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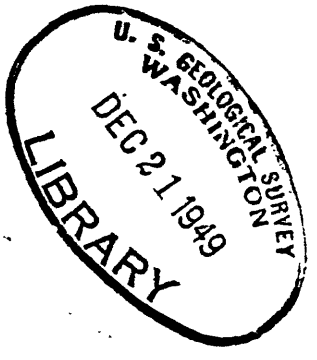
AEROMAGNETIC MAPS AND SECOND VERTICAL DERIVATIVE MAPS OF GREAT SITKIN ISLAND, NORTHERN ADAK ISLAND, AND PART OF NORTHEASTERN UMNAK ISLAND, ALASKA

by Isidore Zietz and Roland G. Henderson



AEROMAGNETIC MAPS AND SECOND VERTICAL DERIVATIVE MAPS OF GREAT SITKIN ISLAND, NORTHERN ADAK ISLAND, AND PART OF NORTHEASTERN UMNAK ISLAND, ALASKA

by Isidore Zietz and Roland G. Henderson

The eight attached maps were constructed from data taken on Project Volcano in the summer of 1947. The project was sponsored by the Office of Naval Research and conducted by the U. S. Geological Survey in cooperation with the Naval Ordnance Laboratory. Field work was done by Fred Keller, Jr., and J. L. Meuschke, Geophysicists of the U. S. Geological Survey, and by L. R. Alldredge, Physicist of the Naval Ordnance Laboratory. The instrument used was a modified AN/ASQ-3A flux-gate type total field magnetometer mounted in the tailcone of a PBY-5A aircraft. It is hoped that observation of the magnetic fields over volcanic areas over a period of years, may lead to prognostication of volcanic activity. These maps represent the results of the first of such surveys.

A) Aeromagnetic map of Great Sitkin Island——uncorrected for regional gradient.

Variations in total intensity were recorded on nine north-south traverses, flown at approximately 1-mile spacings and tied to east-west base lines on the north and south sides of the volcano. The flight altitude was 7,500 feet above sea level.

The northern half of the island is an active volcano and the southern half is a dissected remnant of an older volcano. The basalt dome on the northern half which extruded in 1945 was still glowing and smoking when the survey was made. In general there is good correlation between the known topography of the volcanic cone and the aeromagnetic contours. As it has been hypothesized that extremely hot masses should result in a lower magnetic susceptibility than the surrounding rocks, it is significant that a magnetic low is not associated with the basalt extrusion.

B) Aeromagnetic map of Great Sitkin Island——corrected for regional gradient.

This map was obtained by subtracting from the observed field the earth's normal total intensity field as obtained from the Carnegie Institution of Washington Publication 578, "Description of the Earth's Main Magnetic Field and Its Secular Change, 1905-1945," by E. H. Vestine et al. The resulting map differs insignificantly from the original.

C) Aeromagnetic map of Great Sitkin Island——residual map.

The residual map was constructed to help delineate magnetic structures which would be otherwise obscured by the broad features on the original map. It brings out rather strikingly the changes in gradient of the total field. To compute the residual, a square grid of ½-mile spacing was constructed on the aeromagnetic map. The intensity values were then interpolated and recorded at each grid intersection. Any square containing nine intersections was then selected, and the average value of these points subtracted from the value at the center of the square gave the residual at the center. The process was repeated for all grid intersections which after contouring gave the residual map.

In general the grid size should be of the order of magnitude of the depth of the anomalies under consideration. If the grid spacing is small, near-surface disturbances are accentuated. A large grid will bring into focus broad anomalies

which originate from deeply buried sources. An examination of the residual map shows that the anomaly over the basalt dome as well as several other anomalies have been accentuated. Some of these anomalies appear in almost the same horizontal location as the basalt plugs indicated on the geologic map of the same area. The selection of the ½-mile grid had the effect of essentially removing the large anomaly which conformed with the topography of the island.

D) Aeromagnetic map of Great Sitkin Island——second vertical derivative of the magnetic field.

Like the residual map, the second vertical derivative brings into greater prominence the geologic formations having only slight expression in the magnetic field. To compute the derivative, a grid identical to the one used in the previous paragraph was constructed and the same nine points were considered in determining the second vertical derivative at the center of the square. The formula used appears in a publication by Roland G. Henderson and Isidore Zietz, "The computation of second vertical derivatives of geomagnetic fields," Geophysics, October 1949. The paper also demonstrates that the residual and second-derivative values differ only by a multiplicative constant. This is best illustrated by a comparison between the residual and derivative maps of Great Sitkin Island. It is observed that the maximum as well as the minimum and zero contours appear in exactly the same positions. The second-derivative and residual maps can also be used in estimating depths. This is discussed in a forthcoming memoir to be published by the Geological Society of America, "Interpretation of aeromagnetic maps," by Victor Vacquier, Nelson C. Steenland, Roland G. Henderson, and Isidore Zietz.

E) Aeromagnetic map of northern Adak Island, Alaska——uncorrected for regional gradient.

The northern part of Adak Island was surveyed by running 11 north-south profiles at approximately 1-mile spacing and tying to 2 east-west base lines (indicated on map). The flight altitude was 5,000 feet above sea level.

According to Coats, "Geology of northern Adak Island," Alaskan Volcano Investigation Report 2, part 5, Adak Island is comprised of folded, faulted, and altered Mesozoic volcanic rocks intruded by gabbro in the southern portion and remnants of three Tertiary basaltic volcanoes in the northern mountainous portion.

