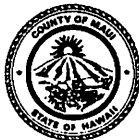


Council Chair  
Mike White

Vice-Chair  
Robert Carroll

Presiding Officer Pro Tempore  
Stacy Crivello

Councilmembers  
Alika Atay  
Elle Cochran  
Don S. Guzman  
Riki Hokama  
Kelly T. King  
Yuki Lei K. Sugimura



**COUNTY COUNCIL**  
COUNTY OF MAUI  
200 S. HIGH STREET  
WAILUKU, MAUI, HAWAII 96793  
[www.MauiCounty.us](http://www.MauiCounty.us)

December 28, 2017

OFFICE OF THE  
COUNTY CLERK

2017 DEC 29 AM 11:04

RECEIVED

The Honorable Mike White  
Council Chair  
County of Maui  
Wailuku, Hawaii 96793

Dear Chair White:

**SUBJECT: AMENDMENTS TO BILL 117 (2017) DECLARING A  
MORATORIUM ON SAND MINING OF CENTRAL MAUI  
INLAND SAND (PAF 17-296)**

May I request the attached proposed amendments to Bill 117 (2017) entitled "A BILL FOR AN ORDINANCE ESTABLISHING A NEW CHAPTER 20.40, MAUI COUNTY CODE, DECLARING A MORATORIUM ON SAND MINING OF CENTRAL MAUI INLAND SAND," be placed on the next Council meeting agenda.

Sincerely,

A handwritten signature in cursive script that reads "Elle Cochran".

ELLE COCHRAN  
Councilmember

paf:mcc:17-296a

Enclosure

COUNTY COMMUNICATION NO. 18-12

MAUI COUNTY COUNCIL  
Amendment Summary Form

Legislation: Bill 117 (2017).

Proposer: Councilmember Elle Cochran *EC*

Description: Amend the definition of Central Maui Inland Sand and attach Exhibit "A" to clarify the definition of Qdo sand.

Motions: Move to amend section 20.40.020 by amending the definition for Central Maui Inland Sand by inserting the term "Qdo" and striking the phrase "classified Qdo by USGS" to read as follows:

"Central Maui inland sand" means Qdo inland sand located within the area shown on the map set forth in section 20.40.080.

and, further, to amend section 20.40.020 by amending the definition of Qdo by inserting the phrase "as classified by the United States Geologic Survey as referenced in Exhibit "A"" to read as follows:

"Qdo" means older dune deposits (Holocene and Pleistocene) as classified by the United States Geological Survey as referenced in Exhibit "A."

and, further, by attaching Exhibit "A," which includes a map entitled "Geological Map of the State of Hawaii, Sheet 7 – Island of Maui" and a document entitled "Metadata for Users of the Geologic Map of the State of Hawaii."

Effect: In Ramseyer format, the changes are as follows:

"Central Maui inland sand" means Qdo inland sand [classified Qdo by USGS] located within the area shown on the map set forth in section 20.40.080.

"Qdo" means older dune deposits (Holocene and Pleistocene) as classified by the United States Geological Survey as referenced in Exhibit "A."

