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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
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Dr. Phillip L. Merritt, Assistant Director
Division of Raw Materials
U. S. Atomic Energy Commission
P. O. Box 30, Ansonia Station
New York 23, New York

Dear Phil:

Transmitted herewith are six copies of TEI-342, "A magnetic investigation of the Round Mountain plug, Castle Valley, Grand County, Utah," by R. A. Black, December 1953.

Sincerely yours,

Andrew Brown

for W. H. Bradley
Chief Geologist

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Geology and Mineralogy

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Series A

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

A MAGNETIC INVESTIGATION OF THE ROUND MOUNTAIN PLUG CASTLE VALLEY, GRAND COUNTY, UTAH*

By

R. A. Black

December 1953

Trace Elements Investigations Report 342

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A MAGNETIC INVESTIGATION OF THE ROUND MOUNTAIN PLUG, CASTLE VALLEY, GRAND COUNTY, UTAH

By R. A. Black

ABSTRACT

A magnetic survey was made in Castle Valley, Grand County, Utah, to determine if the Round Mountain plug was fed laterally from the La Sal Mountains or vertically from a source at depth. Additional measurements were made around the exposure of igneous rock to obtain the shape of the plug at depth.

No indication of a buried lateral igneous feeder was detected on the magnetic profiles. The magnetic contour map showed that the plug was much larger than indicated by the diorite porphyry outcrop, and that the buried part of the plug southeast of Round Mountain has a higher magnetic susceptibility than the diorite outcrop. Theoretical anomalies, calculated using the susceptibility of the diorite outcrop, indicate that a lateral feeder at a depth of greater than 200 feet could not be detected. The size and shape of the magnetic anomaly as shown on the contour map suggest that the plug was fed from a source at depth.

INTRODUCTION

Discussions during the winter of 1952 with C. B. Hunt of the U. S. Geological Survey concerning the intrusives and volcanism phase of Cenozoic studies led to a proposal that a geophysical study be made of the Round Mountain plug in Castle Valley, Grand County, Utah, to determine if the Round Mountain plug was connected to the La Sal Mountains by a relatively shallow lateral feeder, or if it was fed from an individual source at depth, and to obtain information on the shape of the intrusion. This survey was part of Colorado Plateau geologic studies being carried out by the U. S. Geological Survey on behalf of the Atomic Energy Commission.

During a series of aeromagnetic traverses by the U. S. Geological Survey plane in the La Sal Mountain area in February and March 1952, an anomaly of 150 gammas had been detected at an altitude of 2,000 feet above a point half way up the slope of Round Mountain, indicating that the diorite porphyry of the plug is fairly magnetic. From this information and from the knowledge of the geology of the area, it was decided that a ground magnetic survey could best be used to obtain the desired information about the Round Mountain plug . A vertical intensity magnetic survey was carried out in Castle Valley, Utah, during the period May 5 to June 18, 1953, by a field party under the direction of R. A. Black. At various times during this period, P. E. Byerly and R. E. Warrick of the Geological Survey assisted in obtaining the magnetic measurements.

LOCATION AND TOPOGRAPHY

The Castle Valley area is in Grand County, Utah, (fig. 1) approximately 18 miles northeast of Moab, and can be reached by Utah Highway 128. Figure 2 is a more detailed map after Baker (1933) which shows the Valley outline and the location of the Round Mountain stock.

Figure 3 shows the location of the magnetic traverses with relation to the Round Mountain plug. The individual stations occupied on and around the plug are also shown. The area northwest of traverse 5 is a relatively flat valley floor covered with alluvium except for the small circular outcrops of the Paradox member of the Hermosa formation around the base of the plug. The Paradox aureole is sharply upthrust around the base of the plug and displays very steep dips. Southeast of traverse 5, roughly between 0 and 5500 on traverses 5 to 8, there are small rounded hills composed of 30 to 80 feet of Pleistocene gravels covered with thin alluvium. The area between 5500 and 8500 on traverses 5 to 8 is a sagebrush-covered alluvial slope.

GEOLOGY

The major structural feature of the Castle Valley area is the Castle Creek anticline which trends about N. 50° W. and plunges northwest from the La Sal Mountains, flattening near the mouth of Castle Creek. The crest of the anticline has been cut by Castle Creek to form a wide deep valley floored with alluvium. Near the center of the valley is Round Mountain, a steep-sided roughly cylindrical mass of igneous material surrounded by