Four large anomalies are apparent on the aeromagnetic map. The anomaly east of Mount Moffet could easily be identified with the composite parasitic olivine-basalt cone northeast of Mount Moffet. The anomaly at Mount Adagdak is probably associated with the basalt dome. In the lower right portion of the map, the anomaly south of Kuluk Bay occurs over a known massive gabbro intrusion. Finally, there is the anomaly in the southwest area which suggests the existence of a gabbrolike intrusive similar to the one previously mentioned. This area has not yet been mapped geologically. Before the survey, it was hoped that a comparison between the magnetic anomalies of an active volcano such as Great Sitkin and an inactive one such as Mount Adagdak or Mount Moffet might yield significant differences. An actual comparison, however, gave negative results.

F) Aeromagnetic map of northern Adak Island——second vertical derivative of magnetic field.

The map was constructed by superimposing a grid of ½-mile spacing on the aeromagnetic map. The formula used and the method of computation are identical with those given in paragraph (D). The map merely exaggerates the anomalies already apparent on the original map. The horizontal extent of the intrusive in the lower right corner is indicated by the zero contour. This is discussed in the memoir by Vacquier et al, previously mentioned. It appears that this hypothesized area is somewhat larger than that indicated on the geologic map.

G) Aeromagnetic map of part of northeastern Umnak Island--uncorrected for regional gradient.

The magnetic survey consisted of 22 north-south aeromagnetic profiles flown at 1-mile intervals and tied to base lines located along the northeastern and southeastern shores of the island. Flight altitude was 6,500 feet above sea level.

The geology of the area is discussed in Alaskan Volcano Investigation Report 2, 1946, part 3, "Volcano investigations on Umnak Island, 1946," by F. M. Byers, Jr., O. M. Hopkins, K. L. Wier, and Bernard Fisher. The northeastern end of the island is a large, broad volcanic mountain called Okmok volcano. The central part of the volcano is Okmok caldera. It is a large cliff-rimmed depression 7½ miles in maximum diameter containing nine large cinder cones and many small ones on the caldera floor. These cones were smoking and blowing steam during the magnetic survey in July 1947.

The region of sharp gradients shown in the central part of the map nicely outlines the rim of the caldera. However, the correlation between the many cones on the caldera floor and the closed magnetic anomalies within the caldera is poor. Mount Idak, located at lat. 53° 28′ N., long. 167° 54′ W., had no expression in the magnetic map. A more detailed survey would more than likely disclose its magnetic effects. Mount Tulik, rising 4,000 feet above sea level, is prominently displayed in the magnetic picture, its magnitude being second only to that of the large anomaly found over the center of the caldera about 4 miles to the northwest. Both Mount Idak and Mount Tulik are extinct volcanoes.

H) Aeromagnetic map of part of northeastern Umnak Island--second vertical derivative.

A ½-mile grid was applied to the aeromagnetic map and the second vertical derivatives computed. This map was computed primarily to obtain depths to magnetic sources as used in the memoir by Vacquier et al. The geology was generalized from "The Geologic Map of Part of Northeastern Umnak Island, Alaska," by F. M. Byers, Jr., O. M. Hopkins, and Bernard Fisher, 1946.

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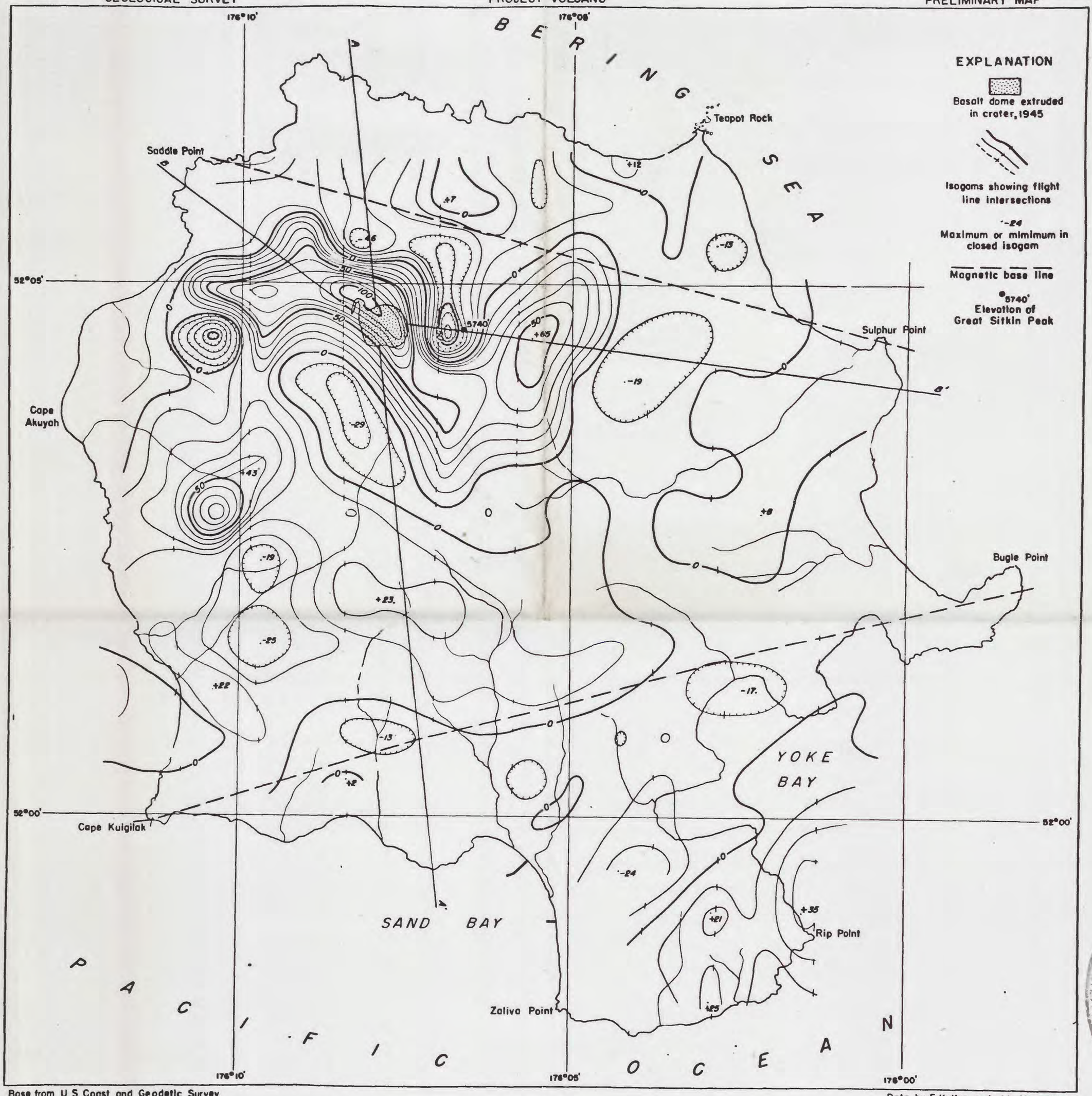
GEOPHYSICAL INVESTIGATIONS
PRELIMINARY MAP