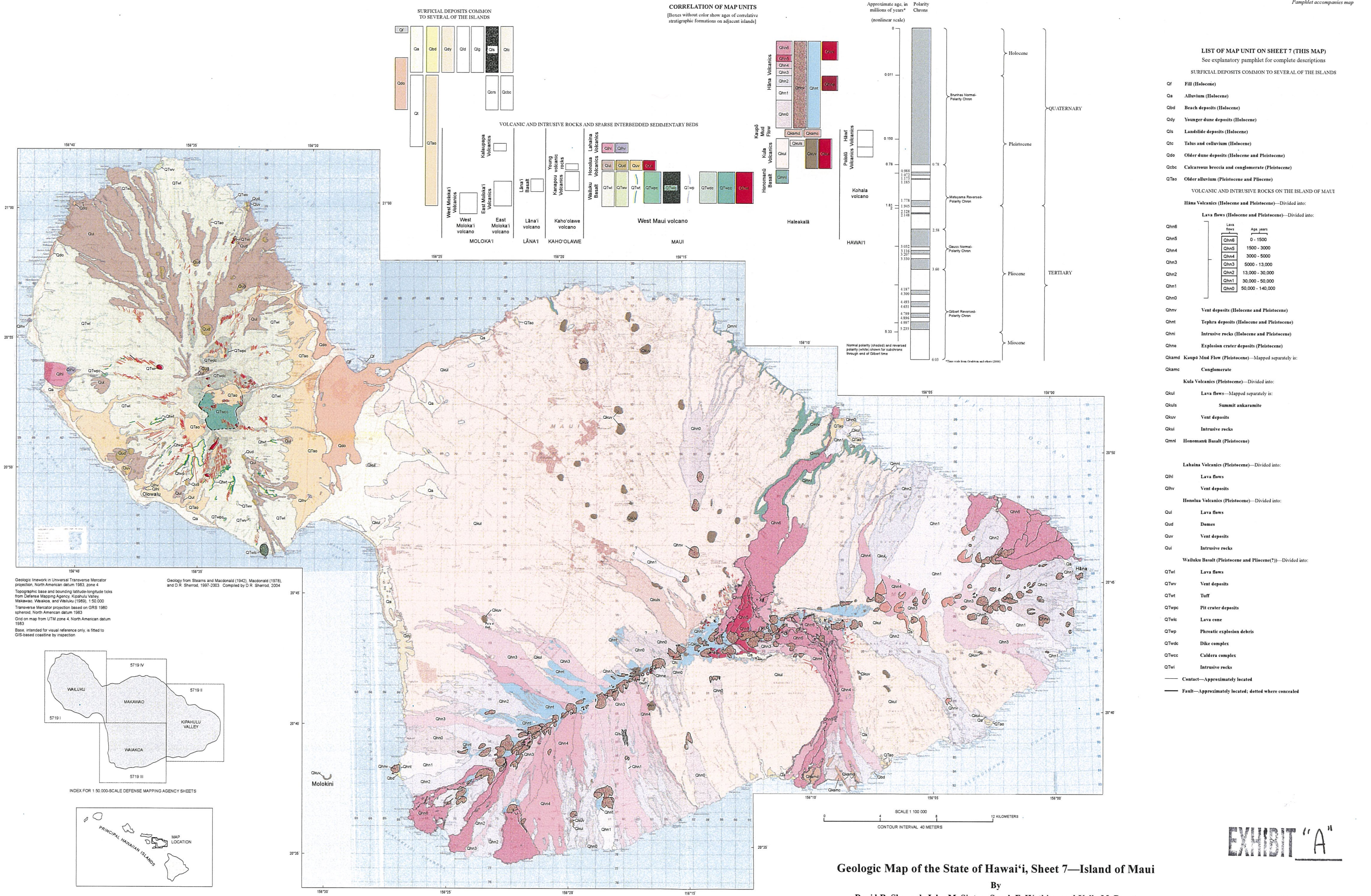
January 5, 2018 Council meeting

BILL 117 (2017)

Attachments: See attached Exhibit "A" as noted.

paf:mcc:17-296b





**LIST OF MAP UNIT ON SHEET 7 (THIS MAP)**

See explanatory pamphlet for complete descriptions

**SURFICIAL DEPOSITS COMMON TO SEVERAL OF THE ISLANDS**

- Qf Fill (Holocene)
- Qa Alluvium (Holocene)
- Qbd Beach deposits (Holocene)
- Qdy Younger dune deposits (Holocene)
- Qls Landslide deposits (Holocene)
- Qtc Talus and colluvium (Holocene)
- Qdo Older dune deposits (Holocene and Pleistocene)
- Qcbc Calcareous breccia and conglomerate (Pleistocene)
- QTao Older alluvium (Pleistocene and Pliocene)

