UNITED STATES DEPARTMENT OF INTERIOR
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PRELIMINARY
BOUGUER ANOMALY AND SPECIFIC GRAVITY MAPS
OF
SEWARD PENINSULA
AND
YUKON FLATS
ALASKA

By
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Open-file report consisting of 4 maps
at a scale of 1:1,000,000 and brief
explanatory text

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Preliminary Bouguer anomaly and specific gravity maps of Seward Peninsula and Yukon Flats, Alaska

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In the course of accumulating data for a reconnaissance gravity map of Alaska (Barnes, 1969) the Geological Survey has obtained preliminary data in both the Yukon Flats and the Seward Peninsula. In neither area are the data considered adequate for more than discontinuous and generalized contours or for more than crude preliminary interpretation. Helicopter support necessary to complete regional contouring and to make good interpretation possible probably will not be available for several years. However, some private industries have recently accumulated confidential gravity data in the Yukon-Kankik region and in Norton Sound. The data contained herein may thus extend these confidential data and facilitate their interpretation. Furthermore, during the government's Alaskan gravity surveys, some samples of exposed surface rocks have been collected and their specific gravities measured. Most of these density measurements have been made by technicians, and no rock identifications or attempts to associate the specimens with established geologic units have been made. Nevertheless, even these preliminary densities may assist the interpretation of the public and private gravity data. The Geological Survey has so far compiled Alaskan gravity data and density-sample localities only on maps with a scale of 1:1,000,000. The Bouguer anomaly maps were also used for the preliminary compilation of the state map presented in the U.S. National Atlas (U.S. Geological Survey, 1970), Barnes (1969), and slightly larger-scaled local maps open-filed in 1967. The maps accompanying this text thus present portions of the Geological Survey's Alaskan gravity and density data on the largest scales at which these data have so far been compiled.

The surveys which produced the data on these maps were conducted over a long period of time and involved a wide variety of field techniques, data-sheet formats, and computing methods. Some of the field techniques have been summarized in Barnes (1965 and 1969), but the reduction techniques have varied greatly and have steadily improved. Extensive use of altimetry has caused some data to be much less accurate than other data, and a computer program used in recent years has provided a complicated output which permits some evaluation of the accuracy of this altimetry and a comparison with elevations obtained from published topographic maps and other surveys. The program is now being modified so that better adjustments can be made and so that summaries of principal facts of all data can be made available to the public. However, the highest priorities for such processing of data to this new standardized format pertain to work in other parts of Alaska. The accompanying maps provide almost all the data that are now readily available and are at a scale consistent with the accuracy of the data.

Field surveys

Field traverses along the Kobuk River and the roads on the Seward Peninsula were begun in 1962 and more road traverses were made in 1966 and 1967. Float and ski-plane landings for additional data were made at scattered intervals, between 1965 and 1967. Considerable helicopter coverage was obtained in 1967 through the cooperation of Dr. D. M. Hopkins of the U.S. Geological Survey and after many unexpected problems a one-day helicopter traverse was made the following year. Much of float and ski-plane coverage on the Seward Peninsula and adjacent areas was obtained with the logistic support of the Office of Naval Research (their task number NR307-265) and the cooperation of Dr. M. C. Brewer at the Arctic Research Laboratory at Point Barrow, Alaska. A few measurements in the Chukchi Sea were made by N. A. Ostenso of the University of Wisconsin (Ostenso, 1968).

Field surveys in the Yukon Flats were begun by river traverses and float plane landings in 1963 and 1964 and some ski-plane landings were made in 1964 and 1965. One to three days of helicopter operations on the margins of the Flats were also completed during each of the years 1965, 1966, 1969, and 1970. The cooperation of R. M. Chapman, F. W. Weber and Harry Hulsing of the Geological Survey in arranging these helicopter flights is gratefully acknowledged.

Most of the gravity measurements were made with carefully calibrated LaCoste and Romberg gravimeters, but some of the pre-1966 measurements were made with older non-thermostated gravimeters. The U.S.G.S. Alaskan Gravity Base Net (Barnes, 1968) was used for datum control, so the gravity datum is nearly identifical with that of Woollard and Rose (1963).

K. L. Holden and R. C. Olsen provided valuable assistance in the compilation of the maps and data, and much of the field work was accomplished by R. V. Allen, R. C. Jachens, R. C. Olsen, K. L. Holden, W. L. Bastion, S. L. Robbins and J. P. Van Hazinga.

Vertical and horizontal control

Altimetry measurements were made at all stations, and a recording base altimeter was used during most of the measurements. The number of altimeters used by the observer increased from one in 1962 to three in all surveys after 1966. On highway and helicopter traverses many measurements were made at government bench marks, and comparison of these elevation data with the altimetry provides some indication of the latter's accuracy. Similarly, spot elevations, river gradients and contour interpolation have been used to obtain comparisons with the altimetry elevations. The author has reviewed the preliminary data and picked gravity anomalies based on elevation measurements that seemed most consistent with the data at nearby stations, but some of these decisions may be revised when final adjustments are made to the altimetry. River gradients from topographic maps were used for vertical control along most of the river traverses. About 500 comparisons between altimetry and map elevations on the Seward Peninsula sheet suggest that more than half of the elevations agree sufficiently to permit an anomaly accuracy of 1 mgal and that 97 percent are better than 5 mgal, which is half the proposed contouring interval. Altimetry data from the Yukon Flats are less consistent with the topographic mapping, and larger errors may occur on the northern and eastern edges of map sheet 3.

