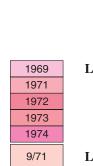
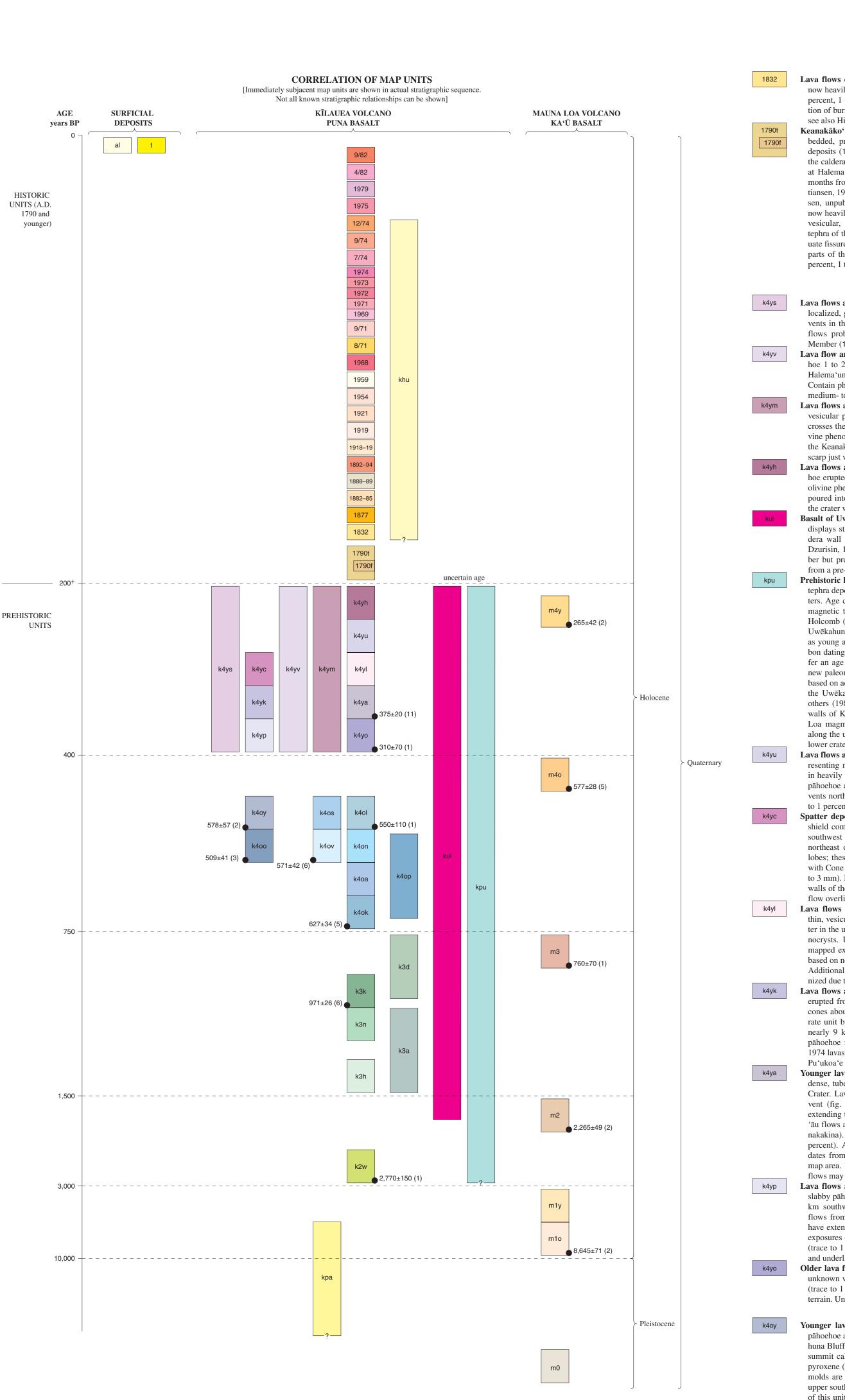


Figure 2. Enlarged map of Kilauea summit area showing extent of historic and prehistoric lava flows. Principal faults, cracks, dikes, and areas where deposits from the Keanakāko'i Ash Member of the Puna Basalt obscure underlying lava flows also shown.

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DESCRIPTION OF MAP UNITS SURFICIAL DEPOSITS

1987)

al Alluvium (Holocene)—Chiefly sand redistributed by running water; mixed with aeolian sand. Derived principally from the Keanakāko'i Ash Member of the Puna Basalt Talus (Holocene)—Angular blocks of basalt forming steep rubble aprons along the base and lower walls of Kilauea caldera, much of which formed during the surface wave magnitude (M_S) 6.6 Ka'ōiki earthquake of November 16, 1983 (Buchanan-Banks, **KĪLAUEA VOLCANO** PUNA BASALT

