To accompany Geologic Map of the State of Hawai‘i: U.S. Geological Survey Open-File Report 2007-1089

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Metadata for Users of the Geologic Map of the State of Hawai‘i

This document is a descriptive version of the metadata for the digital Geologic Map of the State of Hawai‘i. It is intended to be more user friendly than the conventional metadata text document (filename: Hawaii_metadata_20070514.txt). Key data herein are presented in tabular format. Ideally a GIS-oriented user would glance through this text, print a few tables or open them on an adjacent computer screen, and then begin analyzing the data contained in the GIS databases. A few readers may find this document helpful for its explanation of decisions made while assembling data for the geologic map.

Projection and datum

Most GIS users want little from metadata except the map's native projection and datum (table 1). The GIS databases are stored as zone 4 of the Universal Transverse Mercator (UTM) scheme, transverse Mercator projection, North American datum of 1983 (NAD83).

Although Hawai‘i is the fifth smallest of the United States, it is one of the longest when the distant atolls of the Hawaiian archipelago are included in its realm. This geologic map, however, encompasses only the eight major islands, which fall mostly in UTM zone 4. The eastern tip of Maui and the island of Hawai‘i, however, are in zone 5. For simplicity, a single zone is used for all map data, as is common for other statewide GIS databases; examples abound at the State's GIS Web site (http://www.hawaii.gov/dbedt/gis/).

The early version of this map was constructed using the Old Hawaiian datum, because all the legacy map publications were in that datum, as were the then-existent complete set of topographic quadrangle maps. The translation to NAD83 UTM zone 4 may have created some triflingly small positional shifts, unbeknownst to us.

Perhaps of interest to some, we prepared the Island of Hawai‘i's printed map sheet (plate 8, in pdf file format) by recasting the GIS data into zone 5 (UTM, NAD83) so that the geologic linework conforms more closely to the background topgraphic map, a raster image. This nuance has no significance for the digital data (all in zone 4, UTM, NAD83).

Table 1. Projection and datum.

Element	Definition
Projection:	Transverse Mercator
Grid Coordinate System	Universal Transverse Mercator
UTM Zone Number	4
Scale Factor at Central Meridian	0.9996
Origin Longitude	-159.0
Latitude of Projection Origin	0
False Easting	500000
False Northing	0
Horizontal DatumName	North American datum of 1983
Ellipsoid Name	GRS 1980
Semi-major Axis	6378137.0
Denominator of flattening ratio	298.257

Database structure common to all layers

In every GIS coverage for this map publication, the first three columns are structured similarly: *ID*, *Island*, and *Volcano*. So too is the last column, *Data_source*. The *ID* column assigns a unique number (per coverage) to each topologic element or point source. The number is simply the sequential row number, a positive integer. The coding for *Island* and *Volcano* allow the data to be grouped by the island or major volcano (table 2) of which they are a part. *Data_source* lists the published or nonpublished reference used to depict the shape and geographic position of each polygon, arc element, or data point (table 3).

Island names in the database are free of any diacritical marks found in modern Hawaiian typography, in order to avoid problems during software translations. The full spellings are acceptably short, so little is gained by imposing a scheme of numbering or abbreviations that require a look-up table for interpretation.

The assignment to *Volcano* allows all features of a particular volcano to be grouped, even nonvolcanic stratigraphic units such as alluvium, which may be found on more than one volcano or island. The *Volcano* column would be redundant if islands were constructed by single volcanoes, but only four are so disposed (Ni‘ihau, Kaua‘i, Lana‘i, and Kaho‘olawe). The *Volcano* coding is a four-letter abbreviation, typically the first four letters of the volcano name; five exceptions are wmol (West Moloka‘i), emol (East

Table 2. Attributes for *Island* and *Volcano* columns.

Island	Volcano	Volcano abbreviation spelled out
Niihau	niih	Niihau
Kauai	kaua	Kauai
Oahu	kool	Koolau
Oahu	waia	Waianae
Molokai	emol	East Molokai
Molokai	wmol	West Molokai
Lanai	lana	Lanai
Kahoolawe	khoo	Kahoolawe
Maui	hale	Haleakala
Maui	wmau	West Maui
Hawaii	hual	Hualalai
Hawaii	kila	Kilauea
Hawaii	koha	Kohala
Hawaii	mkea	Mauna Kea
Hawaii	mloa	Mauna Loa

Table 3. Sources for unpublished data on geologic map, as reported in *Data_source* column of GIS database files.

