DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

GENERAL DESCRIPTION

The Mauna Loa quadrangle contains the summit of Mauna Loa Volcano (13,677 feet altitude) and its caldera, Mokuaweoweo. Extending south-southwestward from the caldera is the upper end of the southwest rift zone of the volcano, along which lie three pit craters: South Pit, Lua Hohonu, and Lua Hou. At its northern end the caldera coalesces with another pit crater, North Pit, and just beyond is the upper end of the northeast rift zone. Lua Poholo, east of the junction between North Pit and the caldera proper, is a pit crater formed by collapse, probably sometime in the period 1874–1885. East Bay, an indentation in the eastern side of the caldera 1.5 miles south of the northern edge of the quadrangle, also is a pit crater, probably formed since 1885. The cliffs bounding the caldera are slightly eroded fault scarps; the one on the western side is 600 feet high at the highest point, but that on the east is only about 200 feet high. A line of fault scarps from less than a foot to 15 feet high extends southward from the eastern edge of North Pit and marks the eastern limit of slight subsidence of the mountain top.

In 1841, when the summit of Mauna Loa was mapped by members of the United States Exploring Expedition under Lt. Charles Wilkes, U.S.N., Mokuaweoweo contained a nearly circular central pit with its floor approximately 785 feet below the high point of the mountain. North and south of the central pit were crescentic platforms about 100 and 200 feet respectively above the central floor. The edges of these "lunate platforms" are indicated by the concealed (dotted) faults on the map. The floor of North Pit was a little higher than the surface of the northern platform. Repeated eruptions gradually filled the central pit, and in 1914 lava overflowed from the central area onto the north lunate platform. In 1940 lava spread northward through the gap at the northern end of the caldera and completely buried the floor of North Pit. In 1933 and 1940 lava from vents near the center of the caldera spread over most of the south lunate platform, and the platform was completely buried in 1949, although the veneered fault scarp is still clearly discernible at its western end. During the 1949 eruption, lava poured southward through the gap into South Pit, filling it to the level of its southern rim, where it overflowed and continued flowing 6 miles down the mountainside.

During the 1940 and 1949 eruptions lava from vents southwest of the caldera cascaded into South Pit, Lua Hohonu, and Lua Hou. The representation of the cascades on the map is diagrammatic. The actual remnants of the cascades on the crater walls are very thin and discontinuous.

A rift zone extends uninterrupted across the caldera floor. The continuity has been shown by the eruptive fissures of all the recent eruptions within the caldera, though only that of 1949 remains unburied by later flows. All but one of the historic, and nearly all the late prehistoric, lava flows on the flanks of the mountain originated at vents on the rift zones outside the caldera. Only one flow, that of 1949 in the southwestern part of the map, spilled out of the caldera. Other flows originating in the caldera have been confined within it. The portions of the 1933, 1940, and 1942 flows outside the caldera came from vents beyond the caldera boundary, as did the western flow of 1949. However, some of the late prehistoric (lp) flows and apparently all of the earlier prehistoric (pc and lpc) flows on the flanks of the volcano within the boundaries of the quadrangle came from vents within the area of the present caldera before sinking of the mountaintop formed the caldera, or before the collapse was nearly as extensive as it is now. Mokuaweoweo thus appears to be a very young feature in the history of Mauna Loa.

All of the rocks in the Mauna Loa quadrangle belong to the Kau Volcanic Series (Stearns and Macdonald, 1946). All are members of the tholeiitic series (Macdonald, 1968, p. 480–482). Most contain a few phenocrysts of olivine, but a few are olivine free. A few of the prehistoric lavas contain more than 30 percent olivine phenocrysts as much as 8 mm long, but these picritic basalts (oceanites) are rarer within the quadrangle than they are on the lower slopes of the mountain. Phenocrysts of plagioclase up to 1 mm long are present in many lavas. Hypersthene and augite phenocrysts are rare and seldom longer than 1.5 mm. The matrix is medium to dark gray and consists of microscopic crystals of plagioclase, pyroxene, olivine, magnetite, and ilmenite, with varying amounts of glass.