> **Puna Basalt (Holocene)**—All units on this map derived from Kīlauea Volcano are part of the Puna Basalt, which includes all historic and prehistoric lava flows and tephras that overlie the main Pāhala Ash. The base of the Puna Basalt is not precisely defined and may be as old as 39 ka (Beeson and others, 1996). Lavas and tephras of the Puna Basalt within this map area are tholeiitic in composition. Historic Units A.D. 1790 and younger Lava flows and spatter deposits of September 25, 1982—Black, glassy, pāhoehoe

erupted from vents near the southern caldera wall where the high stand of ponded lava produced a 2- to 3-m-high terrace. A 1.5-km-long tongue that exited the caldera and flowed south is locally slabby pāhoehoe and 'a'ā. Lava also spilled across Crater Rim Drive and into the main caldera depression. Low spatter ramparts and open fissures mantled by drainback mark the eruptive vents. Contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm) in a medium-gray groundmass (Banks and others, 1983) Lava flows and spatter deposits of April 30 to May 1, 1982—Black, glassy, shelly pāhoehoe, slabby pāhoehoe, and 'a'ā. Erupted from fissure vents surrounded by spatter ramparts 2 to 4 m high on the central caldera floor and northeast wall of Halema'uma'u Crater. Contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm) in a light- to medium-gray groundmass (Banks and others, 1983) Lava flows and spatter deposits of November 16, 1979—Black, glassy, shelly pāhoehoe, slabby pāhoehoe, and 'a'ā. Erupted from fissures west of, within, and east of Pauahi Crater. Contain scattered olivine phenocrysts (trace to 1 percent; Banks and others, 1981) Lava flows and spatter deposits of November 29, 1975—Black, glassy, shelly pāhoehoe erupted from fissure vents on the central caldera floor and small spatter cone at the base of the northeast wall of Halema'uma'u Crater. Contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm). Eruption followed a M 7.2 earthquake located on Kīlauea Volcano's south flank (Tilling and others, 1976) Lava flows and spatter deposits of December 31, 1974—Black, glassy, shelly pāhoehoe near eruptive vents; slabby pāhoehoe and 'a'ā in distal areas. Erupted from left-stepping en echelon fissure vents in the upper southwest rift zone. Contain conspicuous olivine phenocrysts (5 to 7 percent, 1 to 5 mm) in glassy matrix (Peterson and others, 1976) Historic Kīlauea lavas, undivided—Chiefly pāhoehoe from former overflows and subsidence terraces from lava lakes, now exposed in the walls of Halema'uma'u Crater. Includes lavas from eruptions as recent as September, 1974 and possibly as old as 1832. Also includes gray-black, aphyric, shelly pāhoehoe erupted from 4-mhigh, conical spatter cone 800 m southwest of Pu'ukoa'e. This lava flow covers about 500 m^2 and overlies 1790t. Lava flows and spatter deposits of September 19, 1974-Black, glassy, shelly pāhoehoe erupted from fissure vents on the floor of the summit caldera west of and within Halema'uma'u Crater. Contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm) in a medium- to dark-gray groundmass (Peterson and others, 1976) Lava flows and spatter deposits of July 19 to 22, 1974—Erupted in the summit caldera and upper east rift zone. Summit lavas are chiefly black, glassy, flat-lying, fluid

pāhoehoe, local slabby pāhoehoe, and 'a'ā fed from fissure vents on the floor of the summit caldera southeast of Halema'uma'u to just north of Keanakāko'i. Contain scattered olivine phenocrysts (trace to 1 percent, 1 to 4 mm) in a dark-gray groundmass. Upper east rift zone vents cross the south edge of Keanakāko'i Crater and continue across the Chain of Craters Road near Luamanu Crater. Lavas erupted near Luamanu Crater contain phenocrysts of olivine (3 to 5 percent, 1 to 3 mm) and plagioclase (1 to 2 percent, 2 to 3 mm; Peterson and others, 1976) Lava flows and spatter deposits of the Mauna Ulu eruption-Black, glassy pahoehoe and 'a'ā from fissure vents in the upper east rift zone and from overflows of Mauna Ulu (located just off map southeast of Pu'uhuluhulu). Most lavas contain scattered olivine phenocrysts (trace to 1 percent; Peterson and others, 1976; Swanson and others, 1979; Tilling and others, 1987)

Lava flows and spatter deposits of September 24 to 29, 1971-Black, glassy, vesicular pāhoehoe from fissure vents on the caldera floor and along the upper southwest rift zone as far as the southwest flank of Mauna Iki (fig. 1; off map to

southwest), 12 km from the summit. Contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm) in a dark-gray to black groundmass (Duffield and others, 1982) Lava flows and spatter deposits of August 14, 1971—Black, glassy, pāhoehoe erupted from fissures on the caldera floor southeast of Halema'uma'u and from fissure vents on the southeast caldera rim north of Keanakāko'i Crater. Lava flooded the eastern part of the caldera floor. Contain olivine phenocrysts (1 to 3 percent, 1 to 4 mm) in a dark-gray to black groundmass (Duffield and others, 1982) Lava flows of August 22, 1968—Black, glassy pāhoehoe pad less than 1 m thick and covering about 5,000 m² erupted from fissure vent 1 km east-northeast of Pauahi Crater; additional spatter emitted from a second fissure 0.5 km northeast of Pauahi

Crater is not shown owing to limited extent (these are vents 3 and 2, respectively, of Jackson and others, 1975). A third fissure vent just north of Pauahi Crater emitted only hot gasses. Contain scattered olivine phenocrysts (trace to 1 percent) 1959 Lava flows, spatter deposits, and reticulite of November 14 to December 20, **1959**—Black, glassy pāhoehoe in Kīlauea Iki Crater capping a solidified lava lake 135 m thick (Richter and others, 1970). Surface is generally smooth but is broken into large polygonal plates related to cooling and subsidence of the lake. Contain abundant olivine phenocrysts (15 to 20 percent). Pu'u Pua'i, a 70-m-high cinder and spatter cone on the southwest rim of Kīlauea Iki was built by fallout from lava fountains reaching 580 m in height. The vent is visible as a rubble-choked opening at the base of the southwest wall of Kilauea Iki. Continuous blanket of cinders extends southwest 4 km (Richter and others, 1970) Lava flows and spatter deposits of May 31 to June 3, 1954—Dark-gray to black

pāhoehoe erupted from fissure vents on the central Kīlauea caldera floor. Contain olivine phenocrysts (1 to 3 percent, 1 to 3 mm; Macdonald and Eaton, 1957) Halema'uma'u overflows of January to March, 1921—Light gray, dense pāhoehoe near Halema'uma'u Crater. Surface is flat to undulating, broken in places into blocky piles and patches of slabby and spiny pāhoehoe. A 2- to 4-cm-thick glass rind is locally preserved. Contain olivine phenocrysts (3 to 5 percent) in a sugary groundmass (U.S. Department of Agriculture, 1921). Surface is littered with coarse blocky debris from the 1924 eruption at Halema'uma'u