Citation	Explanation
Powers_1942	H.A. Powers, in Stearns and Macdonald, 1942, p. 79, figure 11, Island of Maui
HVO_2004	Hawaiian Volcano Observatory, unpublished data current as of December 2004, courtesy of C.C. Heliker.
Neal and Sherrod_2004	C.A. Neal and D.R. Sherrod, unpublished data, Kilauea volcano, Island of Hawaii
Sherrod_2004a	D.R. Sherrod, unpublished data, Haleakala volcano, Island of Maui
Sherrod_2004b	D.R. Sherrod, unpublished data, Kilauea volcano, Island of Hawaii
Sherrod_2004c	D.R. Sherrod, unpublished mapping at Kanapou Bay, Island of Kahooolawe
Sinton_2004	J.M. Sinton, unpublished data provided 2004, Waianae volcano, Island of Oahu
Sinton_2006	J.M. Sinton, unpublished data provided 2006, Waianae volcano, Island of Oahu
Swanson_2005	Age determination, by D.A. Swanson on basis of detailed tephra stratigraphic studies, for lava-flow units shown by Wolfe and Morris, 1996
Watkins_2004	S.E. Watkins, 2004, this map, polygons created to fill gaps created by difference between legacy geologic map sources and modern topographic maps. On Island of Molokai, fills gap created by difference between 1924 coastline and 1980 coastline owing to progradation of alluvial deposits. On Island of Oahu, accounts for manmade fill at Kaneohe Bay

Moloka‘i), khoo (Kaho‘olawe), mloa (Mauna Loa), and mkea (Mauna Kea) (table 2). The coding is a simple mnemonic device that avoids the need for look-up tables once the system is understood.

Data_source is a text field with a citation style used widely in scientific publications (for example: “Macdonald and others, 1960”). All published sources are found among the References Cited section of the explanatory pamphlet, and the reader is referred there for complete references, including those for radiometric ages and geochemistry. Unpublished sources require the look-up table (table 3) for explanation. Their citation style differs slightly by use of an underscore instead of comma (for example, Sinton_2004), thereby making it easier to find and remove them if swept into a list that might be viewed as formal independent publications.

Searching for stratigraphic units, faults types, and dikes or sills

For the stratigraphic units, all polygons of a single stratigraphic formation may be selected by using numeric values (Strat_code, a positive integer) or text strings (Unit_label) (table 4). (Table 4 is lengthy, so it follows at the end of this document. It may also be accessed in spreadsheet format, filename EntityAttrib_forTable4.xls.) For faults, which are arc or line elements, the Line_code is similarly effective, allowing selection by fault attribute (table 5). These features allow the user to create their own coloring scheme and line attribution (line weight and line style as solid, dashed, or dotted) if desired. For the State of Hawai‘i, all faults are treated as normal faults, so the attributes are chiefly those of the positional accuracy assigned to known or inferred faults.

Also shown as line elements are dikes and the few mapped sills. Their mapped distribution on previously published maps is more schematic than other parts of those maps; consequently the positional precision and knowledge of along-length extent is limited. A single numeric code characterizes all dikes and sills, each of which has the information of *Island*, *Volcano*, and *Data_source* stored with it. More extensive intrusions such as plugs and a laccolith or two are depicted by polygons and therefore included in the geo-polygon database.

No simple, easily recognizable mnemonic exists for the many stratigraphic units of statewide application. Most users will need the look-up table (table 4) or other metadata documents for utilizing the *Strat_code* number scheme and *Unit_label* text. The *Unit_label* feature allows labeling of the geologic map for onscreen viewing or printing, as commonly found on previously published geologic maps.

Areally, more than half the state’s land area is contained by the Island of Hawai‘i. For consistency between recent digital map publications, our choice of coding numbers matches, as closely as possible, that used by Trusdell and others (2005). The numerical coding used for faults lacks this correspondence, although the underlying assignment is similar for the most part. This divergence from the Trusdell fault-numbering scheme—for simplicity as a statewide map—is only a small annoyance for those comparing digital versions of the State map (this publication) and that for the Island of Hawai‘i (Trusdell and others, 2005), because the number of styles on each are few.

(**Table 4** is lengthy and appears at the end of this document.)

