

Map Unit Properties Table: Pu'ukoholā Heiau National Historic Site

Colored rows indicate geologic units mapped within Pu'ukoholā Heiau National Historic Site.

Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure and Recreation	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Habitat	Geologic Significance	
QUATERNARY (Pleistocene and/or Holocene)	Surficial Deposits	<p><i>caldera:</i> Qcal <i>fill:</i> Qf* <i>landslide deposits:</i> Qls <i>alluvium and colluvium:</i> Qac <i>olian deposits:</i> Qe <i>slope deposits:</i> Qsd</p> <p>*Qf is mapped within Pu'ukoholā Heiau National Historic Site.</p>	Low	With exception of unit Qcal, deposits are unconsolidated, and units Qcal, Qls, Qac, and Qsd are associated with steep slopes, and should be avoided for heavy infrastructure, wastewater treatment facilities, and recreation infrastructure.	Units are prone to mass wasting and erosion, especially where present on a slope. Seismicity of magnitude greater than 4 or 5 may trigger mass movements in these units.	Sedimentary units may contain recent plant and animal remains.	Unit may contain ancient Hawaiian artifacts. Unit Qls contains a landslide from 1868 (Wood Valley) that buried a village and killed 31 people.	Sand, ash, gravel	Units form substrate for many habitats throughout the mapped area.	Units record landscape evolution following volcanic eruptions, as well as anthropogenic alterations to the landscape.	
	Regional Ash Deposits	<p><u>Pāhala Ash</u> Qpha</p>	Moderately low	Easily weathered ash material may form clays that pose infrastructure challenges, especially if shrink-and-swell clays are present. Avoid areas close to active flows. Clays may provide slippery recreational base.	Ash horizons weathered to clay may pose rockfall hazard, if overlain by intact rock and exposed on even moderate slopes.	None documented	Weathered clay may have provided materials for domestic use. Thick ash units may have provided abrasive material.	Clay, hydrated oxides.	Unit contributes to fertile volcanic soils.	Origin is likely reworked and primary tephra-fall deposits; distribution is linked to prevailing wind direction. Age dates range from 31,000 to 23,000 years old. Important marker unit.	
	Kīlauea Volcano	<p><u>Puna Basalt</u> <i>spatter or tuff cones:</i> Qpc5, Qpc4y, Qpc4o, Qpc3, Qpc2 <i>lava flows:</i> Qp5, Qp4, Qp3, Qp2, Qp1y, Qp1o, Qp4y, Qp4o <i>littoral cones:</i> Qpld5, Qpld4o, Qpld3 <i>tephra deposits:</i> Qpa5, Qpa4o, Qpa2</p>	Various subunits contain spatter or tuff cones (Qpc5, Qpc4y, Qpc4o, Qpc3, Qpc2), lava flows (Qp5, Qp4, Qp3, Qp2, Qp1y, Qp1o), littoral deposits in cones (Qpld5, Qpld4o, Qpld3), and tholeiitic basalt tephra deposits (Qpa5, Qpa4o, Qpa2). Compositions vary between tholeiite and transitional alkalic basalt. Cones consist of spatter and scoria deposited during brief explosive eruptions. Lava flows vary from vesicular pāhoehoe to blocky 'a'ā. Littoral deposits are localized along the coast where lava flows entered the water and fragmented during explosive cooling. Deposits include ash, lapilli, and bombs of dense, gray basalt. Tephra deposits include widespread ash and lapilli.	Moderately low to moderate	Avoid areas of active volcanism for all major infrastructure and recreation.	Unit is strongly associated with potentially dangerous, active volcanism (lava flows and pyroclastic events). Recently emplaced lava may still be hot, causing burns. Unit also subject to lava tube collapse and steam explosions. Noxious fumes may still issue from these units.	Tree molds and other casts from recent lava flows and ash falls.	A party of Hawaiian warriors was killed during a pyroclastic surge-steam explosion southwest along Kīlauea Crater. Human footprints are preserved in the Keanakāko'i Ash.	Olivine, plagioclase, pyroxene, basalt, ash, cinders	Very recent volcanic activity provides habitat for early, opportunistic species on Kīlauea Volcano.	These units record accurately dated, recent volcanic activity around Kīlauea Volcano.