Base from U. S. Coast and Geodetic Survey
Charts 9139 and 9193

Data by F. Keller and J.L. Meuschke
Compilation by J.L. Meuschke

AEROMAGNETIC MAP OF GREAT SITKIN ISLAND, ALASKA

Magnetic datum assumed 1000 gammas at Cape Kiuglak

0 MILES

Isogam interval 10 gammas
Residual anomalies

Flight level 7500 feet

1947

Alaska (great Sitkin - Adak - Umnak area). Aeromagnetic. 1:55,000. 1949.
sheets 1-8, attached,
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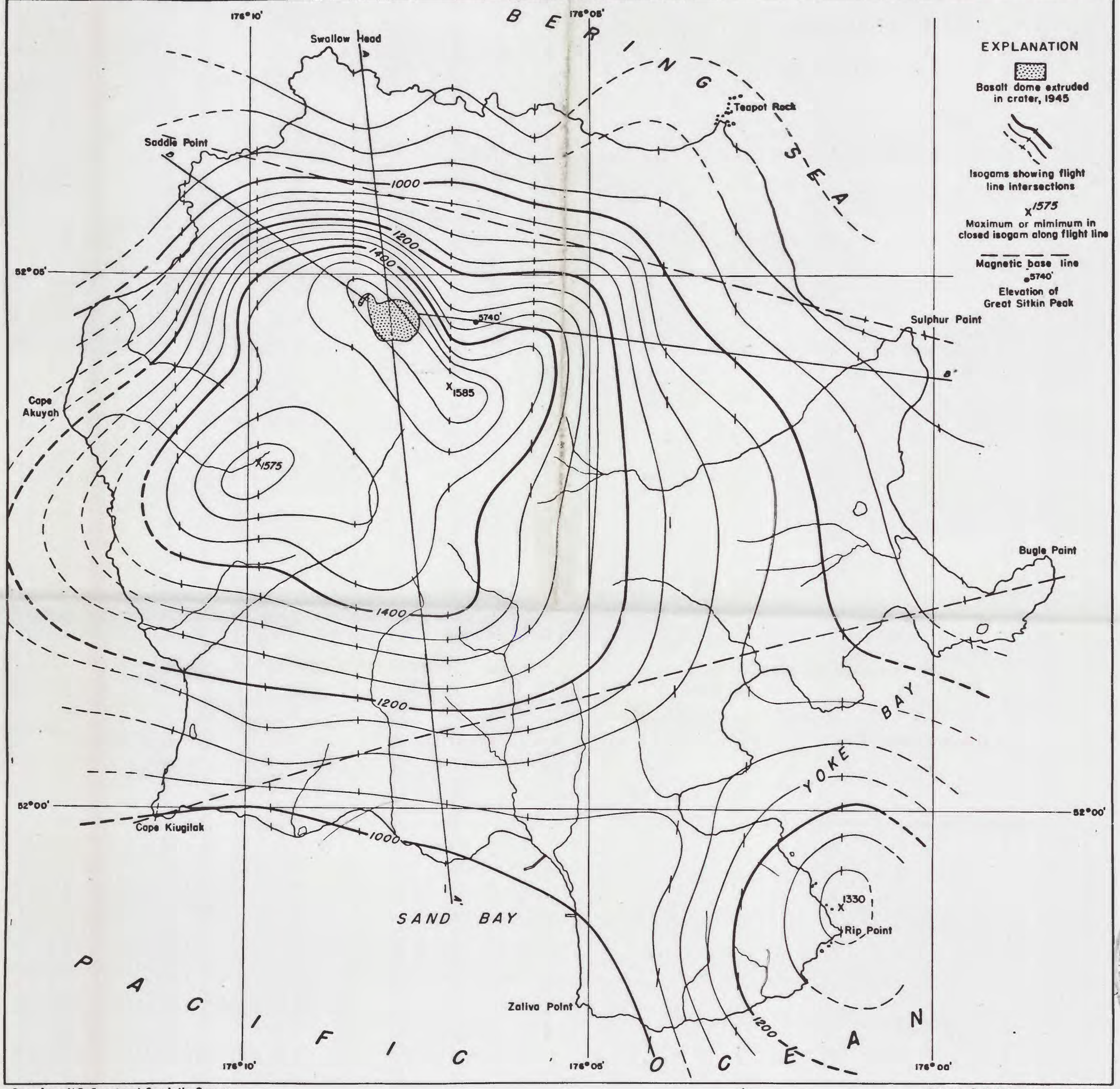
GEOPHYSICAL INVESTIGATIONS
PRELIMINARY MAP