Table 5. Line codes for structural elements (fault), in file (name here).

Line_code	Feature	Typical line style	Explanation
21	Normal fault, well located	Solid	Fault exposed or displaced stratigraphic units sufficiently close that position has been determined by field work to within 50 m on the ground (0.5 mm at 1:100,000 scale)
22	Normal fault, approximately located	Long-dashed	Ground surface morphology sufficiently distinct that fault may be traced as escarpment on air photos or topographic map with confidence that position lies within 50 m on the ground (0.5 mm at 1:100,000 scale)
23	Normal fault, inferred	Short-dashed	Geologic relations or ground surface morphology suggest fault present but not exposed and too uncertain to determine position closer than 100 m with confidence (1 mm at 1:100,000 scale)
24	Normal fault, concealed	Dotted	Trace of fault concealed by younger stratigraphic unit; positional accuracy uncertain but within 1 mm at 1:100,000 (100 m on the ground) and commonly within 0.5 mm (50 m on the ground)
25	Normal fault, flooded	Dotted	Trace of fault beneath sea surface; positional accuracy indeterminate
26	Normal fault, queried	Short-dashed with queries (question marks) placed on fault trace	Trace becomes largely uncertain because juxtaposed stratigraphic relations possibly may be explained by other causes such as depositional cutout

Age of stratigraphic units as an element coded in the geo-polygons database

Age information takes two forms in this database. One column is generalized to an *Age_group*, which is encoded as a series of integer values that correspond to predefined age ranges (table 6). The groupings allow for a rapid collection of all volcanic strata (and some sedimentary units) of commonly used, broadly define age ranges.

Another column, *Age_range*, provides a text string with more specific data where known. As example, several of the vents and lava flows of the Honolulu Volcanics (Island of Oʻahu) were emplaced in the time between 140,000 and 780,000 years ago (group 10). But more precise ages have been published recently and, where applicable, have been inserted as *Age_range* data. Thus the GIS user can query polygons of the informally named Kāneʻohe lava (of the Honolulu Volcanics) and determine that this sequence of flows is about 0.5 Ma (Ozawa and others, 2005), distinguising it from older or younger deposits of the Honolulu Volcanics.

Lava flows and vents younger than 200 years, where precisely known and compiled as *Age_range*, are expressed by their calendar dates (for example, A.D. 1888). All occurences are found on the Island of Hawaiʻi. Values range from A.D. 1790 to 2004, the latter being the status of mapping, on this map, for the eruption at Kīlauea Volcano that has been ongoing since 1983.

The *Age_range* data also allow us to soften the rigid boundaries created by our *Age_group* scheme. For instance, the older volcanic rocks member of the Laupāhoehoe Volcanics stratigraphic unit ranges in age more broadly than any of our predefined groups. Assigning it entirely to group 8 (30,000-50,000 yr in age) is an efficient but misrepresentative classification. The *Age_range* provides the actual age (11,000-64,000 yr). Savvy users will recognize the shortcoming in this methodology but perhaps appreciate its value, which stems from our desire to embed as much information within the GIS database as possible—even if perhaps pushing the limit of our state of knowledge for specific strata.

Table 6. Age ranges for geo-polygons, by integer code.

Code	***Age_range***
0	Sedimentary rocks and deposits that span several age ranges
1	0-200 yr ago, the so-called "historical lavas" of some authors
2	200-750 yr
3	750-1,500 yr
4	1,500-3,000 yr
5	3,000-5,000 yr
6	5,000-10,000 yr
7	10-30 ka
8	30-50 ka
9	50-140 ka
10	140-780 ka
11	780-1,000 ka
12	1-2 Ma
13	2-4 Ma
14	4-6 Ma

Miscellaneous information stored with stratigraphic units (polygon file, filename Haw_St_geo_20070426)

Brief lithologic descriptions (columns *Rock_type* and *Lithology*) are included as tabular data for each of the polygons of the geologic map. Some of the descriptions could be gleaned from the Description of Map Units within the explanatory pamphlet that accompanies the map. Other descriptions assign characteristics to specific polygons. A column showing *Stearns_unit* carries the mnemonic labels used on previously published geologic maps for several of the islands.