Both pahoehoe and aa types of flows are present. Pahoehoe lava is typified by a smooth or billowy surface, locally wrinkled or "ropy." Vesicles are abundant and generally quite regular in shape. Pahoehoe is much more common near the summit, but many flows change from pahoehoe to aa downslope, and aa is almost as abundant as pahoehoe in the southeastern part of the quadrangle. In the summit region several historic pahoehoe flows have a surficial coating of pale brown or golden brown pumice, formed by frothing of the surface of the flow. At some places pahoehoe crust has been fractured into plates from a few inches to several feet across, and the plates have been tilted up, jumbled, or imbricated, to form slab pahoehoe. Near the vents, especially along the southwest rift zone, some pahoehoe flows were very rich in gas and formed many empty tubes and blisters, a few inches to a few feet across covered only by a shell half an inch to two inches thick. This shelly pahoehoe is treacherous to walk upon.

Aa flows have rough surfaces largely covered with fragments of jagged, spinose clinker; these flows have a massive central part containing sparse to moderately abundant vesicles that are usually very irregular in shape. The massive portion is usually underlain by a bottom layer of clinker. The central and bottom portions of flows are exposed at very few places except in the walls of the caldera and pit craters. The types of lava flows are described in greater detail in Stearns and Macdonald (1946), Macdonald (1953), Wentworth and Macdonald (1953), and Macdonald (1967).

In the summit region flows on the flanks of the volcano range from less than a foot to about 30 feet thick and average about 10 feet. Downslope, in the southeastern part of the quadrangle, they are thicker, averaging about 15 feet. Within the caldera the most voluminous flows have ponded to thicknesses of 50 feet or more.

Fountaining at vents of lava flows has built spatter cones or coalescing rows of small cones, known as spatter ramparts. The largest is the spatter cone of 1940, about 170 feet high. Most eruptions produce only a small amount of fragmental pumice, but occasionally eruptions of unusually gas-rich magma form large amounts of pumice. The pumice fragments may be drifted several miles by the wind or may accumulate near the vent as a blanket mantling both the contemporaneous and older lavas. Cinder forms only a small portion of the pyroclastic material, but the main cone of the 1949 eruption, on the caldera rim, consists mostly of cinder and pumice. In comparison, other cones built on the caldera floor by the same eruption are spatter cones, and one is a lava cone formed by repeated small overflows of pahoehoe lava.

Phreatic explosion debris, consisting of angular blocks of rock up to 4 feet across with associated sand and angular gravel, mantles prehistoric lavas on the eastern and northwestern rims of the caldera. This material was thrown out by low-temperature explosions caused by ground water coming in contact with hot rock or rising magma. The site of the explosions was within the caldera. No magmatic material is associated with the phreatic debris, and the blocks show no signs of reheating. Some of the lavas mantled by the debris are quite fresh in appearance and are among the last lavas erupted before the collapse of the caldera.

Two small patches of phreatic explosion debris along the Ainapo Trail 1.8 miles southeast of the caldera rest on reddened weathered pahoehoe that appears considerably older than the lavas at the caldera rim. The debris passes beneath lavas that, on the basis of the degree of weathering, are older than the lavas beneath phreatic debris at the caldera rim. Thus there were at least two different periods of phreatic explosion at the summit of Mauna Loa.

Most of the historic lava flows shown on the map are known from contemporary records. The flows labeled 1877(?) and 1880(?) are somewhat uncertain. In 1877 an eruption in Kealakekua Bay, on the west shore of Mauna Loa, was reported to have been preceded by a brief outbreak on the west flank near the summit. The only flows on the entire upper west flank that appear young enough to have been formed in 1877 are those indicated on the map. In May 1880 an eruption took place in South Pit. In November 1880 another eruption occurred at about 10,500 feet on the northeast rift zone, and this also was reported to have been immediately preceded (as is usually the case) by a brief outbreak in and near the caldera. The 1880 lava on the floors of the caldera and South Pit has long since been buried by later flows. However, the eastern rim of South Pit is veneered with a layer of pyroclastic pumice and pumiceous cow-dung bombs up to a foot across probably formed by the big lava fountain in South Pit in May 1880. At the northeastern edge of the caldera, on the main boundary cliff and on the ledge between the cliff and the outermost fault scarps, is a very recent pahoehoe lava flow with a shiny partly pumiceous surface. A spatter rampart lies along the source fissure on the ledge, and two spatter cones are perched on the cliff. The flow spilled into Lua Poholo, leaving a high-lava mark 20 feet above the present surface on the outermost fault scarp just east of the crater. Since Lua Poholo is not shown on the Hawaiian Government map made by J. M. Lydgate in 1874, both the crater and the lava flow probably were formed after that date. The map of Mokuaweoweo made by J. M. Alexander in 1885 shows both Lua Poholo and a lava cascade on the adjacent caldera wall. On this basis it is believed that the lava flow was formed in or about 1880.

