DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATIONS SERIES
(SHEET 3 OF 3) MAP I–1091–F

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

By
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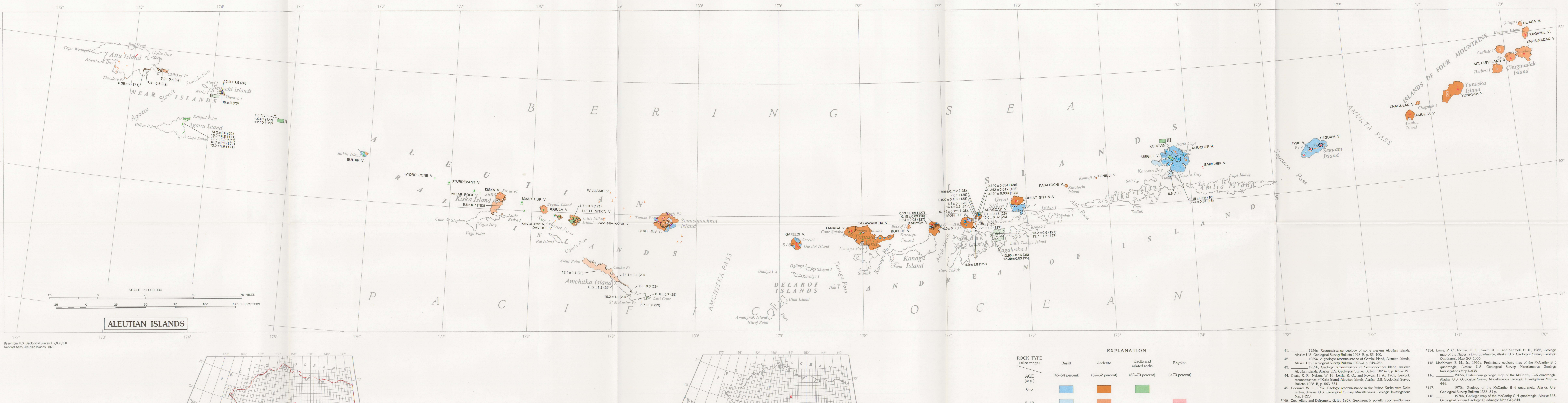
1986



Base from U.S. Geological Survey 1:2,000,000
National Atlas, Aleutian Islands, 1970

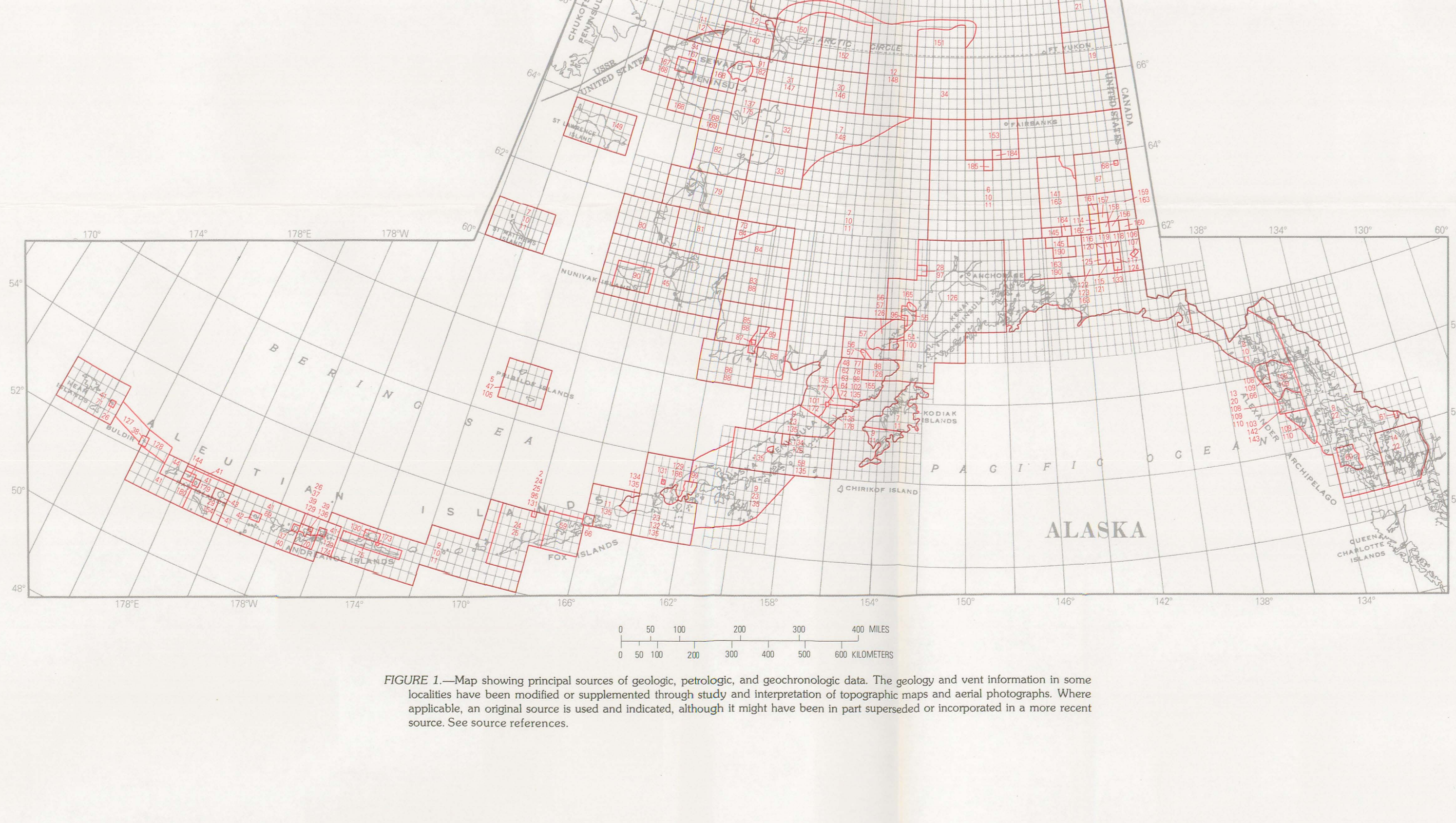


FIGURE 1.—Map showing principal sources of geologic, petrologic, and geochronologic data. The geology and vent information in some localities have been modified or supplemented through study and interpretation of topographic maps and aerial photographs. Where applicable, an original source is used and indicated, although it might have been in part superseded or incorporated in a more recent source.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

