GLACIATION OF MAUNA KEA, HAWAII

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Mauna Kea, the highest of five volcanoes comprising the island of Hawaii, is the only mountain in the central Pacific Ocean that is known to have been glaciated. A summit ice cap of about 70 km^2 formed at least four times during the middle and late Pleistocene, as indicated by interstratification of glacial drift and volcanic rocks on the upper slopes of the mountain. The rocks and sediments are divided into an older Hamakua Group, dominated by a tholeiitic suite that includes basalt, olivine basalt, and oceanite, and a younger Laupahoehoe Group of alkalic rocks, dominated by hawaiite.

The oldest glacial drift, the Pohakuloa Formation, is at or very near the top of the Hamakua Group. It is exposed only in a few gulches that indent the south flank of the mountain. The formation overlies thin-bedded pahoehoe flows of the Hopukani Formation and underlies basal alkalic lavas of the Waikahalulu Formation. Clasts are largely subangular to subrounded and they consist mainly of alkalic olivine basalt and ankaramite. Both till and outwash facies are exposed, the former locally resting on abraded rock surfaces. The formation has a maximum exposed thickness of about 40 m. A basaltic lava flow directly overlain by basal Pohakuloa till is dated 278,000 ± 68,500 K–Ar yr. Older exposed lavas beneath this stratigraphic level are as old as 382,100 ± 60,000 K–Ar yr.

The Waihu Formation is the oldest glacial deposit still exposed at the surface of the volcano; it is extensively exposed only in the southwestern quadrant of the mountain, having been largely buried by younger lavas elsewhere around the shield. Throughout that section it forms subdued moraines, having a mean altitude of 3010 m, that overlie basal as flows of the Waikahalulu Formation. Moraines have slope angles of 5–20° and have been lowered 3 m or more, by erosion, as indicated by tor-like pedestals of tillite on their crests. The drift, containing clasts mainly of hawaiite and alkalic olivine basalt, generally is well indurated. Surface boulders are oxidized yellowish brown and have weathering rinds 1–2 mm thick; those on the upper slopes commonly are pitted (to 10-cm depth), whereas those on the drier lower slopes typically are spalled. The drift consists of diamictite (tillite) and conglomerate (outwash) facies and has a maximum thickness of about 30 m. As in the Pohakuloa Formation, the clasts are mainly subangular and subrounded, and the matrix is very sandy (81% sand). In a number of places the basal tillite overlies abraded and striated lava flows. Subglacially erupted lava flows and cinder cones on the upper slopes of the volcano at the stratigraphic level of the Waihu Formation are dated between 171,900 ± 2200 and 174,400 ± 26,500 K–Ar yr, and they record a time when the Waihu ice cap was close to its maximum extent. Lavas stratigraphically above Waihu drift indicate that the unit is ≥120,700 ± 2100 K–Ar yr old.

Drift of the Makanaka Formation, the youngest glacial deposit in the stratigraphic succession, is divided into two units that are separated by lava flows. The older drift is exposed only locally at and beyond the outer limit of the younger drift. It forms broad rounded moraines that extend as low as about 3200 m and have maximum slope angles of 10–25°. The hard, compact sediments contain mainly hawaiite clasts; surface boulders are oxidized, they have weathering rinds ≥0.5 mm thick, and many have been split by frost action. Moraines of the younger drift are sharp and steep, they have slope angles of 20–30°, and they extend as low as 3420 m. The drift composing them is hard, compact, and generally unweathered. Both till and outwash facies are present, and the drift has a maximum thickness of 50 m. Clasts are dominantly hawaiite and are subangular to subrounded in shape. The matrix is very sandy (average 71% sand). Striated and abraded lava surfaces are ubiquitous inside the belt of end moraines that encircles the upper slopes of the mountain.

The older drift of the Makanaka Formation is stratigraphically above lavas that are 69,500 ± 2600 K–Ar yr old and older. Subglacial eruptions like those in Waihu time left a complex of pyroclastic cones and lava flows near the summit, one of which is 41,300 ± 8300 K–Ar yr old. The younger drift postdates tephra layers on the west rift zone that range in age from 29,700 ± 500 to 37,200 ± 1400 ^{14}C yr old and it is older than basal algal-rich sediments of Lake Waihu near the summit of the mountain having a ^{14}C age of 9080 ± 200 yr BP. Postglacial eruptions that built cinder cones and lava flows on the south rift zone, some of which overlie moraines of the younger Makanaka drift, occurred between 4500 and about 3300 ^{14}C yr ago.

