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SIMPLE BOUGUER GRAVITY AND GENERALIZED GEOLOGIC MAP AND AEROMAGNETIC PROFILES OF THE SCHMIDT HILLS QUADRANGLE AND PART OF THE GAMBACORTA PEAK QUADRANGLE, ANTARCTICA

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INTRODUCTION

During the 1965-66 austral summer we made reconnaissance gravity and magnetic surveys of the Pensacola Mountains and the adjacent ice-covered area, Antarctica. The gravity survey consisted of 397 observations on ice or rock and seismic reflection measurements of ice thickness at 18 stations away from the mountains. Turbine helicopters were used and the work was coordinated with simultaneous geologic and topographic work by the U.S. Geological Survey. Reconnaissance aeromagnetic profiles were also flown perpendicular to the general northeast strike of the Pensacola Mountains. The objective of the geophysical surveys was to complement the geologic mapping in an effort to understand the tectonic development of the Pensacola Mountains and their relationship to the transition from West to East Antarctica. Behrendt, Meister, and Henderson (1966) discussed preliminary results of the geophysical work.

GRAVITY SURVEY

We used one Worden and two LaCoste and Romberg geodetic gravimeters. The Pensacola survey base station at Camp Neptune (Schmidt Hills quadrangle) was tied four times, over a period of several hours each, to the McMurdo base station (Behrendt and others, 1962). An additional check on the base station was a reoccupation of one of the 1957 IGY (International Geophysical Year) traverse stations on bedrock in the Dufek Massif (Behrendt, 1962). A difference of +0.9 mgal was observed when gravity at the base station was compared with that at the IGY traverse station; this difference is acceptable considering that the older data were all tied to North America by ship and land-surface vehicle (Behrendt and others, 1962) over a period of months and years. All gravity observations in this survey were tied to the Pensacola base station within a few hours, and errors in observed gravity are negligible.

Absolute elevations are considered accurate within ±25 m (±5 mgal) and relative elevation within ±10 m (±2 mgal). Two seismic reflections from the water-ice contact at the base of the Ronne Ice Shelf northwest of the Dufek Massif allowed a determination of sea-level elevation based on hydrostatic equilibrium. Corrections were made for changes in seismic velocity due to density increase in the upper ice shelf (Thiel and Behrendt, 1959); and absolute elevation accuracy was estimated conservatively, at the reflection stations, as ±10 m. The reflection stations were tied, one by vertical angle and one by altimetry, to the Pensacola Mountains control net. The elevations at stations in the survey were obtained from altimeter data corrected for temperature and for barometric-pressure variations at a central control station. In addition, 97 gravity stations were at control points where vertical angle observations were made as part of the topographic mapping control. The standard deviation of the unadjusted altimetry data at the vertical angle stations is ±12 m. All altimeter elevations were adjusted by use of the 97 vertical angle stations as control.

Positions of gravity stations located at points in the topographic control net are accurate to tenths of seconds; and stations away from the mountains where graphic solutions of astronomical observations were made are accurate to about a tenth of a minute. Therefore, latitude-correction errors are negligible.

The largest source of error, and the most difficult to evaluate, is the terrain effect. Terrain corrections could not be made in the usual manner because of insufficient detail on the best maps (1:250,000-scale, 200-m contour interval) available. A large unknown effect due to subglacial terrain could not have been corrected for, even if larger scale maps had been available. The corrections could be as great as several tens of milligals in certain cases, but experience suggests they should be no more than 10 mgal for most stations. We attempted to allow for terrain effects in contouring the maps by assuming that all corrections for stations on rock would be positive and that complete Bouguer anomaly (unknown) must be at least as positive as simple Bouguer anomaly.