The volcanic stage of strata is stored in a column *Volc_stage*. Four terms are used, abbreviated where necessary to retain six characters or fewer: “shield” (shield); “postsh” (postshield); “rejuv” (rejuvenated); and “alluv” (alluvium). Most extensive are shield-stage strata (60 percent areally of volcanic map units), followed by postshield-stage (36 percent) and rejuvenated-stage strata (4 percent). Sedimentary deposits are assigned the term “alluv” (alluvium), in order to avoid blank cells within the column. No alluvial stage, per se, exists in the common schemes that typify the volcanic stages of the major volcanoes.

Compositional terms for the volcanic rocks form another column of data. A one-to-one correspondence generally exists for the shield-stage strata of each volcano and their assigned compositional term. This correspondence, for all the islands, has two causes. The first is the tendency, on geologic maps of the older islands, to group numerous lava flows into areally extensive bodies, even though chemical analyses indicate some variability in the upper parts of shield-stage stratigraphic sequences. The second is the observation that, on the comparatively youthful Island of Hawaiʻi where shield-stage strata are mapped with greater distinction, compositions tend to be homogenous.

It has been possible to be more specific for some strata of postshield and rejuvenated-stage volcanism. On several islands these strata have been divided into discrete emplacement units (discrete polygons) for which fairly specific compositional names can be assigned in the GIS database.

Thin tephra beds depicted as line elements (arcs)

Some previously published maps showed thin tephra or ash beds, portrayed as thin lines and typically mapped in canyon walls on the arid leeward flanks of some volcanoes where exposures are suitable. The strata are neither extensive nor notable stratigraphic marker beds. A geologic map's value is not lessened greatly by a decision to ignore them, except for the manner in which they show dip of strata. For these reasons the tephra beds, mapped as line elements on this map, are stored in a separate coverage, filename Haw_St_ash_20070426. Users therefore have greater freedom of choice in the decision to show or ignore the beds on thematic maps.

Regardless, the thin tephra beds are parts of stratigraphic units, so their database includes columns for *Island*, *Volcano*, *Strat_code*, *Data_source*, and several other characteristics. Users frustrated by error messages of "no data found" when searching electronically for specific *Strat_code* designations in the geo-polygon database should remember to check the tephra database.

Whole-rock geochemistry

Whole-rock geochemical analyses are compiled into spreadsheet format (filename: Hawaii_State_Geochem_compilation.xls) from published and some previously unpublished data. A total of 3,631 analyses are presented; of these, 1,786 are from the Island of Hawai‘i (Wolfe and Morris, 1996a) and 1,845 are from the other seven major islands. We have relied heavily on a 1996-vintage compilation undertaken by Kevin Johnson but have added to it by way of additional analyses published or otherwise made available since then and by adding geographic coordinates for as many sample locations as possible. Roughly 90 percent of the listed analyses have location data, obtained chiefly by either scanning and registering small-scale location maps to capture the coordinates or by written communication between us and many originators of data. The latter cooperation included shared field sheets, which have provided a level of accuracy not possible by the other means.

Radiometric ages—K–Ar and $^{40}Ar/^{39}Ar$ data

These 550 ages, from across the island chain, are compiled into spreadsheet format (filename: Hawaii_StateMapAges.xls) from published and some previously unpublished data. Geographic coordinates were obtained for 536 of the samples (95 percent), either as sample locations reported in the source publications, those we have measured from sample-location maps, or locations provided to us by the originators. In this way, the radiometric ages become a GIS database that may be superimposed on the geologic map.

Users can project the data using the coordinates found in the appropriate columns. As is the case for other databases, columns are provided for *Island*, *Volcano*, and *Data_source*, as are the latitude and longitude of points, where known. Every radiometric age sample is assigned to its appropriate stratigraphic group.

It is common in K–Ar dating to obtain multiple gas extractions from a single sample, which allows two or more age determinations and greater precision. In those cases, we report a single weighted mean age. Consequently, some ages may differ slightly from those reported in their source publications. Another source of difference arises because we have recalculated all K–Ar ages for consistency with modern decay constants; see appendix 1 of the explanatory pamphlet.

Radiometric ages—Radiocarbon data

Radiocarbon ages for organic matter, chiefly charcoalized wood or peat, are contained in a separate database (filename: Hawaii_radiocarbon_data.xls), in spreadsheet format similar to that for the K–Ar and $^{40}Ar/^{39}Ar$ ages. Of the 344 ages compiled, 251 are from the Island of Hawai‘i. Another 93 are from Haleakalā volcano, Island of Maui. The Island of Hawai‘i data is current only through about 1995; Island of Maui data is current through about 2005. Geographic coordinates are assigned for nearly 100 percent of the radiocarbon sample locations.