**VOLCANIC AND INTRUSIVE ROCKS ON THE ISLAND OF MAUI**

Hāna Volcanics (Holocene and Pleistocene)—Divided into:

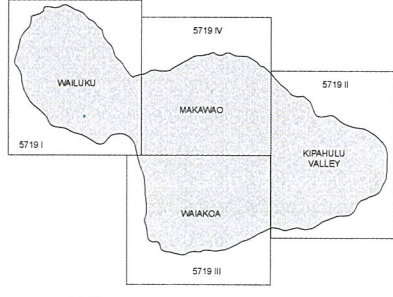
Lava flow	Age, years
Qhn6	0 - 1500
Qhn5	1500 - 3000
Qhn4	3000 - 5000
Qhn3	5000 - 13,000
Qhn2	13,000 - 30,000
Qhn1	30,000 - 50,000
Qhn0	50,000 - 140,000

- Qhvt Vent deposits (Holocene and Pleistocene)
- Qhnt Tephra deposits (Holocene and Pleistocene)
- Qhni Intrusive rocks (Holocene and Pleistocene)
- Qhne Explosion crater deposits (Pleistocene)
- Qkamd Kaupū Mud Flow (Pleistocene)—Mapped separately as: Conglomerate
- Qkmc Conglomerate
- Kula Volcanics (Pleistocene)—Divided into:
  - Qkul Lava flows—Mapped separately as: Summit ankaramite
  - Qkuv Vent deposits
  - Qkui Intrusive rocks
  - Qkmi Homomani Basalt (Pleistocene)

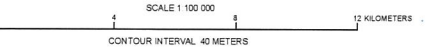
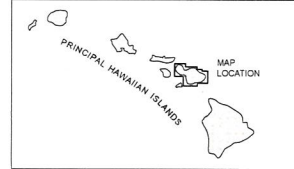
- Lahaina Volcanics (Pleistocene)—Divided into:
  - Qlhi Lava flows
  - Qlhv Vent deposits
- Honolua Volcanics (Pleistocene)—Divided into:
  - Qul Lava flows
  - Qud Dunes
  - Quv Vent deposits
  - Qui Intrusive rocks
- Waikapu Basalt (Pleistocene and Pliocene?)—Divided into:
  - QTwl Lava flows
  - QTwv Vent deposits
  - QTwf Tuff
  - QTwpc Pit crater deposits
  - QTwlc Lava cone
  - QTwpe Phreatic explosion debris
  - QTwde Dike complex
  - QTwcc Calders complex
  - QTwli Intrusive rocks

- QTwl Contact—Approximately located
- QTwl Fault—Approximately located; dotted where concealed

Geologic linework in Universal Transverse Mercator projection, North American datum 1983, zone 4. Topographic base and bounding latitude-longitude ticks from Defense Mapping Agency, Kīpahulu Valley, Makawao, Waiahoia, and Waikapu (1959), 1:50,000. Transverse Mercator projection based on GRS 1960 spheroid, North American datum 1983. Grid on map from UTM zone 4, North American datum 1983. Base, intended for visual reference only, is fitted to GIS-based coastline by inspection.



INDEX FOR 1:50,000-SCALE DEFENSE MAPPING AGENCY SHEETS



**Geologic Map of the State of Hawai'i, Sheet 7—Island of Maui**

By  
David R. Sherrod, John M. Sinton, Sarah E. Watkins, and Kelly M. Brunt  
2007

**EXHIBIT "A"**



# 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 topographic 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,

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

<b>Island</b>	<b>Volcano</b>	<b>Volcano abbreviation spelled out</b>
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

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 3.** Sources for unpublished data on geologic map, as reported in *Data\_source* column of GIS database files.

<b>Citation</b>	<b>Explanation</b>
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 Kahoolawe
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 O'ahu) 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 Kāne'ohe lava (of the Honolulu Volcanics) and determine that this sequence of flows is about 0.5 Ma (Ozawa and others, 2005), distinguishing 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 occurrences are found on the Island of Hawai'i. 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.