1919 Halema'uma'u overflows of March to December, 1919—Dark-gray to black, flatlying to undulating pāhoehoe north of Halema'uma'u Crater. Marked by prominent tumuli as much as 3 m high. Collapsed lava tubes and rubble-filled pits occur north and northwest of Halema'uma'u. The northern margin of this flow field is flat and has a thick glass rind. Contain olivine phenocrysts (1 to 3 percent, generally less than 1 mm) in a feldspathic groundmass. Surface near Halema'uma'u Crater is littered with coarse blocky debris from the 1924 eruption (U.S. Department of Agriculture, 1919)

1918–19 Halema'uma'u overflows of February 23 to March 3, 1918 and February 25 to April 17, 1919—Gray-brown, flat-lying pāhoehoe south of Halema'uma'u Crater. Contain olivine phenocrysts (5 to 7 percent, 1 to 5 mm) visible as white specks in surface glass. Distinguished from the 1894 flow by its darker surface and lower relief. Surface is littered with coarse, blocky debris from the 1924 eruption at Halema'uma'u (HVO Research Association, 1918; U.S. Department of Agriculture, 1919) Halema'uma'u overflows of 1892 to 1894—Gray, hummocky pāhoehoe and small patches of slabby pāhoehoe and 'a'ā east and southeast of Halema'uma'u Crater. Altered locally to whitish-yellow. Several collapse pits up to 5 m across and hollow tumuli characterize the surface. Contain phenocrysts of olivine (5 to 10 percent) and plagioclase (1 to 3 percent), commonly intergrown and visible in the surface glass, imparting a speckled appearance. Surface is littered with coarse, blocky debris from the 1924 eruption at Halema'uma'u. Overflows were recorded in April to September 1892 and February to April 1894. Other overflow events probably went unrecorded (Brigham, 1909, p. 184–191; Volcano House Register, 1891–1898)

Halema'uma'u overflows of 1888 to 1889-Orange-brown, fluid pahoehoe and 1888-89 shelly pāhoehoe with numerous small, hollow lava tubes, exposed east of Halema-'uma'u Crater. Contain scattered olivine phenocrysts (trace to 1 percent, 1 to 2 mm) in a feldspathic groundmass. Surface is littered with coarse, blocky debris from the 1924 eruption at Halema'uma'u. Overflows occurred between July 1888 and May 1889; activity was particularly vigorous on February 8, 1889 (Dana, 1890; Volcano House Register, 1885–1891) 1882-85 Halema'uma'u overflows of 1882 to 1885—Light-gray to brown-gray pāhoehoe

exposed on the central caldera floor. Generally smooth but cut by open cracks and large (4 by 20 m) elongate tumuli. Contain olivine phenocrysts (3 to 5 percent) in a feldspathic groundmass. Plagioclase phenocrysts are conspicuous in glassy samples. Surface is littered with coarse, blocky debris from the 1924 eruption at Halema'uma'u. Overflows from September 1882 to late 1885 covered most of the caldera floor. A hornito called Little Beggar formed March 3, 1884 and continued to be active for several years. It was buried during the 1954 eruption (Brigham, 1909, p. 156–158; Hitchcock, 1909, p. 221–226; Volcano House Register, 1873–1885) Spatter deposits and lava flows of 1877—Gray-brown, oxidized, vesicular spatter and remobilized spatter deposits on the east caldera wall. Deep pit 1 m across at the base of the wall may mark a vent. Contain scattered olivine phenocrysts (trace to 1 percent, 1 to 3 mm). Additional deposits on south caldera wall, at base of south wall, and on the floor of Keanakāko'i Crater (Peterson, 1967) have been largely

covered by younger lavas. Probably erupted in May of 1877 (Brigham, 1909, p. 131–132; Hitchcock, 1909, p. 217; Volcano House Register, 1873–1885)

GEOLOGIC INVESTIGATIONS SERIES I–2759

Pamphlet accompanies map

Lava flows of 1832-Thin layer of tan-gray, vesicular, pahoehoe on Byron Ledge, now heavily masked by vegetation. Contain clear, glassy olivine phenocrysts (2 to 3 percent, 1 to 5 mm). Formerly exposed on the southwest wall of Kīlauea Iki. Location of buried fissure vent approximated from sketches in Brigham (1909, p. 46-47; see also Hitchcock, 1909, p. 182–185; Macdonald and Eaton, 1957, plate 1) Keanakākoʻi Ash Member, tephra and lava flow-Complex assemblage of gray, bedded, primary and reworked phreatomagmatic and phreatic surge and fallout deposits (1790t) up to 12 m thick where exposed in the south caldera rim. Within the caldera, the deposit is overlain by coarse, blocky debris from the 1924 eruption at Halema'uma'u. Most of the Keanakāko'i Ash Member erupted over weeks or months from a source near Halema'uma'u Crater (Powers, 1948; Decker and Christiansen, 1984; McPhie and others, 1990). Approximate 1-m isopach (R.L. Christiansen, unpublished data) illustrates the general distribution of the original deposit, now heavily reworked and unevenly redistributed throughout the Ka'ū Desert. Thin, vesicular, gray-black pāhoehoe flow (1790f), 1.7 km long, is interbedded with tephra of the Keanakāko'i Ash Member south of the caldera. It erupted from an arcuate fissure marked by spatter and 3-m-high spatter cones, all obscured by the upper parts of the Keanakāko'i Ash Member. Flow contains olivine phenocrysts (1 to 3 percent, 1 to 5 mm) in an aphanitic, medium-gray groundmass Prehistoric Units