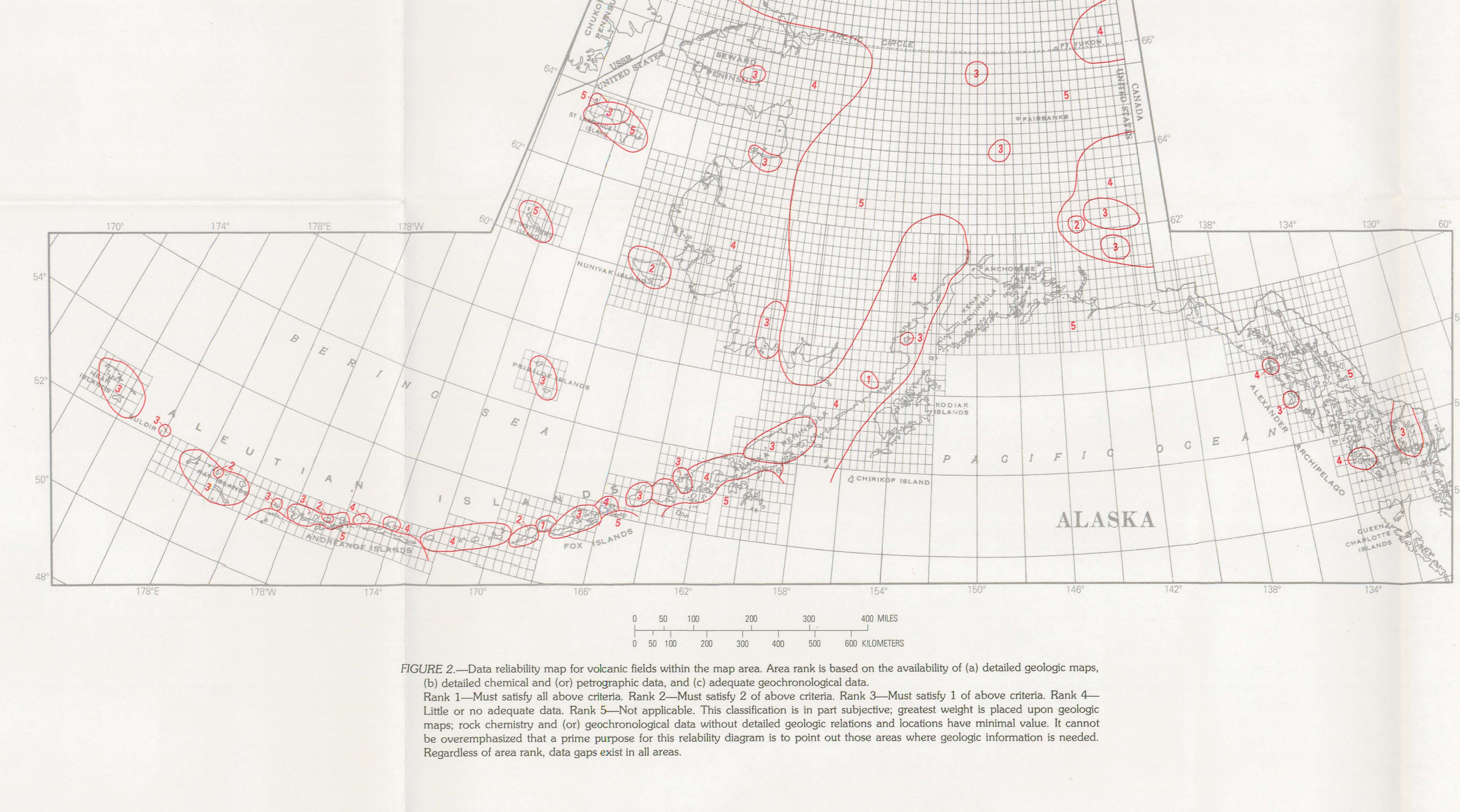


FIGURE 2.—Data reliability map for volcanic fields within the map area. Area rank is based on the availability of (a) detailed geologic maps, (b) detailed chemical and (or) petrographic data, and (c) adequate geochronological data.
Rank 1—Must satisfy all above criteria. Rank 2—Must satisfy 2 of above criteria. Rank 3—Must satisfy 1 of above criteria. Rank 4—Little or no adequate data. Rank 5—Not applicable. This classification is in part subjective; greatest weight is placed upon geologic maps; rock chemistry and (or) geochronological data without detailed geologic relations and locations have minimal value. It cannot be overemphasized that a prime purpose for this reliability diagram is to point out those areas where geologic information is needed. Regardless of area rank, data gaps exist in all areas.

EXPLANATION

ROCK TYPE (silica range) AGE (m.y.)	Basalt (46–54 percent)	Andesite (54–62 percent)	Dacite and related rocks (62–70 percent)	Rhyolite (>70 percent)
0–5	🟦	🟧	🟩	
5–10	🟦	🟧		🟥
10–16 +	🟦	🟧	🟩	

▨ Intrusive mass—Rock type and age indicated by color

— Dike, sill—Rock type indicated by color

◯ Caldera

15 ± 3 (26) Radiometric age in m.y.—Number in parentheses indicates data source. All data are radiometric (K-Ar) determinations unless otherwise noted. Leader indicates point source

Note—Potassium-argon ages are from original sources and are not recalculated using decay constants and isotopic abundance adopted by the International Union of Geological Sciences Commission on Geochronology, August 24, 1976

AGE (m.y.) VENT TYPE	>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	■					
Stratovolcano	✱	✱		✱	✱	✱
Maar				+		
Volcanic neck	×					

〰 Underwater vent

🟩 Areas of small but potentially significant, usually silicic outcrop (rhyolite or dacite) <5 m.y. old that may be obscured by vent symbol; rock type indicated by color
- I. Shemya Island, Aleutians (dacite)
- II. Dredge station, Aleutians (dacite)
- III. Atka Island, Aleutians (dacite)

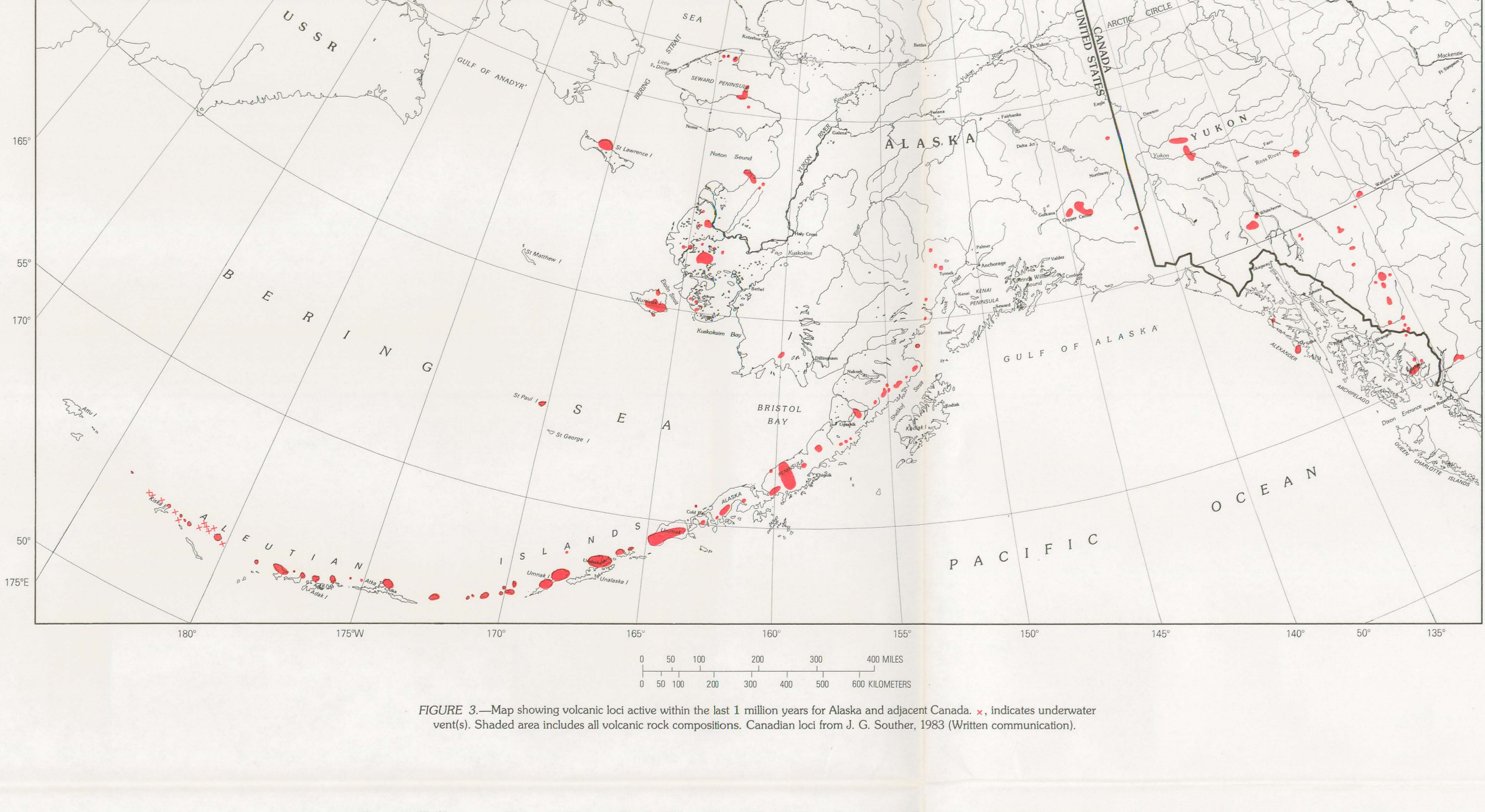


FIGURE 3.—Map showing volcanic loci active within the last 1 million years for Alaska and adjacent Canada. ×, indicates underwater vent(s). Shaded area includes all volcanic rock compositions. Canadian loci from J. G. Souther, 1983 (Written communication).

