DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1091–G

## DISCUSSION

This map, inclusive of data through 1984, is the seventh and last of a series of maps showing the distribution, composition, and age of late Cenozoic volcanoes and volcanic rocks of the United States. Designed primarily as a guide for exploration and evaluation of igneous-related geothermal resources, this map series also should be useful as a base for evaluation of volcanic hazards, for studies of volcanology and volcanotectonics, and for studies of the general geology of volcanic rocks. Because few or no reliable data were available for many areas, this series of maps is, to a considerable degree, our interpretation of the general age and composition of the volcanic rocks. Thus, current gaps in the data may be located by the combined use of the data source and reliability diagrams (figs. 1 and 2).

In the earlier maps of this series (Luedke and Smith, 1978a, 1978b, 1981, 1982, 1983, 1986), the late Cenozoic was designated to extend from 16±1 Ma to the present. This time cutoff was chosen because, in the western conterminous United States, a widespread change in the state of volcanism (and tectonism) occurred at about that time. The same time interval on the earlier maps of the series has been retained for this map. We recognize that, geodynamically, this time frame has less meaning for Hawaii and Alaska than for the western conterminous United States. The principal islands of Hawaii were constructed mostly within the last five million years.

Within this late Cenozoic time interval, the ages of the volcanic rocks are arbitrarily divided into three periods: 0–5 Ma, 5–10 Ma, and 10–16±1 Ma. The time increment from the present to 1 Ma is further subdivided by use of colored vent symbols; vents older than 1 Ma are shown in black. All older K-Ar ages have been recalculated using the conversion tables of Dalrymple (1979) to conform with the recommended new set of decay and abundance constants.

The volcanic rocks, including some hypabyssal rocks, have been classified into five major types based primarily upon their known or assumed silica content. This nongenetic rock-classification scheme permits use of current Hawaiian rock names, permits easier and meaningful comparisons with other maps of the series, and emphasizes dominant rock types:

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|---|---|
| 1. Feldspathoidal basalts, including basanite, ankaramite, tephrite, nephelinite, melilitite | Less than 46 percent $SiO_2$ |
| 2. Basalts, tholeiitic and alkalic (including alkali-olivine basalt, hawaiite, mugearite) | 46–54 percent $SiO_2$ |
| 3. Benmoreite | 54–62 percent $SiO_2$ |
| 4. Trachyte, including rhyodacite | 62–70 percent $SiO_2$ |
| 5. (Not applicable) | Greater than 70 percent $SiO_2$ |

This classification is a compromise between the simple silicic-basic distinction that is considered to be significant for geothermal purposes (Smith and Shaw, 1975, 1979) and a more detailed classification that would be desirable for purely volcanological or petrological purposes.

On the other maps in this series, less commonly identified alkalic rocks were combined for classification on the basis of their silica content with the major rock types represented. In the Hawaiian Islands, however, rock units of the alkalic and nephelinitic rock suites are of great importance in addition to those of the dominantly tholeiitic suite (Macdonald, 1968). In keeping with the established usage of Hawaiian rock-suite terminology and at the same time maintaining our scheme of rock portrayal (based on silica-content), rocks of the alkalic suite (including only those members of the suite within the silica range of 46 to 54 percent) are distinguished by use of a pattern on the maps. The more evolved members of the alkalic suite are distinguished by their map color; rocks of alkalic composition in the nephelinitic suite also are distinguished by their map color.

Rocks of tholeiitic and alkalic character are interbedded within a thin transition zone where observable in the Hawaiian volcanoes. A long time interval, marked by an erosional unconformity, separates rocks of the nephelinitic suite from rocks of other suites. Because much of the available geologic mapping in the Hawaiian Islands is of a reconnaissance nature and the mentioned transition zone is not distinguished on most current geologic maps, many of the mapped units shown on this map therefore consist predominantly of rocks of a major suite but often include some rocks of another suite.

The life history of the subaerial part of the shield volcanoes in the principal Hawaiian Islands (Kauai to Hawaii), begins with rapid eruption of and consists of dominantly tholeiitic lava which may or may not be followed by a late-stage capping of alkalic lava. The building from the sea floor of the tholeiitic phase occurs within a short time of 0.5 to 1.5 Ma (Jackson and others, 1972). The posterosional nephelinitic lavas which follow the main shield building, such as on the island of Oahu, occur after a span of perhaps several million more years (Dalrymple and others, 1980), but not all of the volcanoes enter that stage before dying. Clague and others (1982, fig. 4) show this erosional time interval becoming shorter as volcanism progressed southeastward from Kauai to Maui. A recent suggestion, however, by Moore and others (1982) from their studies of dredge samples from Loihi seamount south of the island of Hawaii, is that Hawaiian volcano growth may begin with alkalic basalt eruptions.

Active and migratory volcanism in Hawaii, at the southeast end of the Hawaiian-Emperor volcanic chain (fig. 3), is currently explained by postulating a melting anomaly or "hotspot" plume, located in the deep mantle, which is overridden by a northwest-moving oceanic plate (Wilson, 1963). Using time-distance-volume data, Jackson and others (1972), Dalrymple and others (1974, 1980), and Shaw and others (1980) have shown that the southeastward progression of volcanic activity along the Hawaiian-Emperor chain has been episodic. Furthermore, a general eastward rate increase of volcanic activity appears to have occurred in the last five million years; that is, progressively shorter times were required for growth of shields down the chain from Kauai to Kilauea. J.G. Moore (1985, oral commun.), however, suggests this acceleration may be illusory and questions the validity of such a rate increase.

In general, considerable geologic mapping and numerous petrologic and other studies have been published on Hawaiian volcanoes, and many more similar and related studies are in progress. The large-scale inset maps, specifically the island of Hawaii, indicates where the most intensive work has been focused, including radiometric dating. There, two of the world's classic oceanic shield and volcanoes, Mauna Loa and Kilauea, are commonly in eruption (table 1) and have been monitored for more than 70 years by the Hawaiian Volcano Observatory, operated continuously by the U.S. Geological Survey since 1948.