References Cited

The full citations for all references cited herein can be found in the explanatory pamphlet that accompanies this open-file report (filename: Hawaii_expl_pamphlet.pdf).

Table 4. Integer values to encode polygons of the various stratigraphic units, and information about formation name, rock type, and age range. This tabulation may also be accessed in spreadsheet format (filename: EntityAttrib_forTable4.xls).

Strat_code	Unit_symbol	Formation_name	Member_name	Rock_type	Age_range (for numbered units)
1	ow	Open water		Open Water	
60	Qcw	Caldera wall rocks		Lava flows and thin tephra deposits	
101	Qpc5	Puna Basalt		Spatter or tuff cones	Age 0-200 yr
102	Qpc4y	Puna Basalt		Spatter or tuff cones	Age 200-400 yr
103	Qpc4o	Puna Basalt		Spatter or tuff cones	Age 400-750 yr
104	Qpc3	Puna Basalt		Spatter or tuff cones	Age 750-1500 yr
105	Qpc2	Puna Basalt		Spatter or tuff cones	Age 1500-3000 yr
106	Qp5	Puna Basalt		Lava flows	Age 0-200 yr
107	Qp4	Puna Basalt		Lava flows	Age 200-750 yr
108	Qp3	Puna Basalt		Lava flows	Age 750-1500 yr
109	Qp2	Puna Basalt		Lava flows	Age 1500-3000 yr
110	Qp1y	Puna Basalt		Lava flows	Age 3000-5000 yr
111	Qp1o	Puna Basalt		Lava flows	Age 5000-16000
112	Qhi	Hilina Basalt		Lava flows	Age greater than 16000 yr
113	Qp4y	Puna Basalt		Lava flows	Age 200-400 yr
114	Qp4o	Puna Basalt		Lava flows	Age 400-750 yr
115	Qpld5	Puna Basalt		Littoral deposits	Age 0-200 yr
116	Qpld4o	Puna Basalt		Littoral deposits	Age 400-750 yr
117	Qpld3	Puna Basalt		Littoral deposits	Age 750-1500 yr
118	Qpa5	Puna Basalt		Ash	Age 0-200 yr
119	Qpa4o	Puna Basalt		Ash	Age 400-750 yr
120	Qpa2	Puna Basalt		Ash	Age 1500-3000 yr
121	Qpa4y	Puna Basalt		Ash	Age 200-400 yr
201	Qkc5	Kau Basalt		Spatter or tuff cones	Age 0-200 yr
202	Qkc4	Kau Basalt		Spatter or tuff cones	Age 200-750 yr
203	Qkc3	Kau Basalt		Spatter or tuff cones	Age 750-1500 yr
203	Qkc3	Kau Basalt		Spatter or tuff cones	Age 750-1500 yr
204	Qkc2	Kau Basalt		Spatter or tuff cones	Age 1500-3000 yr
205	Qkc1	Kau Basalt		Spatter or tuff cones	Age 3000-11000 yr
206	Qkc	Kau Basalt		Spatter or tuff cones	Age greater than 11000 yr
207	Qkc1y	Kau Basalt		Spatter or tuff cones	Age 3000-5000 yr
208	Qkc1o	Kau Basalt		Spatter or tuff cones	Age 5000-11000 yr

Table 4, cont. Integer values to encode polygons of the various stratigraphic units, and information about formation name, rock type, and age range.