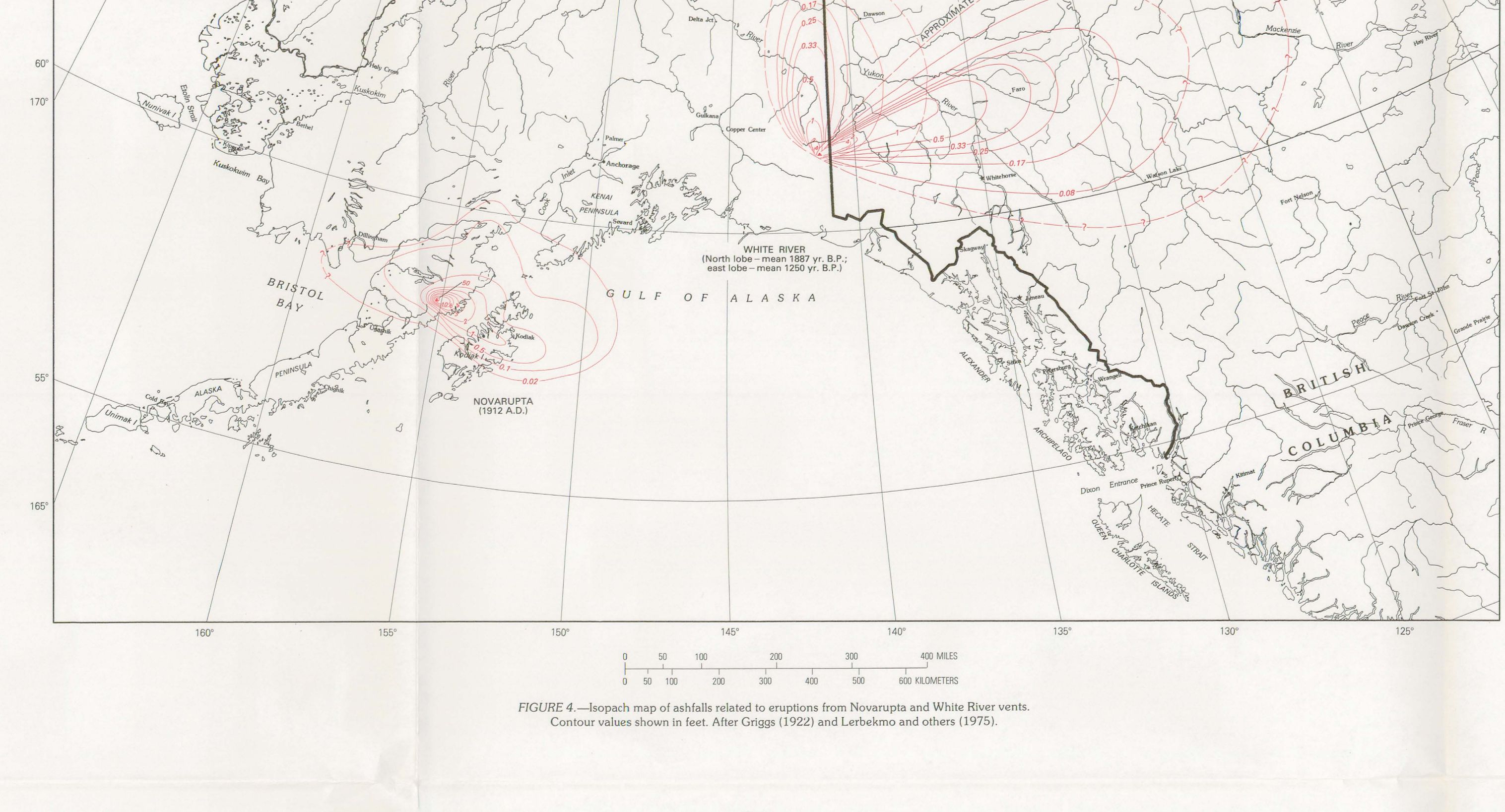
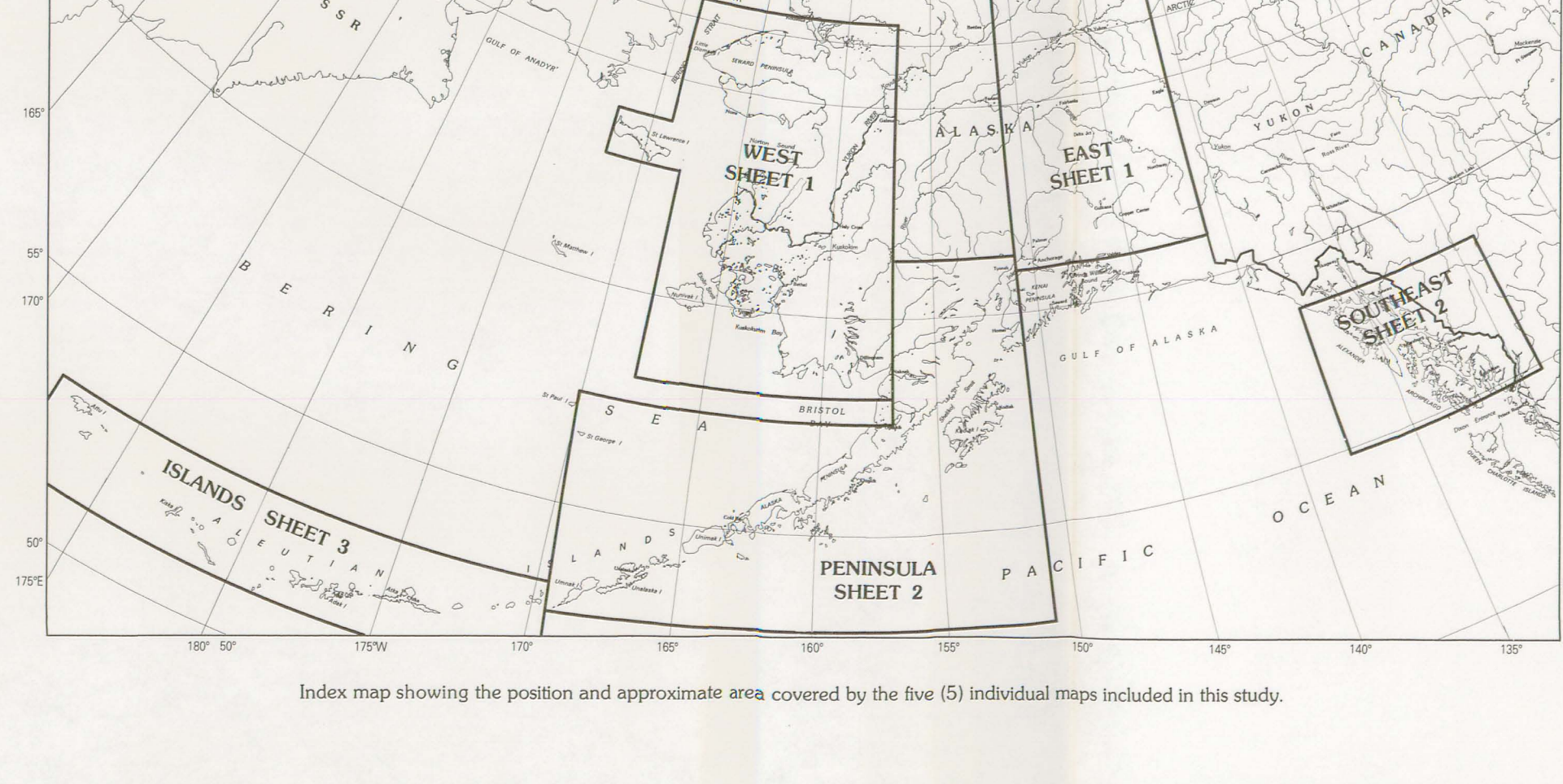
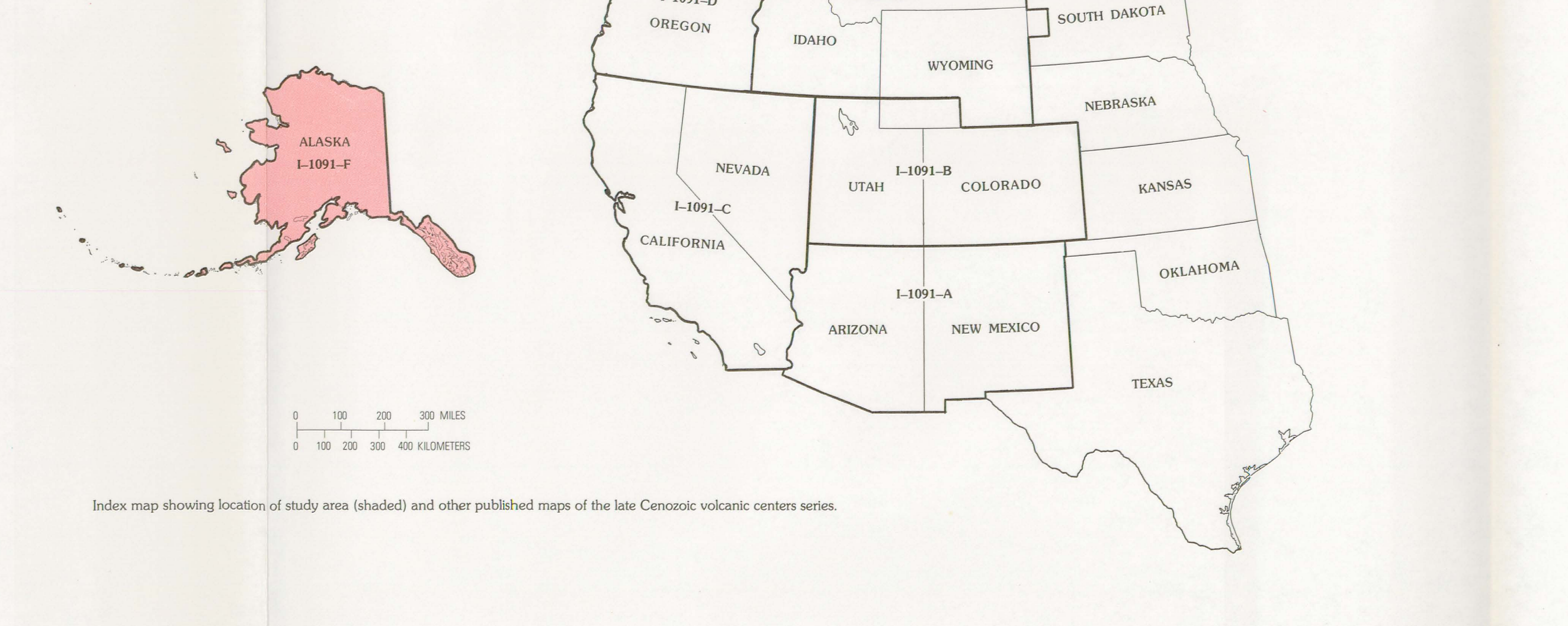


FIGURE 4.—Isopach map of ashfalls related to eruptions from Novarupta and White River vents. Contour values shown in feet. After Griggs (1922) and Lerbekmo and others (1975).