MAGNETIC SURVEY

Total magnetic-intensity measurements were made along the flight paths indicated on the magnetic map by means of an Elsec Wisconsin proton precession magnetometer (Wold, 1964), flown in an LC-117 aircraft at a constant barometric elevation of 2,100 m. Trimetrigon photography provided position control in the area of the mountains. Dead reckoning and solar observations,

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adjusted to the photographically identified indicated points, were the only controls at the northwest and southeast ends of the lines over the featureless ice sheet. Consequently, position errors are variable but are minimal near the control points. Some lines crossed no identifiable rock outcrops and these have greater position errors. A reliable estimate of quantitative error is difficult to obtain but probably errors at the ends of the lines are several kilometers. Diurnal control was obtained from a base line connecting the profiles. No flights were made during magnetic storms.

Because of the widely spaced flight paths, position uncertainties, and relatively low amplitude and areal extent of the anomalies in this quadrangle, profiles rather than contours provide the most geologic information. Because the flight lines approximately parallel the main magnetic field contours, no regional gradient was removed.

SUMMARY OF GEOLOGY

Schmidt and Ford (1969) have described the geology in this quadrangle. A composite stratigraphic section for the Pensacola Mountains, from Schmidt and Ford (1969) is included here.

The oldest rocks are those of the Precambrian Patuxent Formation; these compose most of the exposed rock. The Patuxent is a thick section (at least 10 km) of terrigenous turbidite sedimentary rock, interbedded, in the Williams Hills area, with pillow lavas and basalt flows. Large amounts of diabase and minor amounts of felsic magma were injected into the sedimentary rocks. The diabase, in the form of sills, is found mostly in the Schmidt Hills and Williams Hills where Schmidt and Ford (1969) indicated thicknesses of 2-150 m. They gave a ratio of diabase to sedimentary rock in the Schmidt Hills of 1:2.

After deposition of the Patuxent Formation and the intrusion of diabase, the rocks were uplifted and, in Early Cambrian time, eroded. During subsequent marine transgression, Cambrian limestones, felsic flows and pyroclastic rocks. silt and mud beds, and volcanic rocks were deposited. At the end of Cambrian time the Cambrian rocks were folded, the Precambrian rocks were refolded, and granitic rocks were emplaced in the form of sills and rhyolite porphyries and, in the Torbert Escarpment area, as a thick pluton (granite of Median Snowfield). Schmidt and Ford (1969) reported an Rb-Sr age of 510 million years (Early Ordovician) for the time of cooling of this granite pluton.

After a period of erosion, the Paleozoic Neptune Group was deposited. This consists of about 300 m of quartzose sandstone, about 300 m of interbedded argillaceous siltstone and fine-grained quartz sandstone, about 700 m of carbonate-cemented coarse-grained sandstone (including thin interbeds of shale and conglomerate), and a variable thickness (0-1,000 m) of coarse conglomerate.

Above the Neptune Group is about 2,000 m (Schmidt and Ford, 1969) of sandstone, siltstone, shale, and a mudstone bed containing some tillite. The younger rocks of this sequence are of Permian age. D. L. Schmidt (unpub. data) considers these rocks and the Neptune Group to be generally correlative in age and lithology with Beacon strata. These rocks seem to be of lower density than the Cambrian and Precambrian sedimentary rocks (as discussed below). After the Permian rocks were deposited, tectonic activity deformed the sedimentary rocks into broad and locally tight to overturned folds.

A fourth period of structural deformation folded and faulted the rocks over a broad region.

DISCUSSION OF GRAVITY MAP

The most apparent feature of the gravity map is the existence of anomalies of greater amplitude than the probable errors caused by terrain effects. The Bouguer values decrease regionally from northwest to southeast from +20 to -60 mgal. Local anomalies over the Neptune Range are as low as -70 and -90 mgal. The regional gradient is the result of crustal thickening crossing the transition from West to East Antarctica, as discussed by Behrendt, Meister, and Henderson (1966). The contours separating the Schmidt Hills from the Neptune Range are too closely spaced to be caused by deep crustal effects alone; the gradient here is about 4 mgal/km as compared with the general regional gradient of about 2 mgal/km. D. L. Schmidt (unpub. data) concludes that a fault separates the Schmidt Hills from the Neptune Range, as indicated on our map. This fault is probably associated with the source of the steep gravity gradient, but that is also partly due to crustal thickening. The diabase sills emplaced in the Patuxent Formation in the Schmidt Hills no doubt have increased the mean density of the upthrown western side of the fault. Probably the Patuxent rocks in the Schmidt Hills are representative of a deeper part of the crust. Allowing for the regional gradient, there seems to be about 20-mgal difference across the fault. The elevation is about the same on both sides of the fault. The diabase intrusions in the Patuxent Formation of Williams Hills also are on the high-gravity side of the fault; the gravity gradient, however, is not as linear in this area.