The succession of prehistoric lavas is determined partly by superposition, and partly by the degree of weathering of the flow surfaces. The latter criterion is good only in a broad way. Weathering produces a change of color of the surface from black or golden brown to brown, reddish brown, or yellowish brown. It also destroys the fine details of the original surface, principally by flaking away of a thin crust, 0.05 to 0.5 inch thick, that forms on most pahoehoe flows. The oldest flows are reddish brown, brownish orange, or red, and the original surface is completely gone, although the grosser surface features such as hummocks, toes, and ropy ridges are still clearly discernible. Where one flow is much more weathered than a nearby one with a similar original surface, it is safe to conclude that the more weathered one is considerably older. However, the rate of weathering depends greatly on the original texture, the glass content, and the thickness of the original surface crust. One can find black, fresh-appearing lava and reddish-brown, old-looking lava within a few tens of feet of each other on the surface of what is clearly the same pahoehoe flow. Small differences in color cannot be relied on to establish the succession of flows. Preservation of fine details of the original surface appears to be a somewhat better guide than color, but also is variable within short distances. In general, flows mapped as late prehistoric are very fresh in appearance, with well preserved surfaces; the flows mapped as early prehistoric (pc) are brown, reddish brown, red, or yellowish brown, and the original surfaces of pahoehoe units have been mostly destroyed. Other flows, with better preserved surfaces, are mapped separately (lpc). At many places this succession is confirmed by superposition.

Faults.—The fault scarps bordering the caldera slope inward at an average angle of about 60°. Nowhere, however, are the actual fault surfaces preserved. The scarps have receded an unknown amount, owing to rock falls and occasional slides. During earthquakes, which are frequent during eruptions, many rocks can be heard and seen falling down the caldera walls. The scarps therefore are not a true indication of the steepness, or even the direction of dip, of the actual faults, which may be vertical or even dip outward. It appears safe to assume that they are close to vertical, and the main faults have so been shown in the cross section.

Cracks.—Along the rift zones open cracks are numerous, though only a few are found within the area of the map. The cracks seldom show any fault displacement, the movement instead being a simple dilation normal to the crack surface. Many cracks lie along the zone of outlying faults east of the caldera. Deformation of the surface appears to have begun as a series of monoclinal flexures, which eventually ruptured and became faults. Some of the fault scarps can be traced into monoclines where the displacement decreases at the ends of the breaks; at many places the displacement is partly by faulting and partly by flexure. Most of the associated cracks were formed by stretching of the crests of the monoclines.

Intrusive rocks.—A few dikes and sills are exposed in the walls of Mokuaweoweo Caldera and Lua Poholo. The dikes range from less than a foot to about 4 feet thick. Most of them are essentially vertical. Sills range in thickness up to about 40 feet. They are lenticular and swell and pinch irregularly. Most can be followed with certainty for only a few hundred feet, but in the eastern wall of the caldera one sill is exposed for more than half a mile. Locally many sills cut across the enclosing lava beds. A thick, partly cross-cutting sill, overlain by a conspicuous reddened zone of pneumatolytic alteration, is exposed in the upper middle part of the western wall of the caldera. An irregular dike can be seen to connect with a lenticular sill in the northwestern wall.

DESCRIPTION OF MAP UNITS

Products of 1950 eruption.—The most recent eruption of Mauna Loa, in June 1950, produced a series of lava flows from fissure vents on the southwest rift zone. Spatter ramparts along the northernmost part of the fissures and part of the associated lava flow are shown in the southwestern corner of the map. The lava is mostly pahoehoe near the vents, changing to aa downslope. It contains very few small phenocrysts of olivine, although lavas erupted from vents at lower altitudes a few hours later contain up to about 10 percent olivine phenocrysts (Finch and Macdonald, 1953).

