals; and 7 percent partially altered olivine. Some accessory apatite also present. Few rounded vesicles generally 3 to 4 mm across, but some as large as 1 cm.

Unit, about 2 m thick, is moderately weathered; locally underlies Homelani ash deposits (unit ha) and overlies unit khkg along Wailuku River. Chemical analysis (table 2, Map No. C64)

khkg **Plagioclase aa flow of Kiohoole Gulch**—Basalt characterized by about 6 percent plagioclase, 3 percent olivine, and less than 1 percent opaque minerals as microphenocrysts in groundmass having trachytic texture. Euhedral, blocky, plagioclase (An72; 0.5–6.4 mm long) displays oscillatory zoning with strong reversal on rims to more calcic composition (An35); crystal interiors are vuggy and contain inclusions of melt, opaque minerals, and other plagioclases; some found as glomerocrysts and some as cumulocrysts with olivine. Heavily altered olivine (0.5–1.5 mm long) and opaque minerals (0.2–0.7 mm long) are euhedral to subhedral. Groundmass consists of 39 percent plagioclase, 32 percent clinopyroxene, 18 percent opaque minerals, and 2 percent olivine.

In hand specimen, unit characterized by abundant plagioclase phenocrysts as much as 1 cm across and few phenocrysts of olivine and opaque minerals. Exposed at low water in bed of Wailuku River east of Rainbow Falls; underlies unit khw5. Chemical analysis (table 2, Map No. C65)

khw4 **Pahoehoe flow unit 4 of Wailuku River**—Basalt characterized by about 4 percent plagioclase, 1 to 2 percent olivine, and less than 1 percent clinopyroxene, mostly as microphenocrysts. Plagioclase laths (An54; 0.5–1.0 mm long) are blocky. Blocky, partially altered olivine and kink-banded clinopyroxene are subhedral to euhedral (0.4–1.1 mm long). Groundmass consists of about 43 percent greenish clinopyroxene, 33 percent plagioclase, 18 percent opaque minerals, and 1 percent olivine. Small amount of accessory apatite is present. Rare vesicles are subspherical.

Wailuku River cuts through unit in narrow part of channel north of Reeds Island. Unit, less than 1 m thick, is overgrown with vegetation obscuring possible overlying deposits along south bank, but ash is present above unit on north bank. Overlies unit khw3; size of outcrop is exaggerated on map, and unit is only depicted along south bank of river due to space limitations. Chemical analysis (table 2, Map No. C66)

khw3 **Pahoehoe flow unit 3 of Wailuku River**—Basalt characterized by about 5 percent plagioclase as phenocrysts and microphenocrysts, and 2 percent olivine and 0.5 percent clinopyroxene, mostly as microphenocrysts. Plagioclase laths (An57, rimmed with An32; 0.5–0.7 mm long) are blocky and some form glomerocrysts as much as 1.6 mm across. Subhedral, partially altered olivine and clinopyroxene are 0.3–0.6 mm long. Groundmass consists of about 40 percent plagioclase laths, moderately aligned; 33 percent clinopyroxene; 15 percent blocky to rod-shaped opaque minerals; and 4 percent partially altered olivine. Vesicles are subspherical.

Unit is about 1 m thick; surface altered to red powdery material about 1 to 2 cm thick probably as result of prolonged subaerial exposure before overlain by unit khw4; overlies unit khw2. Unit also exposed on north bank of Wailuku River; size of outcrop exaggerated on map. Chemical analysis (table 2, Map No. C67)

khw2 **Pahoehoe flow unit 2 of Wailuku River**—Vitric basalt characterized by about 5 percent plagioclase and 0.6 percent olivine phenocrysts, and rare microphenocrysts of olivine and opaque minerals. Plagioclase (An64, rimmed with An36; 0.8–1.5 mm long) displays weak oscillatory zoning, is blocky, and commonly forms glomerocrysts; also found as cumulocrysts with microphenocrysts of resorbed olivine, opaque minerals, and groundmass clinopyroxene. Groundmass consists of 45 percent plagioclase, moderately aligned along flow direction; 38 percent mafic minerals, mostly olivine and some clinopyroxene(?); and 11 percent opaque minerals. Vesicular apatite is accessory mineral.

Unit contains lava tubes as much as 1 m in diameter near base, but no charcoal was found; underlies unit khw3 and overlies unit khw1. Also exposed along north bank of Wailuku River; size of outcrop exaggerated on map. Chemical analysis (table 2, Map No. C68)

khw1 **Olivine-bearing to picritic pahoehoe(?) flow unit 1 of Wailuku River**—Basalt characterized by about 48 percent olivine phenocrysts and 2 percent scattered microphenocrysts of opaque minerals. Olivine (1.0–5.0 mm long) contains scattered opaque inclusions and is variably altered; commonly forms cumulocrysts with subhedral opaque minerals. Groundmass (49 percent) consists of 22 percent blocky to lath-shaped plagioclase (An57, rimmed with An36; 0.1–0.3 mm long); 20 percent mafic and 5 percent rod-shaped opaque minerals; and 2 percent blocky to anhedral olivine. Rare vesicles are rounded and range from 0.2 to 5.0 mm across.

In same hand specimen, olivine can vary between dense cluster of phenocrysts in one area to few scattered phenocrysts in another. Unit is severely weathered; underlies unit khw2 and is exposed only at low water in bed of Wailuku River and in base of stream to southwest beneath thick deposit of Homelani ash (unit ha). Size of outcrop exaggerated on map. Chemical analysis (table 2, Map No. C69)

Contact—Dashed where approximately located; dotted where concealed; dashed and dotted where interpreted from aerial photographs

Vent

Pahoehoe phase

•R1 **Radiocarbon sample locality**—Number refers to table 1

•C3 **Chemical analysis sample**—Number refers to table 2

•P6 **Paleomagnetic sample locality**—Number refers to table 3

GEOLOGIC MAP OF THE HILO 7 1/2' QUADRANGLE, ISLAND OF HAWAII

By

Jane M. Buchanan-Banks

1993

For sale by U.S. Geological Survey, Map Distribution, Box 25286, Federal Center, Denver, CO 80225