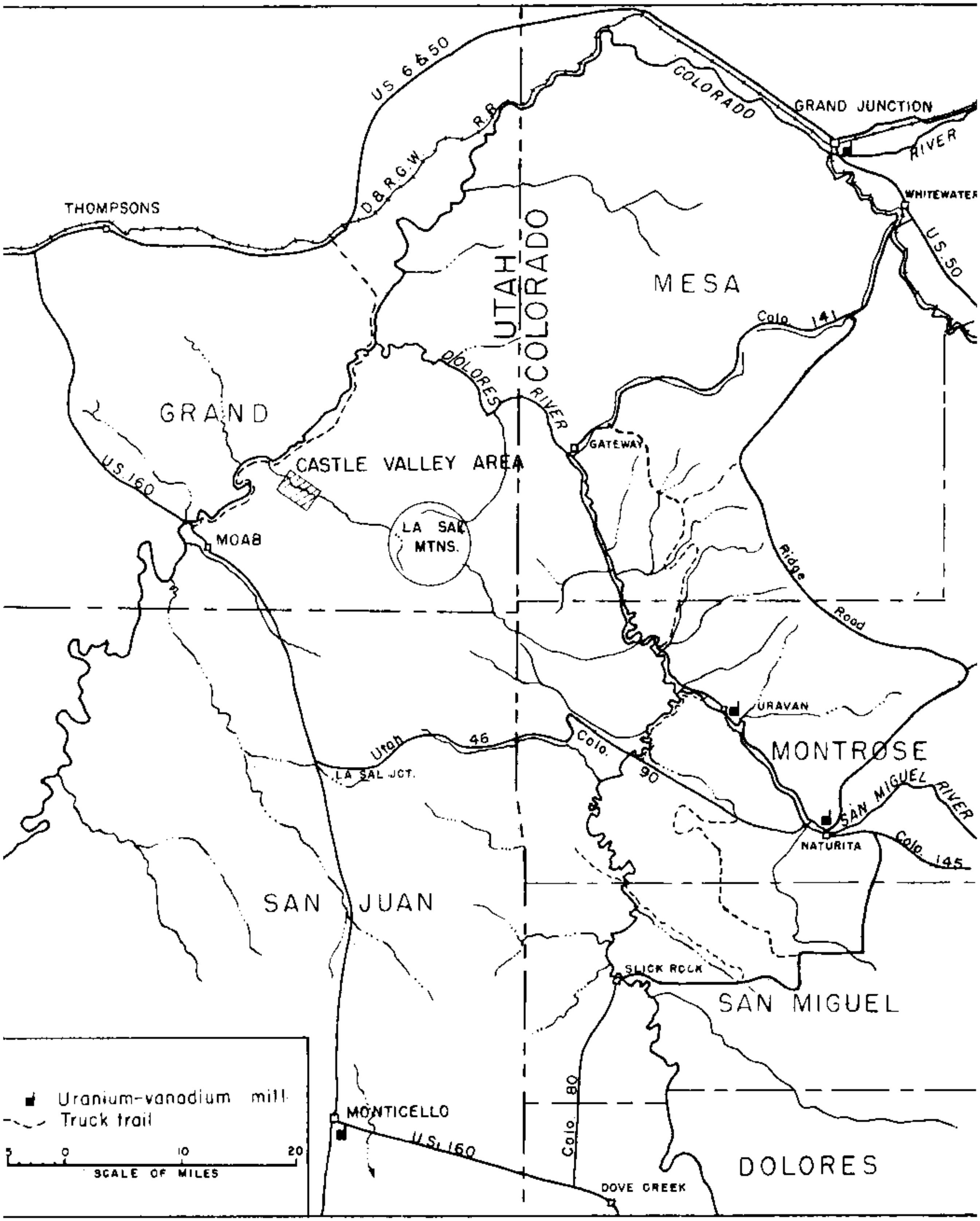

FIGURE 1. INDEX MAP OF PART OF THE COLORADO PLATEAU SHOWING THE LOCATION OF THE CASTLE VALLEY AREA, GRAND COUNTY, UTAH

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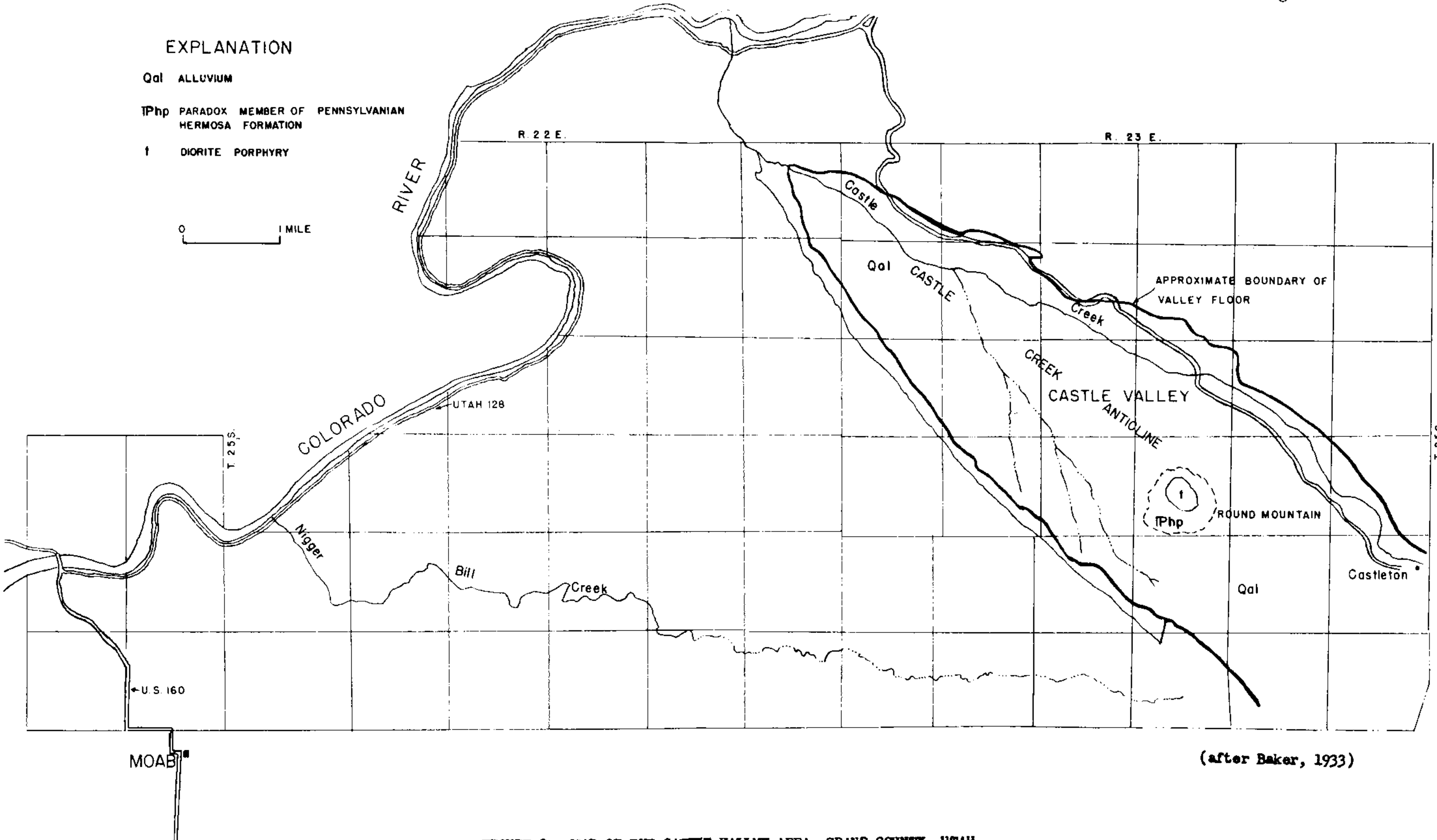