## 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

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

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 Hawai'i 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 <sup>40</sup>Ar/<sup>39</sup>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 charcoaled 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 <sup>40</sup>Ar/<sup>39</sup>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.

Strat_code	Unit_symbol	Formation_name	Member_name	Rock_type	Age_range (for numbered units)
209	Qk5	Kau Basalt		Lava flows	Age 0-200 yr
210	Qk4	Kau Basalt		Lava flows	Age 200-750 yr
211	Qk3	Kau Basalt		Lava flows	Age 750-1500 yr
212	Qk2	Kau Basalt		Lava flows	Age 1500-3000 yr
213	Qk1	Kau Basalt		Lava flows	Age 3000-11000 yr
214	Qk	Kau Basalt		Lava flows	Age greater than 11000 yr
215	Qkh	Kahuku Basalt		Lava flows	
216	Qn	Ninole Basalt		Lava flows	
217	Qk1y	Kau Basalt		Lava flows	Age 3000-5000 yr
218	Qk1o	Kau Basalt		Lava flows	Age 5000-11000 yr
219	Qkld5	Kau Basalt		Littoral deposits	Age 0-200 yr
220	Qkld4	Kau Basalt		Littoral deposits	Age 200-750 yr
221	Qkld3	Kau Basalt		Littoral deposits	Age 750-1500 yr
222	Qkld2	Kau Basalt		Littoral deposits	Age 1500-3000 yr
223	Qkld1	Kau Basalt		Littoral deposits	Age 3000-11000 yr
224	Qka3	Kau Basalt		Ash	Age 750-1500 yr
301	Qhc5	Hualalai Volcanics		Spatter or tuff cones	Age 0-200 yr
302	Qhc4	Hualalai Volcanics		Spatter or tuff cones	Age 200-750 yr
303	Qhc3	Hualalai Volcanics		Spatter or tuff cones	Age 750-1500 yr
304	Qhc2	Hualalai Volcanics		Spatter or tuff cones	Age 1500-3000 yr
305	Qhc1y	Hualalai Volcanics		Spatter or tuff cones	Age 3000-5000 yr
306	Qhc1o	Hualalai Volcanics		Spatter or tuff cones	Age 5000-11000 yr
307	Qhc	Hualalai Volcanics		Spatter or tuff cones	Age greater than 11000 yr
308	Qh5	Hualalai Volcanics		Lava flows	Age 0-200 yr
309	Qh4	Hualalai Volcanics		Lava flows	Age 200-750 yr
310	Qh3	Hualalai Volcanics		Lava flows	Age 750-1500 yr
311	Qh2	Hualalai Volcanics		Lava flows	Age 1500-3000 yr
312	Qh1y	Hualalai Volcanics		Lava flows	Age 3000-5000 yr
313	Qh1o	Hualalai Volcanics		Lava flows	Age 5000-11000 yr
314	Qh	Hualalai Volcanics		Lava flows	Age greater than 11000 yr
315	Qha4	Hualalai Volcanics		Ash	Age 200-750 yr
316	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.

