DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOPHYSICAL INVESTIGATIONS
MAP GP–970

Bathymetry from Gardner and others (1980)

This map is not intended for navigational purposes

SCALE 1:1 000 000

20 0 20 40 60 80 100 120 KILOMETERS

20 0 20 40 60 80 STATUTE MILES

20 0 20 40 60 80 NAUTICAL MILES

ALBERS EQUAL AREA PROJECTION
BASED ON STANDARD PARALLELS
OF 55° AND 65° NORTH

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FREE-AIR GRAVITY ANOMALY MAP OF THE UMNAK PLATEAU REGION, SOUTHEASTERN BERING SEA

By

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EXPLANATION

GRAVITY INTENSITY
(milligals)

120
100
80
60
40
20
0
20
40
60
80

FREE-AIR GRAVITY CONTOURS (1930 DATUM)—Contour interval 10 and 25 milligals. H, L indicate local highs and lows

SHIP TRACKLINE

—200— BATHYMETRIC CONTOUR—Contour interval in meters

LAND AREA

△ SUBMARINE GRAVITY STATION

ABSTRACT

A free-air gravity anomaly map of the southeastern Bering Sea and the adjacent southwestern Gulf of Alaska has been compiled from surface-ship gravity data collected by the U.S. Geological Survey (USGS) and combined with previously collected surface-ship and pendulum data. This map covers a bathymetric feature known as Umnak Plateau and part of the Alaskan Outer Continental Shelf underlain by St. George Basin and Bristol Bay Basin.

INTRODUCTION

Between 1975 and 1981, the USGS collected an extensive amount of marine gravity data throughout the Bering Sea. These new data have been combined with those from earlier surveys in the same area (carried out primarily under the auspices of the National Oceanographic and Atmospheric Administration, formerly Environmental Science Service Administration, and Lamont Doherty Geological Observatory) to create a free-air gravity anomaly map of the Umnak Plateau region of the southeastern Bering Sea. Parts of this area have been covered by previous gravity maps (Watts, 1975; National Oceanographic and Atmospheric Administration, 1971a,b; 1973a,b). Where few or no new data were available, contours were modified to conform to these older maps. Each of the cruises that were used in this compilation are listed in table 1, along with details of the cruise and data collection. Pendulum stations were taken from Worzel (1965). This map complements a magnetic anomaly map of the Umnak Plateau region by Childs and others (1981). A 1:2,500,000-scale free-air gravity anomaly map of the entire Bering Sea region (fig. 1) is available (Childs and others, 1985).

DATA REDUCTION

All of the USGS data used here were collected with LaCoste-Romberg[1] sea gravimeters (S32 and S53) mounted on two- or three-axis inertial stabilized platforms. The theory of operation and calculation methods are described by LaCoste and others (1967) and Valliant and LaCoste (1976). Gravity values were calculated from spring tension and a correction term that included components due to beam motion and inherent cross-coupling errors (LaCoste and others, 1967). Prior to digital recording, the gravity values were filtered with a 4-minute averaging filter to remove the effects of ship motion, and values for the three-axis data were filtered with an additional 84-minute notch filter to remove Schuler period oscillations (Bell, 1969). Observed gravity values were adjusted for meter drift by linear time interpolation between harbor station ties. Eötvös corrections were calculated from 1- or 2-minute fixes of computer-smoothed navigation. Occasional failure of the navigation recording system necessitated the use of longer intervals picked from hand-smoothed navigation plots. Absolute gravity values were obtained by tying to the Alaskan gravity base-station network (Barnes, 1968), which the USGS extended to harbor stations at ports of call.

[1]Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

The free-air gravity for all of the USGS data was originally calculated with reference to the Earth ellipsoid defined by the 1967 Geodetic Reference System (International Association of Geodesy, 1971), and the IGSN–71 datum (International Association of Geodesy, 1974). However, to facilitate incorporation of the Watts map, free-air values were converted to the datum defined by the 1930 International Gravity formula (Cassinis, 1930). The free-air anomaly with respect to the 1930 datum is more positive than the anomaly with respect to the 1967 datum. The 1930 values exceed the 1967 values by 5.3 milligals (mGal) at 50° N. and 8.5 mGal at 65° N. (Barnes, 1977).