FIGURE 2. MAP OF THE CASTLE VALLEY AREA, GRAND COUNTY, UTAH

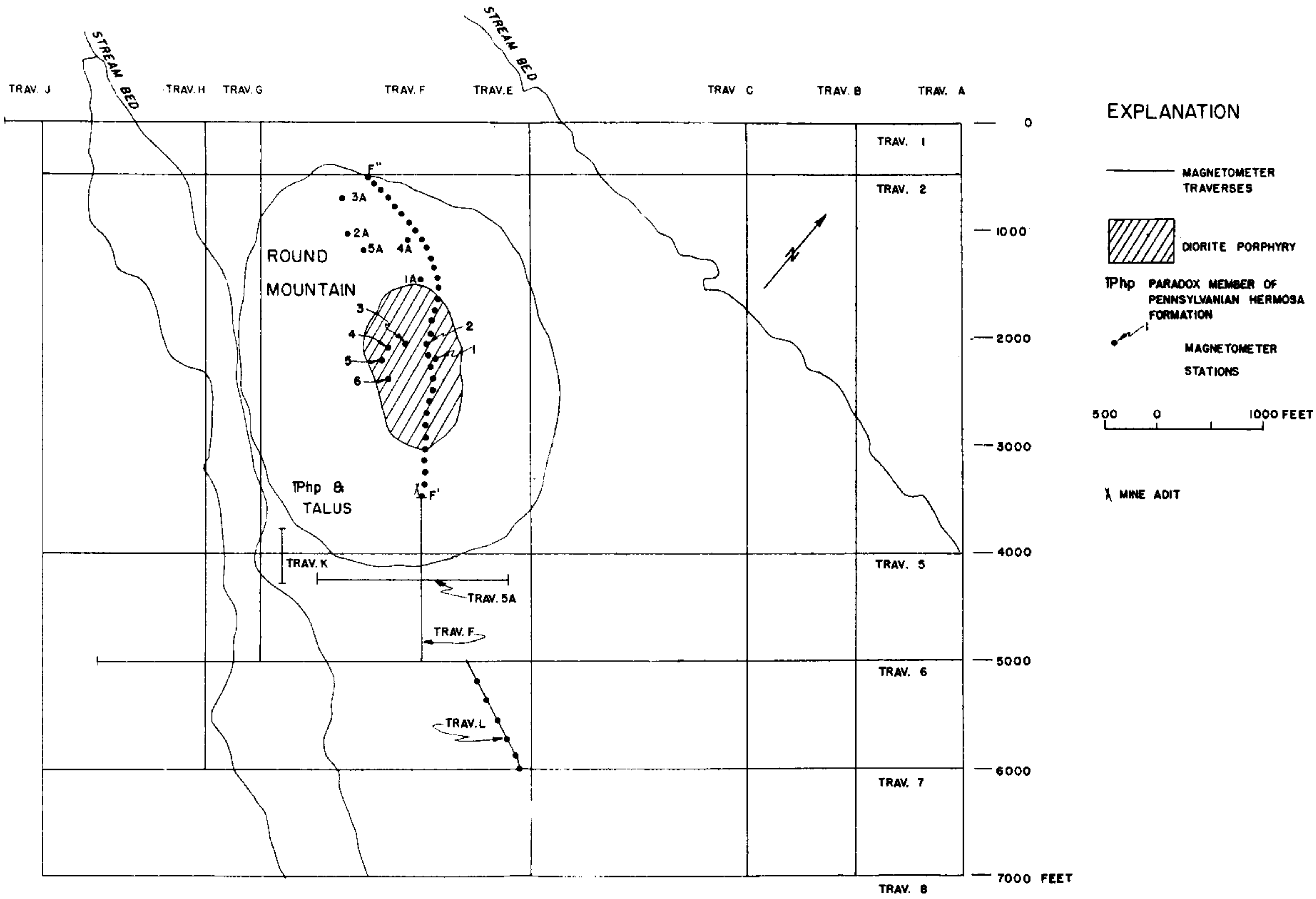

FIGURE 3. MAP SHOWING THE LOCATION OF THE MAGNETIC TRAVERSES WITH RESPECT TO ROUND MOUNTAIN, GRAND COUNTY, UTAH

upthrust Paradox beds through which it has been intruded. The lower slopes of the mountain are covered with talus. The valley floor is estimated to be underlain by 10,000 feet of salt, anhydrite, and gypsum of the Paradox formation, either in the form of a single body or as several adjacent smaller bodies of salt.

Part of the area between magnetic traverses 5 and 8 is underlain by 30 to 80 feet of Pleistocene gravels. These gravels are river terrace gravels derived from the igneous rocks of the La Sal Mountains. The La Sal Mountains are composed primarily of diorite porphyry.

The Round Mountain plug has been described by Baker (1933) as composed of a fine-grained soda trachyte made up of soda-rich plagioclase feldspars with phenocrysts of hornblende, augite, and small amounts of apatite, titanite, and magnetite.

Butler and others (1920) suggested that the Castle Creek anticline might be underlain by igneous material. Baker finds no evidence to support Butler's suggestion, and seems to be more in favor of Gould's idea (1926) that the salt anticlines, although not caused by the laccolithic intrusions that formed the La Sal Mountains, served to some extent to localize the laccoliths at the edges of the La Sal Mountains.

MAGNETIC INVESTIGATIONS

No previous ground geophysical work in the Castle Valley area is known. The only geophysical information available was from the single airborne magnetometer flight line that the Geological Survey plane had flown over the edge of the Round Mountain plug. As previously mentioned, in this flight, at an altitude of 2,000 feet, an anomaly of 150 gammas was detected over the plug. This provided the basis for the choice of the magnetic method as the ground geophysical method to use in investigating the plug.

Geologic conditions in the Castle Valley area seemed favorable for a ground magnetic survey. The igneous plug, a diorite porphyry, could be expected to have a high magnetic susceptibility and the surrounding Paradox member, to be of quite low susceptibility, owing to its salt, gypsum, and anhydrite content.

The area was an excellent one for magnetic investigations because of the lack of artificial sources of magnetic disturbance such as wire fences, buried iron pipes, drill-hole casings, and grounded direct-current machinery.

Field procedures

The magnetic measurements were made with a temperature compensated Askania vertical magnetometer with a scale constant of 10 gammas per scale division.

A three-man crew was used on the survey: an instrument operator, a recorder, and a third crew member who was responsible for laying out the traverse lines and marking the station locations. The traverses were laid out as shown in figure 3, with marker stakes put in at 500-foot intervals. Traverses 5 to 8 were laid out at right angles to the postulated trend of the igneous feeder and were considered sufficient to provide evidence as to its existence. The other traverses were laid out to determine the attitude and lateral extent of the igneous plug.

