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Gravity and Aeromagnetic Anomalies in the Rexburg Area of Eastern Idaho

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Don R. Mabey
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Don R. Mabey
U.S. Geological Survey, Denver, Colorado

Introduction

A caldera complex in the Rexburg area of the eastern Snake River Plain has been defined on the basis of geologic evidence provided by H. J. Prostka and G. F. Embree (written communication, 1977) and named the Rexburg caldera complex. Geothermal resources in the Rexburg area are likely to be related directly or indirectly to this caldera complex, and the area of the complex was selected as the target of geophysical surveys made as part of an investigation of the geothermal resources of the area. To supplement existing gravity and magnetic surveys in the Rexburg area, additional gravity and magnetic data were obtained in the summer of 1977. The purposes of these surveys were to (1) confirm the existence of the caldera complex and provide data on the boundaries, (2) obtain data on the rocks within the caldera complex, and (3) search for geophysical anomalies relating directly or indirectly to geothermal features.

Gravity Data

Gravity stations in the area of interest had been obtained by Blank and Gettings (1974) as part of a study in the Island Park area; by LaFehr (1962) as part of a study of the eastern Snake River Plain; and by Mabey, Peterson, and Wilson (1974) as part of the survey to complete the gravity map of southern Idaho. Immediately to the east is a survey of Teton Valley by Rosa-Lee Brace (unpublished mapping, 1974). To supplement the data from these sources, 250 additional gravity measurements were made to obtain more detail within the Rexburg caldera complex and to define the boundaries of the complex where it is covered by younger rocks. The data from these five surveys have been merged to produce the gravity map in figure 1. The data were reduced to the Bouguer anomaly assuming a density of 2.67 g per cm^3 for the rocks forming the surface relief. Several topographic features are less dense than this and will be reflected in the Bouguer anomaly map. Terrain corrections have not been applied to the data. The terrain correction is significant only in the southwest corner of the map and near Menan Buttes. In these areas the corrections are not large enough to affect the general form of the major features of the gravity anomaly map.