In their assessment of igneous-related geothermal potential, Smith and Shaw (1975) specifically excluded oceanic shield volcanoes from their silicic-basic subdivisions of continental or arc volcanic systems. They concluded that the magma that forms the Hawaiian volcanoes rises from the mantle to the surface during periods of eruption with much of the conomitant heat being dispersed rather than stored, therefore not providing a useful or long-lived geothermal concentration of heat. They recognized, however, that the dominantly basaltic active Hawaiian shields do store magma at relatively shallow levels within the volcanic edifice itself, a condition that rarely occurs in any other type of volcano. Thus, in oceanic shields, some high-level magma chamber that feeds eruptions in the summit caldera of Kilauea also supplies shallow storage chambers in the rift zones that are longer-lived than the dike swarms that intermittently deliver lava to the surface in the rift systems, (Zablocki, 1976; Casadevall and Hazlett, 1983; Moore, 1983). These high-level storage chambers, even though geologically short lived, may provide geothermal potential for many years, although the element of volcanic risk may be great for costly hydroelectric development (Moore, 1983). Development of electric power, by present technology, is doubtful from any stored thermal bodies in Hawaiian volcanoes that have not erupted magma within the last few thousand years. Thus all subaerial volcanic systems except Kilauea, Mauna Loa, Hualali, Haleakala, and perhaps Mauna Kea are unlikely prospects. Low-temperature thermal domains possibly exploitable for other uses are more widespread (Thomas, 1983).

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* Geologic and geochronologic data
** Geochronologic data only (not shown in fig. 1)


Table 1.—Historic eruptions of Hawaiian volcanoes through July 20, 1986

[Numbers in parentheses indicate number of separate eruptions in that year]

| HALEAKALA Year | HALEAKALA Principal location | HUALALAI Year | HUALALAI Principal location | MAUNA LOA Year | MAUNA LOA Principal location | KILAUEA Year | KILAUEA Principal location |
|---|---|---|---|---|---|---|---|
| c. 1790 | S.W. rift | 1800? | N.W. rift | c. 1750 | N. flank | 1750? | E. rift |
| | | 1801 | N.W. rift | 1832 | Summit | 1790?(2) | Summit; E. rift |
| | | | | 1843 | N. flank | 1823 | S.W. rift |
| | | | | 1849 | Summit | 1832 | Summit |
| | | | | 1851 | Summit | 1840 | E. rift |
| | | | | 1852 | N.E. rift | 1868(2) | Summit; S.W. rift |
| | | | | 1855 | N.E. rift | 1877(2) | Summit; E. rift |
| | | | | 1859 | N. flank | 1884 | E. rift (submarine) |
| | | | | 1865 | Summit | 1885 | Summit |
| | | | | 1868 | S.W. rift | 1894(2) | Summit |
| | | | | 1870 | Summit | 1918 | Summit |
| | | | | 1871 | Summit | 1919(2) | Summit; S.W. rift |
| | | | | 1872 | Summit | 1921 | Summit |
| | | | | 1873(2) | Summit | 1922 | E. rift |
| | | | | 1875 | Summit | 1923 | E. rift |
| | | | | 1876 | Summit | 1924(2) | Summit |
| | | | | 1877(2) | Summit; W. flank (submarine) | 1927 | Summit |
| | | | | 1880(2) | Summit; N.E. rift | 1929(2) | Summit |
| | | | | 1887 | S.W. rift | 1930 | Summit |
| | | | | 1892 | Summit | 1931 | Summit |
| | | | | 1896 | Summit | 1934 | Summit |
| | | | | 1899 | N.E. rift | 1952 | Summit |
| | | | | 1903 | Summit | 1954 | Summit |
| | | | | 1907 | S.W. rift | 1955 | E. rift |
| | | | | 1914 | Summit | 1959 | Summit |
| | | | | 1916 | S.W. rift | 1960 | E. rift |
| | | | | 1919 | S.W. rift | 1961(4) | Summit; E. rift |
| | | | | 1926 | S.W. rift | 1962 | E. rift |
| | | | | 1933 | Summit | 1963(2) | E. rift |
| | | | | 1935 | N.E. rift | 1965(2) | E. rift |
| | | | | 1940 | Summit | 1967 | Summit |
| | | | | 1942 | N.E. rift | 1968(2) | E. rift |
| | | | | 1943 | Summit | 1969(2) | E. rift |
| | | | | 1949 | Summit | 1971(2) | Summit |
| | | | | 1950 | S.W. rift | 1973(2) | E. rift |
| | | | | 1975 | Summit; N.E. rift; S.W. rift | 1974(3) | Summit; S.W. rift |
| | | | | 1984 | Summit; N.E. rift; S.W. rift | 1975 | Summit |
| | | | | | | 1977 | E. rift |
| | | | | | | 1979 | E. rift |
| | | | | | | 1980 | E. rift |
| | | | | | | 1982(2) | Summit |
| | | | | | | 1983(12) | E. rift |
| | | | | | | 1984(16) | E. rift |
| | | | | | | 1985(11) | E. rift |
| | | | | | | 1986(7) | E. rift |