Strat_code	Unit_symbol	Formation_name	Member_name	Rock_type	Age_range (for numbered units)
401	Qlcy	Laupahoehoe Volcanics	Younger volcanic rocks member	Scoria cones	
402	Qlc	Laupahoehoe Volcanics	Older volcanic rocks member	Scoria cones	
403	Qhmc	Hamakua Volcanics		Scoria cones	
404	Qlbc	Laupahoehoe Volcanics	Older volcanic rocks member	Scoria cones	
405	Qly	Laupahoehoe Volcanics	Younger volcanic rocks member	Lava flows	
406	Ql	Laupahoehoe Volcanics	Older volcanic rocks member	Lava flows	
407	Qhm	Hamakua Volcanics		Lava flows	
408	Qlb	Laupahoehoe Volcanics		Lava flows	
409	Qlay	Laupahoehoe Volcanics	Younger volcanic rocks member	Tephra deposits	
410	Qla	Laupahoehoe Volcanics	Older volcanic rocks member	Tephra deposits	
411	Qlmt	Laupahoehoe Volcanics	Makanaka Glacial Member	Till	
412	Qhmw	Hamakua Volcanics	Waihu Glacial Member	Till and outwash	
413	Qlmo	Laupahoehoe Volcanics	Makanaka Glacial Member	Outwash	
414	Qhpd	Hamakua Volcanics	Pohakuloa Glacial Member	Till and outwash	
501	Qhwc	Hawi Volcanics		Scoria cones	
502	Qplc	Pololu Volcanics		Scoria cones	
503	Qhwbc	Hawi Volcanics		Benmoreite scoria cones	
504	Qplmc	Pololu Volcanics		Mugearite scoria cones	
505	Qhwd	Hawi Volcanics		Lava domes	
506	Qpld	Pololu Volcanics		Lava dome	
507	Qhwbd	Hawi Volcanics		Benmoreite lava dome	
508	Qhwtd	Hawi Volcanics		Trachytic lava dome	
509	Qhw	Hawi Volcanics		Lava flows	
510	Qpl	Pololu Volcanics		Lava flows	
511	Qhwb	Hawi Volcanics		Benmoreite lava flows	
512	Qplm	Pololu Volcanics		Mugearite lava flows	
513	Qhwt	Hawi Volcanics		Lava flows	
514	Qhwa	Hawi Volcanics		Tephra deposits	
601	Qt	Tephra deposits		Dunes downwind of Lehua Island cone	
701	Qf	Fill		Manmade fill	
702	Qls	Landslide deposits		Landslide deposits	
703	Qa	Alluvium		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.

Strat_code	Unit_symbol	Formation_name	Member_name	Rock_type	Age_range (for numbered units)
707	Qtc	Talus and colluvium		Sand and gravel	
708	Qld	Lacustrine deposits		Calcareous silt and fine-grained sand	
710	Qbd	Beach deposits		Sand and gravel	
711	Qdy	Younger dune deposits		Sand dunes	
712	Qlg	Lagoon deposits		Silt sand and marl	
713	QTao	Older alluvium		Sand and gravel	
713	QTao	Older alluvium		Sand and gravel partly lithified	
714	Qdo	Older dune deposits		Sand dunes	
715	Qcrs	Lagoon and reef deposits		Limestone and mudstone	
716	Qcbc	Marine conglomerate and breccia		Fossiliferous breccia	
1111	Qmnl	Honomanu Basalt		Lava flows	
1211	Qkul	Kula Volcanics		Lava flows	
1212	Qkuv	Kula Volcanics		Cinder and spatter	
1214	Qkuk	Kula Volcanics	Kumuiliahi member	Lava flows	
1215	Qkuv?	Kula Volcanics		Vent deposits (query)	
1216	Qkuv?	Kula Volcanics		Cinder and spatter	
1217	Qkul?	Kula Volcanics		Lava flows	
1218	Qkuls	Kula Volcanics	Ankaramite of Summit House	Lava flows	
1219	Qkui	Kula Volcanics		Intrusive plugs	
1301	Qkamd	Kaupo Mud Flow		Debris-avalanche deposits	
1302	Qkamc	Kaupo Mud Flow		Conglomerate and sandstone	
1401	Qhn6	Hana Volcanics		Lava flows	Age 0-1500 yr
1402	Qhmv6	Hana Volcanics		Cinder and spatter	Age 0-1500 yr
1451	Qhn5	Hana Volcanics		Lava flows	Age 1500-3000 yr
1452	Qhmv5	Hana Volcanics		Cinder and spatter	Age 1500-3000 yr
1501	Qhn4	Hana Volcanics		Lava flows	Age 3000-5000 yr
1502	Qhmv4	Hana Volcanics		Cinder and spatter	Age 3000-5000 yr
1551	Qhn3	Hana Volcanics		Lava flows	Age 5000-13000 yr
1552	Qhmv3	Hana Volcanics		Cinder and spatter	Age 5000-13000 yr
1601	Qhn2	Hana Volcanics		Lava flows	Age 13000-30000 yr
1602	Qhmv2	Hana Volcanics		Cinder and spatter	Age 13000-30000 yr
1651	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.