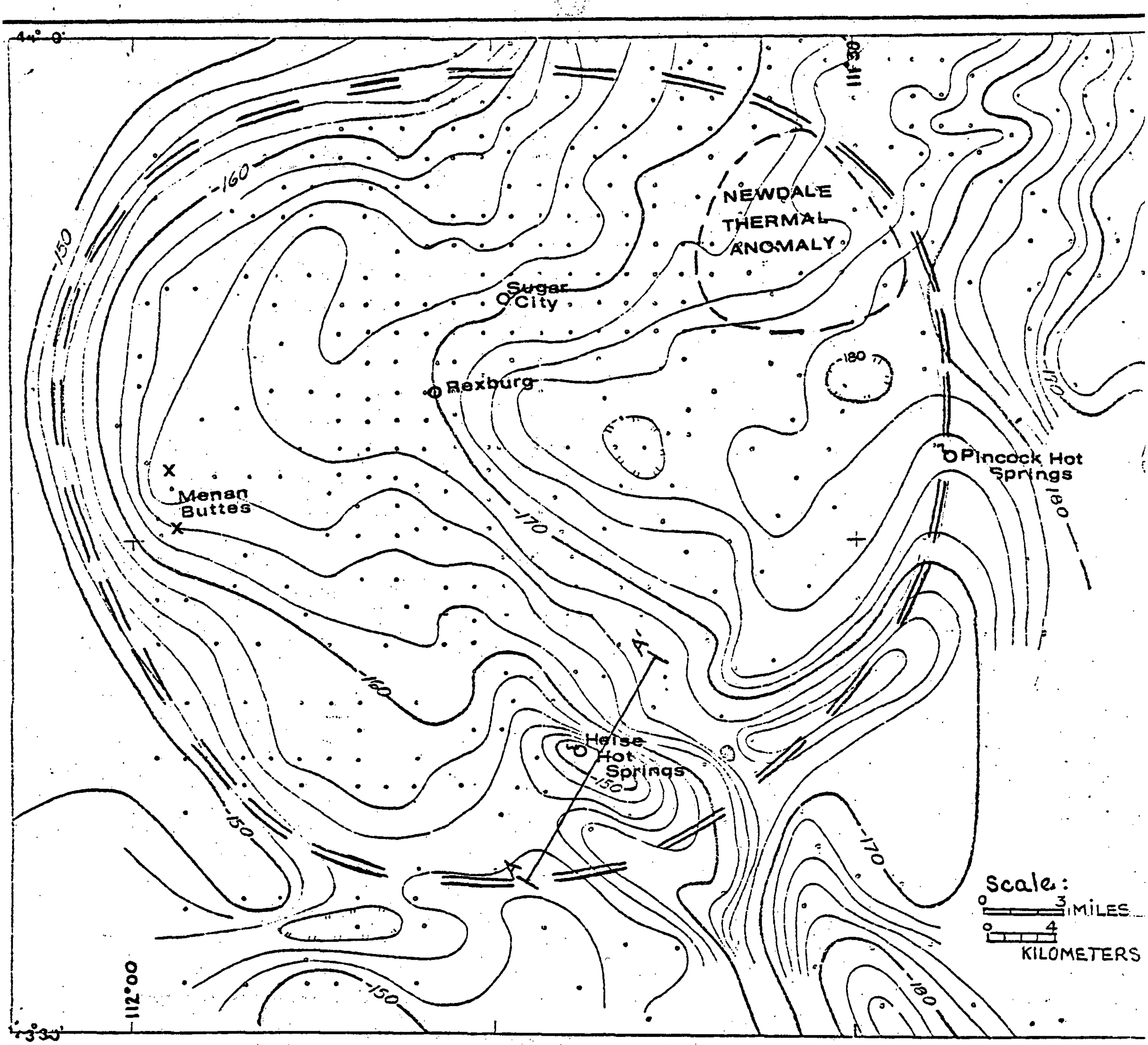

Figure 1. Bouguer gravity anomaly map of the Rexburg area, Idaho showing the outline of the Rexburg caldera complex as inferred from the gravity data. Contour interval is 2 milligals.

The Rexburg caldera complex lies along the southeast edge of the Snake River Plain, with which a large regional gravity high is associated (fig. 2). West of the Rexburg caldera complex, the regional anomaly over the eastern Snake River Plain can be modeled by a thinning of the crust (Mabey, in press), and this interpretation appears to be generally consistent with the data in the area of the Rexburg caldera complex. However, to the northeast the amplitude of the regional gravity high over the plain decreases, and in the Island Park area the amplitude of the regional gravity high is small. Farther to the northeast, over the Yellowstone Plateau on the projection of the Snake River Plain, the regional gravity anomaly is a large low. The northeast decrease in the amplitude of the Bouguer gravity and rise in surface elevation have been related to the evolution of the northeastern Snake River Plain (see Eaton and others, 1975).