Index map showing the position and approximate area covered by the five (5) individual maps included in this study.



Index map showing location of study area (shaded) and other published maps of the late Cenozoic volcanic centers series.

DISCUSSION

This map is the sixth 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 base for evaluation of volcanic hazards, for studies of volcanology and volcanotectonics, and for studies of the general geology of volcanic rocks. Because little or no reliable data are available for many areas, these maps are, 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) the late Cenozoic extends from 16 ± 1 million years (m.y.) ago to the present. This time cutoff (16 ± 1 m.y.) was chosen because in the western conterminous United States it has meaning in both a volcanological and tectonic sense; there, a widespread change in the state of volcanism occurred at about that time.

For the purposes of this map we have retained the same time frame in order to be consistent with the earlier maps of the series. We recognize that, geodynamically, this time frame has less meaning for Alaska than for conterminous United States.

The significance of this time cutoff for geothermal purposes is also problematical. High-grade geothermal resources of the world are located in regions of late Cenozoic volcanic activity. The high-grade geothermal potential of an area declines rapidly with increasing age of volcanism; all high-grade geothermal resources from which energy has been extracted for power are associated with igneous systems active within the last 1 m.y. Lower grade (that is, lower temperature) geothermal resources may be related to the declining thermal stages of igneous systems or to other sources of thermal energy. However, the low-grade geothermal resource is not well defined, and at this time it is a largely unknown quantity. Hot or warm springs are known to be associated with volcanic areas older than 16 ± 1 m.y. It is doubtful that these areas have significant geothermal resources although the utility of low-grade geothermal is currently uncertain. In any case, we suspect that the major thermal source for low-grade resources is very deep in the crust and that the hot-spring activity is related to very deep circulation of ground water. This same statement may apply to most large igneous systems older than a few million years and to many small systems older than a few tens of thousands of years.

Within this late Cenozoic time frame, the ages of the volcanic rocks are arbitrarily divided into three periods: present–5 m.y., 5–10 m.y., and 10–16 ± 1 m.y.. The time increment from the present to 1 m.y. is further subdivided by use of colored vent symbols on the map; all vents older than 1 m.y. are shown in black.

The volcanic rocks, including some hypabyssal rocks, have been classified into five major types based primarily upon their known or assumed silica content:

1. Feldspathoidal basalts including basanite, limburgite, tephrite, and other rare alkalic rocks	Less than 46 percent SiO_2
2. Basalt including trachybasalt, hawaiite, etc.	46–54 percent SiO_2
3. Andesite including trachyandesite, etc.	54–62 percent SiO_2
4. Dacite including rhyodacite, quartz latite, trachyte, etc.	62–70 percent SiO_2
5. Rhyolite including pantellerite, etc.	Greater than 70 percent SiO_2

This rock classification is a compromise between the simple silicic-basic distinction that is considered to be significant for geothermal purposes (Smith and Shaw, 1975 and 1979), and a more detailed classification that would be desirable for purely volcanological purposes. In most areas, the existing published data are inadequate for a systematic application of a more detailed classification. This classification also emphasizes dominant rock types. Unique and otherwise rare alkalic rocks are lumped together with the infrequently occurring feldspathoidal basalts unless, like trachyte, they represent the salic end of a rock series and may be interpreted, like dacite and rhyolite, as suggesting a high-level thermal source.

Considerable effort was made to accurately locate and classify the volcanic vents. The distribution, age, and morphology of vents must be known to interpret structure, type, and geothermal significance of volcanological systems. The type of vent is also a general indicator of rock chemistry and thus allows an interpretation of compositon in the absence of other data.

Within the time frame encompassed by this study, volcanic eruptions have occured almost continuously in Alaska along the Aleutian Islands arc and its extension in the Alaskan Peninsula, the Wrangell Mountains, and the coastal and nearby mountain ranges of southeastern Alaska and adjoining Yukon and British Columbia, Canada (Geological Survey of Canada, 1979 and 1980). These eruptions produced rocks of dominantly basic and intermediate compositons although occurrence and abundance of silicic rocks may be increasing with decreasing age of volcanism. Also, in the last few million years, volcanism has occurred in several intraplate areas, such as the Yukon River delta, Seward Peninsula, and the Bering Sea islands, that are not associated with arc volcanism (fig. 3). Geological exploration of the somewhat remote and inaccessible, vast expanse of Alaska is still identifying heretofore unrecognized volcanoes and volcanic areas. Several volcanoes exhibit crater morphology not unlike that produced by the lateral blast at Mount St. Helens in 1980.

In general, little detailed geologic mapping has been published on Alaskan volcanoes, although several studies are in progress. The larger-scale inset maps accompanying this map in part show those areas where the most intensive work has been focused.

Alaska's volcanic areas are here subdivided geographically into the Aleutian Islands-Alaska Peninsula arc segment, the Wrangell Mountains, the Bering Sea islands including western mainland Alaska and the central and eastern interior, and the southeastern region. The Aleutian arc, one of the world's great active volcanic arcs, contains over 400 volcanoes active in the last one million years, and perhaps 40 active or potentially active today. Many of these are either too active or their andesitic or basaltic magma chambers too deep for meaningful geothermal exploration. There are, however, approximately 20 caldera structures in the arc. Most of these are less than 10,000 years old and have significant geothermal potential. In addition, approximately 10 volcanoes contain silicic domes suggestive of higher level heat sources than the less complex andesitic and basaltic stratovolcanoes. Several areas (northeast Atka Island, north Unalaska, etc.) within the island arc have been or are currently being explored and tested for geothermal resource potential.

The Wrangell Mountains, although clearly related to the arc-trench margin of Alaska are, in a volcanological sense, distinct from the Aleutian-Alaska Peninsula segments. The Wrangell Mountains are a large cluster of giant andesitic stratovolcanoes, most of which are now extinct and heavily glaciated. However, two areas, Mount Wrangell in the west and the White River vent in the east, are probably potentially active volcanic areas. The Mount Wrangell caldera is probably only a few thousand years old and contains post-caldera cinder cones and active solfataras. The White River vent (fig. 4) may be associated with eruptions dated at about 1890 years B.P. and 1250 years B.P. Mount Drum, in the western Wrangell Mountains, is a large and differentiated volcanic system, but last erupted about 240,000 years ago and is probably in thermal decline and of marginal geothermal interest (T. P. Miller and others, oral communications).

The continental interior of Alaska including the Bering Sea Platform contains approximately 20 volcanic loci all of which are basaltic and/or basanitic in composition. All of these loci are less than six million years old and most of them have erupted less than one million years ago. These loci are related to intraplate extensional tectonics and bear a spatial relationship to the Alaskan arc-trench margin similar to many other regions around the circum-Pacific edge irrespective of whether the local tectonic mode is arc-trench or transform. They are thus analogous in some ways to the basic volcanic loci that dominate the less than five-million-year-old volcanic patterns in conterminous U. S. shown on the earlier published maps of this series. A notable similarity is the high incidence of basanitic compositons that have been erupted in both areas in the last few million years. This volcanic manifestation is shared with many other segments of the circum-Pacific margin.

To date, young rhyolitic nuclei suggestive of high-level thermal sources have not been found in any of these Alaskan intraplate volcanic loci. However, the extension of this young volcano-tectonic province into Canada contains, in British Columbia, several loci in which rhyolitic to trachytic nuclei have been found (J. G. Souther, oral communication).

Southeastern Alaska, adjoining the northern British Columbian volcanic province, contains two young volcanic loci: (1) a basaltic locus near Ketchikan, probably the southern tectonic extension of the nearby Canadian volcanics, and (2) Mount Edgecumbe, near Sitka, a local potentially active, differentiated volcanic system that erupted dacite about 9,000 years ago.