Strat_code	Unit_symbol	Formation_name	Member_name	Rock_type	Age_range (for numbered units)
1701	Qhn0	Hana Volcanics		Lava flows	Age 50000-140000 yr
1702	Qhn0v	Hana Volcanics		Cinder and spatter	Age 50000-140000 yr
1902	Qhnv	Hana Volcanics		Cinder and spatter	
1903	Qhne	Hana Volcanics		Explosion crater deposits	
1911	Qhnt	Hana Volcanics		Tephra poorly to nonindurated	
1919	Qhni	Hana Volcanics		intrusion	
2101	QTwl	Wailuku Volcanics		Lava flows	
2102	QTwv	Wailuku Volcanics		Cinder and spatter	
2104	QTwpc	Wailuku Volcanics		Pit crater	
2105	QTwlc	Wailuku Volcanics		Near-vent lava flows	
2107	QTwdc	Wailuku Volcanics		Dike complex	
2108	QTwcc	Wailuku Volcanics		Caldera complex	
2109	QTwi	Wailuku Volcanics		Intrusive rocks	
2201	Qul	Honolua Volcanics		Lava flows	
2202	Quv	Honolua Volcanics		Cinder and spatter	
2203	Qud	Honolua Volcanics		Bulbous dome of massive lava	
2401	Qlhl	Lahaina Volcanics		Lava flows	
2402	Qlhv	Lahaina Volcanics		Vent deposits	
3101	Qyvk	Young volcanic rocks of Kahoolawe		Lava flows and cinder deposits	
3111	Qnpl	Kanapou Volcanics		Lava flows	
3112	Qnpv	Kanapou Volcanics		Cinder spatter and lava flows	
3113	Qnpcl	Kanapou Volcanics		Lava flows	
3114	Qnpct	Kanapou Volcanics		Indurated fallout tephra	
3115	Qnppl	Kanapou Volcanics		Lava flows	
3116	Qnppv	Kanapou Volcanics		Lava flows cinder and spatter	
3201	Qll	Lanai Basalt		Lava flows	
3202	Qlv	Lanai Basalt		Cinder and spatter	
3203	Qlcr	Lanai Basalt		Pit craters from which little lava issue	
3204	Qlbr	Lanai Basalt		Breccia filling eroded pit craters	
3301	Qemul	East Molokai Volcanics	Upper member	Lava flows	
3302	Qemuv	East Molokai Volcanics	Upper member	Vent deposits	
3303	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.