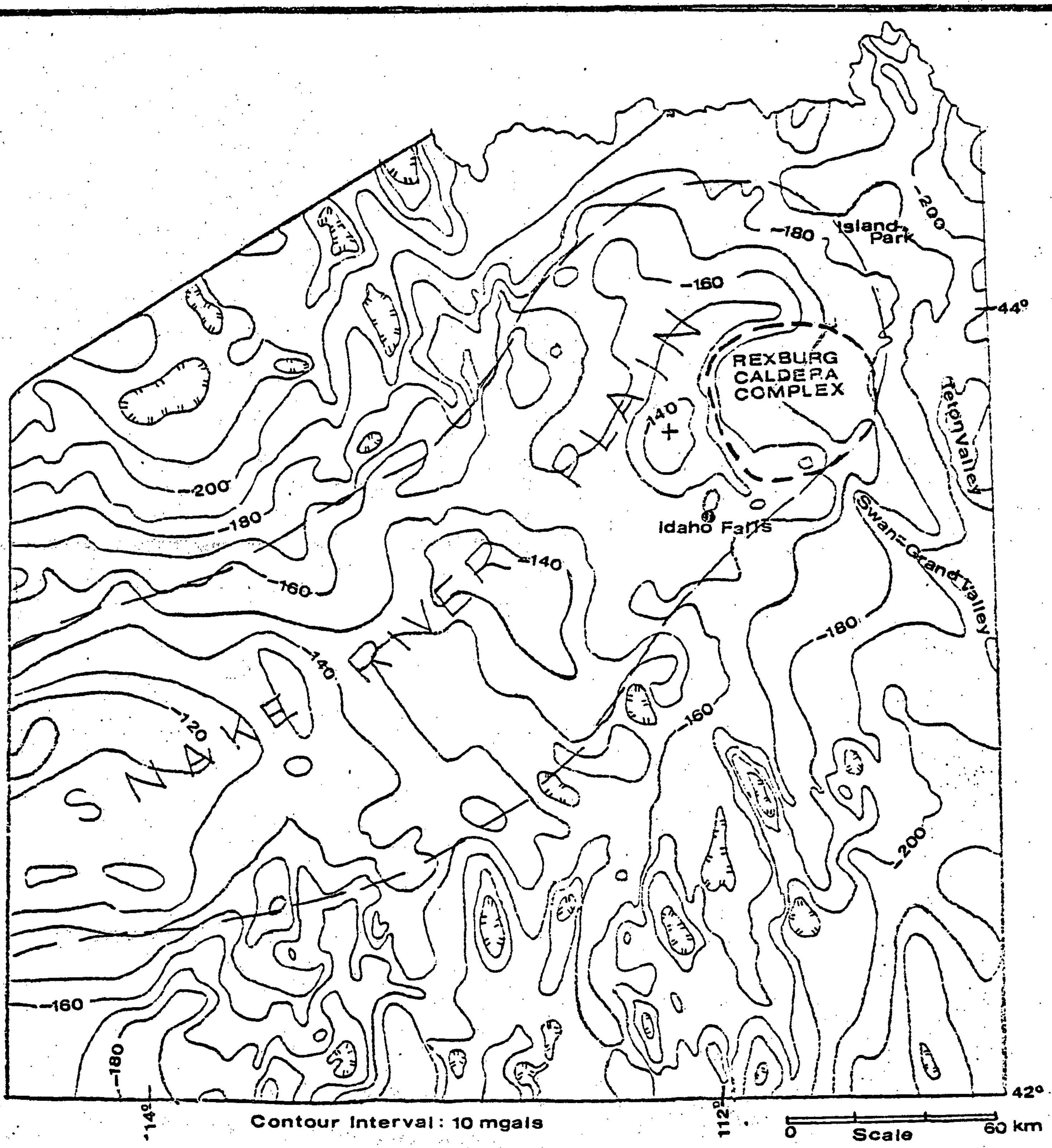

Figure 2. Bouguer gravity anomaly map of southeastern Idaho (from Mabey, in press) showing the location of the Rexburg caldera complex.

A gravity low in the Rexburg area superimposed on the regional high is apparent on the Bouguer gravity map of southeastern Idaho (fig. 2). This anomaly is here called the Rexburg gravity low. The near-circular form of the Rexburg gravity low, in contrast with pronounced elongated lows typical of the Basin and Range structures north and south of the Snake River Plain, suggests that the low reflects a caldera and that the extent of the anomaly is approximately coincident with the extent of the caldera complex inferred by Prostka and Embree. On the west an extensive arcuate gravity high bounds the gravity low. The highest values associated with the high are about 30 km northwest of Idaho Falls. The form of the gravity anomaly near the highest values suggests that a part of the high, the Bouguer anomaly values appear to be approximately normal for this elevation on the eastern Snake River Plain (Mabey, 1966). On the south the Rexburg gravity low is intersected by a north-trending gravity low that is an extension of a gravity low in Swan and Grand Valleys. The southeastern edge of the Rexburg gravity low is coincident with the northwestern limit of pre-Tertiary rocks in the Snake River Range. To the northeast the low is intersected by the northern end of the gravity low in Teton Valley.

Aeromagnetic Data

Regional aeromagnetic data are available from a survey of eastern Idaho (U.S. Geological Survey, 1972), and a more detailed survey was flown of the Heise Hot Springs area as part of the geothermal study. The regional map is based primarily on data obtained along flight lines 3650 m above sea level and five minutes of latitude apart. Surface elevations range from about 1500 m on the Snake River Plain to over 2500 m in the mountains south of the plain. A part of this map showing 100 gamma contours is illustrated in figure 3.