code	Unit_symbol	Formation_name	Member_name	Rock_type	Age_range (for numbered units)
	Qk5	Kau Basalt		Lava flows	Age 0-200 yr
	Qk4	Kau Basalt		Lava flows	Age 200-750 yr
	Qk3	Kau Basalt		Lava flows	Age 750-1500 yr
	Qk2	Kau Basalt		Lava flows	Age 1500-3000 yr
	Qk1	Kau Basalt		Lava flows	Age 3000-11000 yr
	Qk	Kau Basalt		Lava flows	Age greater than 11000 yr
	Qkh	Kahuku Basalt		Lava flows	
	Qn	Ninole Basalt		Lava flows	
	Qk1y	Kau Basalt		Lava flows	Age 3000-5000 yr
	Qk1o	Kau Basalt		Lava flows	Age 5000-11000 yr
	Qkld5	Kau Basalt		Littoral deposits	Age 0-200 yr
	Qkld4	Kau Basalt		Littoral deposits	Age 200-750 yr
	Qkld3	Kau Basalt		Littoral deposits	Age 750-1500 yr
	Qkld2	Kau Basalt		Littoral deposits	Age 1500-3000 yr
	Qkld1	Kau Basalt		Littoral deposits	Age 3000-11000 yr
	Qka3	Kau Basalt		Ash	Age 750-1500 yr
	Qhc5	Hualalai Volcanics		Spatter or tuff cones	Age 0-200 yr
	Qhc4	Hualalai Volcanics		Spatter or tuff cones	Age 200-750 yr
	Qhc3	Hualalai Volcanics		Spatter or tuff cones	Age 750-1500 yr
	Qhc2	Hualalai Volcanics		Spatter or tuff cones	Age 1500-3000 yr
	Qhc1y	Hualalai Volcanics		Spatter or tuff cones	Age 3000-5000 yr
	Qhc1o	Hualalai Volcanics		Spatter or tuff cones	Age 5000-11000 yr
	Qhc	Hualalai Volcanics		Spatter or tuff cones	Age greater than 11000 yr
	Qh5	Hualalai Volcanics		Lava flows	Age 0-200 yr
	Qh4	Hualalai Volcanics		Lava flows	Age 200-750 yr
	Qh3	Hualalai Volcanics		Lava flows	Age 750-1500 yr
	Qh2	Hualalai Volcanics		Lava flows	Age 1500-3000 yr
	Qh1y	Hualalai Volcanics		Lava flows	Age 3000-5000 yr
	Qh1o	Hualalai Volcanics		Lava flows	Age 5000-11000 yr
	Qh	Hualalai Volcanics		Lava flows	Age greater than 11000 yr
	Qha4	Hualalai Volcanics		Ash	Age 200-750 yr
	Qwc	Hualalai Volcanics	Waawaa Trachyte Member	Cinder cone	

Table 4, cont. Integer values to encode polygons of the various stratigraphic units, and information about formation name, rock type, and age range.

Formation_name	Member_name	Rock_type	Age_range (for numbered units)
aupahoehoe Volcanics	Younger volcanic rocks member	Scoria cones	
aupahoehoe Volcanics	Older volcanic rocks member	Scoria cones	
[amakua Volcanics		Scoria cones	
aupahoehoe Volcanics	Older volcanic rocks member	Scoria cones	
aupahoehoe Volcanics	Younger volcanic rocks member	Lava flows	
aupahoehoe Volcanics	Older volcanic rocks member	Lava flows	
[amakua Volcanics		Lava flows	
aupahoehoe Volcanics		Lava flows	
aupahoehoe Volcanics	Younger volcanic rocks member	Tephra deposits	
aupahoehoe Volcanics	Older volcanic rocks member	Tephra deposits	
aupahoehoe Volcanics	Makanaka Glacial Member	Till	
[amakua Volcanics	Waihu Glacial Member	Till and outwash	
aupahoehoe Volcanics	Makanaka Glacial Member	Outwash	
[amakua Volcanics	Pohakuloa Glacial Member	Till and outwash	
[awi Volcanics		Scoria cones	
ololu Volcanics		Scoria cones	
[awi Volcanics		Benmoreite scoria cones	
ololu Volcanics		Mugearite scoria cones	
[awi Volcanics		Lava domes	
ololu Volcanics		Lava dome	
[awi Volcanics		Benmoreite lava dome	
[awi Volcanics		Trachytic lava dome	
[awi Volcanics		Lava flows	
ololu Volcanics		Lava flows	
[awi Volcanics		Benmoreite lava flows	
ololu Volcanics		Mugearite lava flows	
[awi Volcanics		Lava flows	
[awi Volcanics		Tephra deposits	
ephra deposits		Dunes downwind of Lehua Island cone	
ill		Manmade fill	
andslide deposits		Landslide deposits	
.lluvium		Sand and gravel	

Table 4, cont. Integer values to encode polygons of the various stratigraphic units, and information about formation name, rock type, and age range.