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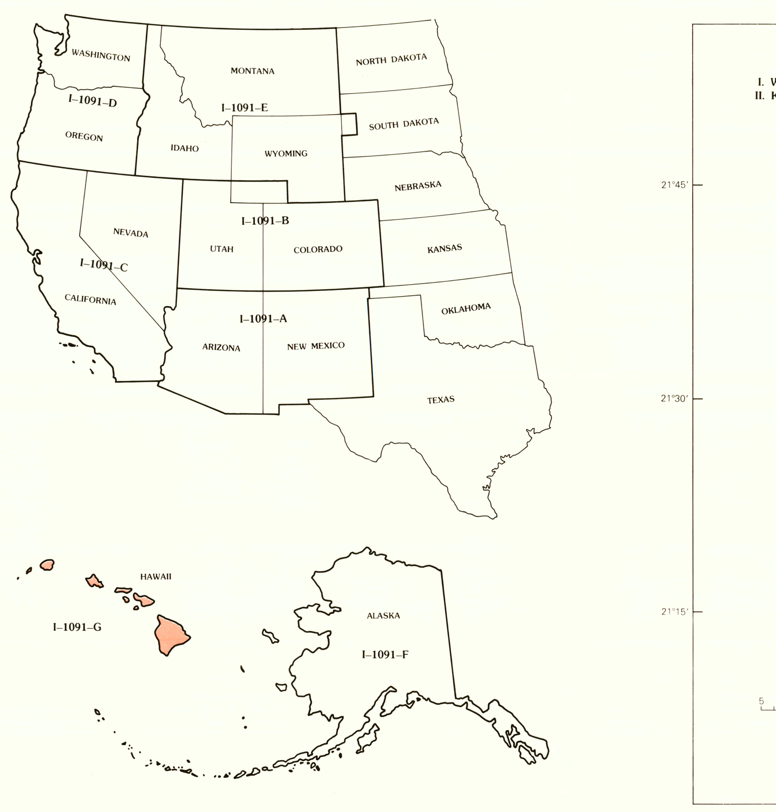
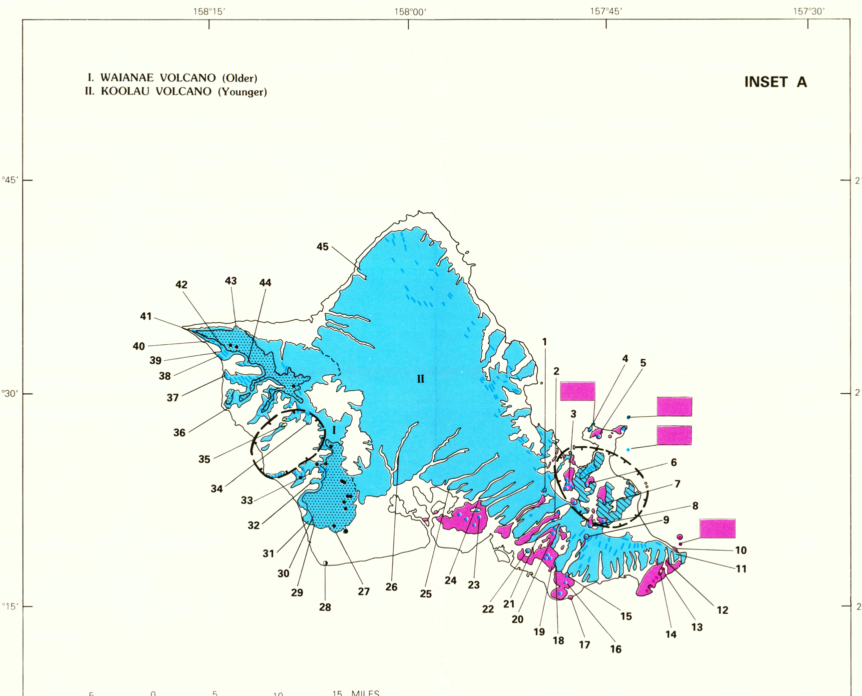
Simkin and others (1981)
U.S. Geological Survey, Hawaiian Volcano Observatory Staff, weekly and monthly reports




Index map showing location of map area (shaded)




EXPLANATION

- - - - - Contact between volcanoes
• Drill hole
3 ⟋ Number and leader indicate point source
Chiefly single and multiple dikes formed in caldera

1. 0.469 ± 0.011(19); 0.476 ± 0.022(19); 0.62 ± 0.04(28); 0.56 ± 0.03(28)
2. 0.427 ± 0.010(19); 0.433 ± 0.013(19); 0.35 ± 0.07(28); 0.39 ± 0.10(28)
3. 0.38 ± 0.15(28); 0.56 ± 0.08(28); 0.76 ± 0.04(28)
4. 0.83 ± 0.10(28); 0.75 ± 0.08(28); 0.56 ± 0.08(28); 3.62 ± 1.1(28)
5. 6.05 ± 1.86(28); 14.3 ± 2.34(28)
6. 0.869 ± 0.008(19); 0.883 ± 0.010(19); 1.04 ± 0.07(28); 0.47 ± 0.17(28); 1.00 ± 0.08(28); 1.00 ± 0.14(28)
7. 0.86 ± 0.15(28); 1.59 ± 0.22(28); 1.16 ± 0.23(28); 1.16 ± 0.11(28)
8. 1.73 ± 0.09(28); 2.09 ± 0.09(28); 2.20 ± 0.09(28)
9. 0.695 ± 0.023(19); 0.634 ± 0.009(19)
10. 0.032 ± 0.005(19); 0.034 ± 0.003(19); 0.052 ± 0.10(28); 0.26 ± 0.06(28); 0.21 ± 0.09(28); 0.33 ± 0.14(28); 0.41 ± 0.09(28)
11. 1.80 ± 0.42(12); 2.32 ± 0.45(12); 1.63 ± 0.13(12); 2.36 ± 0.47(12); 1.85 ± 0.31(12)
12. 0.0333 ± 0.0054(19); 0.0371 ± 0.0036(19)
13. >32,000B.P.(75); >32,000B.P.(75)
14. 0.0446 ± 0.0010(19); 0.0355 ± 0.0022(19); 5800–7000 + B.P.(13)
15. 0.38 ± 0.08(28); 0.44 ± 0.03(28)
16. 0.297 ± 0.007(19); 0.279 ± 0.010(19); 0.294 ± 0.012(19); 0.291 ± 0.019(19)
17. 0.295 ± 0.008(19); 0.296 ± 0.009(19); 0.325 ± 0.010(19); 0.43 ± 0.09(28); 0.60 ± 0.13(28); 0.41 ± 0.04(79); 0.48 ± 0.08(79)
18. 2.63 ± 0.18(12); 2.59 ± 0.08(44); 2.45 ± 0.07(47); 2.45 ± 0.06(47)
19. 0.9 ± 0.5(57)
20. 0.070 ± 0.003(19); 0.068 ± 0.003(19)
21. 2.67 ± 0.17(12); 2.10 ± 0.18(12)
22. 0.305 ± 0.006(19); 0.304 ± 0.010(19); 0.56 ± 0.08(28); 0.53 ± 0.03(28)
23. 0.442 ± 0.025(19); 0.458 ± 0.021(19); 0.429 ± 0.018(19)
24. 1.91 ± 0.14(12); 1.91 ± 0.16(12); 2.28 ± 0.07(44); 2.42 ± 0.07(47); 2.43 ± 0.06(47)
25. 2.01 ± 0.18(12); 1.45 ± 0.07(12); 2.29 ± 0.04(44); 2.14 ± 0.06(44); 2.21 ± 0.06(44)
26. 2.37(44)
27. 3.39 ± 0.10(12); 3.0 ± 0.1(18)
28. 4.1 ± 0.8(18); 3.5 ± 0.3(18)
29. 3.18 ± 0.10(12); 3.14 ± 0.08(12); 2.94(44); 2.88(44); 2.90(44); 2.92 ± 0.02(49)
30. 2.82(43); 2.80(43); 2.83 ± 0.02(49)
31. 3.33(44); 3.40(44); 3.36 ± 0.04(49)
32. 3.86 ± 0.28(12); 3.62 ± 0.26(12); 4.16 ± 0.17(12); 3.23 ± 0.18(12)
33. 1.75 ± 0.15(12); 2.70 ± 0.06(12); 2.84 ± 0.08(12); 3.20 ± 0.15(12); 2.68 ± 0.16(12); 2.68 ± 0.17(12); 3.8 ± 0.4(18); 3.6 ± 0.3(18); 3.1 ± 0.1(18); 3.0 ± 0.1(18)
34. 3.36(43); 3.75(43)
35. 8.48(43)*; 8.69(43)*; 2.4 ± 0.4(18); 3.4 ± 0.2(18); 3.1 ± 0.2(18); 4.4 ± 1.1(18); 2.4 ± 0.5(18); 3.2 ± 0.5(18); 2.4 ± 0.6(18)
36. 3.21(43); 3.01(43); 3.16(44); 3.04(44)
37. 16.5 ± 13.6(18); 6.2 ± 6.2(18); 11.2 ± 3.9(18)
38. 3.00(44); 3.06(44); 3.02(44); 3.03 ± 0.06(49)
39. 3.08 ± 0.16(12); 2.62 ± 0.14(12); 3.20 ± 0.23(12); 4.4 ± 0.6(18); 5.0 ± 0.6(18); 3.3 ± 0.4(18)
40. 3.03 ± 0.17(12); 3.43 ± 0.17(12)
41. 3.38 ± 0.22(12); 3.47 ± 0.30(12); 2.75 ± 0.06(12); 2.98 ± 0.12(12); 2.84(43); 2.82(43)
42. 2.3 ± 0.2(18); 2.7 ± 0.1(18)
43. 3.01 ± 0.06(12); 2.98 ± 0.08(12); 2.77 ± 0.24(12); 2.92 ± 0.05(47); 2.98 ± 0.05(47); 2.99 ± 0.03(47); 2.93 ± 0.03(47)
44. 2.2 ± 0.1(18); 2.7 ± 0.1(18)
45. 2.38 ± 0.17(12); 1.40 ± 0.06(12); 2.63(44); 2.19 ± 0.04(47); 2.30 ± 0.05(47); 2.33 ± 0.05(47)