Detailed mapping and petrologic, geochronologic, and geochemical studies will lead to a better knowledge of the periodicity and episodicity of Alaskan volcanism which in turn will provide a better assessment of the state's geothermal resource potential. This knowledge also will permit more accurate assessment of future volcanic activity and the possible associated hazards to Alaska and nearby Canada.

REFERENCES CITED

Geological Survey of Canada, 1979, Iskut River sheet, British Columbia-Alaska: Geological Survey of Canada Geologic Atlas Map 1418A.
_________ 1980, Macmillan River sheet, Yukon-District of Mackenzie-Alaska: Geological Survey of Canada Geologic Atlas Map 1398A.
Luedke, R. G., and Smith, R. L., 1978a, Map showing distribution, composition, and age of Late Cenozoic volcanic centers in Arizona and New Mexico: U.S. Geological Survey Miscellaneous Investigations Series Map I–1091–A.
_________ 1978b, Map showing distribution, composition, and age of Late Cenozoic volcanic centers in Colorado, Utah, and southwestern Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I–1091–B.
_________ 1981, Map showing distribution, composition, and age of Late Cenozoic volcanic centers in California and Nevada: U.S. Geological Survey Miscellaneous Investigations Series Map I–1091–C.
_________ 1982, Map showing distribution, composition, and age of Late Cenozoic volcanic centers in Oregon and Washington: U.S. Geological Survey Miscellaneous Investigations Series Map I–1091–D.
_________ 1983, Map showing distribution, composition, and age of Late Cenozoic volcanic centers in Idaho, western Montana, western South Dakota, and northwestern Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I–1091–E.
Smith, R. L., and Shaw, H. R., 1975, Igneous-related geothermal systems, *in* White, D. E., and Williams, D. L., eds., Assessment of geothermal resources of the United States—1975: U.S. Geological Survey Circular 726, p. 58–83.
_________ 1979, Igneous-related geothermal systems, *in* Muffler, L. J. P., ed., Assessment of geothermal resources of the United States—1978: U.S. Geological Survey Circular 790, p. 12–17.

SOURCE REFERENCES

[Keyed to fig. 1]