EXPLANATION

Basalt dome extruded in crater, 1945

Isogams showing flight line intersections

X1575
Maximum or mimimum in closed isogam along flight line

Magnetic base line

●5740'
Elevation of Great Sitkin Peak

Base from U.S. Coast and Geodetic Survey
Charts 9139 and 9193

Data by F. Keller and J.L. Meuschke
Compilation by F. Keller

AEROMAGNETIC MAP OF GREAT SITKIN ISLAND, ALASKA

Magnetic datum assumed 1000 gammas at Cape Kiugilak

0 1 MILES

Isogam interval 50 gammas
Regional gradient removed

Flight level 7500 feet
1947

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Alaska (Great Sitkin - Adak Unmakaea). Aeromagnetic
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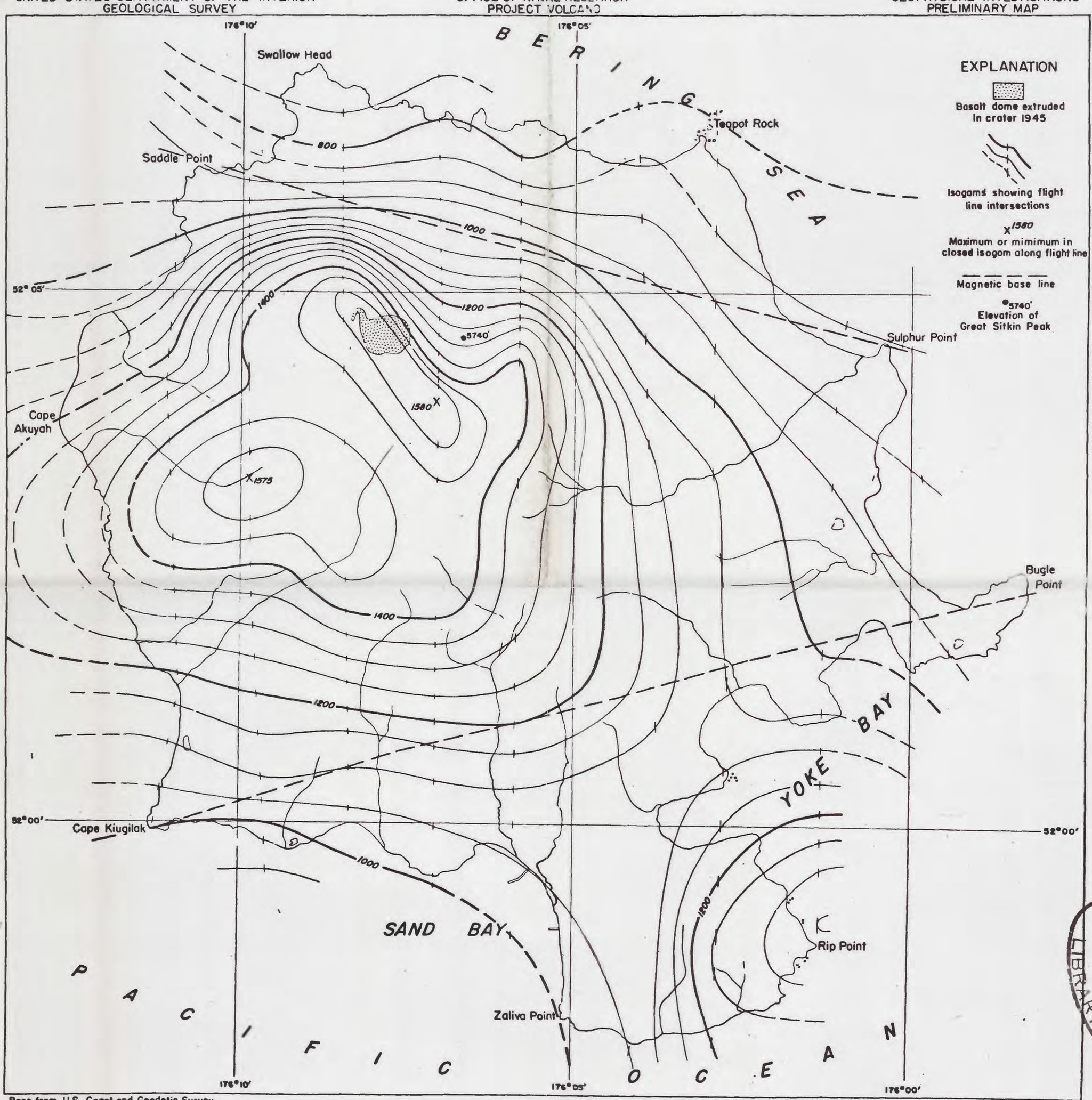
GEOPHYSICAL INVESTIGATIONS
PRELIMINARY MAP



Base from U.S. Coast and Geodetic Survey
Charts 9139 and 9193

Data by F. Keller and J. L. Meuschke
Compilation by F. Keller

AEROMAGNETIC MAP OF GREAT SITKIN ISLAND, ALASKA

Magnetic datum assumed 1000 gammas at Cape Kiugilak

0 1 MILES

Isagam interval 50 gammas
Uncorrected for regional gradient

Flight level 7500 Feet

1947

Alaska (Great Sitkin Island - Umnak area). Aeromagnetic.
sheet 3
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1:55,000. 1949