Compiling data from numerous sources requires careful analysis of errors between different data sets. Prior to contouring, nearly 300 trackline crossings were examined to determine any cross-tie discrepancies. These crossings included both intercruise and intracruise (when a trackline crosses itself) intersections. The mean crossing error between every pair of intersecting cruises was calculated. Two of the older cruises were then discarded as unreliable. The most internally consistent and extensive cruise was chosen as a fixed reference, and an offset was calculated for each remaining cruise to minimize its crossing differences with the reference cruise. The offsets ranged from 0.1 to 12.8 mGal (absolute values). These shifts were applied to the free-air gravity for each data set prior to contouring.

The free-air anomalies were initially contoured by a machine algorithm that mapped all of the data onto an orthogonal grid and fit a third-order spline (minimum curvature) surface to the grid values (Briggs, 1974). The machine contours were then modified to accurately intersect the tracklines and to reflect known geologic structure in areas of sparse coverage, such as the Siberian Continental Margin and Bristol Bay. The free-air anomalies were contoured at 10-mGal intervals, except over the trench south of the Aleutian Arc where a 25-mGal interval was used.

The errors in the gravity data arise primarily from navigational uncertainty, which affects not only the positional accuracy but also the calculation of the Eötvös effect. Secondly, errors arise in correlating the relative marine measurements to absolute datum at harbor ties. The first type of errors are random, while the second are systematic (or constant) for a particular cruise. The base-tie inaccuracies would be partly or totally corrected by the correction method described above. Figure 2 is a histogram of the absolute value of the differences measured at 185 trackline intersections after adjustment for cross-tie discrepancies. The root mean square difference was 5.4 mGal. More than 55 percent of the differences were less than 5 mGal, 70 percent less than 7 mGal, and only 7 percent were greater than 10 mGal.

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REFERENCES CITED

Barnes, D. F., 1968, Alaska gravity base-station network: U.S. Geological Survey open-file report , 21 p.

_____ 1977, Bouguer gravity map of Alaska: U.S. Geological Survey Geophysical Investigations Map GP–913, scale 1:2,500,000.

Bell, F. C., 1969, Schuler's principle and inertial navigation: New York Academy of Sciences Annual, v. 147, p. 493–514.

Briggs, I. C., 1974, Machine contouring using minimum curvature: Geophysics, v. 39, no. 1, p. 39–48.

Cassinis, G., 1930, Seur l'adoption d'une formule internationale pour la pesanteur normale [On the adoption of an international formula for normal gravity]: Bulletin Géodésique, n. 26, p. 40–49.

Childs, J. R., Cooper, A. K., and Wright, A. W., 1981, Residual magnetic map of Umnak Plateau region, southeastern Bering Sea: U.S. Geological Survey Geophysical Investigations Map GP–939, scale 1:1,000,000.

Childs, J. R., Magistrale, H. W., and Cooper, A. K., 195. Free-air gravity anomaly map, Bering Sea: U.S. Geological Survey Miscellaneous Field Studies Map MF-1728, scale 1:2,500,000.

Gardner, J. V., Dean, W. E., and Vallier, T. L., 1980. Sedimentology and geochemistry of surface sediments, outer continental shelf, southern Bering Sea: Marine Geology v. 35, p. 299–329.

International Association of Geodesy, 1971, Geodetic reference system 1967: Special Publications 3, 116 p.

_____ 1974, The international gravity standardization net 1971 (IGSN–71): Special Publication 4, 194 p.

LaCoste, L. J. B., Clarkson, Neil, and Hamilton, George, 1967, LaCoste and Romberg stabilized platform shipboard gravity meter: Geophysics, v. 32, no. 1, p. 99–109.

National Oceanographic and Atmospheric Administration, 1971a, Gravity map, Southeast Bering Sea east of Pribilof Islands: NOS 1711N–17G, scale 1:250,000.