Unit_symbol	Formation_name	Member_name	Rock_type	Age_range (for numbered units)
Qtc	Talus and colluvium		Sand and gravel	
Qld	Lacustrine deposits		Calcareous silt and fine-grained sand	
Qbd	Beach deposits		Sand and gravel	
Qdy	Younger dune deposits		Sand dunes	
Qlg	Lagoon deposits		Silt sand and marl	
QTao	Older alluvium		Sand and gravel	
QTao	Older alluvium		Sand and gravel partly lithified	
Qdo	Older dune deposits		Sand dunes	
Qcrs	Lagoon and reef deposits		Limestone and mudstone	
Qcbc	Marine conglomerate and breccia		Fossiliferous breccia	
Qmnl	Honomanu Basalt		Lava flows	
Qkul	Kula Volcanics		Lava flows	
Qkuv	Kula Volcanics		Cinder and spatter	
Qkuk	Kula Volcanics	Kumuiliahi member	Lava flows	
Qkuv?	Kula Volcanics		Vent deposits (query)	
Qkuv?	Kula Volcanics		Cinder and spatter	
Qkul?	Kula Volcanics		Lava flows	
Qkuls	Kula Volcanics	Ankaramite of Summit House	Lava flows	
Qkui	Kula Volcanics		Intrusive plugs	
Qkamd	Kaupo Mud Flow		Debris-avalanche deposits	
Qkamc	Kaupo Mud Flow		Conglomerate and sandstone	
Qhn6	Hana Volcanics		Lava flows	Age 0-1500 yr
Qhnv6	Hana Volcanics		Cinder and spatter	Age 0-1500 yr
Qhn5	Hana Volcanics		Lava flows	Age 1500-3000 yr
Qhnv5	Hana Volcanics		Cinder and spatter	Age 1500-3000 yr
Qhn4	Hana Volcanics		Lava flows	Age 3000-5000 yr
Qhnv4	Hana Volcanics		Cinder and spatter	Age 3000-5000 yr
Qhn3	Hana Volcanics		Lava flows	Age 5000-13000 yr
Qhnv3	Hana Volcanics		Cinder and spatter	Age 5000-13000 yr
Qhn2	Hana Volcanics		Lava flows	Age 13000-30000 yr
Qhnv2	Hana Volcanics		Cinder and spatter	Age 13000-30000 yr
Qhn1	Hana Volcanics		Lava flows	Age 30000-50000 yr

Table 4, cont. Integer values to encode polygons of the various stratigraphic units, and information about formation name, rock type, and age range.

Unit_symbol	Formation_name	Member_name	Rock_type	Age_range (for numbered units)
Qhn0	Hana Volcanics		Lava flows	Age 50000-140000 yr
Qhn0v	Hana Volcanics		Cinder and spatter	Age 50000-140000 yr
Qhnv	Hana Volcanics		Cinder and spatter	
Qhne	Hana Volcanics		Explosion crater deposits	
Qhnt	Hana Volcanics		Tephra poorly to nonindurated	
Qhni	Hana Volcanics		intrusion	
QTwl	Wailuku Volcanics		Lava flows	
QTwv	Wailuku Volcanics		Cinder and spatter	
QTwpc	Wailuku Volcanics		Pit crater	
QTwlc	Wailuku Volcanics		Near-vent lava flows	
QTwdc	Wailuku Volcanics		Dike complex	
QTwcc	Wailuku Volcanics		Caldera complex	
QTwi	Wailuku Volcanics		Intrusive rocks	
Qul	Honolua Volcanics		Lava flows	
Quv	Honolua Volcanics		Cinder and spatter	
Qud	Honolua Volcanics		Bulbous dome of massive lava	
Qlhl	Lahaina Volcanics		Lava flows	
Qlhv	Lahaina Volcanics		Vent deposits	
Qyvk	Young volcanic rocks of Kahoolawe		Lava flows and cinder deposits	
Qnpl	Kanapou Volcanics		Lava flows	
Qnpv	Kanapou Volcanics		Cinder spatter and lava flows	
Qnpcl	Kanapou Volcanics		Lava flows	
Qnpct	Kanapou Volcanics		Indurated fallout tephra	
Qnppl	Kanapou Volcanics		Lava flows	
Qnppv	Kanapou Volcanics		Lava flows cinder and spatter	
Qll	Lanai Basalt		Lava flows	
Qlv	Lanai Basalt		Cinder and spatter	
Qlcr	Lanai Basalt		Pit craters from which little lava issue	
Qlbr	Lanai Basalt		Breccia filling eroded pit craters	
Qemul	East Molokai Volcanics	Upper member	Lava flows	
Qemuv	East Molokai Volcanics	Upper member	Vent deposits	
Qemud	East Molokai Volcanics	Upper member	Domes	

Table 4, cont. Integer values to encode polygons of the various stratigraphic units, and information about formation name, rock type, and age range.