No regional magnetic anomaly is coincident with the Rexburg caldera complex, but there are magnetic anomalies that appear to be related to the complex. The west edge of the complex is coincident with the east edge of a magnetic high in the area of a gravity high centered northwest of Idaho Falls. A large magnetic high occurs within the complex near Heise Hot Springs, and a smaller magnetic high (indicated on the map by + because it is not defined by the 100 gamma contours) is near the east edge of the complex. Flight-line spacing is such that the shape and amplitude of the latter anomaly are not defined. The more detailed magnetic map of the Heise area (fig. 4), flown 2300 m above sea level with flight lines 1.6 km apart, provides better definition of the large high centered at Heise Hot Springs and defines several smaller anomalies.

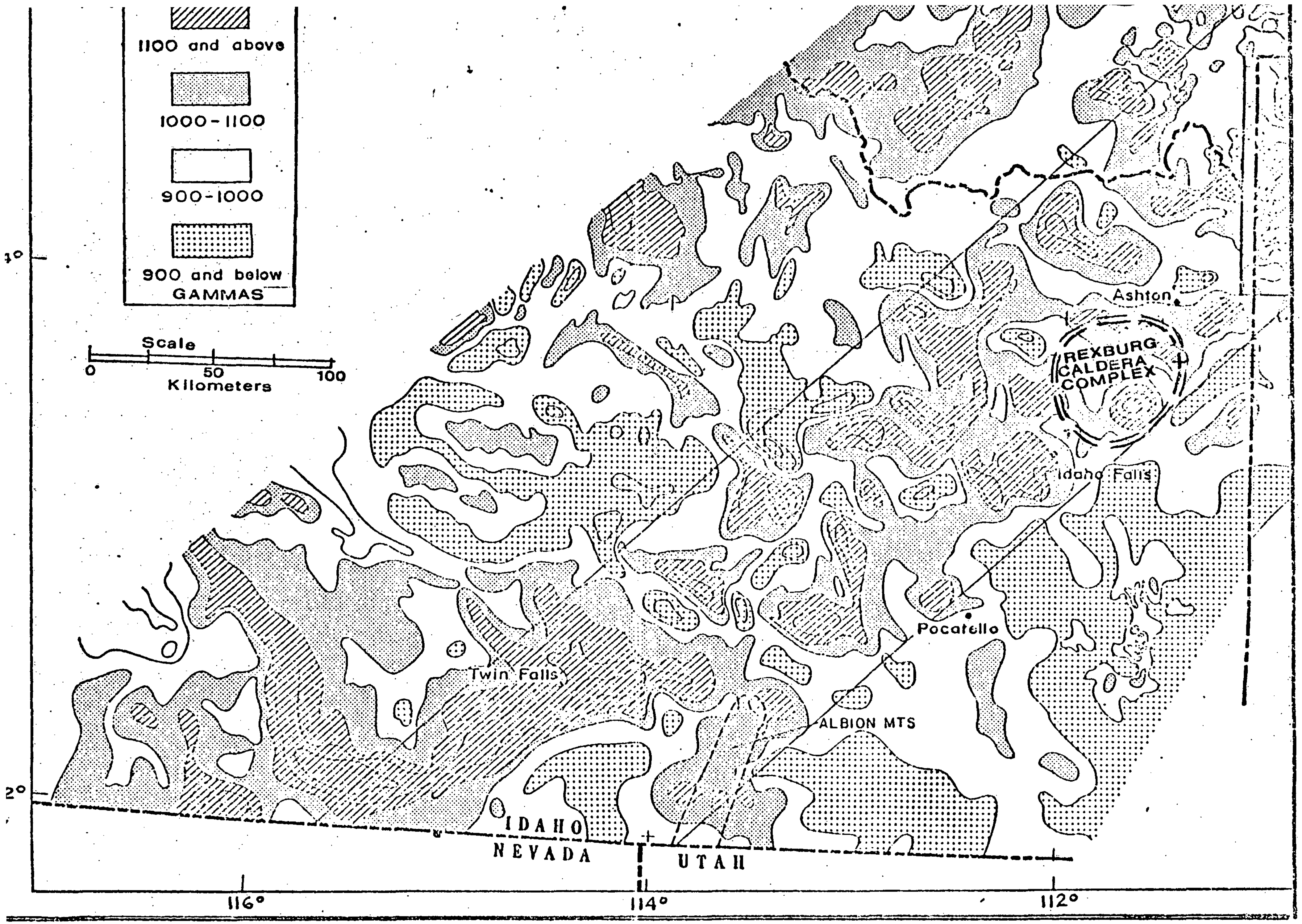

Figure 3. Aeromagnetic map of southeastern Idaho (from Eaton and others, 1975) showing the location of the Rexburg caldera complex.