Units 200 to 400 years old Lava flows and spatter deposits of young southwest rift zone vents—Thin, highly localized, gray-brown, aphyric, vesicular pāhoehoe erupted from two, small fissure vents in the upper southwest rift zone. Grouped on the basis of appearance; these flows probably represent separate eruptions. Mantled by the Keanakāko'i Ash Member (1790t and 1790f). Overlies k4oy Lava flow and spatter deposits of outlet vent-Gray-brown 'a'ā and slabby pāhoehoe 1 to 2 m thick erupted from 1- to 3-m-high spatter rampart 2.7 km south of

Halema'uma'u Crater. Heavily mantled by the Keanakāko'i Ash Member (1790t). Contain phenocrysts of olivine (1 to 3 percent) and plagioclase (2 to 4 percent) in a medium- to dark-gray matrix. Overlie k4oy and k4oa Lava flows and spatter deposits of Kilauea Military Camp—Dark-gray to purple, vesicular pāhoehoe erupted from 250-m-long, 2- to 4-m-high spatter rampart that crosses the eastern access road to the Kīlauea Military Camp. Contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm). Heavily mantled by the Keanakāko'i Ash Member (1790t). Overlie k40y exposed in outer caldera fault scarp just west of Volcano Golf Course access road Lava flows and spatter deposits of Hi'iaka Crater-Brownish-gray shelly pahoehoe erupted from fissure vent on the north rim of Hi'iaka Crater. Contain scattered olivine phenocrysts (trace to 1 percent). In places, fluid pāhoehoe from this eruption

poured into cracks circumferential to Hi'iaka Crater; due to subsequent calving of the crater walls, this pāhoehoe is now exposed as surface-fed dikes Basalt of Uwēkahuna laccolith—Dense intrusion, lenticular in shape. Fine-grained, displays strong vertical zonation in olivine phenocryst abundance. Exposed in caldera wall beneath Uwēkahuna Bluff (Murata and Richter, 1961; Casadevall and Dzurisin, 1987a). Intrudes prehistoric lavas that overlie the Uwekahuna Ash Member but predates modern caldera collapse. Possibly originated by lateral intrusion

from a pre-caldera lava lake 0.5 to 2.0 ka Prehistoric lava flows and tephra deposits, undivided—Prehistoric lava flows and tephra deposits exposed in the caldera walls and walls of upper east rift zone pit craters. Age control is poor except for Uwekahuna Bluff section studied with paleomagnetic techniques by Doell and Cox (1965), Holcomb and others (1986), and Holcomb (1987). Casadevall and Dzurisin (1987a) conclude that lava flows in the Uwēkahuna Bluff section range in age from approximately 2.8 ka near the base to as young as 0.2 ka at the top, based on available paleomagnetic data and radiocarbon dating of possibly correlative lava flows. Hagstrum and Champion (1995) prefer an age of about 3.0 ka for the base of the Uwekahuna Bluff section based on new paleomagnetic interpretations. We infer a 0.5 ka age for the top of the section based on additional radiocarbon dating. No flows of Mauna Loa origin are known in the Uwēkahuna Bluff section (Casadevall and Dzurisin, 1987b), but Rhodes and others (1989) found flows that have chemistry similar to Mauna Loa lavas in the walls of Kilauea Iki and Pauahi Craters and suggested that they represent Mauna Loa magma processed through the Kīlauea plumbing system. At Pauahi Crater along the upper east rift zone and at Pit Craters in the Ka'ū Desert. a portion of the lower crater walls predate the Uwēkahuna Ash Member (Dzurisin and others, 1995) Lava flows and spatter deposits of the Upper East Rift Zone-Composite unit representing multiple eruptions. Undivided due to uncertain internal contact relations in heavily vegetated terrain of the upper east rift zone. Include gray to black, dense pāhoehoe and brownish-gray shelly pāhoehoe erupted from poorly exposed fissure vents north and east of Hi'iaka Crater. Contain scattered olivine phenocrysts (trace

Spatter deposits and lava flows of Cone Crater—Spatter cone atop a small lava shield composed of thin, short, shelly pāhoehoe flows and minor 'a'ā about 7 km southwest of Halema'uma'u Crater. Additional small spatter vents 650 m and 2 km northeast of Cone Crater erupted small fluid pāhoehoe flows and two thin 'a'ā lobes; these are similar in appearance and chemical composition and are grouped with Cone Crater flows. Contain scattered olivine phenocrysts (trace to 1 percent, 1 to 3 mm). Flow field from main vent is cut by two collapse pits, the Pit Craters. The walls of these craters are mantled in places by red, oxidized drainback. Cone Crater

flow overlies pāhoehoe flow of k4yk Lava flows and spatter deposits of Ko'oko'olau Crater-Gray-brown to black, thin, vesicular, glassy pāhoehoe erupted from spatter cone cut by Ko'oko'olau Crater in the upper east rift zone. Typically contains 7 to 10 percent glassy olivine phenocrysts. Unit is heavily vegetated and contacts are difficult to trace. Age and mapped extent differs from that in Holcomb (1987) and Wolfe and Morris (1996) based on new field data. Overlie k4ol and k4ya; overlain by dense pāhoehoe of k4yu. Additional outcrops southeast of its mapped extent have probably gone unrecognized due to poor exposure