Formation_name	Member_name	Rock_type	Age_range (for numbered units)
ast Molokai Volcanics	Upper member	Vent deposits (query)	
ast Molokai Volcanics	Lower member	Lava flows	
ast Molokai Volcanics	Lower member	Vent deposits	
ast Molokai Volcanics	Lower member	Caldera complex	
:alaupapa Volcanics		Lava flows	
:alaupapa Volcanics		Vent deposits	
uff of Mokuhooniki cone		Vent deposits	
Vest Molokai Volcanics		Lava flows	
Vest Molokai Volcanics		Vent deposits	
Vest Molokai Volcanics	Waiele and other late lava	Lava flows	
Vest Molokai Volcanics	Waiele and other late lava	Vent deposits	
Vaianae Volcanics	Palehua member	Lava flows	
Vaianae Volcanics	Palehua member	Vent deposits	
Vaianae Volcanics	Kamaileunu member	Lava flows	
Vaianae Volcanics	Kamaileunu member	Vent deposits	
Vaianae Volcanics	Kamaileunu member	Talus breccia	
Vaianae Volcanics	Kamaileunu member	Mauna Kuwale rhyodacite	
Vaianae Volcanics	Kamaileunu member	Icelandite lava flows	
Vaianae Volcanics	Kamaileunu member	Icelandite vent deposits	
Vaianae Volcanics	Lualualei member	Lava flows	
Vaianae Volcanics	Lualualei member	Vent deposits	
:olekole Volcanics		Lava flows	
:olekole Volcanics		Vent deposits	
:olekole Volcanics		Conglomerate	
:oolau Basalt		Lava flows	
:oolau Basalt	Dike complex	Closely spaced dikes and wallrock	
:oolau Basalt	Breccia deposits	Breccia deposits	
:oolau Basalt	Kailua member	Lava flows	
:oolau Basalt	Kailua member	Dike complex	
[onolulu Volcanics		Lava flows	
[onolulu Volcanics		Vent deposits	
[onolulu Volcanics		Tuff	

Table 4, cont. Integer values to encode polygons of the various stratigraphic units, and information about formation name, rock type, and age range.

Formation_name	Member_name	Rock_type	Age_range (for numbered units)
lonolulu Volcanics	Tantalus vent	Vent deposits	
lonolulu Volcanics	Tantalus member	Lava flows	
lonolulu Volcanics	Koko member	Vent deposits	
lonolulu Volcanics	Koko member	Vent deposits	
lonolulu Volcanics		Breccia deposits	
/aimea Canyon Basalt	Makaweli Member	Lava flows	
/aimea Canyon Basalt	Makaweli Member	Vent deposits	
/aimea Canyon Basalt	Makaweli Member	Mokuone Breccia Beds	
/aimea Canyon Basalt	Haupu Member	Lava flows	
/aimea Canyon Basalt	Haupu Member	Breccia	
/aimea Canyon Basalt	Olokele Member	Lava flows	
/aimea Canyon Basalt	Olokele Member	Vent deposits	
/aimea Canyon Basalt	Olokele Member	Breccia	
/aimea Canyon Basalt	Napali Member	Lava flows	
/aimea Canyon Basalt	Napili Member	Lava flows	
:oloa Volcanics		Pahoehoe and aa	
:oloa Volcanics		Vent deposits	
:oloa Volcanics		Tuff	
:oloa Volcanics		Ash	
:oloa Volcanics		Lava flows (query)	
:oloa Volcanics	Palikea Breccia member	Conglomerate	
:oloa Volcanics	Palikea Breccia member	Breccia and conglomerate	
:oloa Volcanics		Intrusive rocks	
aniau Basalt		Lava flows	
aniau Basalt		Shallow intrusive plug	
:iekie Volcanics		Lava flows	
:iekie Volcanics		Coarse near-vent fallout	