Interpretation

The boundary of the Rexburg caldera complex is best defined by the surface geology in the southeastern quadrant, and here there is very good correlation between the boundary of the Rexburg gravity low and the caldera complex boundary. On the west and north the gravity data may be the best information available on the boundary of the caldera complex, and the inferred boundary of the caldera complex shown in figure 1 coincides with the edge of the negative mass anomaly indicated by the gravity data. To the northeast the caldera complex appears to overlap another depression, and the margin here is not well defined by either the geology or the gravity data. The inferred boundary here is primarily a connection of the better defined segments. The lowest gravity values occur in the eastern and western parts of the caldera complex, near Menan Buttes and east of Rexburg. The subdued high between these lows appears to be a northwestward-trending gravity high centered over Heise Hot Springs and a southwest-trending high west of Sugar City.

Gravity lows associated with calderas in the western United States usually result from two sources: low density fill within the caldera or an underlying body of intrusive rock that is less dense than the enclosing basement. The coincidence of the southwestern boundary of the Rexburg caldera complex with steep gravity gradients suggests a near-surface source, caldera fill. Except in the vicinity of the gravity high at Heise Hot Springs, the rocks exposed or penetrated by drill holes as deep as 420 m in the area of the gravity low are stream gravels, basalt and welded tuff of Quaternary age, and Pliocene rhyolite. No attempt has been made to determine the density of these rocks in the area of the Rexburg caldera complex, but the average bulk density of similar rocks in the region ranges from about 2.0 to 2.65 g per cm^3. The average bulk density of pre-Tertiary rocks in the region is about 2.65 g per cm^3. Thus a mass of the low-density Quaternary and Tertiary sedimentary and volcanic rock enclosed by pre-Tertiary rock would produce a gravity low, and this seems a probable cause of a major part of the low. Nowhere does the gravity anomaly require a deep source, although the existence of such a source smaller in extent than the inferred caldera complex is not inconsistent with the gravity data.

Although the Rexburg gravity low appears in large part to reflect fill within the Rexburg caldera complex, a precise quantitative interpretation of the anomaly is not justified. The amplitude of the gravity low cannot be accurately determined because of uncertainties in isolating the anomaly from the more regional high associated with the eastern Snake River Plain. No approximation of the regional gravity anomaly over the Snake River Plain can be computed by assuming that a linear relationship exists between the gravity anomaly and the regional topography (Mabey, 1966). However, in the northeast part of the Snake River Plain, the area over which the elevations are averaged strongly affects the regional determined and thus the amplitude of the computed residual. Even if the local low could be isolated from the regional high, the fill and the enclosing rock cannot be accurately estimated. Also the possibility of a significant contribution to the gravity anomaly by an underlying intrusive body cannot be discounted. The residual amplitude of gravity is estimated to be about 20 mgals. The average density contrast between the fill and the enclosing rock is likely to be between 0.2 and 0.5 g per cm^3. A 20-mgal anomaly could be produced by a thickness of 1 to 2.5 km of rocks having this density contrast.

The most prominent local gravity and magnetic anomalies are highs within the Rexburg caldera complex in the area of Heise Hot Springs. Although the crests of the anomalies are coincident, the extent of the anomalies are different and they cannot reflect entirely the same mass. Mesozoic sedimentary rocks overlain by Pliocene rhyolite flows and welded tuffs are exposed in the area of the anomalies. Rhyolite dikes are locally abundant. The northwest-trending Heise fault (Prostka and Hackman, 1974), which forms a southwest-facing scarp locally 300 m high, is parallel to and near the crest of the anomalies. The correlation between the gravity high and outcropping Mesozoic sedimentary rock suggests that the gravity anomaly reflects in large part a structural high elevating the more dense pre-Tertiary rocks. The shape and extent of the magnetic anomaly, the abundant rhyolite dikes in the area, and the indication by the magnetic gradients that the source lies below the surface all suggest that a major part of the magnetic high is produced by a large buried intrusive body. Some features of the magnetic anomaly reflect the near-surface volcanic rocks.