Products of 1949 eruption.—The 1949 eruption took place from a series of fissures that crossed the floor and southwestern wall of the caldera and continued down the southwestern flank of the mountain. Spatter cones and ramparts up to 20 feet high were built along the fissures. Where fountaining persisted for several weeks, a double spatter cone 80 feet high was built on the caldera floor, and a cone of cinder, spatter, and pumice was built against the wall and on the rim of the caldera. Wind-transported pumice formed a mantle several feet thick west of the cone. Repeated small overflows of pahoehoe formed a lava cone 115 feet high with slopes averaging about 35°. The eruptive fissure split the 1940 spatter cone and veneered it with new spatter and thin rootless flows formed by coalescence of copious showers of spatter. Lava flows on the caldera floor and the part of the southwestern flow within the map area are almost entirely pahoehoe. Lava that cascaded into South Pit is partly aa. The head of the flow extending southward out of South Pit is pahoehoe, but its distal part is aa. Dendritic (arborescent) lava is exposed along cracks in the flow surface just south of South Pit. The lava is basalt containing about 3 percent of small phenocrysts of olivine (Macdonald and Orr, 1950).

Products of 1942 eruption.—An eruption fissure opened in the northwestern wall of the caldera and the southwestern wall of North Pit and at the upper end of the northeast rift zone. Pahoehoe lava formed cascades on the walls of the caldera and North Pit and buried the northwestern part of the caldera floor and most of North Pit. Other pahoehoe flows spread from the rift zone fissures. The surface of the flow in the caldera is undulating and in places pumiceous. Spatter ramparts were built on the rift zone, but only small amounts of spatter accumulated along the fissures on the caldera wall. The lava is tholeiitic basalt, with only a few small phenocrysts of olivine (Macdonald, 1943, 1954).

Products of 1940 eruption.—Spatter ramparts were built along fissures that extended for 3 miles across the caldera floor and wall on the southwestern flank of the mountain. After a few hours activity became restricted to a short length of fissure on the southwestern part of the caldera floor, where it continued for more than 2 months. Here, large lava fountains built a spatter cone 170 feet high, burying the remains of the cones of the 1914 and 1933 eruptions. Pahoehoe lava spread over the caldera floor and through the gap into North Pit. In late phases of the eruption, pressure ridges as much as 35 feet high formed on the flow surface near the north edge of the caldera. Intrusion of lava beneath the surface of the new flow raised the surface as much as 40 feet near the northern edge of the caldera, creating a "pressure plateau" that decreased in height northward into North Pit. The eastern edge of the pressure plateau in North Pit is a fault scarp that passes into a monocline. Flows along the southwest rift zone are shelly pahoehoe near the vents, but some change into aa downslope. The lava is hypersthene-bearing basalt with scattered small phenocrysts of olivine (Schulz, 1943; Macdonald, 1954).

Products of 1935 eruption.—Spatter cones and pahoehoe lava flows cover part of the northeast rift zone just northeast of North Pit. Much of the flow surface near the vents is pumiceous. Downslope beyond the limits of the map, the flows change to aa. The lava is basalt with only a few small scattered phenocrysts of olivine (Waesche, 1939).

Products of 1933 eruption.—The main spatter cone, on the southwestern floor of the caldera, has been wholly buried by later eruptive products, as has most of the 1933 lava in the caldera and along the southwest rift zone. A small patch of shelly pahoehoe remains unburied just south of South Pit, and an area of massive pahoehoe can be seen near the center of the caldera. At the northeastern edge of the caldera floor a patch of pahoehoe is cut by a fissure along which there is a small amount of spatter. This fissure is not one of the main eruption fissures, which trended southwestward across the center of the caldera in the vicinity of the 1940 and 1949 fissures. It appears, instead, to lie above one of the buried caldera-boundary faults. The surface of the lava at the fissure is continuous with the flow surface that forms the floor of East Bay. The lava is basalt poor in olivine (Jaggar, 1936).