Modern maps of 1:63,360 or 1:250,000 scale were used for field locations of most of the stations on the Seward Peninsula, where the smaller-scale maps were used only for stations obtained by landings during long aircraft flights. The smaller-scale 1:250,000 maps had to be used in many more parts of the Yukon Flats, and in some parts of this survey only the older reconnaissance series maps were available. The compilation base was prepared by mosaicing and reducing the drainage net of the modern 1:250,000 maps to provide the 1:1,000,000 scale maps on which the original compilation was made and on which the data are now presented. The drainage net should thus provide a guide for locating the stations with a precision consistent with the accuracy of the anomalies. The omission of the names of geographic features should not be an inconvenience to people who are already working with data from the areas.

Bouguer anomaly maps

The figures next to each station position indicate simple Bouguer anomalies to the nearest milligal, one milligal being the reliability of most of the data. Along the seacoast on the Seward Peninsula elevation measurements are more reliable, and anomaly values are given to the nearest tenth of a milligal. The density used in the reduction was the standard 2.67 gm/cm^3, which seems to be representative of most of the areas with large topographic relief. No terrain corrections have been made, and for most stations the accuracy of the data does not justify such additional precision. However, in some areas the probable effects of terrain corrections have influenced the contouring. Similarly most contours which would be based on only one gravity measurement have been omitted although the maps show the uncontoured measurements. For most of such measurements there is no basis for drawing arbitrary lines around stations where measurements differing from those at nearby stations were made.

The scale of the maps, however, does not permit labeling anomaly values for all the closely spaced stations at which measurements have been made along rivers and roads, so space limitations force the omission of perhaps half the stations on these traverses. However, an effort was made to show enough stations to provide both a regional average, and to show the variability of the data on each traverse. The only other stations which were omitted are closely spaced stations in towns (most of which are described in the base station report), a few in which locations or measurements are considered very unreliable, and some detailed stations east of the Koyukuk and Yukon Rivers at the edge of the Seward Peninsula map. In the latter area some large and closely spaced variations in gravity suggest either an extremely complex gravity field or possibly erroneous data. This problem cannot be resolved by available information.

Specific gravity maps

The maps showing specific gravity measurements are based only on surface samples, which were collected where the gravity field parties stopped at rock outcrops and no measurements have been made on collections obtained by geological field parties. Some of the samples were probably taken from outcrops where weathering and frost action may have altered or fractured the specimen. No special precautions have been made to assure consistent treatment of porosity effects in the samples. On perhaps 10 percent of the specimens such porosity effects may be significant, but no special treatment will be initiated until interpretation of gravity data has begun. The value of these limited density data is probably questionable, but the information might provide a starting point for some interpretations.

Seward Peninsula anomalies

Even a preliminary examination of the two gravity maps reveals some interesting anomalies, which will be briefly mentioned and which are identified by capital letters on the maps. On the Seward Peninsula map these anomalies are listed by starting at the northeast corner of the map and working towards the southwest.

A) The narrow low in the Kobuk-Selawik lowland suggests that a sedimentary section of limited thickness and very narrow width may be present but more detailed data are needed to determine its extent. Possible continuity of a drainage system which deposited the sediments is suggested, but the system may be both narrow and sinuous. Igneous rocks may cause the marginal highs, but few gravity data are available from outcrop areas.

B) The single helicopter traverse crossing the Koyukuk geosyncline shows evidence of the thick sedimentary section indicated by earlier aeromagnetic surveys (Zietz and others, 1959). Some of the gravity low may, however, be caused by crustal thickening beneath the relatively high terrain of the Nulato hills. The high gravities measured on the western flank of this low occur near outcrops of probably denser Mesozoic and Cenozoic volcanics (Patton, 1967).

C) Complex anomalies on Cape Espenberg suggest complicated anomalies caused by volcanic rocks of variable densities.

D) The Serpentine Hot Springs granite is represented by a low with a magnitude of about 20 mgals.

E) A broad low seems to be associated with the Bendeleben Mountains, The Kuzitrine River Flats, and Imuruk Volcanic plains. This may be caused by several factors including crustal thickening or an intrusive body that is considerably more extensive than the granite outcrops in the Bendeleben Mountains, some large thicknesses of vesicular volcanics, and sediments under the Kuzitrine and Fish River alluvial flats.

F) The lowest Bouguer gravities measured on the map were obtained within the low described above (E) and in the vicinity of Fish River Flats. Here the evidence for a thick prism of Cenozoic sediments is suggested by fault scarps on the northeast side of the flats (Hopkins, 1963), but the thickness and areal extent of the sedimentary unit cannot be determined without closely spaced data.

G) Another small low probably represents a thick sedimentary sequence of limited extent in the vicinity of Imuruk basin, but the data are insufficient to define its limits.