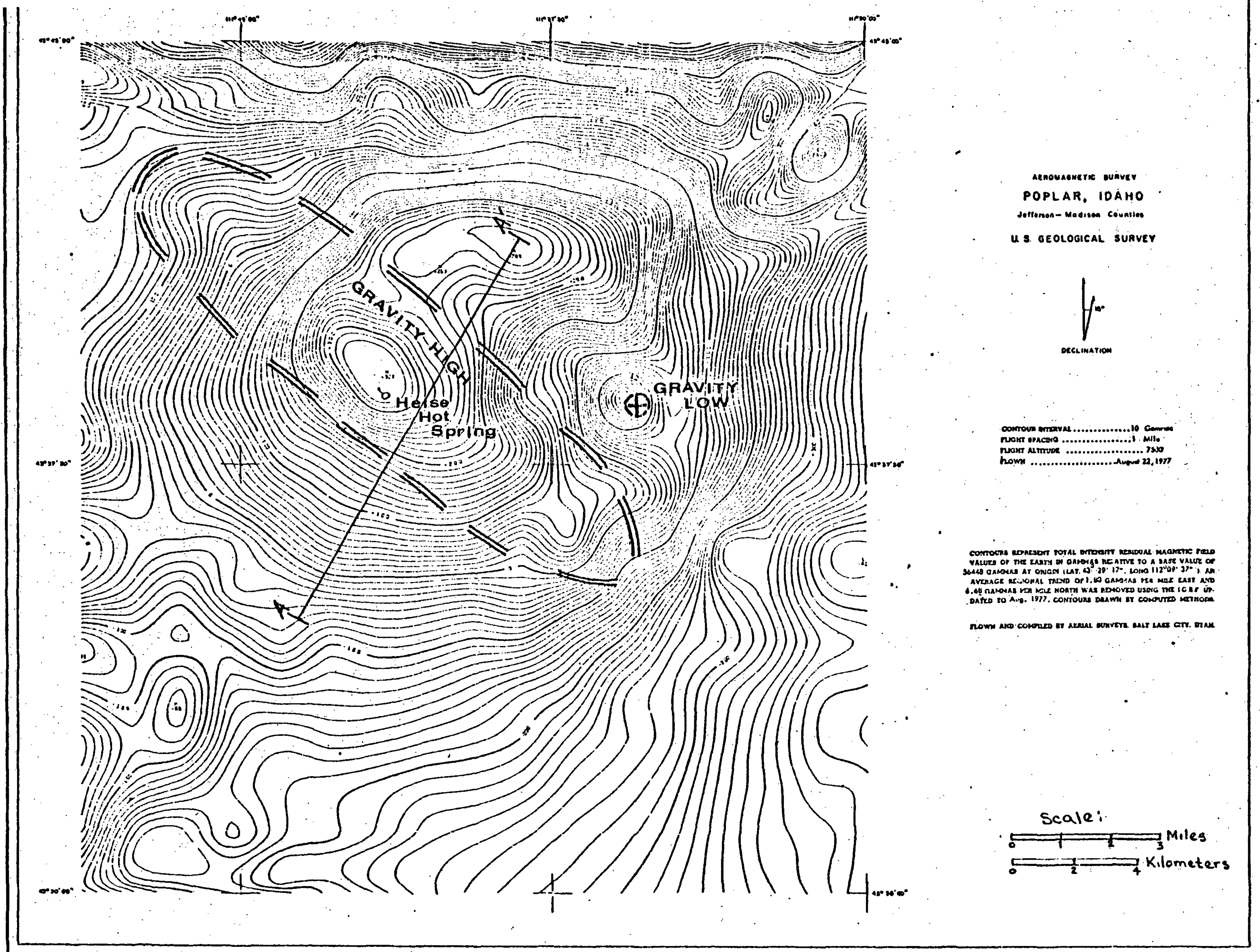

Figure 4. Residual aeromagnetic map of the area of Heise Hot Springs showing the location of the gravity high at Heise Hot Springs and a gravity low to the east.