Products of 1926 eruption.—Lava flows along the southwest rift zone are pahoehoe near the vents, changing to aa downslope. Spatter ramparts were built along the vent fissures, but within the map area all but one of the 1926 vents have been buried by the lava of 1950. The 1926 lava is basalt with sparse to moderately abundant phenocrysts of olivine.

Products of November 1880(?) eruption.—Fresh pahoehoe, with a brown pumiceous surface, and associated spatter cones and ramparts are found on the northeastern rim of Mokuaweoweo, mantling the caldera wall, and in the bottom of Lua Poholo. The lava is basalt nearly devoid of olivine.

Pumice mantle of May 1880(?) eruption.—The thin layer of pumice and pumiceous cow-dung bombs on the eastern rim of South Pit was probably formed by a high lava fountain in South Pit in May 1880 (Brigham, 1909).

Products of 1877(?) eruption.—Black pahoehoe, with a somewhat weathered surface, and associated spatter ramparts can be seen on the upper western flank of Mauna Loa. The lava is basalt containing very little olivine.

Products of 1851 eruption.—Black, somewhat weathered pahoehoe, containing very little olivine, and associated spatter ramparts occur along the southwest rift zone. The 1851 lava is extensively exposed farther west, but within the Mauna Loa quadrangle it is largely buried by later flows.

Talus.—Several small cones of angular lava blocks rest against the lower part of the caldera walls; only the larger accumulations are shown on the map. In Lua Poholo a mass of talus was covered by a sheet of lava, and the entire mass was tilted eastward during renewed subsidence of the crater floor before the lava of 1880(?) poured into the crater (Stearns and Macdonald, 1946).

Late prehistoric volcanic rocks.—Lava flows (lp), predominantly pahoehoe but including some aa, and associated spatter cones and ramparts, of very recent appearance but not correlated with historic eruptions represent late prehistoric volcanic products. Undoubtedly, some flows which erupted during the historic period are included; the tilted lava slab overlying talus in Lua Poholo probably was formed between 1874 and November 1880. The lavas are basalts, containing sparse to moderately abundant phenocrysts of olivine.

Phreatic explosion debris.—Angular fragments of basaltic lava flows and intrusive bodies ranging in size from blocks 4 feet across to dust, have been thrown out by steam explosions within Mokuaweoweo. The resulting deposits locally occur near the east and west margins of Mokuaweoweo. Many of the blocks are gray, dense, and aphanitic; others are brownish gray, brown, and red, some dense and some vesicular. The deposits are too thin to completely mask the underlying flows.

Older prehistoric volcanic rocks.—Lava flows (pc), predominantly pahoehoe but including some aa, and associated spatter ramparts, dikes, and sills are the most widely exposed rocks in this quadrangle. Flow surfaces are brownish and reddish, and the original surface details are largely destroyed. Some aa flows (pca) can be mapped for several miles as separate units, but upslope they change to pahoehoe and none has been traced to the vents from which the lava issued. Flows with surfaces better preserved than most, yet more weathered than the late prehistoric flows, have been mapped separately (lpc). Most of the lavas are basalt, with sparse to moderately abundant olivine, but in the caldera walls are a few flows of picritic basalt (oceanite) containing as much as 40 percent olivine phenocrysts.

Area of fuming and sulfur deposition.—An area about 300 feet long near the center of Mokuaweoweo Caldera has been fuming persistently since 1940 and probably since 1885. The fume, largely steam but containing readily detectable amounts of sulfur dioxide, issues from cracks in the surface of the 1940 lava flow. Small amounts of sulfur and gypsum have been deposited along the cracks and in vesicles, small tubes, and blisters in the adjacent lava. Some fume commonly issues also from the vents of the spatter cones of 1949, and less commonly in the crater of the 1940 cone. The base of the western wall of Mokuaweoweo shows extensive yellowish discoloration due to fumarolic alteration, but no fume can now be detected there.