_____ 1971b, Gravity map, Southwest Bristol Bay, vicinity of Amak Island: NOS 1711N–18G, scale 1:250,000.

_____ 1973a, Gravity map, Seamap Series: NOS 15248–14G, scale 1:1,000,000.

_____ 1973b, Gravity map, Seamap Series: NOS 16648–14G, scale 1:1,000,000.

Valliant, H. D., and LaCoste, L. J. B., 1976, Theory and evaluation of the LaCoste and Romberg three-axis inertial platform for marine gravimetry, Geophysics, v. 41, no. 3, p. 459–467.

Watts, Anthony, 1975, Gravity field of the northwest Pacific Ocean basin and its margin: Aleutian Island Arc-Trench system: Geological Society of America Map and Chart Series MC–10, scale 1:2,500,000.

Worzel, J. L., 1965, Pendulum gravity measurements at sea, 1936–1959: New York, John Wiley & Sons, 422 p.

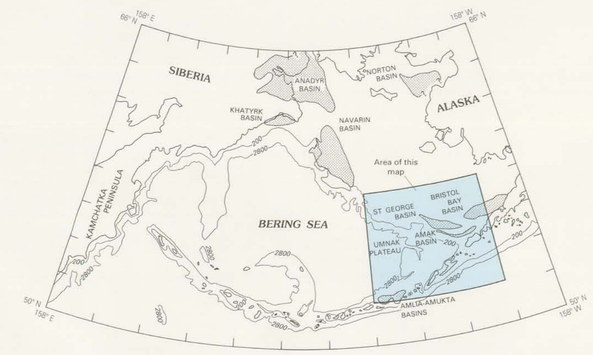

Figure 1.—Reference map of the Bering Sea indicating the locations of major sedimentary basins (shaded), as defined by the 1.5- or 2-km isopach, and physiographic features.

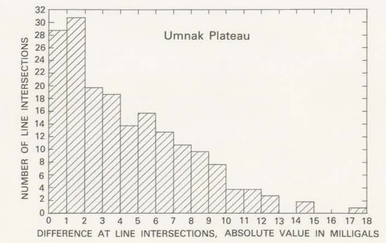

Figure 2.—Histogram of the absolute values of the differences measured at 185 trackline intersections after adjustment for cross-tie discrepancies.

TABLE 1.—*Cruise- and gravity-collection data, Umnak Plateau region*
[na, not available]

Ship	Year	Cruise	Ports of call	Navigation	Gravimeter	Platform	Correction for cross coupling
Conrad	1966	C1009	Adak-Adak	Celestial	Gss2 No. 6	Anschutz	No
Do.	1968	C1208	Adak-Honolulu	Satellite	Gss2 No. 31	–do–	Do.
Do.	1971	C1406	Adak-Adak	–do–	–do–	–do–	Yes
		C1407					
Hudson	1970	HD01	Vancouver-Resolute	–do–	Gss2 No. 17 and vibrating string accelerometer	–do–	Do.
Baffin	–do–	na	na	na	na	na	
Rainier	–do–	na	na	na	na	na	
Sea Sounder	1976	S476BS	Dutch Harbor-Nome	Integrated system: Satellite, Loran C	LaCoste and Romberg S–32	Gimbal mounted two-axis	Do.
Do.	1977	S377BS	Nome	–do–	–do–	–do–	Do.
Do.	–do–	S677BS	Dutch Harbor-Dutch Harbor	–do–	–do–	–do–	Do.
Do.	1979	S679NP	–do–	–do–	–do–	–do–	Do.
S. P. Lee	1975	BERS75XA	–do–	Integrated system Satellite, Doppler sonar, Loran C	La Coste and Romberg S–53	–do–	Do.
Do.	1976	L576BS	Kodiak-Dutch Harbor-Nome	–do–	–do–	–do–	Do.
Do.	–do–	L776BS	Nome-Adak	–do–	–do–	–do–	Do.
Do.	1977	L877BS	Kodiak-Nome	–do–	–do–	Gimbal mounted three-axis	Do.
Do.	1978	L578BS	–do–	–do–	–do–	–do–	Do.
Do.	1980	L680BS	Dutch Harbor-Nome	–do–	–do–	Gimbal mounted two-axis	Do.

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