A profile (fig. 5) normal to the trend of the gravity high shows a section that would produce the major features of the gravity and magnetic fields in the vicinity of Heise Hot Springs. The gravity anomaly is attributed to a high on the surface of the pre-Cenozoic rocks at Heise Hot Springs and to an area of thicker Cenozoic rocks under the valley of the Snake River to the southwest. The depression containing the thicker Cenozoic rocks is parallel to and within a northwestward projection of the Swan-Grand Valley trend into the Rexburg caldera complex. The magnetic anomaly has two major components: a local high at Heise Hot Springs superimposed on broader, more deeply buried source. Both components probably reflect a large body of intrusive rock with the apex near Heise Hot Springs. The intrusive mass, which may be the same age as the rhyolite dikes, lies within the Rexburg caldera complex where the Swan-Grand Valley trend intersects the caldera. Magnetic anomalies suggesting a similar intrusive body occur elsewhere along the southeastern margin of the Snake River Plain, where major Basin and Range structures intersect the plain (Mabey, in press). Along the northeastern part of the profile, the magnetic anomaly appears to reflect both Cenozoic volcanic rock and the underlying intrusive body.

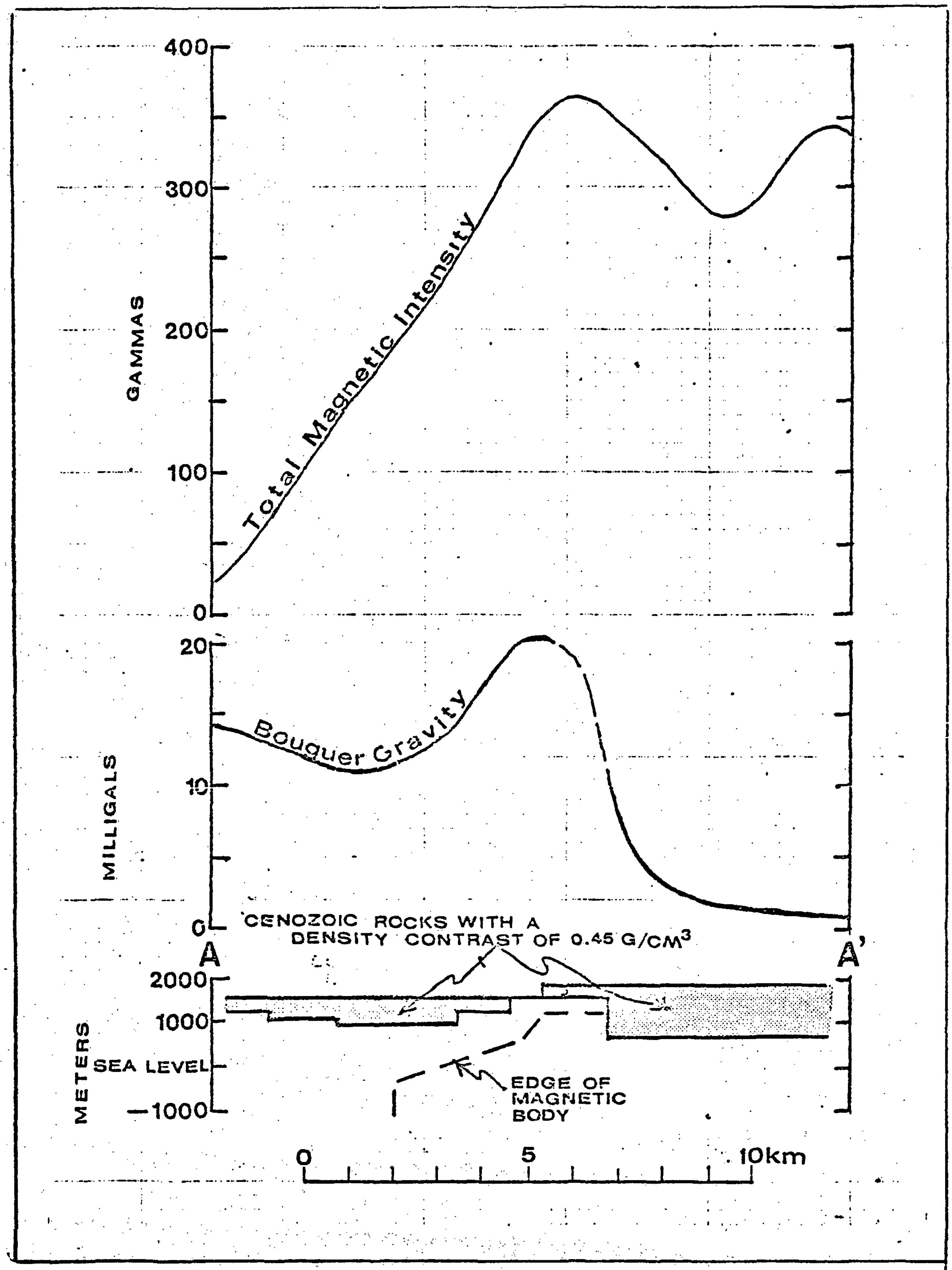

Figure 5. Magnetic and gravity profiles and interpreted section across the anomalies at Heise Hot Springs.

Heise Hot Springs and the warm springs to the northwest occur along the crest of the gravity and magnetic highs. The springs are in a structurally complex area where northwest-trending faults, probably related to the Basin and Range structure of Swan and Grand Valleys, displace a structural high over the inferred intrusive body. Although the Heise fault forms a prominent southwest-facing scarp and the presence of the Snake River against this scarp attests to recent movement of the fault, the geophysical data indicate that the Heise fault is near the crest of the structural high.

The north side of the magnetic high is an east-trending zone that coincides with a subtle east trend in the gravity anomaly contours. The zone coincides with west-trending segments of major canyons and is north of the northernmost outcrops of rhyolite. Another east-trending gravity feature is apparent about 5 km farther north.

About 8 km east of Heise Hot Springs are coincident gravity and magnetic lows (fig. 4). The cause of the lows is not apparent on the geologic map of Prostka and Hackman (1974). The anomalies appear to reflect a zone in which both the density and magnetization of the underlying rocks are lower than those of the enclosing rocks.

