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SUMMARY OPERATIONAL REPORT OF A PRELIMINARY GRAVITY SURVEY OF SOUTHEASTERN ALASKA

by

DAVID F. BARNES

UNITED STATES GEOLOGICAL SURVEY

Menlo Park, California

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PREPARED WITH SUPPORT OF

U.S. ARMY TOPOCOM

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This report is preliminary and
has not been edited or reviewed
for conformity with Geological
Survey standards

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Summary Operational Report of a
Preliminary Gravity Survey of Southeastern Alaska

by David F. Barnes

Introduction

In 1968 the U.S. Geological Survey with the support of the U.S. Army TOPOCOM (Project Order 3-68) initiated a gravity survey of southeastern Alaska, which was planned as part of the Survey's effort to prepare a gravity map of the State of Alaska (Barnes, 1969). The initial effort was to make measurements at intervals of about 1½ miles along the thousands of miles of shoreline which traverse this Alaskan archipelago. A few supporting measurements were also made using float planes and helicopters for transportation. During the summers of 1968 and 1969 about 3000 measurements were completed along almost all of the waterways east of Chatham Straits. The survey will probably be completed with cooperation of the State of Alaska during the summer of 1972. This report briefly summarizes the field methods, the logistics and the preliminary results of the 1968 and 1969 field work.

Previously published gravity surveys in southeastern Alaska include measurements on the land by Thiel and others (1958), Woollard and others (1960) and by Rice (1969), marine measurements by Dehlinger and others (1966 and 1970), and calculations by Banks (1969). A few unpublished measurements of gravity have also been made as parts of local mineral and glaciological investigations. The present regional survey was designed both to determine the geologic factors influencing the gravity field and to provide a framework for past and future local and marine surveys. Other reports in this release describe the establishment of a base station network, the data reduction and show day-by-day tabulations of the measurements.

Field measurements

Almost all field travel was by small skiffs operating with the support of a larger vessel to provide safety and living quarters. In the first week of 1968 field season and during about three weeks in the 1969 field season, the gravity party accompanied geologists working off the M/V DON J. MILLER. However, during most of the field work smaller vessels were chartered for the exclusive support of the gravity survey. The latter system enabled the project chief to plan the field work so that shorelines of large water bodies were mapped in calm weather, and the smaller, more-sheltered bays could be mapped in bad weather. Thus the use of smaller support vessels was more efficient, and inspite of Alaskan weather, some field work was perfomed on almost every day away from port. The most efficient coverage was also obtained by two skiffs operating from a one support vessel.

LaCoste geodetic gravimeters were used for almost all of the measurements except that Worden meter 226 replaced one of the meters during the first three weeks of the 1968 season and first two weeks of the 1969 season while the availability of a second LaCoste meter was delayed. Meter temperature was maintained with the standard 4-ampere-hour nickel-cadmium batteries, which were charged each night from the support vessels' power supply. Electrical problems on some of the support vessels caused a few charging failures and later losses of meter-temperature, but none of these late-in-the-day battery failures significantly delayed the field work nor influenced data quality. Drift control was maintained through a large network of base and control stations established at overnight anchorages and traverse-intersection points, and this network is described in a separate report. Meter drift was apparently accelerated by the vibrations encountered by the light skiffs travelling in choppy waters, and many loop and traverse closures ranged from ±.05 to ±0.15 mgals. This complicated the adjustment of the base network, but most of the tabulated observed gravities should have precisions of ±0.10 mgals or better. The few traverses that include uncertainties greater than 0.2 mgal have been identified in the tabulated data.

Sea level corrected for tidal variations was used for almost all of the elevation control, so the elevation datum for the survey is mean-tide level. Almost 200 tidal bench marks were also occupied during the survey, and their elevations were measured and calculated by the same hand-leveling and tidal-correction techniques used for the other gravity stations. A comparison between our calculated elevations at these bench marks and those obtained from the U.S. Coast and Geodetic Survey's tidal records, suggests that 60 percent of the gravity-station elevations are within a foot of their precise elevation and that less than 2 percent might contain errors of more than a meter.

In other parts of Alaska the elevation uncertainty is much larger because of frequent use of altimetry, so terrain corrections have not been made on most USGS Alaskan gravity data. However, both the quality of the elevation control in Southeastern Alaska and the abundance of steep topography suggest that terrain corrections are desirable for these data. However, such corrections will require a great deal of effort and they will not be funded until the field survey is completed and until a preliminary interpretation has been made of the data.