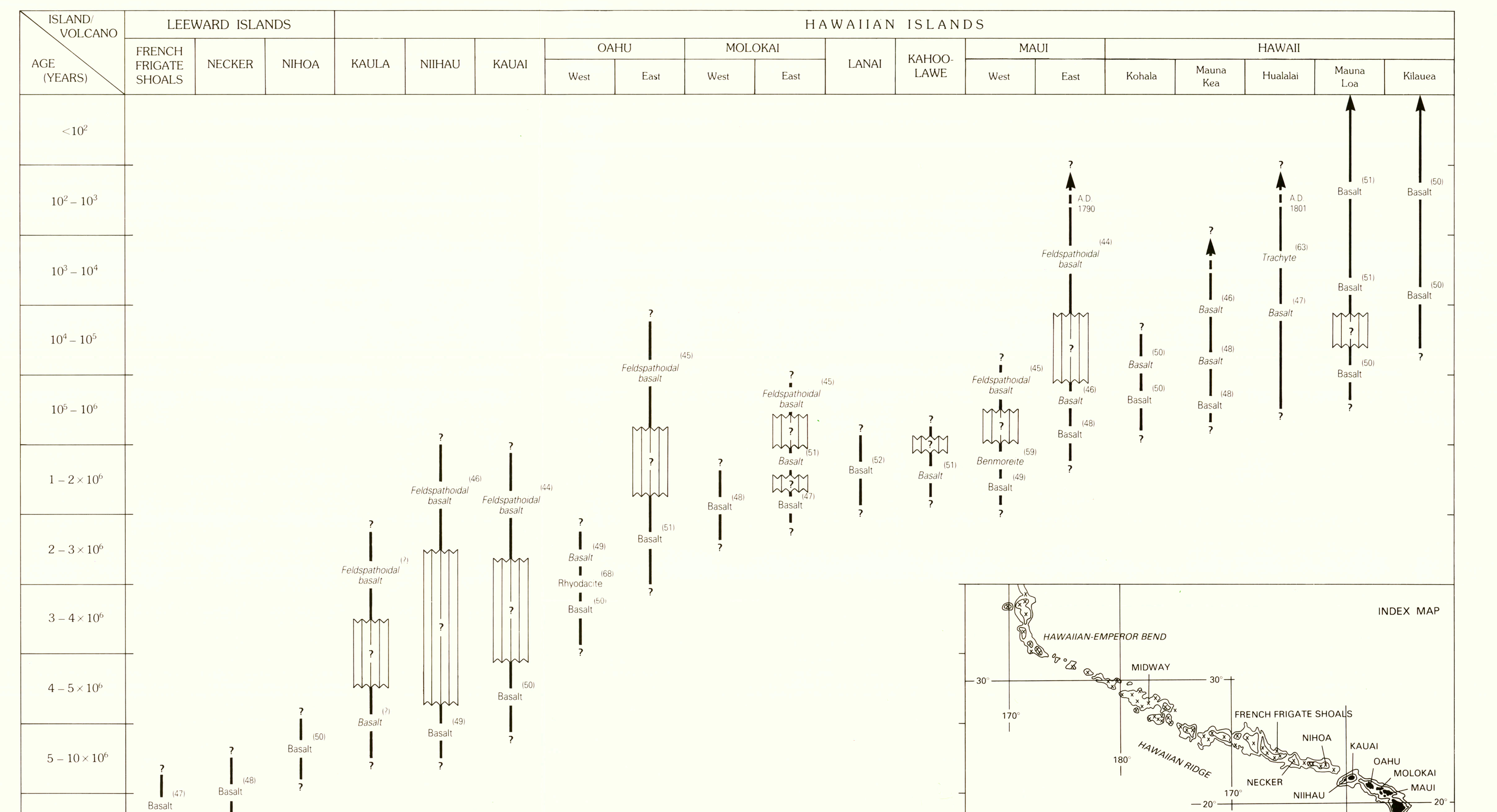



Figure 3.—Chart showing dominant rock types and their approximate age for the Hawaiian and easternmost Leeward Islands. Italicized rock names denote those of the alkalic suite versus that of the tholeiitic suite. Number in parentheses indicates average $SiO_2$ weight percent of lavas. Ruled spaces denote a hiatus or major erosional period. Queries denote uncertainty.