Lava flows and spatter deposits of Pu'ukoa'e—Gray to black, pāhoehoe and 'a'ā erupted from Pu'ukoa'e, a 35-m-tall spatter cone and two, partially buried spatter cones about 7 km southwest of Halema'uma'u Crater. Pāhoehoe (mapped as separate unit by Walker, 1969) erupted first followed by 'a'ā. Main 'a'ā flow traveled nearly 9 km south. Lavas are chiefly aphyric. Small fissure vents and vesicular pāhoehoe flows 1.8 km northeast of Pu'ukoa'e (Walker, 1969), mostly buried by 1974 lavas, are grouped with Pu'ukoa'e lavas. Overlie 'a'ā flow of k4yp just west of

Younger lava flows of 'Aila'āu—Black, glassy, vesicular surface-fed pāhoehoe and dense, tube-fed pāhoehoe erupted from vent(s) near the east margin of Kīlauea Iki Crater. Lava flows in the map area include the youngest flows from the 'Aila'āu vent (fig. 3), the source of voluminous lava flows containing large lava tubes extending to the east coast of Kīlauea (Holcomb, 1981; 1987). The youngest 'Aila-'āu flows are well exposed along Crater Rim Drive near Thurston Lava Tube (Keanakakina). Typically contain semi-equant and acicular olivine phenocrysts (5 to 15 percent). Age estimated on the basis of superposition and multiple radiocarbon dates from beneath surface flows correlated with the 'Aila'āu shield northeast of map area. ¹⁴C ages range from <200 to 620 ± 70 (table 1). Some or all of these dated flows may actually be older than k4ya Lava flows and spatter deposits of Cone Peak—Gray-brown vesicular pāhoehoe,

slabby pāhoehoe, and 'a'ā erupted from Cone Peak, a 900-m-long spatter rampart 2 km southwest of Halema'uma'u Crater. Unit includes thin, vesicular pāhoehoe flows from fissure vents extending as much as 5 km downrift. Initial fissure may have extended uprift to the southwest margin of the caldera. Pāhoehoe is denser in exposures on caldera side of Cone Peak vent. Contain scattered olivine phenocrysts (trace to 1 percent; generally less than 1 mm) in a dark-gray matrix. Overlies k40y and underlies k4yk Older lava flows of 'Aila'āu—Black, glassy, dense tube-fed pāhoehoe erupted from unknown vent(s) in the Kīlauea summit area. Contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm). Poorly exposed in heavily vegetated

terrain. Underlie olivine-rich flows of k4ya. ¹⁴C age 310±70 (table 1) Units 400 to 750 years old Younger lava flows of the Observatory vent-Tan-gray, chiefly dense, tube-fed pāhoehoe and five prominent 'a'ā lobes erupted from unknown vent(s) near Uwēkahuna Bluff (Observatory vent of Holcomb, 1987). Flows extend southwest from the summit caldera and typically contain phenocrysts of olivine and intergrown clinopyroxene (3 to 10 percent) and conspicuous plagioclase (1 to 5 percent). Large tree molds are preserved in this flow 1 km west of the Kilauea Military Camp. In the upper southwest rift zone and southwest caldera wall, the uppermost flow (or flows) of this unit is a vesicular to dense picritic pāhoehoe (indicated by small v pattern), in places only a few cm thick, that contains olivine phenocrysts up to 7 mm across. This flow is characterized in places by strong vertical zonation in olivine abundance (scattered outcrops indicated by asterisk) and is correlative with the patches of picritic basalt mapped by Walker (1969) and the regional prehistoric pāhoehoe picrite

complex of Wright (1971). It may represent a late, olivine-rich phase from the Observatory vent (fig. 3) or a separate eruption possibly fed by a dike exposed in the southwest caldera wall (dike 5S; see fig. 14.1 in Casadevall and Dzurisin, 1987a). Contacts between the picrite and earlier, less olivine-rich flows of k4oy are obscured by the Keanakāko'i Ash Member (1790t). In a caldera-wall exposure just east of BM 3724 in unit k4yp, the picrite is overlain by olivine-rich scoria, ash, and reticulite of unknown origin. ¹⁴C ages range from 410 ± 100 to 960 ± 60 (table 1) Lava flows of Steaming Bluff—Dense, tube-fed pāhoehoe erupted from unknown vent(s) in the Kīlauea summit area. Flows extend north of the summit caldera and contain conspicuous plagioclase, olivine, and clinopyroxene phenocrysts in a crystalline groundmass. Overlie k4ov in road cuts along Highway 11. Heavily mantled by the Keanakāko'i Ash Member (1790t; see isopach on map). May be correlative

with k40

to 8 mm)