The lack of roads in the area and the presence of numerous rocky washes in the valley floor prohibited the use of vehicles and made it necessary to run the traverses on foot. These facts, plus the length of the traverses, made it impossible to obtain more than four to six base station readings per day for purposes of determining the base and diurnal correction. After a number of traverse lines had been completed, a system of moving bases was employed. The original base was read at the beginning and end of the day, and at various intervals during the day stations were occupied along previously run traverses. This system permitted closer control of the diurnal variation.

In general, magnetometer stations were occupied at 200 foot intervals along the traverses, and where anomalous readings were obtained, more detailed observations were made.

In addition to the regular grid, stations on traverse F' F" and eleven individual magnetometer stations on and around the diorite porphyry outcrop were occupied. The steep slopes of the plug made it difficult to obtain any uniform pattern of stations; their location was decided by accessibility.

Theoretical anomalies

Magnetic anomalies result chiefly from differences in magnetic susceptibility between the geologic feature causing the anomaly and the surrounding medium. These anomalies are interpreted by relating their size and shape to geologic conditions which could be responsible for them. A knowledge of the type and size of anomaly to be expected from a certain known set of geologic conditions can be of considerable aid in interpreting magnetic data. One of the more convenient methods of computing the surface magnetic effect of a buried geologic body is to assume that it roughly approximates one of several simple geometric shapes for which the magnetic effect can be computed.

The geologic problem investigated in the Castle Valley area was essentially that of determining the presence or absence of a lateral igneous feeder connecting Round Mountain and the La Sal Mountains. To obtain some idea as to the magnitude and shape of the anomaly to be expected from this igneous feeder, it was assumed to have either of two simple two-dimensional shapes for which the theoretical anomalies were then computed.

The igneous feeder was first assumed to approximate the shape of a vertical igneous dike of infinite depth extent. To simplify the calculations the dike was assumed to be vertically polarized and uniformly magnetized; induced polarization was further assumed. Calculations were made for a dike of a width of 400 feet, buried at depths of 200, 400, and 1,000 feet. The normal vertical intensity of the earth's magnetic field at this latitude is about 0.5 gauss, and the magnetic dip is about 65 degrees. Fourteen rock samples were taken from the Round Mountain plug and the surrounding sediments for susceptibility determinations. The magnetic susceptibility of fresh samples taken from the igneous rocks averaged about 400×10^{-6} cgs units and the sedimentary samples showed a magnetic susceptibility of practically zero. On the basis of this information a susceptibility difference of 400×10^{-6} cgs units was assumed to exist between the postulated lateral feeder and the surrounding sediments.

Figure 4 shows the theoretical anomalies that would be produced by a vertical dike of infinite depth extent, a width of 400 feet, a susceptibility of 400×10^{-6} in contrast to 0.5×10^{-6} for the surrounding sediments, buried at depths of 200, 400, and 1,000 feet respectively.

The second shape assumed for the igneous feeder was that of a horizontal cylinder. Again for simplification the cylinder was assumed to be vertically polarized and uniformly magnetized. Calculations were made for a horizontal cylinder of radius 200 feet, buried at depths of 200, 400, and 1,000 feet, using the same assumptions about the intensity of the earth's magnetic field, and magnetic susceptibilities of the cylinder and surrounding rock. Figure 5 shows the theoretical anomalies from such a body.