Strat_code	Unit_symbol	Formation_name	Member_name	Rock_type	Age_range (for numbered units)
3305	Qemuv?	East Molokai Volcanics	Upper member	Vent deposits (query)	
3321	QTemll	East Molokai Volcanics	Lower member	Lava flows	
3322	QTemlv	East Molokai Volcanics	Lower member	Vent deposits	
3323	QTemlcc	East Molokai Volcanics	Lower member	Caldera complex	
3351	Qppl	Kalaupapa Volcanics		Lava flows	
3352	Qppv	Kalaupapa Volcanics		Vent deposits	
3353	Qmv	Tuff of Mokuhooniki cone		Vent deposits	
3401	QTwml	West Molokai Volcanics		Lava flows	
3402	QTwmv	West Molokai Volcanics		Vent deposits	
3403	QTwmw	West Molokai Volcanics	Waiele and other late lava	Lava flows	
3404	QTwmwv	West Molokai Volcanics	Waiele and other late lava	Vent deposits	
4101	Tapl	Waianaean Volcanics	Palehua member	Lava flows	
4102	Tapv	Waianaean Volcanics	Palehua member	Vent deposits	
4121	Takl	Waianaean Volcanics	Kamaileunu member	Lava flows	
4122	Takv	Waianaean Volcanics	Kamaileunu member	Vent deposits	
4131	Takbr	Waianaean Volcanics	Kamaileunu member	Talus breccia	
4141	Takmk	Waianaean Volcanics	Kamaileunu member	Mauna Kuwale rhyodacite	
4151	Takil	Waianaean Volcanics	Kamaileunu member	Icelandite lava flows	
4152	Takiv	Waianaean Volcanics	Kamaileunu member	Icelandite vent deposits	
4161	Tall	Waianaean Volcanics	Lualualei member	Lava flows	
4162	Talv	Waianaean Volcanics	Lualualei member	Vent deposits	
4171	Talel	Kolekole Volcanics		Lava flows	
4172	Talev	Kolekole Volcanics		Vent deposits	
4173	Talec	Kolekole Volcanics		Conglomerate	
4401	QTkl	Koolau Basalt		Lava flows	
4421	QTkdc	Koolau Basalt	Dike complex	Closely spaced dikes and wallrock	
4431	Tkbr	Koolau Basalt	Breccia deposits	Breccia deposits	
4441	QTkkl	Koolau Basalt	Kailua member	Lava flows	
4451	QTkkdc	Koolau Basalt	Kailua member	Dike complex	
4601	Qol	Honolulu Volcanics		Lava flows	
4602	Qov	Honolulu Volcanics		Vent deposits	
4603	Oot	Honolulu 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.

<b>Strat_code</b>	<b>Unit_symbol</b>	<b>Formation_name</b>	<b>Member_name</b>	<b>Rock_type</b>	<b>Age_range (for numbered units)</b>
4612	Qott	Honolulu Volcanics	Tantalus vent	Vent deposits	
4621	Qokl	Honolulu Volcanics	Tantalus member	Lava flows	
4622	Qokt	Honolulu Volcanics	Koko member	Vent deposits	
4623	Qoks	Honolulu Volcanics	Koko member	Vent deposits	
4630	Qobr	Honolulu Volcanics		Breccia deposits	
5101	Twml	Waimea Canyon Basalt	Makaweli Member	Lava flows	
5102	Twmv	Waimea Canyon Basalt	Makaweli Member	Vent deposits	
5111	Twmm	Waimea Canyon Basalt	Makaweli Member	Mokuone Breccia Beds	
5121	Twhl	Waimea Canyon Basalt	Haupu Member	Lava flows	
5123	Twhb	Waimea Canyon Basalt	Haupu Member	Breccia	
5131	Twol	Waimea Canyon Basalt	Olokele Member	Lava flows	
5132	Twov	Waimea Canyon Basalt	Olokele Member	Vent deposits	
5133	Twob	Waimea Canyon Basalt	Olokele Member	Breccia	
5141	Twnl	Waimea Canyon Basalt	Napali Member	Lava flows	
5142	Twnv	Waimea Canyon Basalt	Napili Member	Lava flows	
5401	QTkol	Koloa Volcanics		Pahoehoe and aa	
5402	QTkov	Koloa Volcanics		Vent deposits	
5403	QTkot	Koloa Volcanics		Tuff	
5404	QTkoa	Koloa Volcanics		Ash	
5405	QTkol?	Koloa Volcanics		Lava flows (query)	
5480	QTkop	Koloa Volcanics	Palikea Breccia member	Conglomerate	
5481	QTkop?	Koloa Volcanics	Palikea Breccia member	Breccia and conglomerate	
5499	QTkoi	Koloa Volcanics		Intrusive rocks	
5801	Tpl	Paniau Basalt		Lava flows	
5809	Tpi	Paniau Basalt		Shallow intrusive plug	
5851	QTekl	Kiekie Volcanics		Lava flows	
5852	QTekv	Kiekie Volcanics		Coarse near-vent fallout	