1. Anderson, A. T., 1976, Magma mixing—Petrological process and volcanological tool: Journal of Volcanology and Geothermal Research, v. 1, no. 1, p. 3–33.
2. Arculus, R. J., and others, 1977, The alkalic rock suite of Bogoslof Island, eastern Aleutian arc, Alaska: Journal of Geology, v. 85, no. 2, p. 177–186.
**3. Armstrong, R. L., Harakal, J. E., and Hollister, V. F., 1976, Age determination of late Cenozoic porphyry copper deposits of the North American Cordillera: Institution of Mining and Metallurgy Transactions, Section B, Applied Earth Science, v. 85, p. B239–B244.
**4. Arnold, J. R., and Libby, W. F., 1951, Radiocarbon dates: Science, v. 113, no. 2927, p. 111–120. [Radiocarbon date.]
5. Barth, T. F. W., 1956, Geology and petrology of the Pribilof Islands, Alaska: U.S. Geological Survey Bulletin 1028–F, p. 101–160.
6. Beikman, H. M., 1974a, Preliminary geologic map of the southeast quadrant of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF–612.
7. _________ 1974b, Preliminary geologic map of the southwest quadrant of Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF–611.
8. _________ 1975a, Preliminary geologic map of southeastern Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF–673.
9. _________ 1975b, Preliminary geologic map of the Alaskan Peninsula and Aleutian Islands: U.S. Geological Survey Miscellaneous Field Studies Map MF–674.
10. _________ 1978, Preliminary geologic map of Alaska: U.S. Geological Survey, scale 1:2,500,000.
11. _________ 1980, Geologic map of Alaska: U.S. Geological Survey, scale 1:2,500,000.
12. Beikman, H. M., and Lathram, E. H., 1976, Preliminary geologic map of northern Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF–789.
13. Berg, H. C., and Hinckley, D. W., 1963, Reconnaissance geology of northern Baranof Island, Alaska: U.S. Geological Survey Bulletin 1141–O, 24 p.
*14. Berg, H. C., Elliott, R. L., Smith, J. G., and Koch, R. D., 1978, Geologic map of Ketchikan and Prince Rupert quadrangles, Alaska: U.S Geological Survey Open-File Report 78–73A.
**15. Berry, A. L., Dalrymple, G. B., Lanphere, M. A., and von Essen, J. C., and others, 1976, Summary of miscellaneous potassium-argon age measurements, U.S. Geological Survey, Menlo Park, California, for the years 1972–74: U.S. Geological Survey Circular 727, 13 p.
**16. Bingham, D. K., and Stone, D. B., 1972, Paleosecular variation of the geomagnetic field in the Aleutian Islands: Royal Astronomical Society Geophysical Journal, v. 28, no. 4, p. 317–335.
**17. Black, R. F., 1975, Late-Quaternary geomorphic processes—Effects on the ancient Aleuts of Umnak Island in the Aleutians: Arctic, v. 28, no. 3, p. 159–169. [Radiocarbon and geologic estimate dates.]
**18. Black, R. F., and Laughlin, W. S., 1964, Anangula—A geologic interpretation of the oldest archeologic site in the Aleutians: Science, v. 143, no. 3612, p. 1321–1322. [Radiocarbon dates.]
19. Brabb, E. E., 1970, Preliminary geologic map of the Black River quadrangle, east-central Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–601.
*20. Brew, D. A., Muffler, L. J. P., and Loney, R. A., 1969, Reconnaissance geology of the Mount Edgecumbe volcanic field, Kruzof Island, southeastern Alaska, *in* Geological Survey Research 1969: U.S. Geological Survey Professional Paper 650–D, p. D1–D18. [Radiocarbon dates.]
21. Brosgé, W. P., and Reiser, H. N., 1969, Preliminary geologic map of the Coleen quadrangle, Alaska: U.S. Geological Survey Open-File Report.
22. Buddington, A. F., and Chapin, Theodore, 1929, Geology and mineral deposits of southeastern Alaska: U.S. Geological Survey Bulletin 800, 398 p.
23. Burk, C. A., 1965, Geology of the Alaska Peninsula—Island arc and continental margin: Geological Society of America Memoir 99, 250 p.
24. Byers, F. M., Jr., 1959, Geology of Umnak and Bogoslof Islands, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028–L, p. 267–369.
25. _________ 1961, Petrology of three volcanic suites, Umnak and Bogoslof Islands, Aleutian Islands, Alaska: Geological Society of America Bulletin, v. 72, no. 1, p. 93–128.
*26. Cameron, C. P., and Stone, D. B., 1970, Outline geology of the Aleutian Islands with paleomagnetic data from Shemya and Adak Islands: Alaska University Geophysical Institute Science Report UAG R–213, 153 p.
**27. Capps, S. R., 1915, An ancient volcanic eruption in the Upper Yukon Basin: U.S. Geological Survey Professional Paper 95–D, p. 59–64. [Geologic estimate.]
28. _________ 1935, The southern Alaska Range: U.S. Geological Survey Bulletin 862, 101 p.
*29. Carr, W. J., Quinlivan, W. D., and Gard, L. M., Jr., 1970, Age and stratigraphic relations of Amchitka, Banjo Point, and Chitka Point Formations, Amchitka Island, Aleutian Islands, Alaska, *in* G. V. Cohee, R. G. Bates, and W. B., Wright, Changes of stratigraphic nomenclature by the U.S. Geological Survey, 1969, U.S. Geological Survey Bulletin 1324–A, p. A16–A22.
30. Cass, J. T., 1957, Reconnaissance geologic map of the Kateel River quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–243.
31. _________ 1959a, Reconnaissance geologic map of the Candle quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–287.
32. _________ 1959b, Reconnaissance geologic map of the Norton Bay quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–286.
33. _________ 1959c, Reconnaissance geologic map of the Unalakleet quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–288.
34. Chapman, R. M., Yeend, W. E., Brosgé, W. P., and Reiser, H. N., 1975, Preliminary geologic map of the Tanana and northeast part of the Kantishna River quadrangles, Alaska: U.S. Geological Survey Open-File Report 75–337.
**35. Citron, G. P., and others, 1980, Tectonic significance of early Oligocene plutonism on Adak Island, central Aleutian Islands, Alaska: Geology, v. 8, no. 8, p. 375–379.
**36. Coats, R. R., 1950, Volcanic activity in the Aleutian arc: U.S. Geological Survey Bulletin 974–B, p. 35–47. [Geologic estimates and reported observations.]
37. _________ 1952, Magmatic differentiation in Tertiary and Quaternary volcanic rocks from Adak and Kanaga Islands, Aleutian Islands, Alaska: Geological Society of America Bulletin, v. 63, no. 5, p. 485–514.
38. _________ 1953, Geology of Buldir Island, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 989–A, p. 1–26.
39. _________ 1956a, Geology of northern Adak Island, Alaska: U.S. Geological Survey Bulletin 1028–C, p. 45–67.
40. _________ 1956b, Geology of northern Kanaga Island, Alaska: U.S. Geological Survey Bulletin 1028–D, p. 69–81.
41. _________ 1956c, Reconnaissance geology of some western Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028–E, p. 83–100.
42. _________ 1959a, A geologic reconnaissance of Gareloi Island, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028–J, p. 249–256.
43. _________ 1959b, Geologic reconnaissance of Semisopochnoi Island, western Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028–O, p. 477–519.
44. Coats, R. R., Nelson, W. H., Lewis, R. Q., and Powers, H. A., 1961, Geologic reconnaissance of Kiska Island, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028–R, p. 563–581.
45. Coonrad, W. L., 1957, Geologic reconnaissance in the Yukon-Kuskokwim Delta region, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–223.
**46. Cox, Allan, and Dalrymple, G. B., 1967, Geomagnetic polarity epochs—Nunivak Island, Alaska: Earth and Planetary Science Letters, v. 3, no. 2, p. 173–177.
*47. Cox, Allan, Hopkins, D. M., and Dalrymple, G. B., 1966, Geomagnetic polarity epochs, Pribilof Islands, Alaska: Geological Society of America Bulletin, v. 77, no. 9, p. 883–910.
48. Curtis, G. H., 1968, The stratigraphy of the ejecta from the 1912 eruption of Mount Katmai and Novarupta, Alaska, *in* Coats, R. R., Hay, R. L., and Anderson, C. A., eds., Studies in volcanology—A memoir in honor of Howel Williams: Geological Society of America Memoir 116, p. 153–210.
**49. Dadisman, S. V., 1980, Radiometric ages of rocks in south-central Alaska and western Yukon Territory: U.S. Geological Survey Open-File Report 80–183, 82 p.
**50. Dalrymple, G. B., Cox, Allan, Doell, R. R., and Grommé, C. S., 1967, Pliocene geomagnetic polarity epochs: Earth and Planetary Science Letters, v. 2, no. 3, p. 163–173.
**51. Deininger, J., 1972, Petrology of the Wrangell Volcanics near Nabesna, Alaska: Fairbanks, University of Alaska, unpublished M. S. thesis, 66 p.
**52. DeLong, S. E., and McDowell, F. W., 1975, K-Ar ages from the Near Islands, western Aleutian Islands, Alaska—Indications of a mid-Oligocene thermal event: Geology, v. 3, no. 12, p. 691–694.
**53. Denton, G. H., and Armstrong, R. L., 1969, Miocene-Pliocene glaciations in southern Alaska: American Journal of Science, v. 267, no. 10, p. 1121–1142.
54. Detterman, R. L., 1973, Geologic map of the Iliamna B–2 quadrangle, Augustine Island, Alaska: U.S Geological Survey Geologic Quadrangle Map GQ–1068.
55. Detterman, R. L., and Hartsock, J. K., 1966, Geology of the Iniskin-Tuxedni region, Alaska: U.S Geological Survey Professional Paper 512, 78 p.
56. Detterman, R. L., and Reed, B. L., 1964, Preliminary map of the geology of the Iliamna quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–407.
57. _________ 1980, Stratigraphy, structure, and economic geology of the Iliamna quadrangle, Alaska: U.S. Geological Survey Bulletin 1368–B, 86 p.
58. Detterman, R. L., Miller, T. P., Yount, M. E., and Wilson, F. H., 1981, Generalized geologic map of Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I–1229.
59. Drewes, Harald, Fraser, G. D., Snyder, G. L., and Barnett, H. F., Jr., 1961, Geology of Unalaska Island and adjacent Insular Shelf, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028–S, p. 583–676.
60. Eberlein, G. D., and Churkin, Michael, Jr., 1970, Paleozoic stratigraphy in the northwest coastal area of Prince of Wales Island, southeastern Alaska: U.S. Geological Survey Bulletin 1284, 67 p.
*61. Elliott, R. L., Koch, R. D., and Robinson, S. W., 1981, Age of basalt in the Blue River valley, Bradfield Canal quadrangle, *in* Albert, N. R. D., and Hudson, Travis, eds., The United States Geological Survey in Alaska; Accomplishments during 1979: U.S. Geological Survey Circular 823–B, p. B115–B116. [Radiocarbon date.]