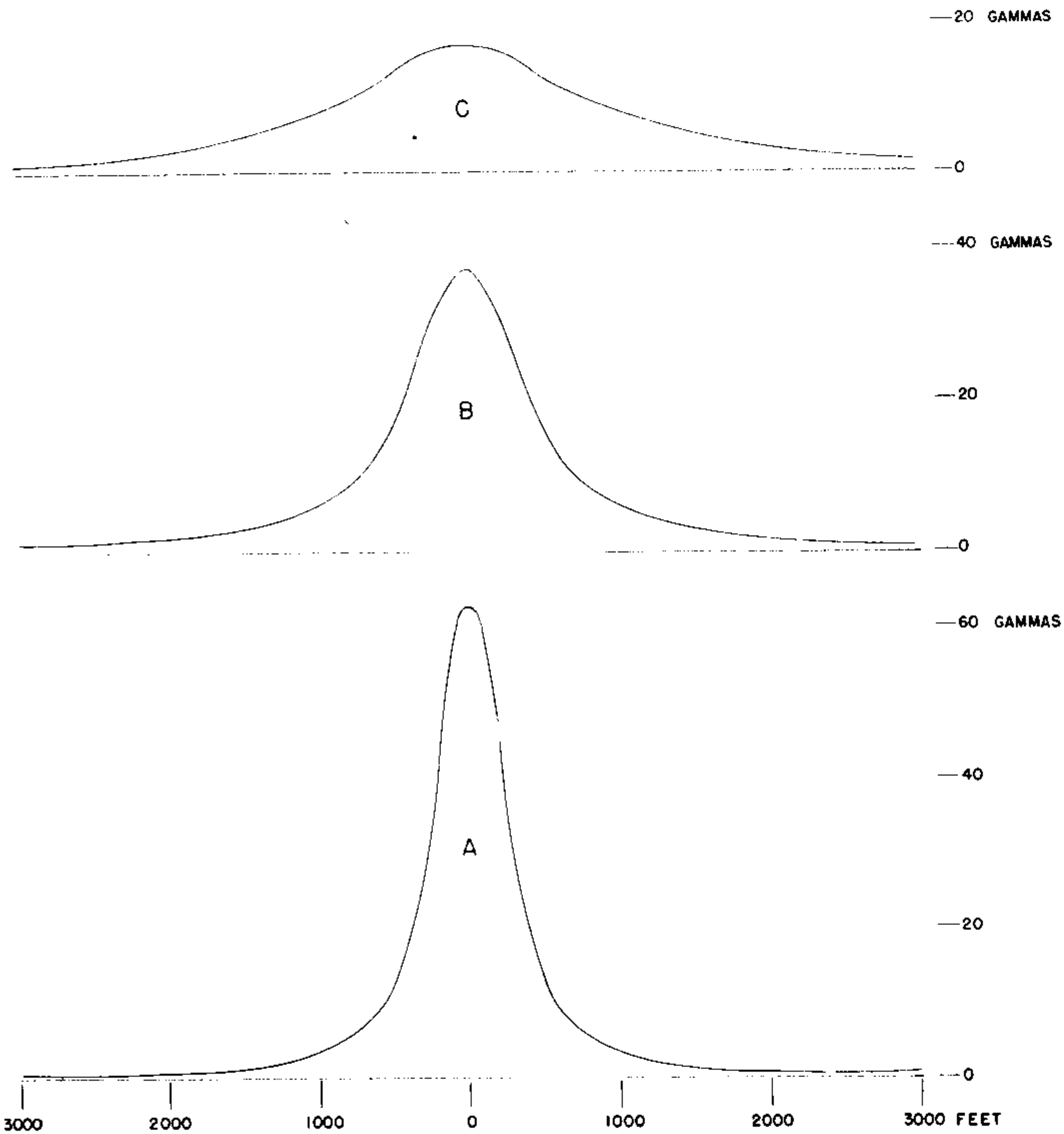

FIGURE 4. THEORETICAL VERTICAL INTENSITY MAGNETIC ANOMALIES OVER A VERTICAL DIKE BURIED AT DEPTHS OF (A) 200 FEET, (B) 400 FEET, AND (C) 1,000 FEET

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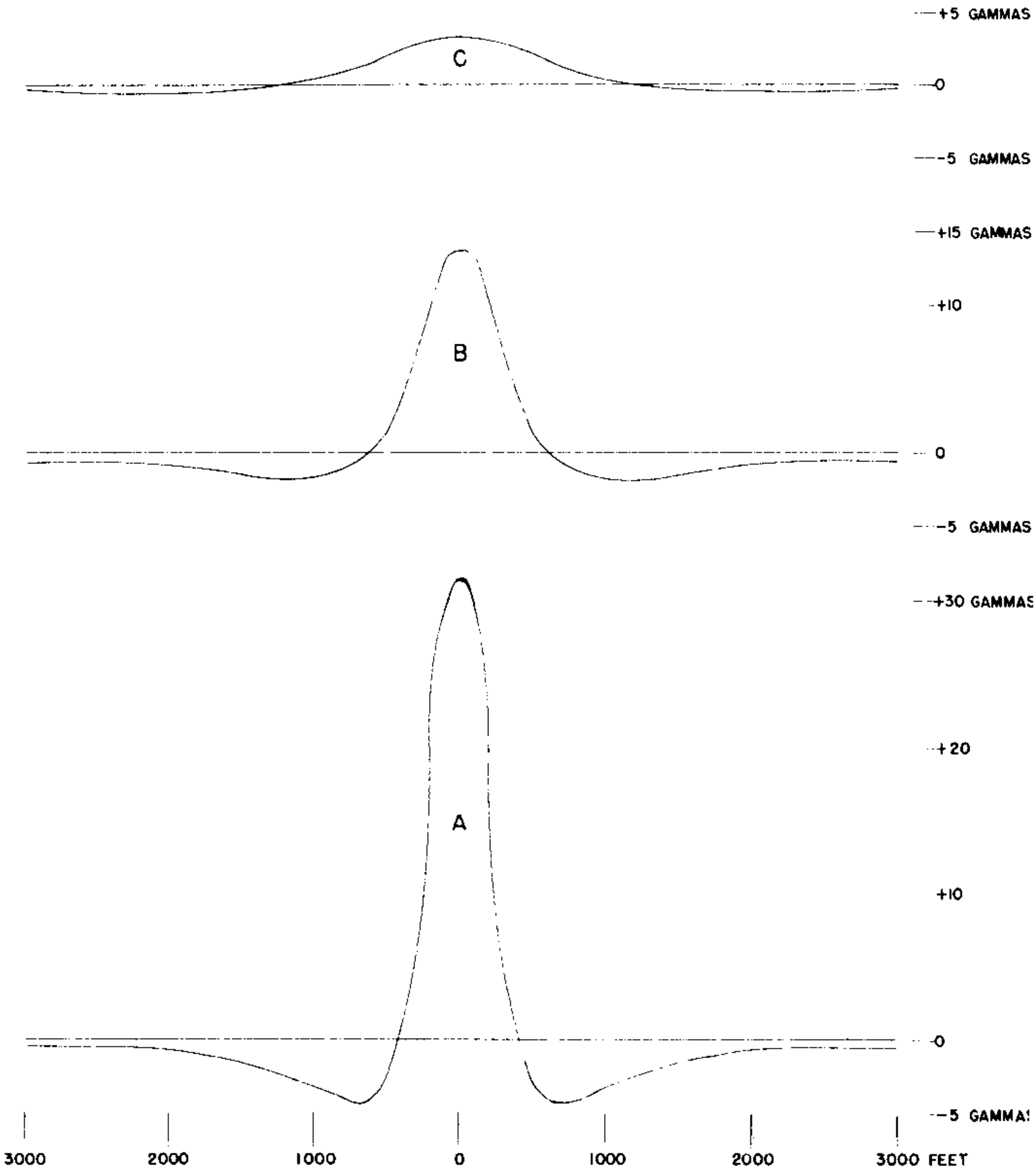

FIGURE 5. THEORETICAL VERTICAL INTENSITY MAGNETIC ANOMALIES OVER A HORIZONTAL CYLINDER BURIED AT DEPTHS OF (A) 200 FEET, (B) 400 FEET, AND (C) 1,000 FEET

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Results

The magnetic observations obtained in the Castle Valley area were corrected for diurnal and base variation and, where necessary, auxiliary magnet corrections were applied. The corrected data were first plotted as magnetic profiles as shown in figures 6 and 7, and then a magnetic contour map (fig. 8) was prepared. The magnetic contour map was prepared in the following manner. The corrected magnetic values for each station were plotted at the appropriate station location on a planimetric map with a scale of 1 inch to 1,000 feet. Each set of three consecutive magnetic values along each traverse line was averaged and the average value was plotted at the middle station location. The erratic disposition of the station locations within the area enclosed by traverses 2, G, 5, and E, made it necessary to use a different system for obtaining average values for use in contouring this area. A transparent template of the area was prepared with a series of collinear circles, half an inch in radius and tangent to each other. This template was laid over the area in question, and all station values that lay within any given circle were averaged and this average was plotted on the map at the center of the circle. The template was then offset by half an inch and the averaging process was repeated. A second offset was then made at a right angle to the first offset and the averaging process was repeated. The average values obtained were used to contour the area bounded by traverses 2, G, 5, and E. The averaging process smoothed the erratic values due to washes and boulders and made the values easier to contour without changing the general magnetic picture of the area.