		<p><u>Hilina Basalt</u> <i>lava flows:</i> Qhi</p>	This unit crops out in kīpukas surrounded by younger units, and contains lava flows and intercalated ash deposits. Approximately 95% of the exposed unit is pāhoehoe and 'a'ā lava flows at least 300 m (1,000 ft) thick. Compositions are mostly tholeiite. Ash layers can reach 4 m (13 ft) in thickness, with vitric to lithic textures. Unit weathers to reddish-brown clays.	Moderately low to moderate	Suitable for most infrastructure, unless close to active flows of Kīlauea Volcano. 'A'ā can be a suitable trail base if trail is properly constructed.	Ash horizons weathered to clay may pose rockfall hazard if overlain by intact rock and exposed on even moderate slopes.	None documented	Thick ash units may have provided abrasive material.	Olivine, plagioclase, pyroxene, ash, basalt.	Weathered areas of this unit support soil and palagonite horizons.	Unit predates unit Qpha and is older than 23,000 years old.
	Mauna Loa Volcano	<p><u>Ka'ū Basalt</u> <i>spatter or tuff cones:</i> Qkc5, Qkc4, Qkc3, Qkc2, Qkc1, Qkc, Qkc1y, Qkc1o <i>lava flows:</i> Qk5, Qk4, Qk3, Qk2, Qk1, Qk, Qk1y, Qk1o <i>littoral cones:</i> Qkld5, Qkld4, Qkld3, Qkld2, Qkld1 <i>tephra deposits:</i> Qka3</p>	Moderately low to moderate.	Unit is associated with recent volcanism on an active volcano, and should be avoided for major infrastructure. Avoid unstable areas and areas with sharp substrates for recreation infrastructure.	Unconsolidated cinder cones may be unstable on slopes. Lava tubes may collapse in lava flows within this unit. Sharp fragments are present throughout these units.	Tree molds and other casts from recent lava flows and ash falls.	Formation of these units was witnessed and revered by ancient Hawaiians.	Olivine, plagioclase, pyroxene, ash, basalt, cinders	Very recent volcanic activity provides habitat for early, opportunistic species on Mauna Loa volcano.	Deposits and flows are historically datable from Mauna Loa volcano, and formed during brief eruptive spurts. Ash and pyroclastic deposits can record prevailing wind and current directions. Radiocarbon ages from unit Qk range from 31,000 to 10,000 years old.	

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QUATERNARY (Pleistocene and/or Holocene)	Mauna Loa Volcano	<u>Kahuku Basalt</u> <i>lava flows:</i> Qkh	Moderate	Heterogeneous nature of this unit may render it unstable on slopes; canyons should be avoided for infrastructure and recreation. 'A'ā can be a suitable trail base if trail is properly constructed.	Unit Qn is associated with steep canyon slopes and landslides, which may have contributed to canyon growth.	Tree molds and other casts from recent lava flows and ash falls.	Canyons may have been preferred travel routes.	Olivine, plagioclase, ash, basalt.	None documented	Unit Qkh is useful in relative age dating, predates unit Qpha and the 31,000 year old part of unit Qk. Unit Qn is 300,000 to 100,000 years old, as determined by Potassium-Argon radiometric dating.	
		<u>Nīnole Basalt</u> <i>lava flows:</i> Qn									
	Hual	<u>Hualālai Volcanics basalt member</u> <i>spatter or scoria cones:</i> Qhc5, Qhc4, Qhc3, Qhc2, Qhc1y, Qhc1o, Qhc <i>lava flows:</i> Qh5, Qh4, Qh3, Qh2, Qh1y, Qh1o, Qh <i>tephra deposits:</i> Qha4	Units include spatter or scoria cones (Qhc5, Qhc4, Qhc3, Qhc2, Qhc1y, Qhc1o, Qhc), lava flows (Qh5, Qh4, Qh3, Qh2, Qh1y, Qh1o, Qh), and tephra deposits (Qha4). Compositions range from alkalic and transitional basalt to hawaiite. Vent deposits comprise small spatter cones with larger scoria and spatter cones deposited locally by short extrusive events. Flows are pāhoehoe and/or 'a'ā. Unit Qha4 contains weakly consolidated light-gray tuff, with lapilli and large alkalic basalt, tholeiitic basalt, and trachyte blocks. *Qh1o, Qh1y, and Qh2 are mapped within Pu'ukoholā Heiau National Historic Site.	Moderately low to moderate.	Unconsolidated tephra and cinders should be avoided for major infrastructure. Suitable for most recreation unless fresh and sharp fragments exist.	Unconsolidated units may fail on even moderate slopes during heavy precipitation or seismic events. Recent flows may pose hazard for lava tube collapse.	Tree molds and other casts from recent lava flows and ash falls.	Formation of younger units may have been viewed by ancient Hawaiians.	Olivine, pyroxene, plagioclase, basalt, ash, cinders, trachyte, hawaiite	Unit provides substrate for upland, scrubby vegetation locally.	Unit Qha4 records steam-driven explosive events at 700 years before present. Flows are at least as old as 13,000 years, but historic activity was as recent as A.D. 1800–1801.