Pincock Hot Spring, on the east edge of the Rexburg caldera, lies midway between two flight lines about 9 km apart on the regional map (fig. 2). Along both flight lines a magnetic high was measured opposite the hot spring. Although existing data are not adequate to define this anomaly, the data suggest a magnetic high in the area of Pincock Hot Spring.

Away from Heise Hot Springs the gravity field within the Rexburg caldera is a complex of local anomalies and trends. The low marked by the -180 closed contour is over Canyon Butte, but elsewhere the correlation of the local gravity features with surface geologic features is not apparent. The local gravity anomalies likely reflect both mass anomalies within the Cenozoic volcanic and sedimentary rock and relief on the top of the underlying rock. A northwest trend of the gravity contours is apparent in the southwest quarter of the caldera, perhaps reflecting structure related to the Swan-Grand Valley trend to the southeast. In the northwest quarter, east to northeast trends are dominant. Although outside of the area of Heise Hot Springs the gravity data alone cannot be used to infer a model of the subsurface geology within the Rexburg caldera, any model based on other data must be consistent with the gravity data.

Geothermal Resources

Although the heat-flow anomaly associated with the eastern Snake River Plain is not well defined, the data available indicate the presence of a major crustal heat source apparently related to the plain (Brott and Blackwell, 1976). Thus relatively high thermal gradients are to be expected in the Rexburg area at depths where the movement of ground water is not affecting the temperatures. In addition to the regional thermal anomaly, local heat sources may be related to the Rexburg caldera complex. Also, structure within and perhaps related to the caldera complex may control convecting hydrothermal systems that are transporting heat toward the surface. Major reservoirs of hot water are likely to be poorly consolidated sedimentary rocks or more indurated rock that has been fractured. Hot water occurs at Heise Hot Springs and Pincock Hot Spring and in wells near Newdale. Warm water has been reported in wells from other areas.

Three factors suggest the area of Heise Hot Springs as favorable for the occurrence of a geothermal resource: (1) evidence of a large intrusive body that may be young enough to be a source of heat, (2) structural complexity that may favor the development of both a convective hydrothermal systems and fractured rock reservoirs, and (3) the known occurrence of hot water. Although comparable data have not been obtained at Pincock Hot Spring, similar conditions may exist there.

Elsewhere within the Rexburg caldera complex, no gravity or magnetic evidence of a local heat source exists, and local thermal anomalies are likely to be related to convecting hydrothermal systems with structural control.

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