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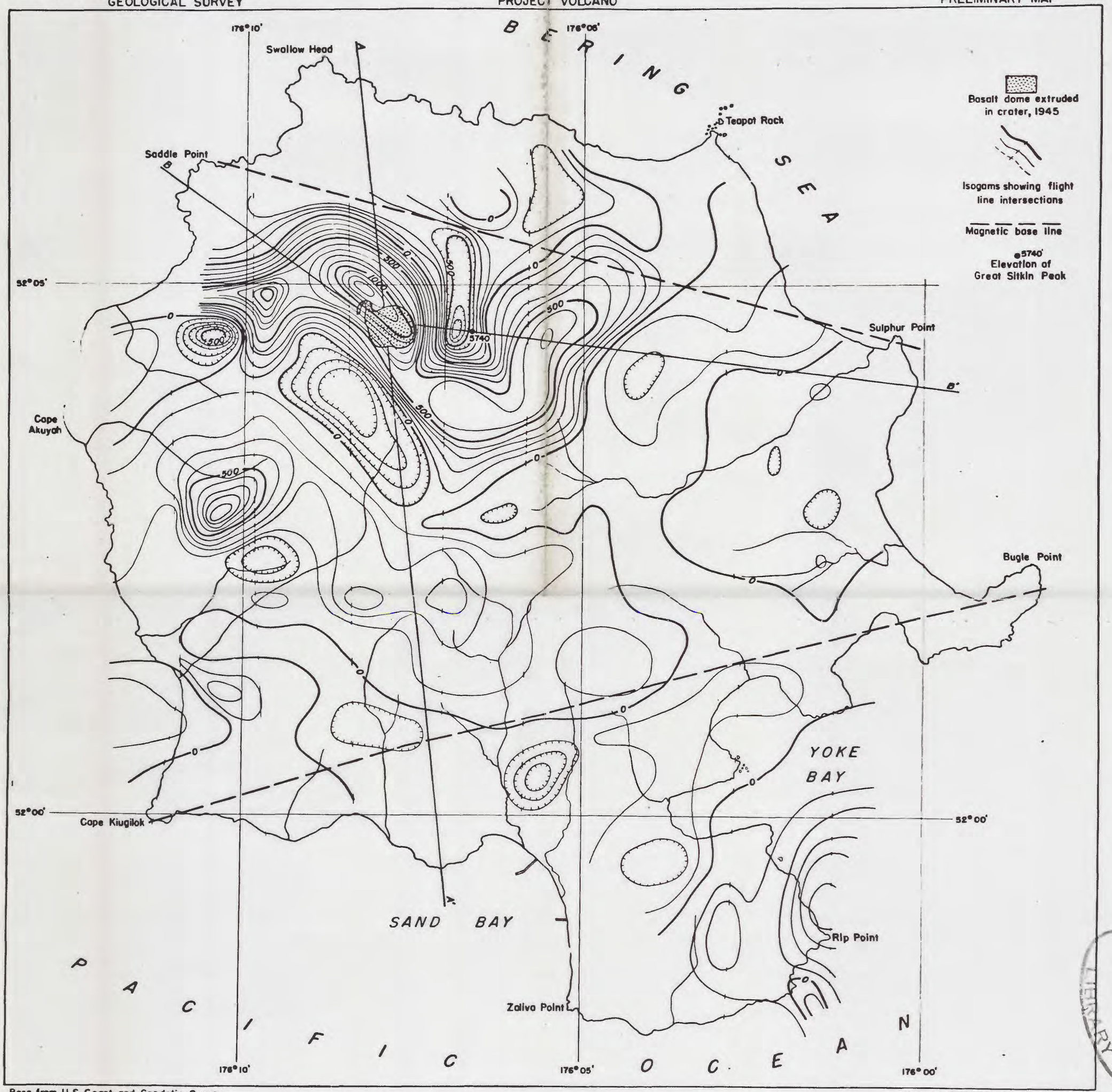
GEOPHYSICAL INVESTIGATIONS
PRELIMINARY MAP



Base from U.S. Coast and Geodetic Survey
Charts 9139 and 9193

Data by F. Keller and J.L. Meuschke
Compilation by F. Keller

AEROMAGNETIC MAP OF GREAT SITKIN ISLAND, ALASKA

Magnetic datum assumed 1000 gammas at Cape Kiugilak

0 1 MILES

Second vertical derivative $\frac{\partial^2 \Delta T}{\partial z^2}$ of magnetic field.
interval - 100 gammas / (0.5 mile)^2