Estimates of the vertical displacement on this fault could be made by fitting the observed data with theoretical models. But uncertainty about the density contrasts between the various rock units make this approach rather speculative. The relative masses required to produce a Bouguer anomaly relief of 20 mgal would be 4.8 and 2.4 for density contrasts of 0.1 and 0.2, respectively.

The higher peaks of the southern Neptune Range on which Cambrian sedimentary rocks crop out have an associated 10- to 20-mgal positive anomaly relative to the Patuxent Formation (Precambrian in the northern Neptune Range and about 20- to 30-mgal positive anomaly relative to the Beacon(?) rocks (Paleozoic) mapped on the flanks. There is a negative anomaly on the west side of the southern Neptune Range over Beacon(?) rocks. Because a density contrast greater than 0.1-0.2 g/cm^3 between different Paleozoic sedimentary rocks is unlikely, a 10- to 30-mgal difference in gravity corresponds to 2.4-7.2 km for $\Delta\rho = 0.1$ g/cm^3 and half as much for $\Delta\rho = 0.2$ g/cm^3. These values are suggestive of the relative variation in thickness of the Beacon(?), Cambrian, and Patuxent sedimentary rock units.

A small positive anomaly over the Cambrian sedimentary rocks of the Hill Nunatak area southeast of the Neptune Range indicates that the density of these rocks is higher than that of the Beacon(?) rocks.

The anomaly over the granite of Median Snowfield and Beacon(?) sedimentary rocks in the Torbert Escarpment area is at least 30 mgal less than that over the Patuxent Formation in the Neptune Range. The granite must have a lower density than the Patuxent Formation if it is the source of this anomaly. Densities for granite as low as 2.5 g/cm^3 are not uncommon (Woollard, 1962), so this is a reasonable explanation. It is not easy to separate the effect of the Beacon(?) rocks from that of the underlying granite in the Torbert Escarpment area. The combined thickness could be as great as 7.2 km for $\Delta\rho = 0.1$ g/cm^3 relative to the Patuxent Formation.

DISCUSSION OF THE MAGNETIC PROFILES

There are no high-amplitude anomalies in these profiles such as those exceeding 1,000γ associated with the magnetic upper part of the Dufek mafic intrusion to the north (Behrendt and others, 1966). A line of 50-100γ anomalies is associated with the fault separating Schmidt Hills from the Neptune Range. These anomalies may be due to diabase intrusions in the lower part of the Patuxent Formation.

Most of the magnetic field is smooth over the thick section of sedimentary rocks in the Neptune Range. A broad negative anomaly is apparently associated with these nonmagnetic rocks.

Near the east end of line profile 38 above Loren Nunataks there is a 40γ anomaly of unknown origin; this same feature can be seen farther south on lines 39, 40, and 41. The width of this anomaly on line 40 south of Hill Nunatak suggests that a fairly magnetic body of substantial thickness must underlie the sedimentary rocks at a depth of several kilometers. Possibly the anomaly marks the location of a mafic intrusion similar in age and character to the Dufek intrusion, but this is speculative. The southeast end of line 41 shows short-wave length anomalies of about 100γ amplitude whose sources must be close to the base of the ice. Probably the sedimentary rocks are thin or absent there, and the source of these anomalies is the same as that of the broader anomaly to the northwest. A broad 150γ anomaly south of the Neptune Range crossed by line 42 may be a part of this same intrusion although this would require a curve to the west, southwest of line 41. Additional anomalies on lines 43 and 44 also suggest mafic intrusions.

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