62. Fenner, C. N., 1920, The Katmai region, Alaska, and the great eruption of 1912: Journal of Geology, v. 28, no. 7, p. 596–606.
63. _________ 1923, The origin and mode of emplacement of the great tuff deposit in the Valley of Ten Thousand Smokes: National Geographic Society Contributed Technical Papers [Katmai Series] no. 1, 74 p.
64. _________ 1926, The Katmai magmatic province: Journal of Geology, v. 34, no. 7, pt. 2, p. 673–772.
**65. Fernald, A. T., 1962, Radiocarbon dates relating to a widespread volcanic ash deposit, eastern Alaska, *in* Geological Survey Research 1962: U.S. Geological Survey Professional Paper 450–B, article 11, p. B29–B30. [Radiocarbon dates.]
66. Finch, R. H., 1935, Akutan volcano: Zeitschrift fur Vulkanology, v. 16, no. 3, p. 155–160.
67. Foster, H. L., 1970, Reconnaissance geologic map of the Tanacross quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–593.
68. Foster, H. L., Forbes, R. B., and Ragan, D. M., 1966, Granulite and peridotite inclusions from Prindle volcano, Yukon-Tanana Island, Alaska: U.S. Geological Survey Professional Paper 550–B, p. B115–B119.
69. Fraser, G. D., and Barnett, H. F., Jr., 1959, Geology of the Delarof and westernmost Andreanof Islands, Aleutian Islands, Alaska: U.S. Geological Survey Bulletin 1028–I, p. 211–248.
70. Fraser, G. D., and Snyder, G. L., 1959, Geology of southern Adak Island and Kagalaska Island, Alaska: U.S. Geological Survey Bulletin 1028–M, p. 371–408.
71. Gates, Olcott, Powers, H. A., and Wilcox, R. E., 1971, Geology of the Near Islands, Alaska, *with a section on* Surficial geology, by J. P. Schafer: U.S. Geological Survey Bulletin 1028–U, p. 709–822.
72. Griggs, R. F., 1922, The Valley of Ten Thousand Smokes: Washington, D.C., National Geographic Society, 340 p.
73. Harrington, G. L., 1918, The Anvik-Andreafski region, Alaska: U.S. Geological Survey Bulletin 683, 70 p.
**74. Hein, J. R., and McLean, Hugh, 1980, Paleogene sedimentary and volcanogenic rocks from Adak Island, central Aleutian Islands, Alaska, *in* Shorter contributions to stratigraphy and structural geology, 1979: U.S. Geological Survey Professional Paper 1126–E, 16 p.
75. Hein, J. R., McLean, Hugh, and Vallier, T. L., 1981, Reconnaissance geologic map of Atka and Amlia Islands, Alaska: U.S. Geological Survey Open-File Report 81–0159.
**76. Heusser, C. J., 1960, Late Pleistocene environments of North Pacific, North America: American Geographical Society Special Publication no. 35, 308 p. [Radiocarbon date.]
77. Hildreth, Wes, 1979, Written communication.
78. Hildreth, Wes, 1983, The compositionally zoned eruption of 1912 in the Valley of Ten Thousand Smokes, Katmai National Park, Alaska: Journal of Volcanological and Geothermal Research, v. 18, p. 1–56.
79. Hoare, J. M., and Condon, W. H., 1966, Geologic map of the Kwiguk and Black quadrangles, western Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–469.
80. _________ 1968, Geologic map of the Hooper Bay quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–523.
81. _________ 1971a, Geologic map of the Marshall quadrangle, western Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–668.
82. _________ 1971b, Geologic map of the St. Michael quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–682.
83. Hoare, J. M., and Coonrad, W. L., 1959a, Geology of the Bethel quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–285.
84. _________ 1959b, Geology of the Russian Mission quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–292.
85. _________ 1961a, Geologic map of the Goodnews quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–339.
86. _________ 1961b, Geologic map of the Hagemeister Island quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–321.
*87. _________ 1978a, A tuya in Togiak Valley, southwest Alaska: U.S. Geological Survey Journal of Research, v. 6, no. 2, p. 193–201.
*88. _________ 1978b, Geologic map of the Goodnews and Hagemeister Island quadrangles region, southwestern Alaska: U.S. Geological Survey Open-File Report 78–9–B.
89. _________ 1980, The Togiak Basalt, a new formation in southwestern Alaska: U.S. Geological Survey Bulletin 1482–C, 11 p.
90. Hoare, J. M., Condon, W. H., Cox, Allan, and Dalrymple, G. B., 1968, Geology, paleomagnetism and potassium-argon ages of basalts from Nunivak Island, Alaska, *in* Coats, R. R., Hay, R. L., and Anderson, C. A., eds., Studies in volcanology—A memoir in honor of Howel Williams: Geological Society of America Memoir 116, p. 377–414.
91. Hopkins, D. M., 1963, Geology of the Imuruk Lake area, Seward Peninsula, Alaska: U.S. Geological Survey Bulletin 1141–C, 101 p.
**92. _________ 1976, Fault history of Pribilof Islands and its relevance to bottom stability in St. George Basin, *in* Environmental asssessment of the Alaskan Continental Shelf: Environmental Research Laboratories, Boulder, Colorado, v. 13, p. 41–67. [Geologic estimate.]
**93. Hopkins, D. M., Matthews, J. V., Wolfe, J. A., and Silberman, M. L., 1971, A Pliocene flora and insect fauna from the Bering Strait region: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 9, no. 3, p. 211–231.
*94. Hopkins, D. M., Rowland, R. W., Echols, R. E., and Valentine, P. C., 1974, An Anvilian (early Pleistocene) marine fauna from western Seward Peninsula, Alaska: Quaternary Research, v. 4, no. 4, p. 441–470.
95. Jaggar, T. A., 1908, The evolution of Bogoslof volcano: American Geographical Society Bulletin, v. 40, no. 7, p. 385–400.
96. Juhle, R. W., 1955, Iliamna volcano and its basement: U.S. Geological Survey Open-File Report, 74 p.
97. Juhle, R. W., and Coulter, H. W., 1955, The Mt. Spurr eruption, July 9, 1953: American Geophysical Union Transactions, v. 36, no. 2, p. 199–202.
98. Keller, A. S., and Reiser, H. N., 1959, Geology of the Mount Katmai area, Alaska: U.S. Geological Survey Bulletin 1058–G, p. 261–298.
99. Kennedy, G. C., and Waldron, H. H., 1955, Geology of Pavlof volcano and vicinity, Alaska: U.S. Geological Survey Bulletin 1028–A, p. 1–19.
100. Kienle, Juergen, and Forbes, R. B., 1976, Augustine—Evolution of a volcano, *in* Annual report 1975–76: Fairbanks, University of Alaska, Geophysical Institute, p. 26–48.
101. Kienle, Juergen, and others, 1980, Ukinrek maars, Alaska I. April 1979 eruption sequence, petrology and tectonic setting: Journal of Volcanology and Geothermal Research, v. 7, no. 1/2, p. 11–37.
102. Kosco, D. G., 1981a, Characteristics of andesitic to dacitic volcanism at Katmai National Park, Alaska: Berkeley University of California, unpublished Ph. D., dissertation, Part II, 249 p.
103. _________ 1981b, The Mt. Edgecumbe volcanic field, Alaska—An example of tholeiitic and calc-alkaline volcanism: Journal of Geology, v. 89, no. 4, p. 459–477.
**104. Lankford, S. M., and Hill, J. M., 1979, Stratigraphy and depositional environment of the Dutch Harbor Member of the Unalaska Formation, Unalaska Island, Alaska: U.S. Geological Survey Bulletin 1457–B, 14 p.
*105. Lee-Wong, Florence, Vallier, T. L., Hopkins, D. M., and Silberman, M. L., 1979, Preliminary report on the petrography and geochemistry of basalt from the Pribilof Islands and vicinity, southern Bering Sea: U.S. Geological Survey Open-File Report 79–1556, 53 p.
106. Lerbekmo, J. F., and Campbell, F. A., 1969, Distribution, composition and source of the White River ash, Yukon Territory: Canadian Journal of Earth Sciences, v. 6, no. 1, p. 109–116.
*107. Lerbekmo, J. F., Westgate, J. A., Smith, D. G. W., and Denton, G. H., 1975, New data on the character and history of the White River volcanic eruption, Alaska, *in* Suggate, R. P., and Cresswell, M. M., eds., Quaternary Studies: The Royal Society of New Zealand Bulletin 13, p. 203–209 [Radiocarbon dates.]
108. Loney, R. A., Berg, H. C., Pomeroy, J. S., and Brew, D. A., 1963, Reconnaissance geologic map of Chichagof Island and northwestern Baranof Island, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–388.
109. Loney, R. A., Brew, D. A., Muffler, L. J. P., and Pomeroy, J. S., 1975, Reconnaissance geology of Chichagof, Baranof, and Kruzof Islands, southeastern Alaska: U.S. Geological Survey Professional Paper 792, 105 p.
110. Loney, R. A., Pomeroy, J. S., Brew, D. A., and Muffler, L. J. P., 1964, Reconnaissance geologic map of Baranof and Kruzof Islands, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–411.
**111. Lowden, J. A., and Blake, W., Jr., 1968, Geological Survey of Canada radiocarbon dates VII: Radiocarbon, v. 10, no. 2, p. 207–245. [Radiocarbon dates.]
**112. _________ 1970, Geological Survey of Canada radiocarbon dates IX: Radiocarbon, v. 12, no. 1, p. 46–86. [Radiocarbon dates.]
**113. Lowden, J. A., Wilmeth R., and Blake, W., Jr., 1970, Geological Survey of Canada radiocarbon dates X: Radiocarbon, v. 12, no. 2, p. 472–485. [Radiocarbon dates.]
*114. Lowe, P. C., Richter, D. H., Smith, R. L., and Schmoll, H. R., 1982, Geologic map of the Nabesna B–5 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–1566.
115. MacKevett, E. M., Jr., 1965a, Preliminary geologic map of the McCarthy B–5 quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–438.
116. _________ 1965b, Preliminary geologic map of the McCarthy C–6 quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–444.
*117. _________ 1970a, Geology of the McCarthy B–4 quadrangle, Alaska: U.S. Geological Survey Bulletin 1333, 31 p.
118. _________ 1970b, Geologic map of the McCarthy C–4 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–844.
119. _________ 1970c, Geologic map of the McCarthy C–5 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–899.
120. _________ 1972, Geologic map of the McCarthy C–6 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–979.
121. _________ 1974, Geologic map of the McCarthy B–5 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–1146.
122. _________ 1976, Mineral deposits and occurrences in the McCarthy quadrangle, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF–773–B.
*123. _________ 1978, Geologic map of the McCarthy quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I–1032.
124. MacKevett, E. M., Jr., and Smith, J. G., 1972a, Geologic map of the McCarthy B–4 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–943.
125. _________ 1972b, Geologic map of the McCarthy B–6 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–1035.