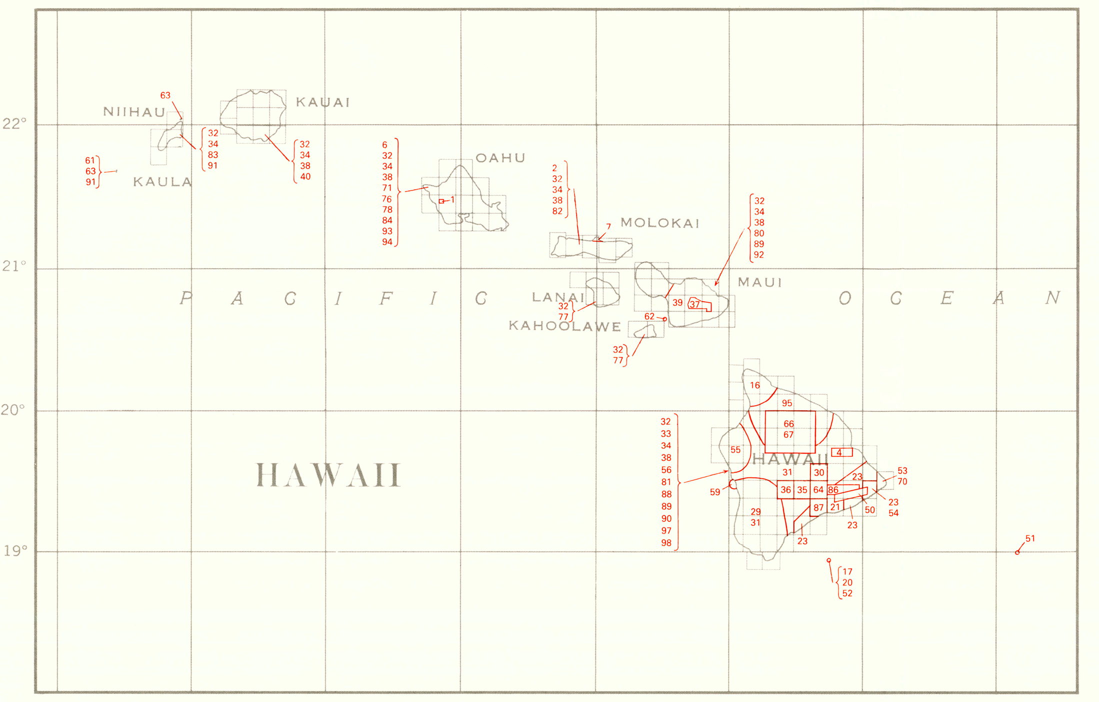



Figure 1.—Map showing principal sources of geologic, petrologic, and geochronologic data. The geology and vent information in some localities have been modified or supplemented through study and interpretation of topographic maps and aerial photographs. Where applicable, an original source is used and indicated, although it may have been in part superseded or incorporated in a more recent source. Numbers correspond to source reference list.