Flight level 7500 feet
1947

Ce 1:55,000

Alaska (Great Sitkin-Adak-Umnak area) Aeromagnetic
sheet 4 1:55,000. 1949
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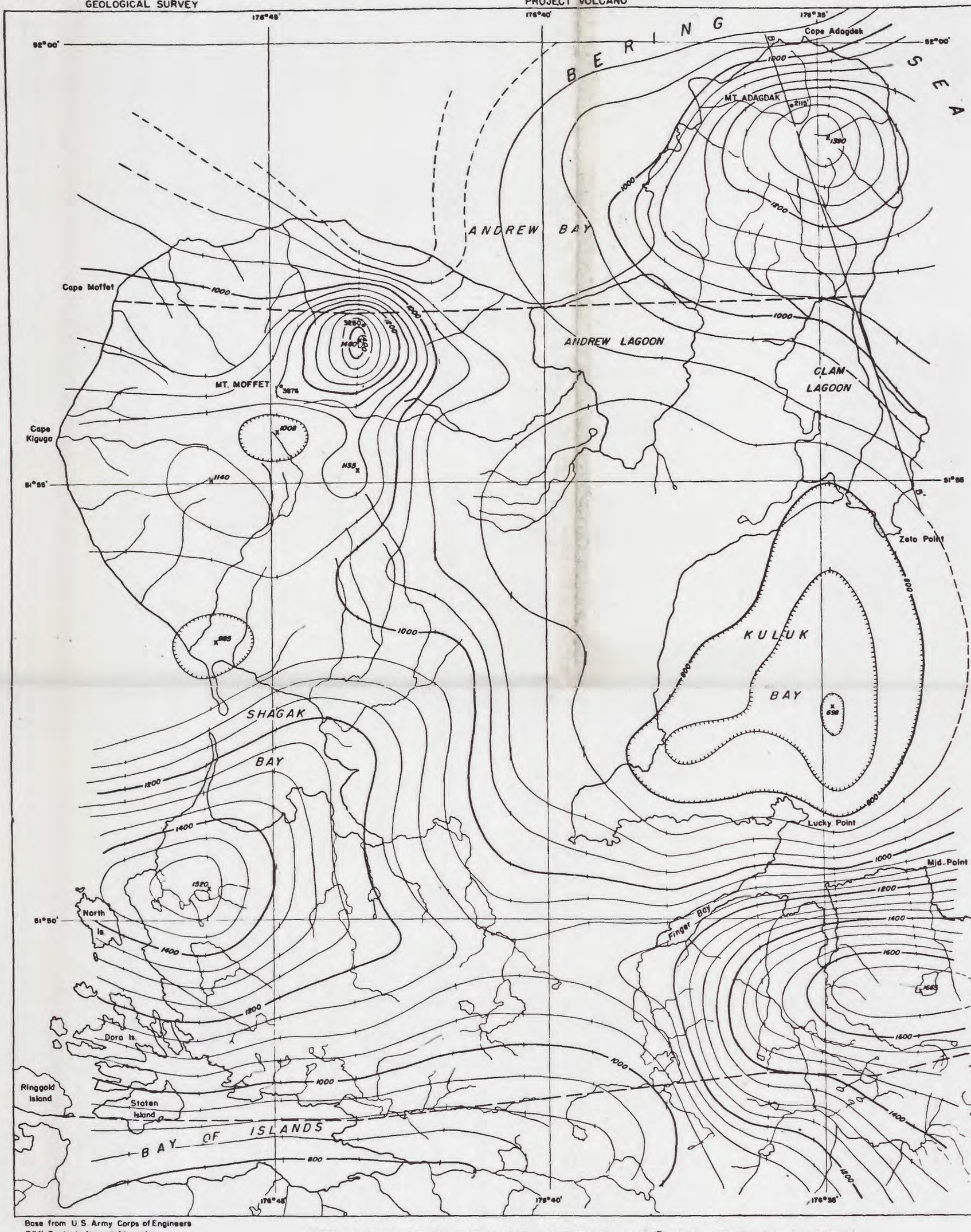
GEOPHYSICAL INVESTIGATIONS
PRELIMINARY MAP



EXPLANATION

Isogams showing flight line intersections

Magnetic base line

3878' Elevation of peak

1460 Maximum of mimimum in closed isogam along flight line

Base from U.S. Army Corps of Engineers
7.5 X 10 minute topographic series

Data by F. Keller and J. L. Meuschke
Compilation J. L. Meuschke

AEROMAGNETIC MAP OF NORTHERN ADAK ISLAND, ALASKA

Magnetic datum assumed 1000 gammas at Cape Moffet

0 MILES

Flight level 5000 feet
1947

Isogam interval 50 gammas
Uncorrected for regional gradient

49-9

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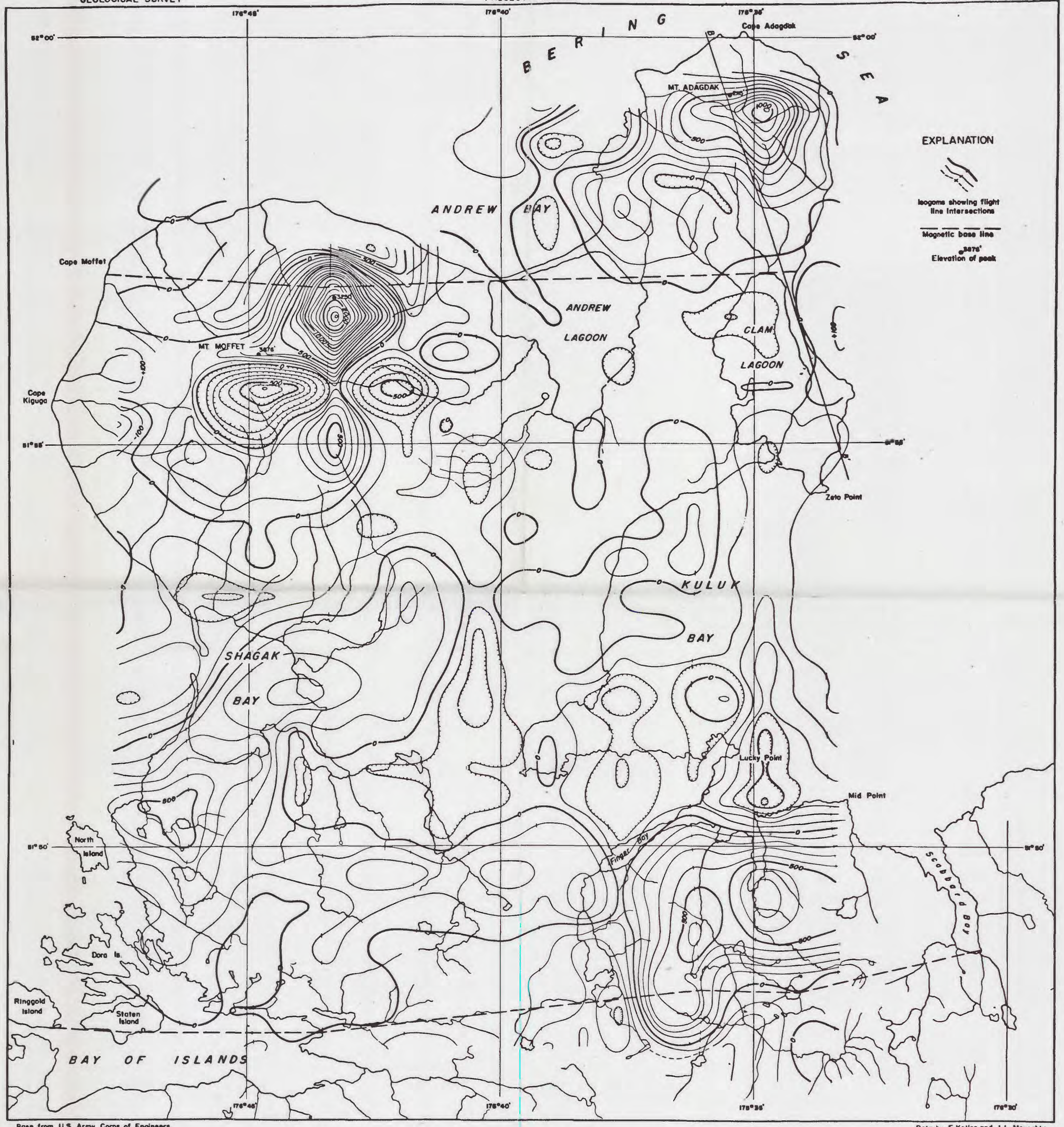
GEOPHYSICAL INVESTIGATIONS
PRELIMINARY MAP