		<u>Hualālai Volcanics Wa'awa'a Trachyte Member</u> <i>spatter or scoria cones:</i> Qwc <i>lava flows:</i> Qw	Units consist of a scoria cone (Qwc) and a lava flow (Qw). Unit Qwc contains loose fragments of pumice, obsidian, some sheared trachyte flows, and altered volcanic rocks. Unit Qw contains sheared flows of trachyte, now slightly altered and appearing light brown.	Moderately low to moderate	Friable nature of this unit renders it relatively unsuitable for major infrastructure, especially if exposed on steep slopes. Suitable for most recreation unless sharp fragments exist.	Unit may be extensively altered locally and unstable on steep slopes.	Tree molds and other casts from recent lava flows and ash falls.	Obsidian and pumice may have provided tool and trade material.	Biotite, plagioclase, pyroxene (phenocrysts are rare), trachyte, obsidian, pumice.	Unit provides substrate for upland, scrubby vegetation locally.	Unit is Potassium-Argon radiometric age-dated to approximately 105,000–100,000 years old. Unit is present as xenoliths elsewhere on Hualālai.
Mauna Kea Volcano	<u>Laupāhoehoe Volcanics younger volcanic rocks member</u> <i>scoria cones:</i> Qlcy <i>lava flows:</i> Qly <i>tephra deposits:</i> Qlay	The younger volcanic rocks member contains scoria cones (Qlcy), lava flows (Qly), and tephra deposits (Qlay). Unit Qlcy consists of scoria cones, containing vesicular lapilli and lesser amounts of ash and bombs with local agglutinated spatter. Fresh exposures are dark gray to red. Unit Qly deposits are predominantly 'a'ā and blocky 'a'ā, with some localized pāhoehoe flows. Flow surfaces are brown to gray with dense, massive, gray interiors. Surfaces are relatively fresh. Unit Qlay contains lapilli and ash distributed by pyroclastic flow. Exposures are black where fresh, and yellowish-brown where weathered. The older volcanic rock member contains scoria cones (Qlc, Qlbc), lava flows (Ql, Qlb), and tephra deposits (Qla). Compositions range from hawaiite and mugearite to benmoreite. Units are more weathered than their younger counterparts and may be mantled by eolian, tephra-fall or colluvial deposits.	Moderately low to moderate.	Unconsolidated areas of these units should be avoided for major infrastructure. Blocky 'a'ā flows can be suitable trail bases if properly constructed; avoid young flows for recreation infrastructure.	Younger units contain sharp 'a'ā lava flows. Weathered units may contain clay that can cause unsafe conditions, and slip surfaces if overlain by intact rock, posing landslide hazards.	Tree molds and other casts from recent lava flows and ash falls.	None documented	Hawaiite, mugearite, benmoreite, ash, basalt, cinders	Weathered units contribute to fertile, clayey soil in localized areas.	Potassium-Argon radiometric ages for older Laupāhoehoe Volcanics range from 65,000 to 14,000 years old.	