spicuous, plagioclase microlites. Overlie k40k

k4ov

k4oa

Lava flows of Luamanu—Gray to black, dense pāhoehoe and vesicular surface-fed pāhoehoe erupted from unknown vent(s) in the Kīlauea summit area. Flows extend south-southeast from the caldera. Contact relations with adjacent units are approximate due to vegetation, cover by Keanakāko'i Ash Member (1790t; see isopach on map), and indistinct lithologic contrasts. Part of Kokoolau Flows of Holcomb (1987). Flows contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm) in a light- to medium-gray, well-crystallized groundmass. May be closely related in age to k4ov and k4oo. ^{14}C age 550 ± 110 (table 1) Older lava flows of Observatory vent—Gray to black, dense, low-relief, tube-fed pāhoehoe erupted from unknown vent(s) in the Kīlauea summit area. Flows exposed only locally in summit region several km southwest of Halema'uma'u Crater as thin, vesicular, surface-fed pāhoehoe beneath k4oy. Many small patches unmappable on the western flank of the Observatory shield (fig. 3). Unit is areally extensive southwest of map area as far as the coast. Lavas are chiefly aphyric but occasionally contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm) in a light- to medium-gray feldspathic groundmass. Closely related in age to k40l and k4ov. ¹⁴C ages range from 450 ± 60 to 590 ± 100 (table 1) Lava flows of Volcano village—Dense, hummocky tube-fed pāhoehoe and small patches of rubbly 'a'ā erupted from unknown vent(s) in the Kīlauea summit area. Flows extend northeast from the summit caldera beneath Volcano village. Heavily

mantled by Keanakāko'i Ash Member (1790t; see isopach on map). Lavas are chiefly aphyric but occasionally contain scattered olivine phenocrysts (trace to 1 percent, generally less than 1 mm) in a light- to medium-gray feldspathic groundmass. Closely related in age to k400 and k40l. ¹⁴C ages range from 350±60 to $1,170\pm150$ (table 1) 'A'ā flow and spatter deposits of Keanakāko'i—'A'ā erupted from 300-m-long spatter rampart 600 m south of Keanakāko'i Crater. Weathered surface is orangegray. Contain phenocrysts of olivine (2 to 4 percent, generally less than 1 mm) and rare phenocrysts of plagioclase. Heavily mantled by the Keanakāko'i Ash Member (1790t; see isopach on map) and 1959 tephra. Overlie k40a and is overlain by k40l Lava flows and spatter deposits of Pu'uhuluhulu—Dense, tube- and surface-fed pāhoehoe and vesicular, glassy spatter erupted from Pu'uhuluhulu at the east margin

of the map. The surface of the pahoehoe is poorly exposed beneath 10 to 20 cm of

tephra from Mauna Ulu (fig. 1; lava shield off map area southeast of Pu'uhuluhulu), a few cm of the Keanakāko'i Ash Member, and 5 to 10 cm of reddish-brown lithic ash from unknown source(s). Contain glassy olivine phenocrysts (5 to 12 percent, 1 Lava flows of Ahua—Dense, hummocky tube-fed pāhoehoe erupted from unknown vent(s) in the Kīlauea summit area. Flows extend south from the summit caldera. Surface is characterized by numerous tumuli. Part of Kalue flows of Holcomb (1987). Contain scattered phenocrysts of olivine (trace to 1 percent, generally less than 1 mm) in a light- to medium-gray groundmass characterized by abundant, con-

Younger lava flows of Kālu'e—Tan-gray, tube-fed pāhoehoe with abundant tumuli and small patches of 'a'ā from unknown vent(s) in the Kīlauea summit area. Flows extend south from the caldera. Part of Kalue flows of Holcomb (1987). Contain phenocrysts of olivine (5 to 7 percent) and plagioclase (3 to 5 percent) that are often intergrown. ¹⁴C ages range from 460 ± 60 to 740 ± 100 (table 1) Units 750 to 1,500 years old

Lava flows and spatter deposits of Devil's Throat-Red, oxidized, aphyric cinder, spatter, and vesicular to dense pāhoehoe erupted from small cone exposed in roadcut along Chain of Craters Road adjacent to northwest margin of Hi'iaka Crater and 150 m southeast of Devil's Throat. Most of the pahoehoe flows originated as agglutinated spatter, which is visible on some flow surfaces. Overlain by k4ya and shelly pāhoehoe of k4yu. Age assignment is older than that of Holcomb (1980; 1981) and Wolfe and Morris (1996) based on new field data Older lava flows of Kālu'e—Gray to orange-tan, dense, tube-fed pāhoehoe and small patches of 'a'ā erupted from unknown vent(s) in the Kīlauea summit area. Flows exposed along Hilina Pali Road at the south edge of map. Part of Kalue flows of Holcomb (1987). Flows of this unit reach the coastline south of map area. Contain phenocrysts of olivine (2 to 4 percent) and minor equant plagioclase (trace to 2 per-

cent) in fine-grained groundmass. ¹⁴C ages range from 320±50 to 1150±70 (table 1)