<u>Brief field work narrative</u>

The field work began on May 26, 1968 when J. D. Luetscher initiated measurements along the west shore of the Portland Canal working with some geologists off the USGS M/V DON J. MILLER. The project chief joined the ship on May 30 at Hyder, and a 4-man party continued the survey back down the Portland Canal, into Boca-de-Quadra and then through the Behm Canal until June 6. The M/V TAKU was then chartered at Ketchikan and the party proceeded northward to Petersburg and Wrangell, where the support vessel developed mechanical and electrical problems. After these were repaired the group worked southward amongst the big bays on the east side of Prince of Wales Island and then northward on the Pacific coast of Dall Island, where bad weather caused some delays. This survey from the M/V TAKU reached as far north as Craig and then returned southward through Cordova Bay, which was completely surveyed before the vessel's charter ended on July 13, 1968.

During the summer of 1968, a long helicopter traverse was also completed between Cordova and Petersburg, which obtained data on the Yakutat coastline and in parts of the Coast Range mountains. However, the primary purpose of this trip was to ferry a helicopter from one geological party in the Wrangell Mountains to another geological party on Kosciusko Island, and the amount of time and data collection were limited. Late in August the project chief and R. C. Olson returned to Ketchikan for small-boat traverses on waters near the city and for float-plane traverses to establish base-control for the earlier surveys and to obtain new stations on interior lakes. The final 1968 traverse was made along the highway between Haines and the Canadian border.

On June 11, 1969 the survey resumed at Craig, where Barnes and Peter Popenoe joined a geological party working off the M/V DON J. MILLER amongst the islands northwest of the limit of the 1968 survey. When the geologists headed southward the gravity party left the MILLER and moved to Wrangell to complete traverses left undone, when the M/V TAKU had developed mechanical troubles during the previous summer. On June 24 the M/V BLUE STAR was chartered at Petersburg and it supported traverses in Sumner and Keku Straits and left Popenoe and Mike Klupfel to continue the survey from a shore base at Kake. This two-man party later rejoined the M/V DON J. MILLER at Petersburg and accompanied its geological party for traverse on the southwest shore of Stevens Passage. When this work ended, they moved to Yakutat for skiff and road traverses near Yakutat and Dry Bays. Popenoe left the party in early August, and further work that month was slowed by mechanical and weather problems. Two traverses were made near Haines, some road traverses were made at Juneau, and R. C. Olson completed a traverse along the Alaskan portion of the White Pass and Yukon Railway.

The remainder of the survey was completed by a five-man party working with two skiffs off the USGS M/V WATERS on two trips from Juneau. The first trip began on August 26 and completed the survey of Lynn Canal and its tributaries between Juneau and Skagway. The second trip completed traverses on Stevens passage between Juneau and Petersburg and the vessel then headed southwest. Traverses around Kosciusko Island filled the gap left between the prior surveys from the M/V DON J. MILLER and M/V BLUE STAR. The WATERS returned to Juneau via Chatham Straits, but heavy rain and strong winds limited the data collection to Port Malmesbury and the bays near Killisnoo. Other bays were left unsurveyed to provide sheltered work for periods of bad weather while the traverses along Chatham Strait are completed in 1972. The 1969 data collection ended on September 12.

Supporting investigations

Although the collection of gravity data was the initial objective of the Southeastern Alaskan gravity survey, the ultimat objective is a geological interpretation of the region's gravity field. To aid this interpretation, hand specimens for laboratory density measurements were collected of the rock outcrops at about two-thirds of the gravity stations. These laboratory measurements have now been completed on about two-thirds of the specimens, but much additional work must be done before all the specimens are identified and associated with specific geologic units. However, these density data will eventually provide a useful aid for the interpretation of the gravity data.

Secondly, the possibility of using altimetry control for additional gravity stations inland from the waterways was also considered. On a good many days one skiff carried a set of surveying altimeters and measurements were made at all stations. These altimeter measurements could be processed with very little additional effort on the same computer program that reduced the gravity data. The simplest possible base control of linear interpolation between morning and evening measurements was used and the results can be compared with the sea-level elevations to estimate the range and the frequency of local atmosphere pressure variations. These altimeter measurements were made in all weather types except high winds and heavy rain. Preliminary inspection of the results suggests that in Southeastern Alaska very few local or temporal atmospheric pressure variations would cause altimetry errors greater than 3 meters.