H) High Bouguer gravities were measured at many points near the southern coastline and may have a complex tectonic origin. This high gravity field is perhaps similar to the gravity high on the south flank of the Brooks Range (Barnes, 1970). Preliminary offshore gravity data (U.S. Coast and Geodetic Survey, 1970) suggest that the Seward Peninsula high probably extends offshore towards King Island.

I) At Port Safety, east of Nome, the gravity high is interrupted by a gravity low which probably represents a wedge of Cenozoic sediments. This wedge could be a tributary of the offshore sedimentary basin postulated by Scholl and Hopkins (1968).

Yukon Flats anomalies

The anomalies on the Yukon Flats map seem to be more complicated and are difficult to contour and interpret. However, features which are worth listing from north to south are:

J) A series of gravity highs form a fairly continuous trend across the northern part of the map and are best developed near Bettles (Barnes, 1970). Another near-zero simple Bouguer anomaly was measured near the Canadian border and about 15 miles north of the northeast corner of the map.

K) The most significant break in this trend of highs is suggested by very widely spaced measurements near the southern part of the drainage divide between the Chandalar and Koyukuk Rivers. More detailed data might show a local high.

L) A local gravity low southwest of the big bend in the Black River is associated with an outcrop and probable eruptive center for Cenozoic volcanics. This gravity low thus suggests that these volcanic rocks may be vesicular and have low densities. The author believes that the combined gravity and aeromagnetic characteristics of many of the geophysical anomalies mapped in the alluvial covered parts of the Yukon Flats resemble the geophysical characteristics of these Cenozoic volcanics, which might thus partly overlie sedimentary rocks.

M) Low Bouguer gravities measured in the Yukon Flats are now believed to represent Cenozoic basins, which may or may not be connected or continuous. The gravity lows are similar in magnitude and area to other lows which have been observed in Alaska at Minto Flats (Barnes, 1961), Noatak Flats (Barnes and Tailleur, 1970) and along the middle Tanana River (Barnes, 1969) and which are believed to represent Cenozoic basins. The low in the Yukon Flats may be the largest in area but its magnitude suggests a comparable thickness of sediments.

N) One possible interpretation which the author informally considered for the low Bouguer values on the Flats (M) was that these anomalies could represent the extension of older Paleozoic sedimentary rocks beneath the flats, because the largest of these lows was located along the strike of the outcrops of the Paleozoic sedimentary rocks in the adjacent Yukon-Tanana upland. However, 1970 gravity measurements near these Paleozoic (N) outcrops produced significantly higher Bouguer anomalies than were measured in the gravity lows in the alluvial-covered flats. Thus the latter lows are probably caused by sediments, which have significantly lower densities and younger ages than the Paleozoic sedimentary rocks in the Yukon-Tanana upland.

O) Low gravities measured west of the Yukon Flats in the Ray Mountains are probably caused primarily by granitic intrusives but isostatic, crustal thickening may be a contributing factor. However, very little geologic and geophysical mapping has been done in this area, and the real nature of these anomalies and the possibility of their extension towards the Yukon Flats cannot be determined.

P) A single anomalously high measurement north of the Ray Mountain low (O) is probably reliable and represents mafic rocks which crop out a short distance south of the measurement (Patton & Miller, 1970).

Q) Both high Bouguer gravities and high densities have been measured near outcrops of the Permo-Triassic Circle and Rampart volcanics, which are now considered to be largely intrusive (Churkin, 1970). High gravities have not been found in parts of the Yukon Flats which are covered by surficial deposits. Therefore, these rocks are not believed to be the cause of the shallow-depth aeromagnetic anomalies measured over the Flats (Brosgé and others, 1970).

R) A small area of low gravity was encountered in the southwest corner of the map where Hess Creek joins the Yukon River. Thick Tertiary sediments crop out on the banks along the River and are the obvious cause of the gravity low. This is the only gravity low on the map that can be positively correlated with Tertiary sediments, but similar sediments are considered to be the source of several other gravity lows. The Hess Creek anomaly has a limited extent, and the gravity data do not reveal any connection between it and the larger gravity lows near the center of the map.

S) A very narrow gravity low was detected northeast of Circle Hot Springs on the margin of a much broader gravity low (T) that extends into the Yukon-Tanana Upland. This narrow low is believed to represent a sedimentary trough along the Tintina fault zone. The trough probably extends southeastward towards Eagle where Tertiary sediments have been mapped geologically, but the gravity data are too scattered to determine the extent and magnitude of the anomaly in this direction. To the northwest the anomaly seems to be obscured by the high gravities associated with the Circle volcanics, but much more detailed gravity data might show a continuation of this narrow feature.

T) Calculation of the magnitude of the Tintina fault anomaly is complicated by the fact that it lies on the margin of a much broader low which extends into the Yukon-Tanana Upland where there are many granitic outcrops. The broad gravity low thus suggests that the areal extent of this granitic mass may be significantly larger than its outcrop area.

U) A broad gravity low occurs in the southeast corner of the map where very limited data are available. This low is believed to represent the older Mesozoic and Paleozoic sediments within the Kandik basin.

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