*126. Magoon, L. B., Adkison, W. L., and Egbert, R. M., 1975, Map showing geology, wildcat wells, Tertiary plant fossil localities, K–Ar age dates, and petroleum operations, Cook Inlet area, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I–1019.
*127. Marlow, M. S., Scholl, D. W., Buffington, E. C., and Alpha, T. R., 1973, Tectonic history of the central Aleutian arc: Geological Society of America Bulletin, v. 84, no. 5, p. 1555–1574.
128. Marlow, M. S., and others, 1970, Buldir Depression—A late Tertiary graben on the Aleutian Ridge, Alaska: Marine Geology, v. 8, no. 1, p. 85–108.
*129. Marsh, B. D., 1976, Some Aleutian andesites—Their nature and source: Journal of Geology, v. 84, no. 1, p. 27–45.
*130. _________ 1981, Oral communication.
131. Marsh, B. D., and Leitz, R. E., 1979, Geology of Amak Island, Aleutian Islands, Alaska: Journal of Geology, v. 87, no. 6, p. 715–723.
132. McLean, Hugh, Engelhardt, C. L., and Howell, D. G., 1978, Reconnaissance geologic map of the Cold Bay and False Pass quadrangles, Alaska: U.S. Geological Survey Open-File Report 78–323.
133. Miller, D. J., and MacColl, R. S., 1964, Geologic map and sections of the northern part of the McCarthy A–4 quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–410.
*134. Miller, T. P., and Smith, R. L., 1977, Spectacular mobility of ash flows around Aniakchak and Fisher calderas, Alaska: Geology, v. 5, no. 3, p. 173–176. [Radiocarbon date.]
135. _________ 1981, Oral and written communications.
**136. Miller, T. P., Smith, R. L., and Rubin, Meyer, 1979, Written communication. [Radiocarbon dates.]
137. Miller, T. P., Grybeck, D. G., Elliott, R. L., and Hudson, Travis, 1972, Preliminary geologic map of the eastern Solomon and southeastern Bendeleben quadrangles, eastern Seward Peninsula, Alaska: U.S. Geological Survey Open-File Report 1767, 11 p.
**138. Miller, T. P., Smith, R. L., Dalrymple, G. B., and Lanphere, M. A., 1981, Written communication.
**139. Miller, T. P., and others, 1981, Written communication.
140. Moffit, F. H., 1905, The Fairhaven gold placers, Seward Peninsula, Alaska: U.S. Geological Survey Bulletin 247, 85 p.
141. _________ 1954, Geology of the eastern part of the Alaska Range and adjacent area: U.S. Geological Survey Bulletin 989–D, p. 63–218.
142. Myers, J. D., 1979, Geology and petrology of Edgecumbe volcanic field, southeastern Alaska: Baltimore, Johns Hopkins University, unpublished Ph. D. dissertation, 293 p.
143. Myers, J. D., and Marsh, B. D., 1981, Geology and petrogenesis of the Edgecumbe volcanic field, SE Alaska—The interaction of basalt and sialic crust: Contributions to Mineralogy and Petrology, v. 77, no. 3, p. 272–287.
144. Nelson, W. H., 1959, Geology of Segula, Davidof, and Khvostof Islands, Alaska: U.S. Geological Survey Bulletin 1028–K, p. 257–266.
145. Nichols, D. R., and Yehle, L. A., 1969, Engineering geologic map of the southeastern Copper River Basin, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–524.
146. Patton, W. W., Jr., 1966, Regional geology of the Kateel River quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–437.
147. _________ 1967, Regional geologic map of the Candle quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–492.
148. _________ 1973, Reconnaissance geology of the northern Yukon-Koyukuk province, Alaska: U.S. Geological Survey Professional Paper 774–A, 17 p.
*149. Patton, W. W., Jr., and Csejtey, Bela, Jr., 1980, Geologic map of St. Lawrence Island, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I–1203.
150. Patton, W. W., Jr., and Miller, T. P., 1968, Regional geologic map of the Selawik and southeastern Baird Mountains quadrangles, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–530.
151. _________ 1973, Bedrock geologic map of Bettles and southern part of Wiseman quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF–492.
152. Patton, W. W., Jr., Miller, T. P., and Tailleur, I. L., 1968, Regional geologic map of the Shungnak and southern part of the Ambler River quadrangles, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–554.
153. Péwé, T. L., Wahrhaftig, Clyde, and Weber, Florence, 1966, Geologic map of the Fairbanks quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–455.
154. Powers, H. A., Coats, R. R., and Nelson, W. H., 1960, Geology and submarine physiography of Amchitka Island, Alaska: U.S. Geological Survey Bulletin 1028–P, p. 521–554.
155. Ray, D. K., 1976, Geochemistry and petrology of the Mt. Trident andesites, Katmai National Monument, Alaska: Fairbanks, University of Alaska, unpublished Ph. D. dissertation, 198 p.
156. Richter, D. H., 1971a, Reconnaissance geologic map and section of the Nabesna A–3 quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–655.
157. _________ 1971b, Reconnaissance geologic map and section of the Nabesna B–4 quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–656.
158. _________ 1973, Reconnaissance geologic map of the Nabesna A–4 quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–789.
159. _________ 1976, Geologic map of the Nabesna quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I–932.
160. Richter, D. H., and Jones, D. L., 1973, Reconnaissance geologic map of the Nabesna A–2 quadrangle, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–749.
*161. Richter, D. H., and Schmoll, H. R., 1973, Geologic map of the Nebesna C–5 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–1062.
*162. Richter, D. H., and Smith, R. L., 1976, Geologic map of the Nebesna A–5 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–1292.
163. _________ 1981, Oral and written communications.
164. Richter, D. H., Smith, R. L., Yehle, L. A., and Miller, T. P., 1979, Geologic map of the Gulkana A–2 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–1520.
*165. Riehle, J. R., Kienle, Juergen, and Emmel, K. S., 1981, Lahars in Crescent River valley, lower Cook Inlet, Alaska: Alaska Division of Geological and Geophysical Surveys Geologic Report 53, 10 p. [Radiocarbon dates.]
166. Rossman, D. L., 1959, Geology and ore deposits of northwestern Chichagof Island, Alaska: U.S. Geological Survey Bulletin 1058–E, p. E139–E216.
167. Sainsbury, C. L., 1972, Geologic map of the Teller quadrangle, western Seward Peninsula, Alaska: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–685.
168. _________ 1976, Geology, ore deposits and mineral potential of the Seward Peninsula, Alaska: U.S. Bureau of Mines Open-File Report 73–75, 108 p.
169. Sainsbury, C. L., Hudson, Travis, Ewing, Rodney, and Marsh, W. R., 1972, Reconnaissance geologic map of the west half of the Solomon quadrangle, Alaska: U.S. Geological Survey Open-File Report, 10 p.
**170. Scholl, D. W., Marlow, M. S., and Buffington, E. C., 1973, Pliocene and Pleistocene eruptive rocks of the western Aleutian Ridge—A bleeding strike-slip plate boundary(?) [abs.]: Geological Society of America Abstracts with Programs, v. 5, no. 1, p. 101.
**171. Scholl, D. W., Marlow, M. S., MacLeod, N. S., and Buffington, E. C., 1976, Episodic Aleutian Ridge igneous activity—Implications of Miocene and younger submarine volcanism west of Buldir Island: Geological Society of America Bulletin, v. 87, no. 4, p. 547–554.
172. Self, Stephen, Kienle, Juergen, and Huot, Jean-Paul, 1980, Ukinrek maars, Alaska, II. Deposits and formation of the 1977 craters: Journal of Volcanology and Geothermal Research, v. 7, no. 1/2, p. 39–65.
173. Simkin, Tom, and others 1981, Volcanoes of the world: Stroudsburg, Pennsylvania, Hutchinson Ross Publishing Company, 232 p.
174. Simons, F. S., and Mathewson, D. E., 1955, Geology of Sitkin Island, Alaska: U.S. Geological Survey Bulletin 1028–B, p. 21–43.
175. Smith, P. S., and Eakin, H. M., 1911, A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska: U.S. Geological Survey Bulletin 449, 146 p.
176. Smith, W. R., 1925a, Aniakchak crater, Alaska Peninsula: U.S. Geological Survey Professional Paper 132–J, p. 139–149.
177. _________ 1925b, The Cold Bay-Katmai district, *in* A. H. Brooks and others, Mineral resources of Alaska [Report on progress of investigations in 1925], U.S. Geological Survey Bulletin 773, p. 183–207.
178. Smith, W. R., and Baker, A. A., 1924, The Cold Bay-Chignik district, Alaska: U.S. Geological Survey Bulletin 755–D, p. 151–218.
179. Snyder,G. L., 1957, Ocean floor structures, northeastern Rat Islands, Alaska: U.S. Geological Survey Bulletin 1028–G, p. 161–167.
180. _________ 1959, Geology of Little Sitkin Island, Alaska: U.S. Geological Survey Bulletin 1028–H, p. 169–210.
**181. Stuiver, Minze, Borns, H. W., and Denton, G. H., 1964, Age of widespread layer of volcanic ash in southwestern Yukon Territory: Arctic, v. 17, no. 4, p. 259–261. [Radiocarbon dates.]
182. Swanson, S. E., Turner, D. L., Forbes, R. B., and Hopkins, D. M., 1981, Petrology and geochronology of Tertiary and Quaternary basalts from the Seward Peninsula, western Alaska [abs.]: Geological Society of America Abstracts with Programs, v. 13, no. 7, p. 563.
**183. von Huene, Roland, Carr, W. J., McManus, Dean, and Holmes, Mark, 1971, Marine geophysical study around Amchitka Island, western Aleutian Islands, Alaska: U.S. Geological Survey Technical Letter, Amchitka, no. 22, 31 p.
184. Wahrhaftig, Clyde, 1970a, Geologic map of the Fairbanks A–3 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–809.
*185. _________ 1970b, Geologic map of the Healy D–4 quadrangle, Alaska: U.S. Geological Survey Geologic Quadrangle Map GQ–806.
186. Waldron, H. H., 1961, Geologic reconnaissance of Frosty Peak volcano and vicinity, Alaska: U.S. Geological Survey Bulletin 1028–T, p. 677–708.
**187. Wilson, F. H., 1978, Map showing preliminary results of K-Ar studies in the Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Open-File Report 78-1064.
**188. _________ 1980, Late Mesozoic and Cenozoic tectonics and the age of porphyry copper prospects, Chignik and Sutwik Island quadrangles, Alaska Peninsula: U.S. Geological Survey Open-File Report 80-543, 99 p.
**189. Wilson, F. H., Guam, W. C., and Herzon, P. L., 1981, Map and tables showing geochronology and whole-rock geochemistry, Chignik and Sutwik Island quadrangles, Alaska: U.S. Geological Survey Miscellaneous Field Studies Map MF–1053–M.
190. Winkler, G. R., 1980, Oral and written communications.

* Geologic and geochronologic data
** Geochronologic data only