k3n	Lava flows of Kīpukanēnē—Gray to orange-tan, hummocky, dense, tube-fed pāhoe- hoe and small patches of rubbly 'a'ā erupted from unknown vent(s) in the Kīlauea summit area. Flows extend from the south edge of the map to the coast. Part of Kipuka Nene flows of Holcomb (1987). Weathered surface nearly white where devoid of glass. Surface glass is more intact in vegetated areas. Contain olivine phe- nocrysts (3 to 5 percent) in a feldspathic groundmass. Age estimated on the basis of weathering and paleomagnetic data. Unit overlain by k3k, k4ok, k4ol
k3a	Lava flows of 'Ainahou Ranch-Dense, gray-brown, aphyric tube-fed pahoehoe
	erupted from unknown vent(s) in the Kīlauea summit areas. Located in southeast corner of map. In low-lying areas covered by prehistoric lithic ash of unknown origin up to 35 cm thick. Part of Kipuka Nene flows of Holcomb (1987). Age estimated on the basis of weathering; overlain by k4ol and tube-fed pāhoehoe of k4yu
k3h	Lava flows of hornet kīpuka—Light-gray pāhoehoe that has a distinctive knobby surface; erupted from unknown vent(s) in the Kīlauea summit area. Flows exposed in two small kīpuka along Hilina Pali Road about 2.4 km southwest of the intersection with Chain of Craters Road. Contain equant and lath-shaped olivine phenocrysts (5 to 7 percent) and scattered, finely fractured, tabular olivine as much as 1 cm across in a feldspathic groundmass. Surface glass contains visible olivine phenocrysts that display a yellowish alteration. Age estimated on the basis of outcrop weathering and paleomagnetic data; overlain by k4ol
k2w	Units 1,500 to 3,000 years old Lava flows of Wright Boad Danse tube for $p\bar{p}$ hopping erupted from unknown

Lava flows of Wright Road—Dense, tube-fed pāhoehoe erupted from unknown vent(s) in Kīlauea summit area. Flows extend northeast of the summit caldera. Contain rounded olivine phenocrysts (3 to 4 percent). Outcrops are rare owing to extensive cover of the Uwekahuna (30 to 50 cm thick) and Keanakako'i (1 to 80 cm thick) Ash Members. ¹⁴C age 2,770±150 (table 1) Pleistocene and Holocene

Pāhala Ash—The Pāhala Ash is a general term that has been used for thick sequences of deeply weathered yellow, yellow-orange, and reddish ash over large parts of the Island of Hawai'i. Consists of lithic and vitric fallout and possibly surge deposits which are widely reworked by water and wind. The Pāhala Ash is often divided into the Main Pāhala Ash, which overlies lava flows and tephras of the Hilina Basalt (age greater than 39 ka; Beeson and others, 1996), and the Upper Pāhala Ash, which is intercalated with lava flows of the Puna Basalt as young as 3 to 5 ka (Easton, 1987). Within the map area the Pāhala Ash is exposed in kīpuka on the surface of Mauna Loa where it is as much as 4 m thick. It consists of multiple pyroclastic units from explosive eruptions from the late Pleistocene to middle or late Holocene. The source of the Pāhala Ash is most likely Kīlauea Volcano (Easton, 1987; Beeson and others, 1996)

MAUNA LOA VOLCANO Ka'ū Basalt (Holocene and Pleistocene)—Within the map area, all lava flows derived from Mauna Loa Volcano are part of the Ka'ū Basalt, which includes all historic lava flows and tephras as well as prehistoric lava flows and tephras that overlie the main Pāhala Ash. The base of the Ka'ū Basalt is at least 31 ka (Wolfe and Morris, 1996) and perhaps as old as 39 ka (Beeson and others, 1996). Lavas and tephras of the Ka'ū Basalt within this map area are tholeiitic in composition Prehistoric Holocene Units Units 200 to 400 years old

Younger Keamoku lava flows of Kīpukakī—Dark brown to tan, dense, massive 'a'ā flow enclosing Kīpukakī. Erupted from a fissure vent trending obliquely across Pu'ukūlua, 15 km northwest of the map area on Mauna Loa's northeast rift zone at 9,000' elevation. Contain trace amounts of clear olivine phenocrysts (less than 1 percent, as large as 4 mm) and anhedra of plagioclase (generally less than 1 mm). Overlain by discontinuous, thin, accretionary lapilli-rich beds of the Keanakāko'i Ash Member of the Puna Basalt (1790t). This is the youngest of several separate 'a'ā flows labeled the Keamoku Flows on previous maps and was termed the lobe of Kipuka Kekake by Peterson (1967). The flow traveled southeast down Mauna Loa's flank until reaching the Kīlauea shield, where it was deflected westward along the Kīlauea-Mauna Loa boundary. 14 C ages range from 230±60 to 300±60 (table 1) Units 400 to 750 years old

Older Keamoku lava flows of Kīpukapuaulu—Gray-brown to tan pāhoehoe and 'a'ā, this unit is the most widespread of the Keamoku flows. It directly underlies m4y and surrounds Kīpukapuaulu. Erupted from a fissure system that cuts Pu'u'ula-'ula along the northeast rift zone about 13 km northwest of the map area. Contain conspicuous anhedral laths and aggregates of plagioclase (5 to 10 percent, laths generally less than 1 mm, aggregates as large as 2 mm across) and anhedral, sugary phenocrysts of olivine (2 to 6 percent, as much as 1.5 mm across). 'A'ā of this unit was mapped as one of the lower lobes of the Keamoku lava flows by Peterson (1967). The bulk of the unit consists of pāhoehoe emplaced as fast-moving, highly fluid lava after most of the 'a'ā was emplaced. This pāhoehoe ponded in the saddle between Mauna Loa and the Kīlauea shield and is characterized by pseudo-karst pits caused by lateral drainage and crustal subsidence. Large tree molds and casts occur in several places north of the map area. ¹⁴C ages range from 330±60 to 830±60 (table 1)