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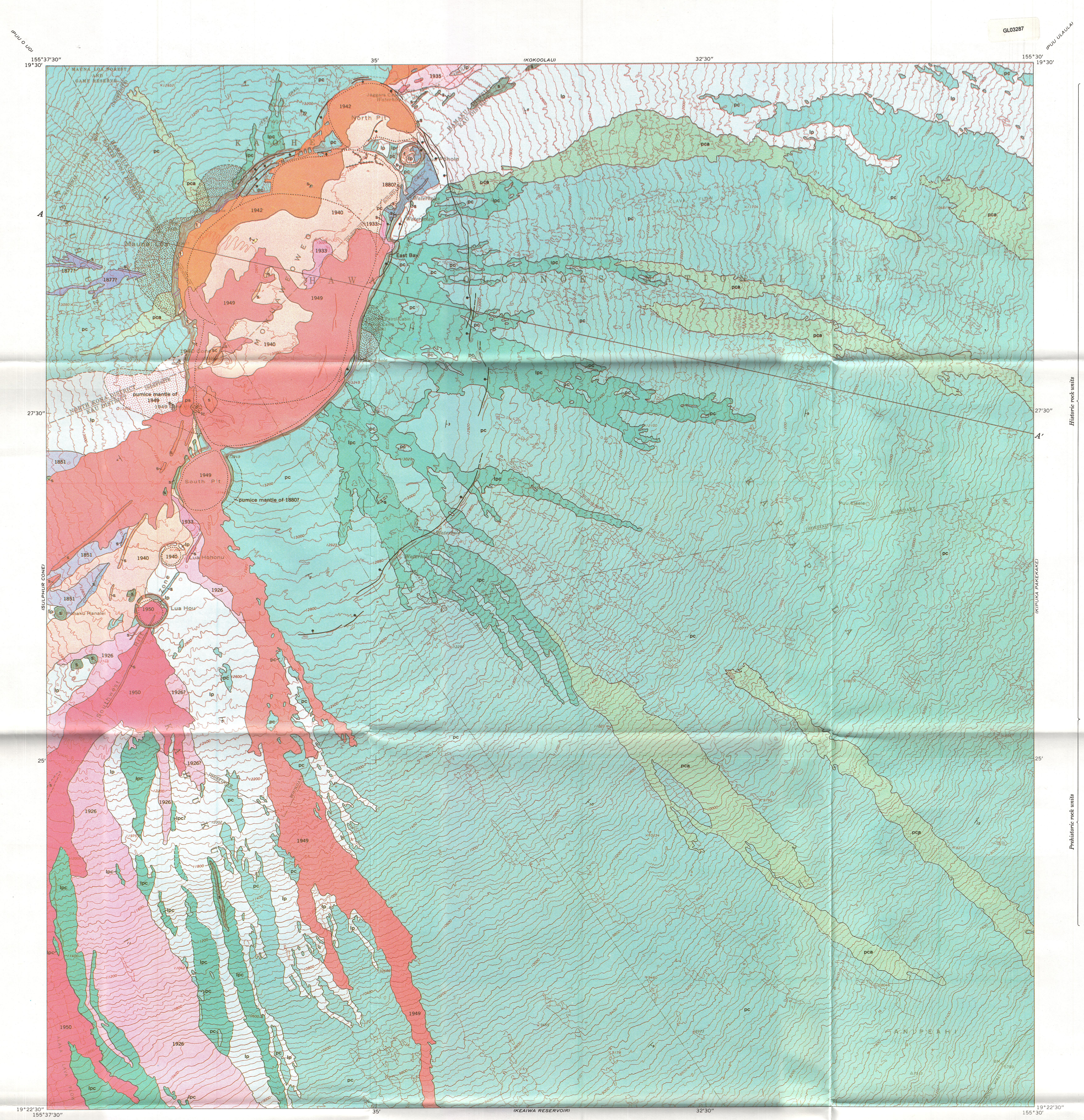


GEOLOGIC QUADRANGLE MAP
MAUNA LOA QUADRANGLE, HAWAII
GQ–897

EXPLANATION

Kau Volcanic Series — QUATERNARY

Historic rock units

1950 s

Products of 1950 eruption
Lighter shade shows lava flows, darker shade (s) shows spatter cones and ramparts along eruption fissures

1949 ps s lc

Products of 1949 eruption
Lighter shade shows lava flows, darker shade (s) shows spatter cones and ramparts along eruption fissures, fine stippling (ps) shows pumice and cinder cone, coarse stippling shows pumice mantle on 1949 and older flows. Cone pattern (lc) shows lava cone