Base from U.S. Army Corps of Engineers
7.5 X 10 minute topographic series

Data by F. Keller and J. L. Meuschke
Compilation J. L. Meuschke

AEROMAGNETIC MAP OF NORTHERN ADAK ISLAND, ALASKA

Magnetic datum assumed 1000 gammas at Cape Moffet

1 0 1 MILES

Flight level 5000 feet

1947

Second vertical derivative $\frac{\partial^2 \Delta T}{\partial z^2}$ of magnetic field

Interval - 100 gammas / (0.5 mile)^2

Alaska (Great Sitkin - Adak - Umnak area). Aeromagnetic 1:55,000.
1949
sheet 6
cop 2
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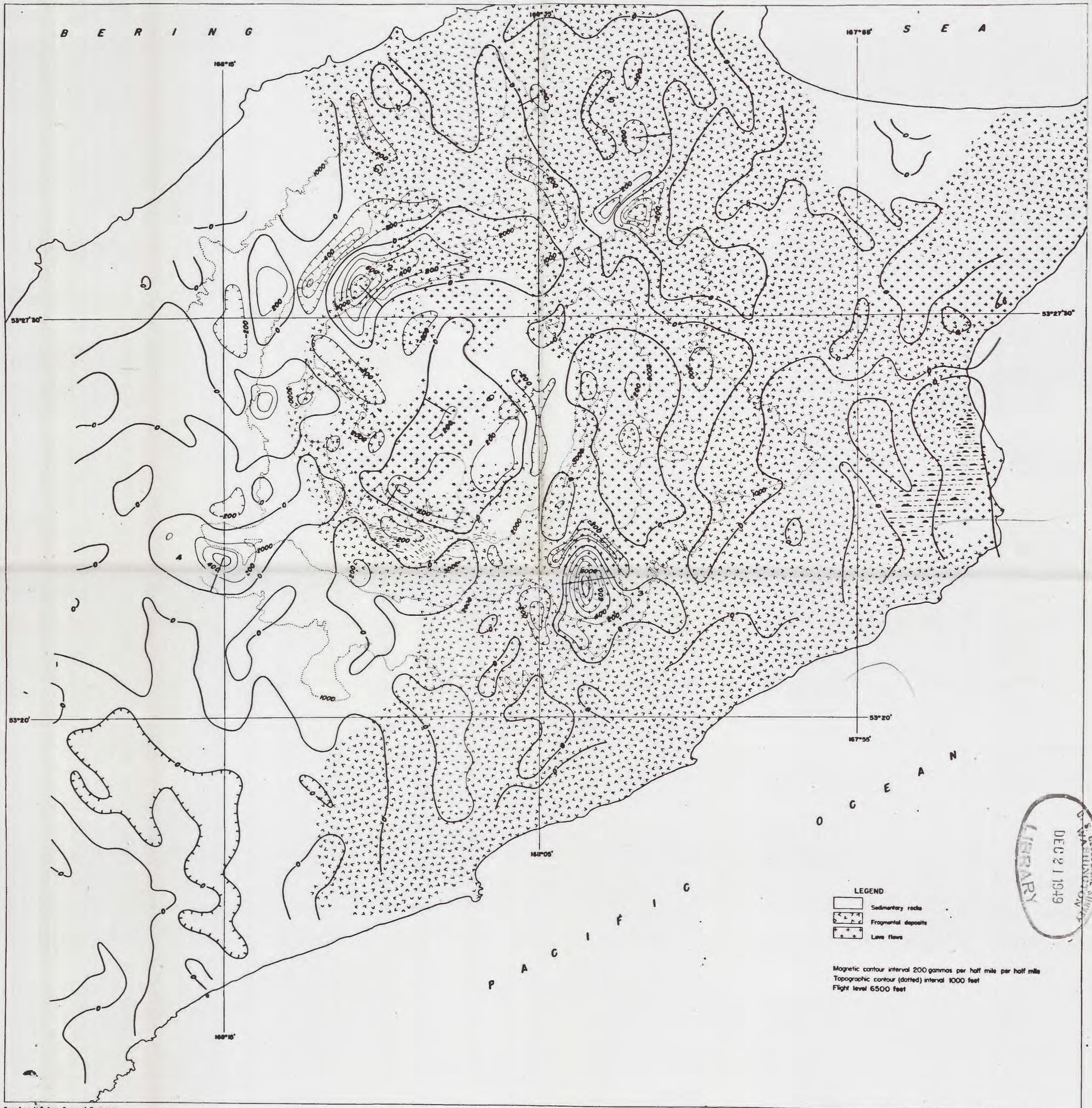
GEOPHYSICAL INVESTIGATIONS
PRELIMINARY MAP