Units 750 to 1,500 years old Lava flows of Keauhou Ranch—Dark gray, glassy (where undisturbed) tube-fed pāhoehoe erupted from unknown, possibly-buried vents along the northeast rift zone. Unit is exposed in several grass-covered kipuka along the north margin of the map area. Contain inconspicuous, sugary, anhedral olivine phenocrysts (4 to 10 percent, as much as 3 mm across) and subhedral plagioclase phenocrysts (2 to 8 percent, generally less than 1 mm). Surface outcrops are similar to those of the overlying pāhoehoe of the Keamoku lava flow of Kīpukapuaulu, but they can be distinguished by more dense grass cover and also by a speckled surface caused by weathered olivine phenocrysts. ^{14}C age 760±70 (table 1) Units 1,500 to 3,000 years old

'A'ā flows of eastern Ka'ōiki Pali—Distinctive, dense, flinty 'a'ā lobes that drape the Ka'ōiki faults at the north-central edge of the map area (fig. 1). Erupted from unknown, now-buried vents along the northeast rift zone. Contain conspicuous anhedral plagioclase phenocrysts (3 percent, as much as 0.5 mm across). Unit is mantled by thin, discontinuous deposits of the Keanakāko'i Ash Member (1790t) and the upper Uwekahuna Ash Member of the Puna Basalt, which support dense grass. Typical exposures consist of isolated blocks of 'a'ā projecting above grasscovered areas; well-exposed in a small quarry where the Pu'u 'O'ō Trail crosses the Ka'ōiki faults. ¹⁴C ages range from $2,190\pm70$ to $2,340\pm70$ (table 1) Units 3,000 to 10,000 years old

'A'ā flow west of Kīpukakī—Distinctive 'a'ā west of Kīpukakī. Erupted from unknown, now-buried vents along the northeast rift zone. Contains clear, euhedral olivine phenocrysts (6 to 8 percent, as much as 6 mm across) and subhedral plagioclase phenocrysts (3 to 5 percent, generally less than 1 mm) in a dense, mediumgray matrix. The flow is as much as 9 m thick and forms bold, brush-covered outcrops above adjoining grass-covered older flows. Unit is mantled by discontinuous deposits of the Uwēkahuna Ash Member of the Puna Basalt, but overlies the Pāhala Ash. Its age is estimated by outcrop weathering at 4,000 to 5,000 years

Lava flows of Pu'u'ula'ula—Deeply weathered pāhoehoe along the northwest boundary of the map area. On the basis of chemical and paleomagnetic data, the likely source of this flow is Pu'u'ula'ula, about 13 km northwest of the map area at 10,000' elevation on the northeast rift zone. Typically aphyric but contains scattered, inconspicuous, anhedral, olivine phenocrysts (1 to 2 percent, generally 1 mm across). Unit is buried by as much as 2 m of the Uwekahuna Ash Member of the Puna Basalt and upper units of the Pāhala Ash in the map area, and it is exposed only in deep gullies, where it overlies thick older units of the Pāhala Ash. The sizes of ash-free exposures have been exaggerated on the map. At higher elevations this flow has an orange-weathered surface. ¹⁴C ages range from 8,550±100 to 8,740±100 (table 1)

Pleistocene Unit 'A'ā flow northeast of Volcano Golf Course—Distinctive, plagioclase-rich 'a'ā at the north edge of the map. Erupted from unknown vents on the northeast rift zone. Generally covered by as much as 2.5 m of the Uwēkahuna Ash Member of the Puna Basalt and the upper part of the Pāhala Ash. Where artificially exposed, the surface is deeply weathered to orange clay around 'a'ā clasts and along fractures. Fresh rock contains subhedral plagioclase phenocrysts (15 to 18 percent, as much as 5 mm in length) and clear, euhedral olivine phenocrysts (5 to12 percent, as much as 8 mm across). Its age is unknown but almost certainly is pre-Holocene

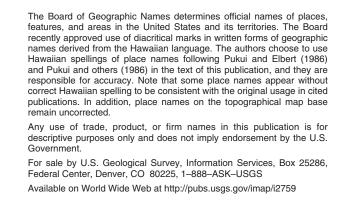
'A'ā lava flow Cinder or spatter cone

Picrite—Picritic lava flow of unit k4oy. Scattered outcrops of picrite indicated by asterisk (*). Correlative with lkp of Walker (1969) Uwēkahuna Ash—Shown where greater than approximately 30 cm in thickness. Deposits are typically yellow-brown in contrast to the gray Keanakāko'i and yellow-orange Pāhala Ash Pāhala Ash—Shown where greater than approximately 1.5 m in thickness

Dikes—Located in walls of Kīlauea and Kīlauea Iki Craters. Bars represent approximate location and strike; solid circles denote variable or unknown orientation. Size exaggerated for clarity. From Casadevall and Dzurisin (1987a) - Contact—Dashed where approximately located; dotted where concealed; queried where inferred and highly uncertain. Internal contacts distinguish 'a'ā or cinder or spatter cones of same map unit **• Fault**—Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side Crack or non-eruptive fissure

- 1959 Kilauea Iki isopachs-Isopachs represent thickness, in cm, of tephra-fall deposits. Outer isopach represents approximate limit of continuous cover. Dotted where concealed. Adapted from Richter and others (1970) and new field data - Keanakāko'i Ash Member isopach—Isopach shows 1-meter thickness. Dotted where _____ concealed. From R.L. Christiansen, unpublished data **Fissure vent**—Shows limits of spatter rampart where mappable. Dotted where con-Crater—Hachures shown inward facing. Not shown on caldera walls and some small craters for clarity. Dotted where concealed o/y Age relations—Shows older (o) and younger (y) age relations between units. Indicated where contact is well exposed and age relations are certain

▲ W4367 Radiocarbon sample locality—Shows Lab Number and ¹⁴C age in years BP (table 1)



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