Summary of quadrangle coverage

Figure 1 shows the completed traverses and serves as an index for the 14 1:250,000 quadrangle maps on which the gravity station numbers and simple-Bouguer anomalies are plotted. No stations were obtained in the Mt. Fairweather quadrangle, and future surveys are planned for it, the Juneau, Sitka and Port Alexander quadrangles. Table 1 lists fourteen quadrangles and the number of gravity stations now available in each quadrangle.

Table 1

Southeastern Alaskan Gravity Coverage by Quadrangle

Quadrangle	Number of Stations	Quadrangle	Number of Stations
Prince Rupert	126	Sumdum	285
Dixon Entrance	187	Sitka	145
Ketchikan	516	Taku River	54
Craig	692	Juneau	233
Bradfield Canal	49	Atlin	4
Petersburg	588	Skagway	134
Port Alexander	80	Yakutat	172

The total number of stations is 3265. Many of the quadrangles cover large portsions of Canada and the Pacific Ocean, so the relative number of stations is not a good indication of density of coverage.

Preliminary results

The broad gravity coverage in the southern part of Southeastern Alaska permits easy contouring which reveals the important features of the gravity field. In the northern part of the archipelago, the data are still limited to a narrow belt, where contouring is more difficult, but where the same regional features as in the south may be recognized.

Even the contouring based on the early data of Thiel and others (1958) revealed that the gravity field decreased from positive simple Bouguer anomalies near the western coastline to negative anomalies below -100 mgals near the Canadian border. The new data show that this decrease does not occur in a continuous gradient, but in two gradients separated by a fairly flat gravity field of positive values (mostly 0 to +40 mgals) over the western islands of the archipelago. Furthermore, on the boundary between this flat field and the negative gradient on its eastern side, is a narrow regional high, which is marked by sharp local highs associated with known mafic intrusions. The two largest positive anomalies are at opposite ends of the archipelago and occur over the Haines gabbro body in the north and the Duke Island mafic complex in the south. Smaller gravity highs along the intervening trend are associated with more local mafic outcrops.

Recent geologic interpretations (Jones, 1971) suggest that the Paleozoic rocks, which outcrop in the western islands, may be a fragment of older continental rocks displaced from much more southern latitudes along one of the transform faults bounding the Pacific Ocean. The relatively high gravity which occurs over these rocks suggests a thin crust, so the section might be considered a thin raft which could logically be moved along with an adjoining oceanic plate.

Much of the rich mineralization of southeastern Alaska occurs along the flanks of the belt of high gravity, and a more detailed study of the relationship between the gravity field and the mapped geology may have future economic significance. Several of the local gravity lows are associated with granitic intrusives, so the dimensions of these may be calculated after the densities of the intrusives and surrounding rocks have been determined. Comparison of the new land data and the marine data obtained by Dehlinger and others (1966 and 1970) will reveal the offshore extent of the anomalies and provide information about the thickness of sediments beneath the inland marine passages. For example, the marine data show negative anomalies below -30 mgals in Clarence Strait and Dixon Entrance, where the shoreline anomalies average close to +20 mgals. The resulting 50-mgal. negative anomaly suggests a sedimentary basin thick enough to have petroleum potential.

The negative gradient on the east side of the central belt of high gravities probably represents a thickening crust with a smaller contribution from low-density granitic intrusives. This gradient causes a fairly continuous gravity decrease of about -100 mgals in a distance of about 75 miles or 1.3 mgals per mile, which suggests that it is caused by deep changes at the base of the crust. Furthermore, isostatic corrections calculated by Banks (1969) eliminate most of the negative anomaly and further suggest that the gradient is caused by crustal thickness changes. Locally the Simple-Bouguer anomaly may be as steep as 5 mgals per mile, but many of these gradient changes correlate better with changes of estimated terrain effects than with mapped changes of geologic outcrops. Thus terrain corrections may be necessary before the gravity data can provide maximum geologic usefulness. The gravity traverses almost reached or crossed the eastern Canadian border on the White Pass and Yukon Railway, the Taku River, the Whiting River, the Stikine River, and the Portland Canal. In all of these traverses except the Stikine River, the lowest gravity anomalies were measured west of the international boundary, and the anomalies then rise towards less negative values east of the border.