	<u>Laupāhoehoe Volcanics older volcanic rock member</u> <i>scoria cones:</i> Qlc, Qlbc <i>lava flows:</i> Ql, Qlb <i>tephra deposits:</i> Qla										
QUATERNARY (Pleistocene)	<u>Laupāhoehoe Volcanics Mākanaka Glacial Member</u> <i>glacial deposits:</i> Qlmt, Qlmo	Glacial till unit (Qlmt) contains massive, poorly consolidated diamict, with angular to subrounded cobbles and boulders. Some individual clasts may be larger than 2 m (7 ft) in diameter and consist of dense, light- to medium-gray hawaiite or mugearite. The matrix is gray to light yellowish brown, fine grained, and unsorted. Unit Qlmo contains unconsolidated gravel, with subrounded to rounded cobbles, and boulders of similar composition to those in unit Qlmt.	Low	Due to poor consolidation and heterogeneous nature of this unit, avoid for most major infrastructure. Jumbled nature of unit makes it an unstable trail base.	Poorly consolidated or unconsolidated parts of these units are prone to mass wasting and erosion, especially if exposed on slopes.	Some remains may be present in glacial member.	Unconsolidated parts may have provided construction material for early Hawaiians.	Cobbles, boulders.	None documented	Relative age dating of nearby flows suggests that the age of these units is between 40,000 and 14,000 years old, during the Mākanaka glaciation.	

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QUATERNARY (Pleistocene)	Mauna Kea Volcano	<u>Hāmākua Volcanics basalt member</u> <i>spatter or scoria cones:</i> Qhmc <i>lava flows:</i> Qhm*	Moderately low to moderate	Avoid weathered and/or unconsolidated units for heavy infrastructure. 'A'ā can be a suitable trail base if trail is properly constructed.	Intense erosion and mass wasting associated with these units. Areas exposed on slopes are vulnerable to fail during moderate seismic events.	Some remains may be present in glacial member.	Unconsolidated parts may have provided construction material for early Hawaiians.	Olivine, plagioclase, clinopyroxene, basalt, cinders, ash.	Weathered areas contribute to primitive, fertile soils when combined with mantling younger deposits.	Unit includes an unmapped glacial till of the Pōhakuloa Glacial Member on the flanks of Mauna Kea. Potassium-Argon radiometric age dates range from 250,000–200,000 years to 70,000–65,000 years. Unit Qhmw is poorly constrained by Potassium-Argon radiometric age-dating at 150,000–70,000 years old.
		<u>Hāmākua Volcanics Waihū Glacial Member</u> <i>glacial deposits:</i> Qhmw								
	*Qhm is mapped within Pu'ukoholā Heiau National Historic Site.									
QUATERNARY (Pleistocene)	Kohala Volcano	<u>Hāwī Volcanics</u> <i>scoria cones:</i> Qhwc, Qhwbc <i>lava flows:</i> Qhw, Qhwb*, Qhwt <i>lava domes:</i> Qhwd, Qhwbd, Qhwtd <i>tephra deposits:</i> Qhwa	Moderately low to moderate	Suitable for most infrastructure and recreation except where steep slopes are present.	Units are prone to rockfall if undercut and/or exposed on steep slopes. Areas exposed on slopes are vulnerable to failure during moderate seismic events.	None documented	Unconsolidated parts may have provided construction material for early Hawaiians. Hāwī is an ancient royal site.	Trachyte with strongly aligned plagioclase crystals in a finer matrix, benmoreite, hawaiite, mugearite.	Unit supports a wide variety of vegetation and associated animal habitat. Weathering contributes material to fertile soils.	Potassium-Argon radiometric ages for lava flows range from 230,000 to 120,000 years old.
		*Qhwb is mapped within Pu'ukoholā Heiau National Historic Site.								
QUATERNARY (Pleistocene)	Kohala Volcano	<u>Pololū Volcanics</u> <i>scoria cones:</i> Qplc, Qplmc <i>lava flows:</i> Qpl*, Qplm <i>lava domes:</i> Qpld	Moderately low to moderate	Avoid areas especially rich in clay or weathered on slopes for major infrastructure. 'A'ā can be dangerous trail base if trail is not properly constructed, but weathering has dulled the sharpness of many areas.	Weathered ash horizons may pose rockfall hazard if overlain by intact rock and exposed on even moderate slopes.	None documented	None documented	Olivine, plagioclase, clinopyroxene, mugearite, basalt, cinders.	Extensively weathered, this unit provides material for fertile volcanic soils locally. Unit supports forests on the windward side of the island.	Potassium-Argon radiometric age dating suggests the magma evolved from tholeiitic basalt to transitional and alkalic basalt 400,000 years ago and erupted until at least 250,000 years ago. Older lava flows are as old as 700,000 years and are the oldest exposed rocks on Hawai'i. All exposed Pololū Volcanics strata were emplaced during the Brunhes Normal-Polarity Chron (they are younger than 780,000 years old).
		*Qpl is mapped within Pu'ukoholā Heiau National Historic Site.								