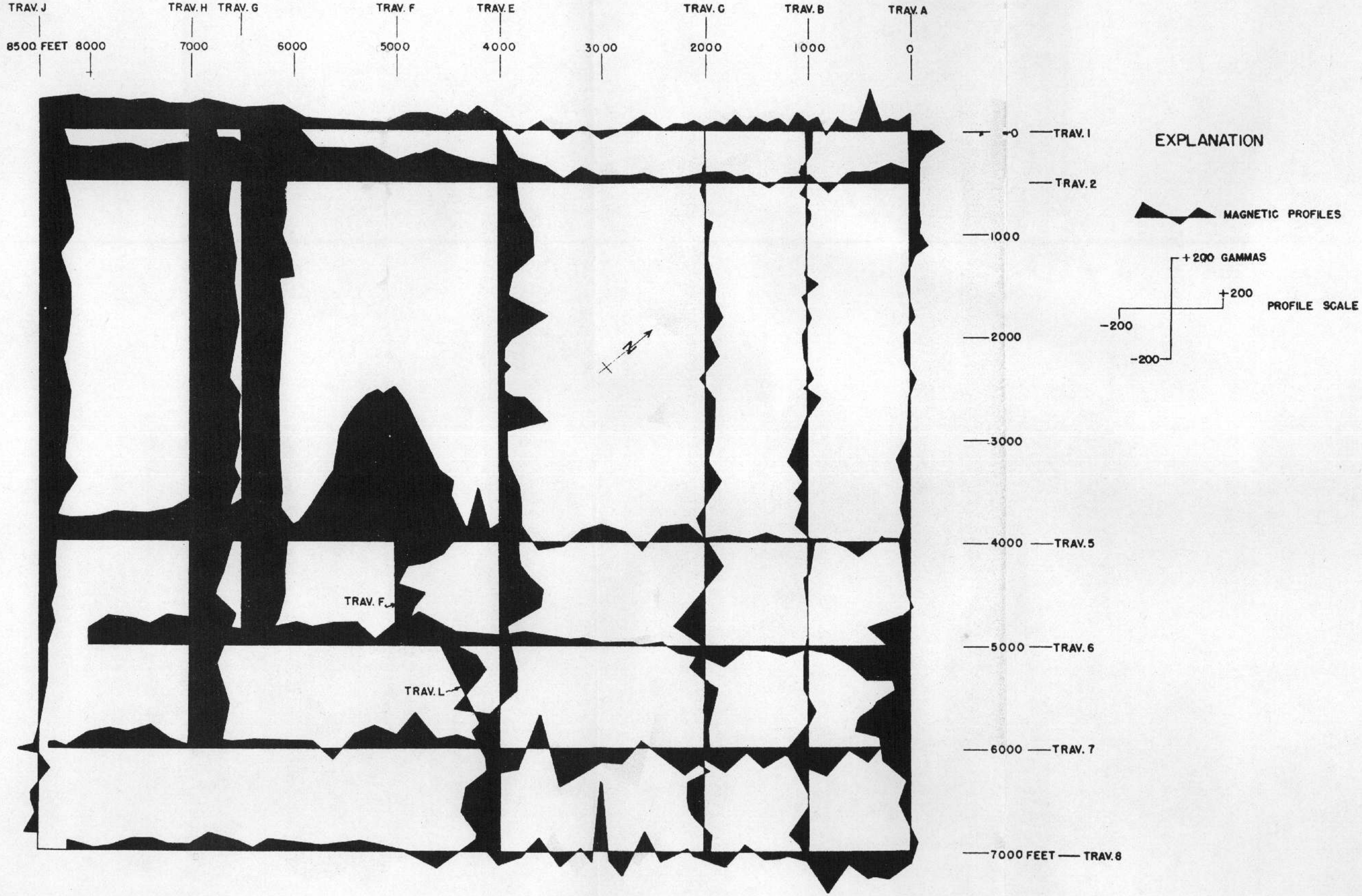

FIGURE 6. DIAGRAM SHOWING SOME OF THE MAGNETIC PROFILES IN THE CASTLE VALLEY AREA, GRAND COUNTY, UTAH

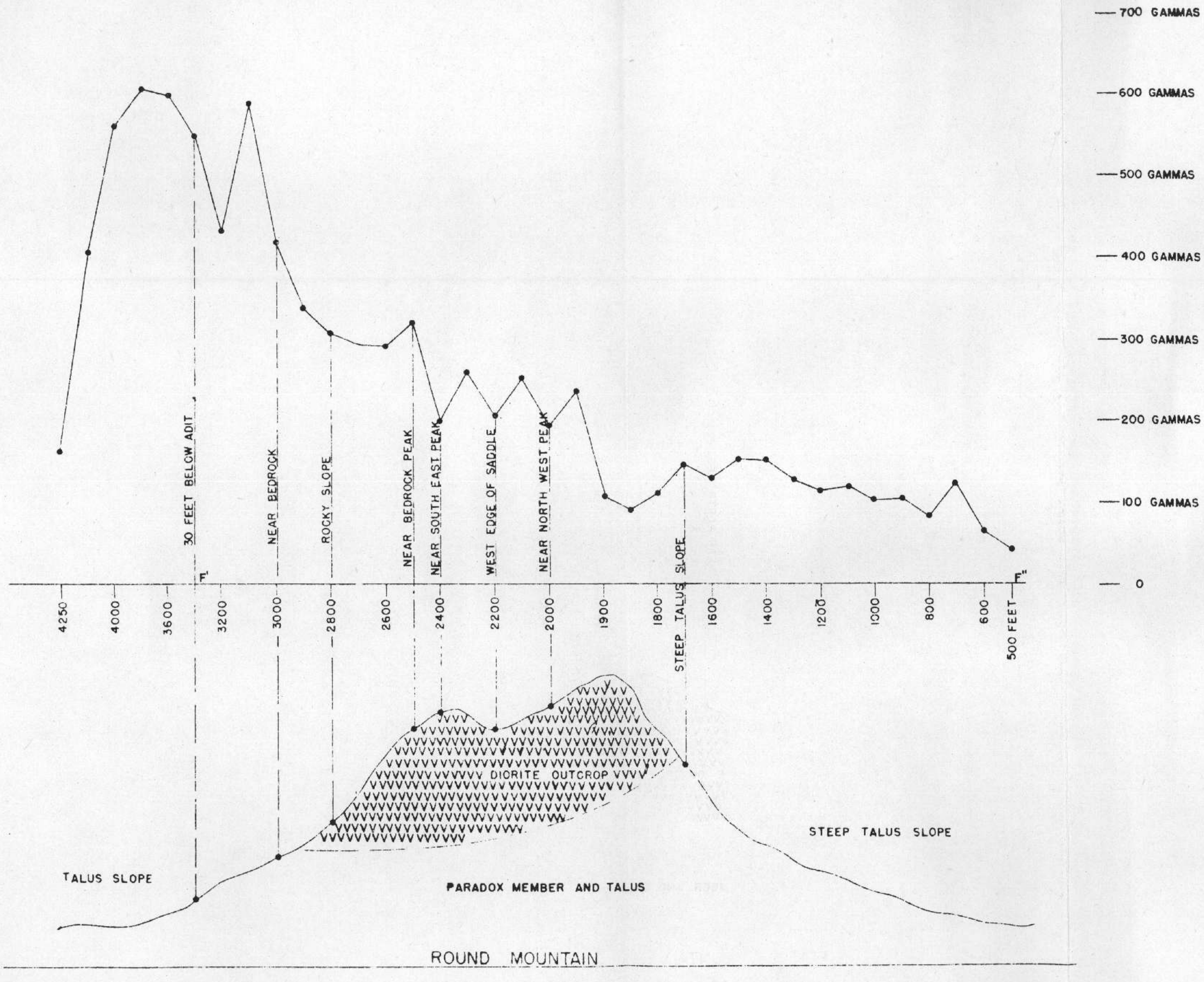

FIGURE 7. DIAGRAM SHOWING MAGNETIC PROFILE OBTAINED OVER ROUND MOUNTAIN, CASTLE VALLEY AREA, GRAND COUNTY, UTAH

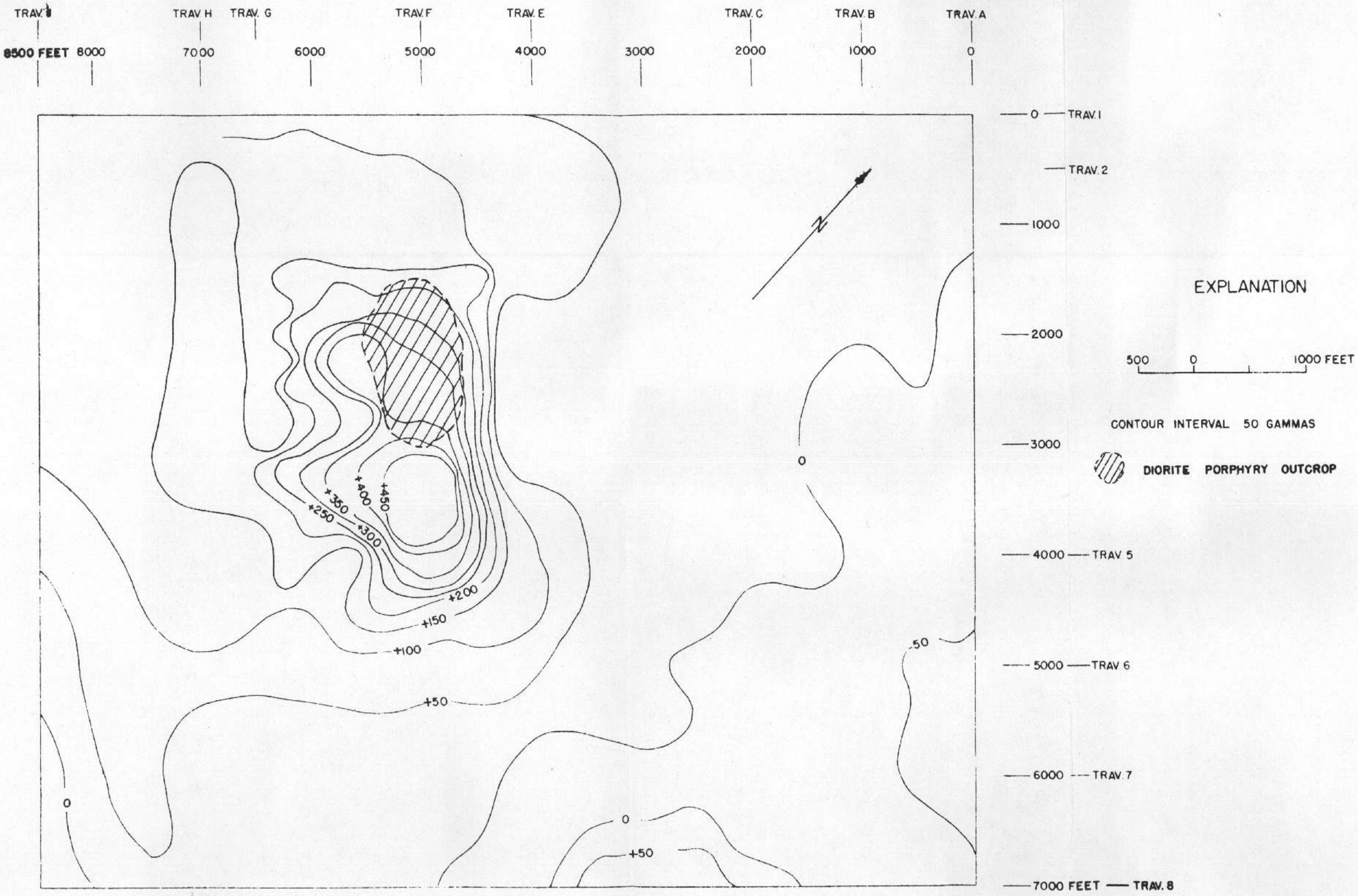

FIGURE 8. MAGNETIC VERTICAL INTENSITY CONTOUR MAP OF THE AREA AROUND ROUND MOUNTAIN, CASTLE VALLEY AREA, GRAND COUNTY, UTAH

When the magnetic profiles shown in figure 6 are considered, a number of interesting features are noted. On traverses 1 and 2, the magnetic profiles are relatively flat, averaging about 40 gammas out to 3,700 to 4,000 feet, at which point they increase sharply and flatten off again for the remainder of the traverse at an average value of about 100 gammas. This same plateau effect is evident on traverse 5, and to a lesser extent on traverse 6. Traverses A, B, and C average 20 to 40 gammas from 0 to 5,000 feet, while traverse E displays much higher values in the same interval. Traverses G, H, and J also exhibit this plateau effect.