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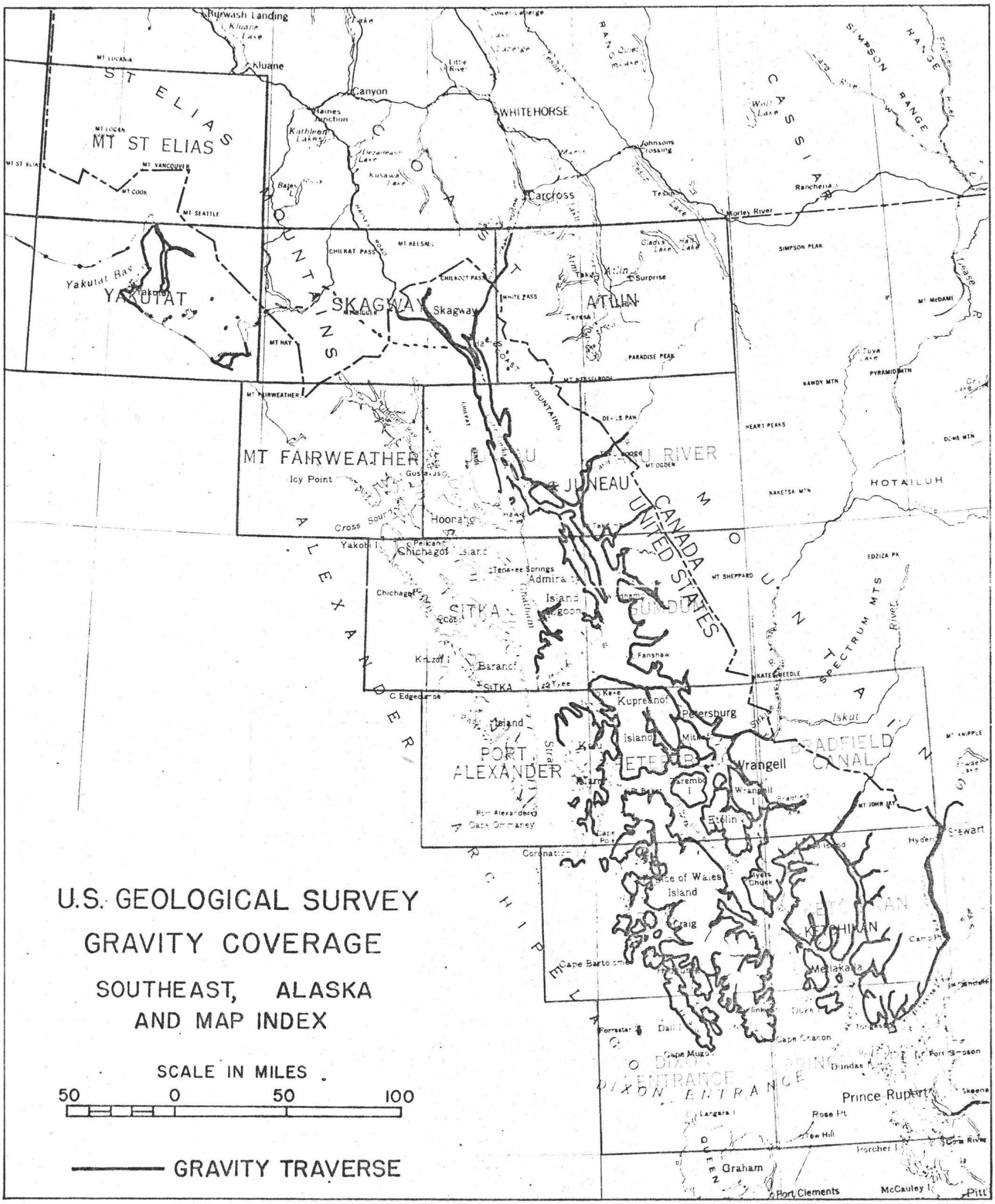

U.S. GEOLOGICAL SURVEY
GRAVITY COVERAGE
SOUTHEAST, ALASKA
AND MAP INDEX
SCALE IN MILES
50 0 50 100
GRAVITY TRAVERSE
MT ST ELIAS
YAKUTAT
SKAGWAY
ATLIN
MT FAIRWEATHER
JUNEAU
SITKA
SUMDUM
PORT ALEXANDER
BRADFIELD CANAL
KETCHIKAN
HOTAILUH
ST ELIAS
COAST MOUNTAINS
CASSIAR
SIMPSON RANGE
CANADA
UNITED STATES
ALEXANDER ARCHIPELAGO
DIXON ENTRANCE
WHITEHORSE
Carcross
Kluane
Canyon
Haines Junction
Johnsons Crossing
Morley River
Teslin
Yakutat Bay
Skagway
Icy Point
Cross Sound
Hoonah
Chichagof Island
Admiralty Island
Baranof
Kupreanof
Petersburg
Wrangell
Etolin
Prince of Wales Island
Craig
Metlakatla
Hyder
Stewart
Prince Rupert
Graham
Port Clements

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