REFERENCES

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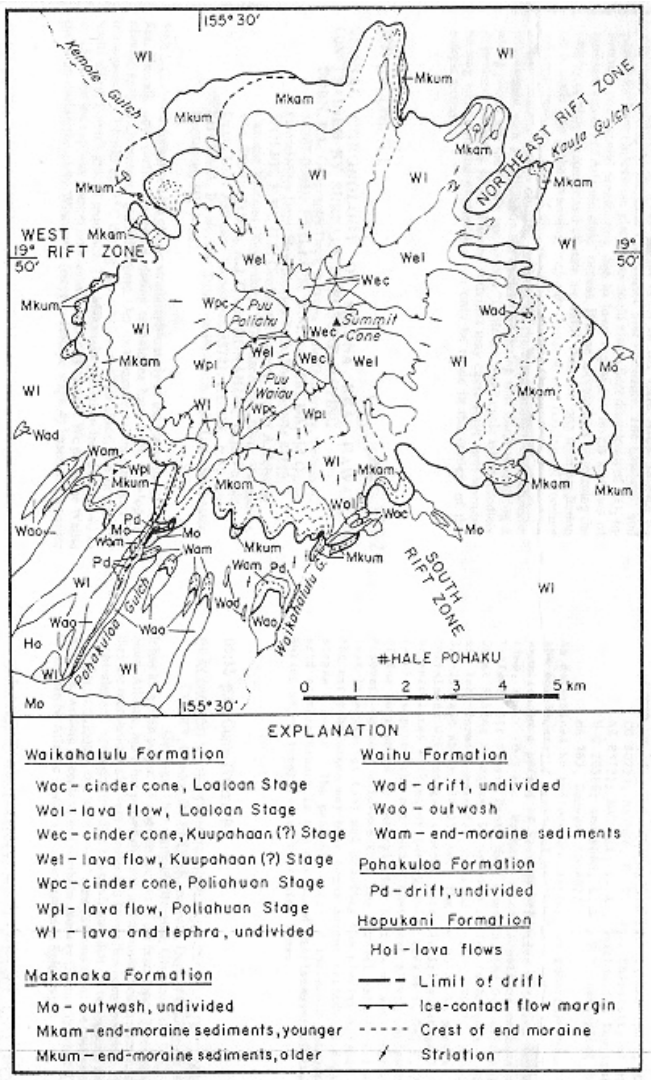

FIG. 1. Glacial-geological map of the upper slopes of Mauna Kea (from Porter, 1979b, Fig. 4).

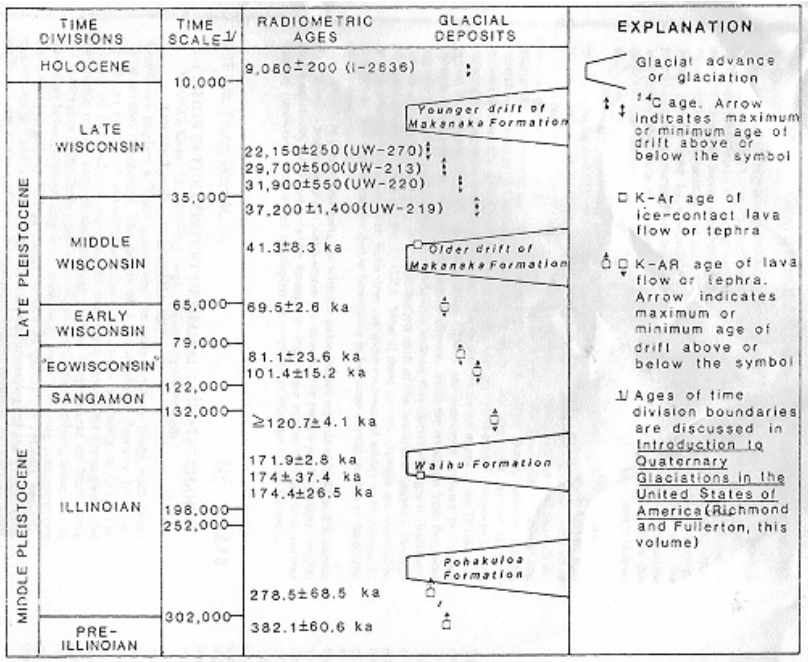

FIG. 2. Chronology of Quaternary glaciations on Mauna Kea, Hawaii.