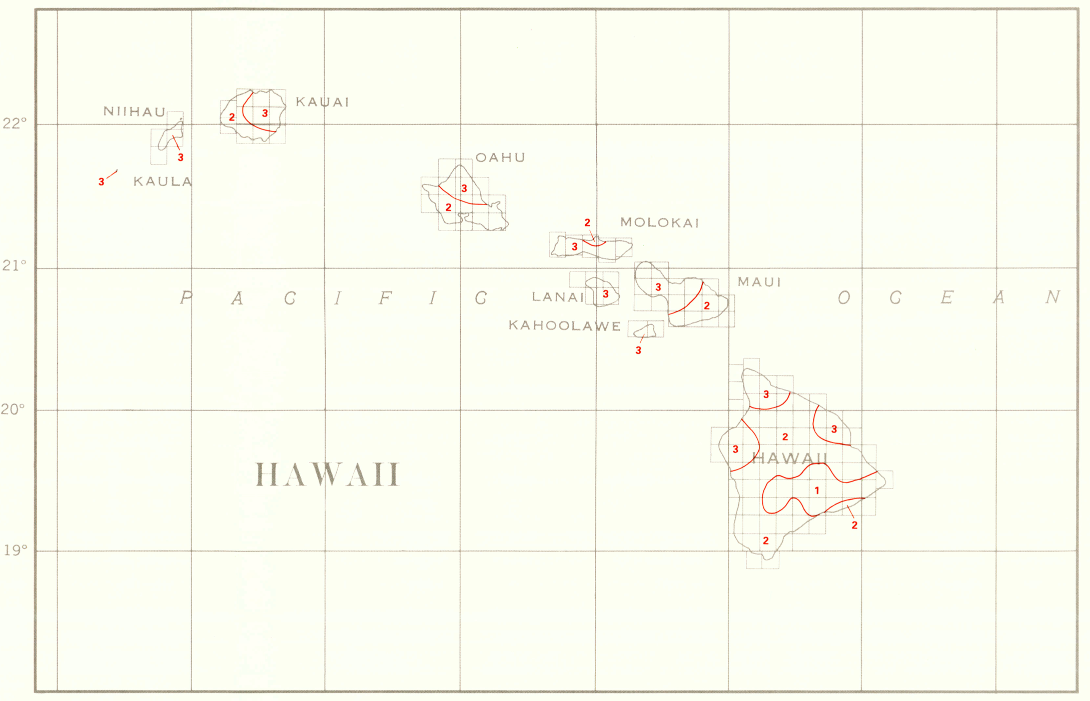
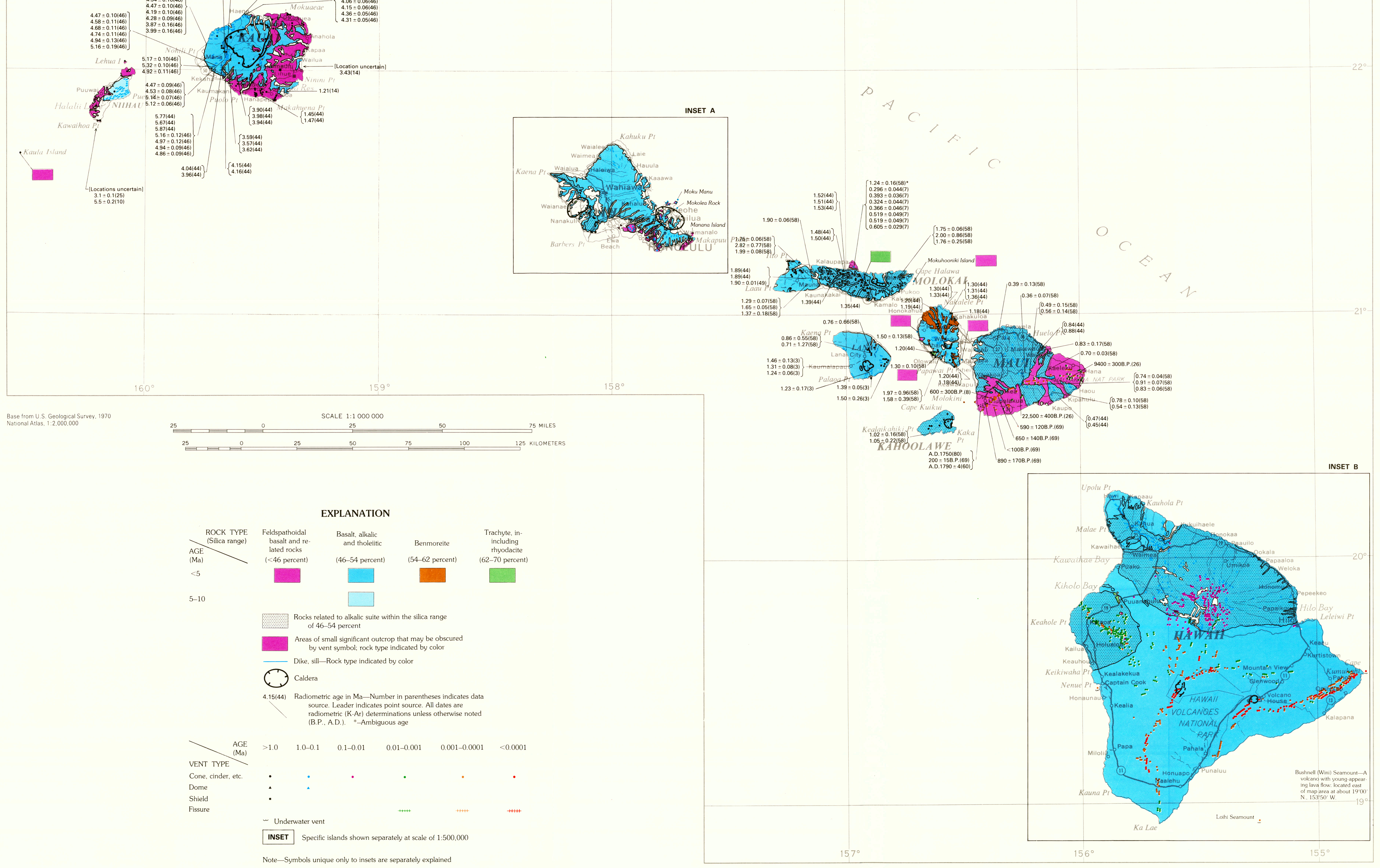



Figure 2.—Data reliability map for volcanic fields within the map area. Area rank is based on the availability of (a) detailed geologic maps, (b) detailed chemical and(or) petrographic data, and (c) adequate geochronologic data.
RANK 1—Must satisfy all above criteria. RANK 2—Must satisfy two of above criteria. RANK 3—Must satisfy one of above criteria.
This classification is in part subjective. Greatest weight is placed upon geologic maps; rock chemistry and(or) geochronologic data without detailed geologic relations and locations have minimal value. This reliability map emphasizes areas where geologic information is needed. Regardless of area rank, data gaps exist in all areas.




EXPLANATION

| ROCK TYPE (Silica range) / AGE (Ma) | Feldspathoidal basalt and related rocks (<46 percent) | Basalt, alkalic and tholeiitic (46–54 percent) | Benmoreite (54–62 percent) | Trachyte, including rhyodacite (62–70 percent) |
|---|---|---|---|---|
| <5 | [magenta] | [blue] | [orange] | [green] |
| 5–10 | | [light blue] | | |

Rocks related to alkalic suite within the silica range of 46–54 percent

Areas of small significant outcrop that may be obscured by vent symbol; rock type indicated by color

Dike, sill—Rock type indicated by color

Caldera

4.15(44) Radiometric age in Ma—Number in parentheses indicates data source. Leader indicates point source. All dates are radiometric (K-Ar) determinations unless otherwise noted (B.P., A.D.). *–Ambiguous age

| VENT TYPE / AGE (Ma) | >1.0 | 1.0–0.1 | 0.1–0.01 | 0.01–0.001 | 0.001–0.0001 | <0.0001 |
|---|---|---|---|---|---|---|
| Cone, cinder, etc. | • | • | • | • | • | • |
| Dome | ▲ | ▲ | | | | |
| Shield | ■ | | | | | |
| Fissure | | | | ++++ | ++++ | ++++ |

Underwater vent

INSET — Specific islands shown separately at scale of 1:500,000

Note—Symbols unique only to insets are separately explained

EXPLANATION

- - - - - - Contact of dated flows
1955 Date of historic flow
♦ Littoral cone
3 —— Number and leader indicate point source