1942 s

Products of 1942 eruption
Lighter shade shows lava flows, the darker lines (s) show spatter ramparts along the eruption fissures

r s 1940 sc

Products of 1940 eruption
Lighter shade shows lava flows, darker shade (s) shows spatter cones and ramparts along eruption fissures; the main cone (sc) is partly mantled with spatter and rootless flows formed in 1949. Crosshatched line (r) shows pressure ridge

1935 s

Products of 1935 eruption
Lighter shade shows lava flows, darker shade (s) shows spatter cones along eruption fissure

1933 s

Products of 1933 eruption
Lighter shade shows lava flows, darker line (s) shows a fissure with minor amounts of spatter near the northeastern edge of the caldera (not the main eruption fissure)

1926 s

Products of 1926 eruption
Lighter shade shows lava flows, darker shade (s) shows a spatter rampart along the eruption fissure

1880? s

Products of November 1880(?) eruption
Lighter shade shows lava flows, darker shade (s) shows a spatter rampart and spatter cones along the eruption fissures

Pumice mantle of May 1880(?) eruption

1877? s

Products of 1877(?) eruption
Lighter shade shows lava flows, darker shade (s) shows spatter ramparts along the eruption fissures

1851 s

Products of 1851 eruption
Lighter shade shows lava flows, darker shade (s) shows spatter ramparts along the eruption fissures

t

Talus
Partly historic and partly prehistoric

Prehistoric rock units

lp s

Late prehistoric volcanic rocks
Lava flows (lp), and spatter cones and ramparts along eruption fissures (s); probably includes some unidentified volcanics of historic age

Phreatic explosion debris

pca lpc pc s

Older prehistoric volcanic rocks
Lava flows (pc), and spatter cones (s) at vents. Mappable aa flows (pca) of about the same age as associated pahoehoe flows commonly pass into pahoehoe upslope and cannot be traced to their sources. The latest flows (lpc) are mapped separately. Purple lines show dikes and sills

f

Area of fuming and sulfur deposition

Contact
Dashed where approximately located; querried where doubtful. Contacts are shown within units to separate flows of slightly different age

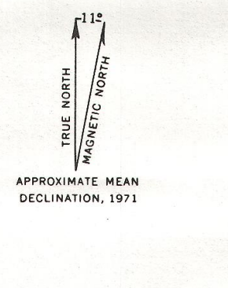
Fault
Dashed where approximately located; dotted where concealed. Ball on downthrown side

Crack

6

Strike and dip of beds

Base from U.S. Geological Survey, 1966



APPROXIMATE MEAN DECLINATION, 1971

SCALE 1:24 000

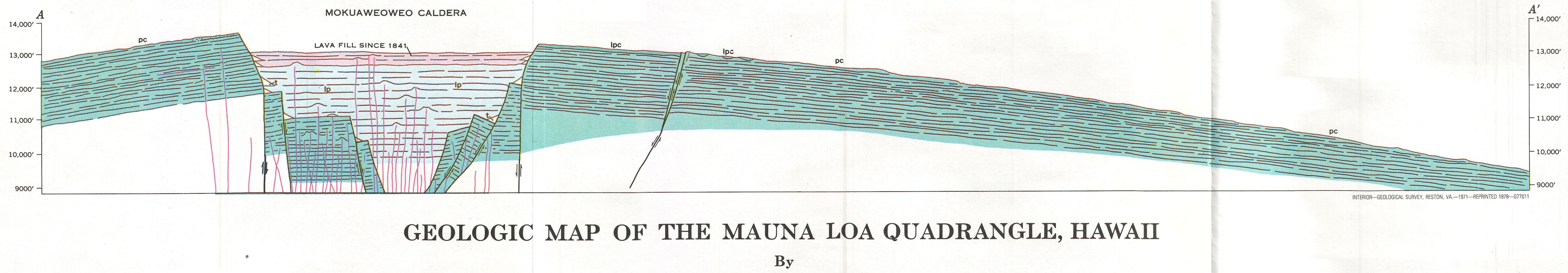
1 ½ 0 1 MILE

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

Geology mapped in 1943, 1967–68



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GEOLOGIC MAP OF THE MAUNA LOA QUADRANGLE, HAWAII

By
Gordon A. Macdonald
1971

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