Base from U S Army Corps of Engineers
1943

Geology and topography after Byers, Hopkins, and Fisher, 1946

GENERAL GEOLOGIC AND AEROMAGNETIC MAP OF PART OF UMNAK ISLAND, ALASKA

SHOWING SECOND VERTICAL DERIVATIVE OF THE TOTAL INTENSITY COMPUTED ON HALF-MILE GRID

1 1/2 0 1 2 3 MILES

1948

1: 105,000

Alaska (Great Sitkin - Adak - Umnak area)
sheet 1
cop 2
Aeromagnetic. 1:55,000.
1949

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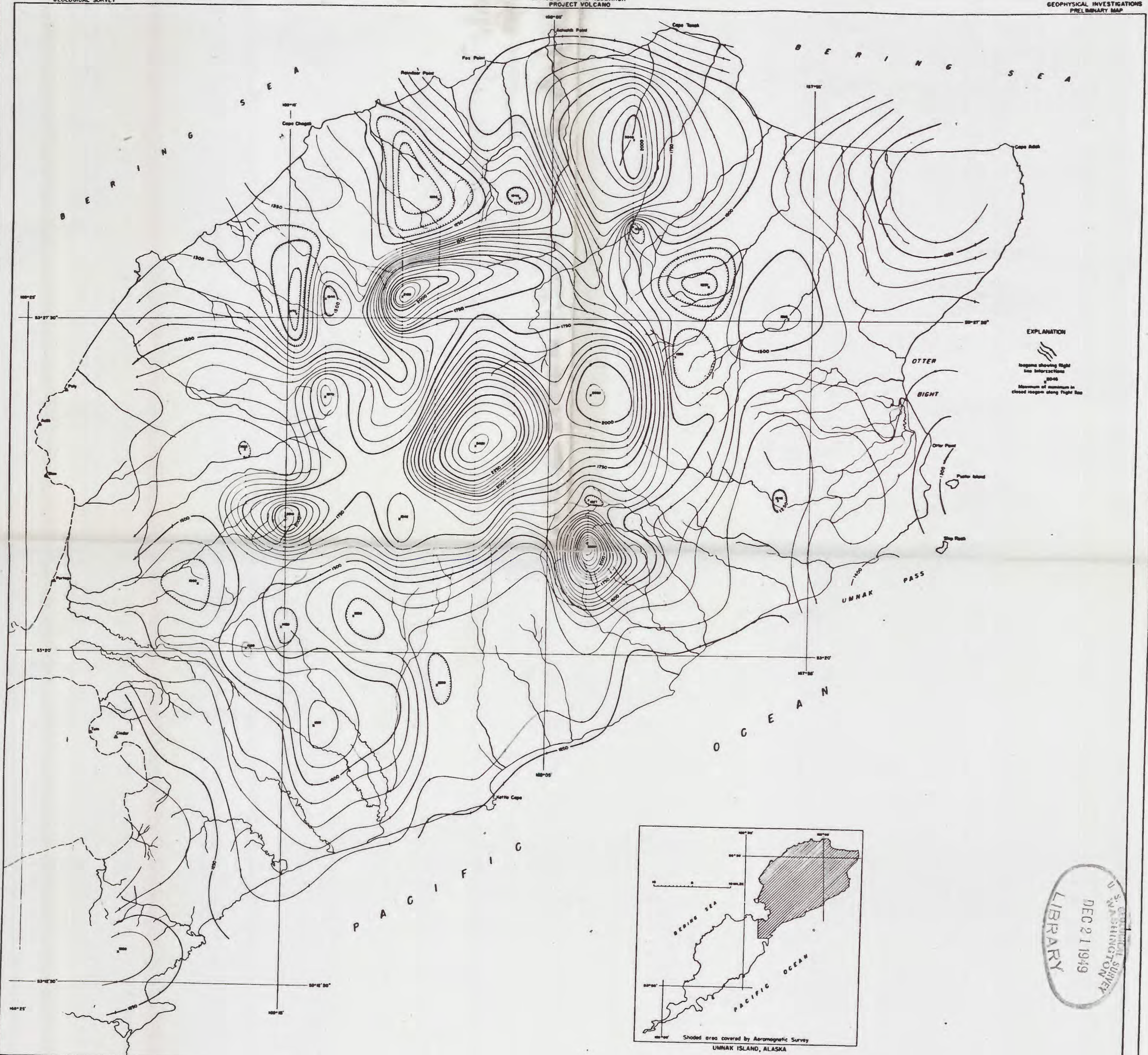
GEOPHYSICAL INVESTIGATIONS
PRELIMINARY MAP



Base from U.S. Army Corps of Engineers 1943

AEROMAGNETIC MAP OF PART OF NORTHEASTERN UMNAK ISLAND, ALASKA

Magnetic datum assumed 1250 gammas at Kettle Cape

Flight level 6500 feet

1948

Data by F. Keller and J. L. Meuschke
Compilation by F. Keller

Isogam interval 50 gammas
Uncorrected for regional gradient