### I. KOHALA VOLCANO

1. 0.346 ± 0.013(48)
2. 0.409 ± 0.024(48)
3. 0.232 ± 0.002(48)
4. 0.425 ± 0.018(48); 0.459 ± 0.027(48); 0.414 ± 0.141(48)
5. 0.152 ± 0.003(48); 0.162 ± 0.003(48); 0.154 ± 0.002(48); 139,000 ± 16,000B.P.(42)
6. 0.336 ± 0.045(48); 0.304 ± 0.089(48); 0.411 ± 0.060(48)
7. 0.00(14); 0.44(14); 0.97 ± 0.42(9); 1.31 ± 0.46(9); 0.47 ± 0.36(9); 0.74 ± 0.24(9); 0.62 ± 0.15(9)
8. 0.061 ± 0.001(48); 0.064 ± 0.002(48); 70,000 ± 14,350B.P.(42)
9. 0.208 ± 0.009(45); 0.195 ± 0.009(45); 195,000 ± 18,500B.P.(42)
10. 0.170 ± 0.005(45); 0.152 ± 0.003(45); 0.148 ± 0.003(45); 150,000 ± 13,000B.P.(42)
11. 0.153 ± 0.006(45); 0.141 ± 0.005(45); 0.139 ± 0.005(45); 150,000 ± 14,500B.P.(42)
12. 0.184 ± 0.003(48); 183,000 ± 19,000B.P.(52)
13. 0.186 ± 0.003(48); 95,000 ± 21,000B.P.(42)
14. 0.270 ± 0.005(48); 0.253 ± 0.005(48)
15. 0.157 ± 0.003(48)
16. 0.392 ± 0.016(48)
17. 0.411 ± 0.008(48)

### II. MAUNA KEA VOLCANO

1. 0.0811 ± 0.0236(68)
2. 0.0413 ± 0.0083(68)
3. 2270 ± 500B.P.(96); 7160 ± 500B.P.(96); 4130 ± 135B.P.(5); 5910 ± 170B.P.(5); 7540 ± 220B.P.(5); 7790 ± 270B.P.(5); 9080 ± 200B.P.(5); 4180 ± 600B.P.(41); 5500 ± 500B.P.(41); 6520 ± 300B.P.(26)
4. 0.1740 ± 0.0374(68)
5. 0.6 ± 0.3(57)
6. 0.1719 ± 0.0028(68)
7. 0.0695 ± 0.0026(68)
8. ≥0.1098 ± 0.0056(68); ≥0.1207 ± 0.0041(68); ≥0.1224 ± 0.0073(68)
9. 100 ± 200B.P.(26)
10. 4560 ± 110B.P.(65)
11. 4420 ± 110B.P.(65)
12. 1970 ± 200B.P.(26)
13. 4460 ± 110B.P.(65)
14. 4400 ± 110B.P.(65)
15. 4790 ± 70B.P.(65)
16. 845 ± 95B.P.(65); –12,000 ± 23,500B.P.(42)
17. 4470 ± 70B.P.(65)
18. 4500 ± 100B.P.(15)
19. 0.2785 ± 0.0685(68)
20. ≥0.0945 ± 0.0061(68)
21. ≥0.1141 ± 0.0076(68)
22. 0.1740 ± 0.0265(68)
23. 29,700 ± 500B.P.(15); 31,900 ± 550B.P.(15); 37,200 ± 1400B.P.(15)
24. 22,150 ± 250B.P.(15)
25. 0.3821 ± 0.0606(68)
26. 0.1014 ± 0.0152(68)

### III. HUALALAI VOLCANO

1. 9490 ± 100B.P.(55)
2. 3990 ± 70B.P.(55)
3. 12,230 ± 150B.P.(55)
4. 2030 ± 80B.P.(26)
5. 0.4 ± 0.3(57)
6. 3100 ± 80B.P.(55)
7. 300 ± 60B.P.(55)
8. 1180 ± 200B.P.(55)
9. 2390 ± 60B.P.(55)
10. 2670 ± 80B.P.(55)
11. 900 ± 110B.P.(55)
12. 8770 ± 200B.P.(55)
13. 2350 ± 80B.P.(55)
14. 710 ± 150B.P.(55)
15. 6360 ± 100B.P.(55)
16. 5350 ± 180B.P.(55)
17. 4390 ± 70B.P.(55)
18. 1330 ± 50B.P.(55)
19. 2290 ± 70B.P.(55)
20. 10,370 ± 150B.P.(55)
21. 12,950 ± 150B.P.(55)
22. 4720 ± 80B.P.(55)
23. 3600 ± 70B.P.(55)
24. <200B.P.(55)
25. <200B.P.(55)
26. 1030 ± 60B.P.(55)