On traverse 5 a large positive anomaly of 600 gammas was found over the talus slope near the base of Round Mountain. No igneous rock is exposed, but this area is certainly underlain by igneous material. No other large anomalies are noted on any of the rest of the profiles shown in figure 6.

The parts of traverses 5 to 8 (figure 6) which cross the gravel deposits are quite irregular, as could be expected. Even so, the general level of the profiles is low, and anomalous readings can be attributed to the presence of large boulders of igneous material and steep stream beds. In almost every case, the stream beds produced a sharp negative magnetic anomaly, while boulders produced sharp positive or negative anomalies, no doubt according to their orientation.

The plateau-like effect on the magnetic profiles could be explained by a talus sheet of diorite buried under the alluvium, a sill-like intrusion surrounding the central plug, or simply by a larger buried plug which would naturally have a steeper magnetic gradient on the north side. The smooth nature of the profiles and the geology of the area suggest that a buried plug much larger than the diorite exposure is the most logical supposition.

Assuming the susceptibilities used in calculating the theoretical anomalies to be reasonably correct, it seems apparent from examination of figures 4 and 6 that a feeder of the shape of a vertical dike could not be detected at a depth greater than 200 feet. The corrected magnetic profiles (fig. 6) show irregularities due to dry washes and magnetic float which often exceed the maximum calculated anomaly that would be produced by a dike-shaped feeder buried at a depth of 200 feet. It is probable, however, that the broad anomaly produced by the dike could be distinguished from the narrow sharp anomalies due to surface irregularities. The magnetic profiles (fig. 6) show no broad anomalies which could be considered to be indicative of a buried igneous feeder shaped like a vertical dike.

Figure 5 shows that the maximum anomaly to be expected from a buried horizontal cylinder at a depth of 200 feet is approximately 30 gammas. It is very doubtful that such a small anomaly could be distinguished from the anomalies produced by surface effects.

Figure 7 shows the magnetic profile obtained on traverse F' F" over the Round Mountain plug. The section of the profile between 600 and 1,900 feet exhibits the same general plateau-like effect previously noted on the northeastern side of the plug. A sharp increase is noted between

1,900 and 2,600 feet which corresponds to the exposed diorite outcrop. The somewhat erratic nature of the profile in this interval is no doubt due to local concentrations of magnetite. From 2,600 to 4,250 feet on the profile, a definite positive anomaly is noted which does not correspond to any surface features.

The magnetic contour map (fig. 8) prepared from the averaged magnetic values shows no indication of a lateral feeder extending from the igneous plug in any direction. A positive closure is shown in the vicinity of the diorite porphyry outcrop, with the highest point of the anomaly offset to the southeast of the outcrop of igneous rock.

The contour map suggests that the plug is much larger than indicated by the surface exposure and further suggests that the 450-gamma anomaly is underlain by a part of the plug which has a higher magnetic susceptibility than the exposed igneous material. This could be explained by magmatic differentiation within the plug with a resultant concentration of heavy magnetic minerals in one part of the plug. Application of depth rules to the 450-gamma anomaly shown on the contour map gives a depth estimate of 600 feet to the top of the source of the anomaly. Although it is difficult to define the slope of a buried feature from the anomaly it produces, the 100-gamma contour line on figure 8 could be considered a reasonable estimate of the limits of the buried plug.

CONCLUSIONS

The magnetic investigation made in the Castle Valley area was intended primarily to determine the presence or absence of a postulated buried igneous feeder connecting Round Mountain to the La Sal Mountains. This feeder had been estimated to be buried not more than 200 feet in the vicinity of the plug, but possibly as much as 2,000 feet at the base of the La Sal Mountains. No indication of a buried lateral igneous feeder was detected on the magnetic profiles, but this does not definitely eliminate the possibility that a lateral feeder is present. The magnetic susceptibility contrast between the igneous material and the Paradox formation was considerably less than anticipated. Theoretical anomalies computed from the measured susceptibility values show that a low susceptibility feeder in the shape of a horizontal cylinder would not have been detected, and a low susceptibility dike-like feeder would not have been detected at a depth greater than 200 feet.

The magnetic contour map shows that the igneous plug is much larger than indicated by the surface outcrop. The 100-gamma contour line could be considered as roughly outlining the plug. The contour map also indicates that the plug contains a material of higher susceptibility than the exposed diorite porphyry. This could be due to magmatic differentiation with resultant concentration of heavy magnetic minerals in the southeastern part of the plug.

The large size of the plug makes it seem unlikely that it was fed laterally from the La Sal Mountains, and the presence of a higher susceptibility at depth offers a possibility that, if present, a lateral feeder would be of higher susceptibility than the exposed diorite. Calculations show that a feeder of ten times the susceptibility of the exposed diorite could be detected as a dike at nearly 1,000 feet and a horizontal cylinder could be detected to a depth of 300 feet. No indication of such a feeder is shown on the magnetic profiles.

The possibility of a deep low-susceptibility feeder cannot be eliminated, but a shallow high-susceptibility feeder is certainly not present, and the shape and large size of the plug would seem to indicate that a vertical feeder is more likely than a lateral one.

LITERATURE CITED

Baker, A. A., 1933, Geology and oil possibilities of the Moab district, Grand and San Juan Counties, Utah: U. S. Geol. Survey Bull. 841.

Butler, B. S., Laughlin, G. F., and others, 1920, The ore deposits of Utah: U. S. Geol. Survey Prof. Paper 111, p. 612.

Gould, L. M., 1926, The role of orogenic stresses in laccolithic intrusions: Am. Jour. Sci., 5th ser., v. 12, p. 119-129.