### IV. MAUNA LOA VOLCANO

1. 220 ± 60B.P.(27)
2. 300 ± 60B.P.(27)
3. 300 ± 50B.P.(27)
4. 910 ± 70B.P.(27)
5. 580 ± 80B.P.(27)
6. 1690 ± 70B.P.(30)
7. 590 ± 50B.P.(30)
8. <200B.P.(30)
9. 620 ± 70B.P.(30)
10. 1320 ± 50B.P.(26)
11. 1490 ± 50B.P.(30)
12. 1400 ± 70B.P.(30)
13. 4070 ± 70B.P.(30)
14. 330 ± 60B.P.(30)
15. 880 ± 60B.P.(30)
16. 420 ± 70B.P.(27)
17. 450 ± 60B.P.(27)
18. 2550 ± 80B.P.(30)
19. 2190 ± 70B.P.(27)
20. 830 ± 60B.P.(27)
21. 2000 ± 150B.P.(72); 2070 ± 250B.P.(72)
22. 4050 ± 50B.P.(27)
23. 2890 ± 70B.P.(27)
24. 5650 ± 90B.P.(27)
25. 1380 ± 60B.P.(30)
26. 530 ± 60B.P.(27)
27. 420 ± 70B.P.(27)
28. Modern(27)
29. <200B.P.(27)
30. 230 ± 60B.P.(27)
31. 4210 ± 90B.P.(27)
32. 8550 ± 100B.P.(27)
33. 9500 ± 140B.P.(27)
34. 290 ± 70B.P.(27)
35. <200B.P.(27)
36. 2830 ± 60B.P.(27)
37. 1840 ± 60B.P.(27)
38. 1330 ± 70B.P.(27)
39. 2880 ± 70B.P.(27)
40. 600 ± 250B.P.(24); 4030 ± 350B.P.(24)
41. 4340 ± 80B.P.(27)
42. 1270 ± 60B.P.(27)
43. 2950 ± 80B.P.(27)
44. 1980 ± 80B.P.(27)
45. 2010 ± 70B.P.(27)
46. 3750 ± 70B.P.(27)
47. 1400 ± 60B.P.(27); 1470 ± 60B.P.(27)
48. 9170 ± 100B.P.(27)
49. 3900 ± 80B.P.(27)
50. 1810 ± 80B.P.(27)
51. 3900 ± 90B.P.(27); 5160 ± 100B.P.(27)
52. 2300 ± 60B.P.(27)
53. 3800 ± 90B.P.(27)
54. 7950 ± 110B.P.(27)
55. 2440 ± 60B.P.(27)
56. 26,410 ± 390B.P.(27)
57. 10,820 ± 90B.P.(27)
58. 2180 ± 60B.P.(27)
59. 10,290 ± 150B.P.(27)
60. 6160 ± 110B.P.(27)
61. 7300 ± 100B.P.(27); 13,210 ± 190B.P.(27)
62. 31,100 ± 900B.P.(27)
63. 10,140 ± 300B.P.(74)
64. 3740 ± 250B.P.(73); 3620 ± 250B.P.(85)
65. 11,780 ± 100B.P.(27)
66. 330 ± 70B.P.(26)
67. 490 ± 80B.P.(26)
68. 780 ± 70B.P.(26)
69. 740 ± 60B.P.(27)
70. 890 ± 60B.P.(27)
71. 3600 ± 70B.P.(26)
72. 740 ± 60B.P.(27)
73. 4770 ± 90B.P.(26)
74. <200B.P.(27)
75. 900 ± 60B.P.(26)
76. 0.07(14); 0.54(14)
77. 640 ± 45B.P.(27)
78. 1860 ± 70B.P.(27)
79. 2000 ± 70B.P.(27)
80. 590 ± 70B.P.(27)
81. 31,400 ± 1600B.P.(27)
82. 13,800 ± 300B.P.(55)
83. 1150 ± 200B.P.(55)

### V. KILAUEA VOLCANO

1. 340 ± 60B.P.(27); 1040 ± 70B.P.(27); 2080 ± 70B.P.(27)
2. 730 ± 80B.P.(27)
3. Modern(27)
4. 250–500B.P.(22)
5. 500–1000B.P.(22)
6. 1500–2000B.P.(22)
7. 310 ± 70B.P.(27); 2160 ± 70B.P.(27)
8. 250–500B.P.(22)
9. 250–500B.P.(22)
10. 260 ± 70B.P.(27)
11. 250–500B.P.(22)
12. 3690 ± 70B.P.(27)
13. 500–1000B.P.(22)
14. 500–1000B.P.(22)
15. 450 ± 60B.P.(27)
16. 250–500B.P.(22)
17. 500–1000B.P.(22)
18. 250–500B.P.(22)
19. 250–500B.P.(22)
20. 250–500B.P.(22)
21. 1500–2000B.P.(22)
22. 250–500B.P.(22)
23. 250–500B.P.(22)
24. 1500–2000B.P.(22)
25. 500–1000B.P.(22)
26. 250–500B.P.(22)
27. <200B.P.(27)
28. 250–500B.P.(22)
29. 250–500B.P.(22)
30. 1500–2000B.P.(22)
31. 1270 ± 70B.P.(54)
32. 500–1000B.P.(22)
33. 2000–2500B.P.(22)
34. c. 1000B.P.(22)
35. c. 1000B.P.(22)
36. 1500–2000B.P.(22)
37. 350 ± 60B.P.(27)
38. <200B.P.(72)
39. 1500–2000B.P.(22)
40. 1500–2000B.P.(22)
41. 1500–2000B.P.(22)
42. 1500–2000B.P.(22)
43. 1500–2000B.P.(22)
44. 450 ± 60B.P.(27)
45. c. 1000B.P.(22)
46. 500–1000B.P.(22)
47. <200B.P.(27); <200B.P.(27)
48. 500–1000B.P.(22)
49. 500–1000B.P.(22); 500–1000B.P.(22)
50. 250–500B.P.(22)
51. <200B.P.(27)
52. 250–500B.P.(22)
53. <200B.P.(27)
54. 500–1000B.P.(22)
55. 500–1000B.P.(22)
56. 22,500 ± 300B.P.(27); 17,360 ± 650B.P.(74)
57. 22,800 ± 340B.P.(27)
58. 6620 ± 150B.P.(27)
59. 250–500B.P.(22)
60. 500–1000B.P.(22)
61. 500–1000B.P.(22)
62. 1800 ± 80B.P.(27)
63. 500–1000B.P.(22)
64. 0–250B.P.(22)
65. <200B.P.(27)
66. 250–500B.P.(22)
67. 500–1000B.P.(22)
68. 3610 ± 60B.P.(27)
69. 330 ± 60B.P.(27)
70. 670 ± 60B.P.(27)
71. 210 ± 60B.P.(27)
72. 1000–1500B.P.(22)
73. 250–500B.P.(22)
74. 250–500B.P.(22)
75. 250–500B.P.(22)
76. 500–1000B.P.(22)
77. 250–500B.P.(22)
78. 450 ± 60B.P.(27)
79. 250–500B.P.(22)
80. 250–500B.P.(22)
81. 250–500B.P.(22)
82. 1130 ± 60B.P.(27); 3480 ± 80B.P.(27); 4820 ± 90B.P.(27); 10,680 ± 130B.P.(27)
83. 500–1000B.P.(22)
84. Modern(27); <200B.P.(27); <200B.P.(27)
85. 250–500B.P.(22)
86. 0–250B.P.(22)
87. 1500–2000B.P.(22)
88. 500–1000B.P.(22); 1500–2000B.P.(22)
89. 2500–250B.P.(75)
90. 350 ± 60B.P.(27)

# MAP SHOWING DISTRIBUTION, COMPOSITION, AND AGE OF LATE CENOZOIC VOLCANIC CENTERS IN HAWAII

By
Robert G. Luedke and Robert L. Smith

1988

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