283 item 11

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RENO, NEVADA 89507

GRAVITY SURVEY OF THE PIUTE CLAIMS, PERSHING COUNTY, NEVADA.
by J. I. Gimlett (September 1961)

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James I. Gimlett, Geophysicist

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Introduction:

The following is a brief report covering the gravity survey of the Piute claims, which are located some 14 airline miles southeast of Lovelock, Nevada. The survey covers the 12 Piute South, the 11 Piute North claims, and the area between them. In addition one mile of traverse was run along the road from the east boundary of the Piute North and another from the west boundary of the Piute South group of claims. The delivery items for this survey are this report plus a simple Bouguer anomaly map of the area.

Stations:

The Gravity Map was prepared from gravity data taken at 155 stations, 91 of which are on the claims proper. All of the stations on the claims, except one, were located by chaining from claim-corner or side-center posts. The southwest corner post of claim P22 could not be located; the ¼ corner pole some 240 ft to the west was used instead. The claim stations are located at the corners of a rectangular grid, the unit cell of which is 500 ft long in the north-south direction and 600 ft long in the east-west direction. The stations along the road were located 0.1 mile apart using an automobile odometer; the odometer readings on these two traverses had to be adjusted slightly to fit map-identifiable features such as bends in the road. The stations between the two groups of claims were located using a Brunton compass and pacing from claim-corner or side-center posts or from map-identifiable features. The pacing accuracy was checked (1) by closing the traverses, (2) against the automobile odometer, and (3) using the level stadia.

The elevations of all of the above stations were obtained by differential leveling with a Zeiss Ni 2 self-leveling level. As there is no B. M. in the immediate vicinity, all elevations were measured with respect to a hub set at the ¼ pole at the southeast corner of claim P. Using the U. S. G. S. 15' Lovelock quadrangle sheet as a guide, the elevation of this hub was taken as 3950.00 ft.

To furnish data for the interpretation two additional gravity stations were established, one at the summit of Wildhorse Pass, and the other at the y-intersection of the power lines in Sec. 30, T. 25 N., R. 33 E. The elevations of these two stations were taken off the Lovelock sheet.

Data Reduction:

For convenience, the hub used as the elevation base was selected as the primary gravity base station. This station was reoccupied every two hours during the course of the gravity survey in order to minimize errors due to instrument drift and earth tides. A smooth drift curve was constructed every day from the base readings. The instrument drift proved to be very small.

The simple Bouguer anomaly Δg as plotted on the Gravity Map was computed from

$$\Delta g = \underbrace{g_b}_{\text{Measured gravity with respect to base}} + \underbrace{0.06216(h - 3900.0)}_{\text{Free-air and simple Bouguer correction}} + \underbrace{g_L}_{\text{Latitude correction}}$$

where h is the elevation of the station.

The first term of this equation was determined by subtracting the instrument reading at the base (corrected for drift) from the instrument reading at the station and converting the resulting difference to mgal. For the Worden (Ser. No. 407) gravity meter used the scale constant is 0.4657 mgal/div. From previous surveys with this meter it has been determined that the probable error of the instrument reading accuracy and the drift removal procedure, combined, is about 0.1 mgal. The only two stations repeated checked within 0.01 and 0.03 mgal; this is better than should be expected.

The constant in the second term in the equation, the combined simple Bouguer, free-air correction, 0.06216 mgal/ft, corresponds to an assumed density of 2.50 g/cc for the surrounding bedrock. This figure was selected as a rough average of the densities of the Tertiary pyroclastics, which can range from 2.10 to 2.45 g/cc, and the densities of the Mesozoic metamorphic and igneous rocks exposed in the West Humboldt Range. These latter are on the order of 2.70 g/cc. Errors induced in the anomaly by errors in assumed density should be quite small, because only small differences in elevation exist between gravity stations over the entire area (maximum difference = 195.6 ft). The Bouguer, free-air correction is not very density dependent for small changes in elevation.

All of the elevations obtained with the level should be accurate to 0.1 ft or less. Most stations were on closed level traverses with the maximum error of closure on any traverse being less than 0.3 ft. Hence, errors in the anomaly due to errors in elevation are negligible.

The latitude correction factor was calculated from

$k = 1.307 \sin 2\varphi$ mgal/mi = 0.1219 mgal/500ft

where φ is the latitude. All stations were plotted as accurately as possible on the map. In order to deal only with positive corrections, the northern boundary of the Piute North claims was chosen as the zero of latitude. g_L was determined using k, as given above, and the measured distance from the zero line. It is estimated that the northings of all stations should be accurate to 50 ft. Hence, errors in the anomaly due to positioning errors should be negligible.

The probable error of the simple Bouguer anomaly at any station is estimated to be 0.1 mgal.

It should be noted here that the word "simple" means that terrain corrections were not included in the anomaly. The terrain correction was calculated for only two stations: the gravity base station (0.44 mgal), and the Wildhorse Pass station (0.73 mgal). These two were determined for use in the interpretation. The calculation is fairly simple but laborious, and, hence, expensive to do (an estimated 20 work days for 150 stations). Including the terrain correction would only add some 0.2 mgal to the anomaly to those stations nearest the range. The shape of the anomalies would be unchanged.

The Simple Bouguer Anomaly Map:

The gravity data were plotted and contoured on a 0.5 mgal contour interval. The Gravity Map is in the pocket at the back of this report. The smoothness of the gravity contours indicates that the station density is sufficiently high to accurately depict the gravity pattern. No additional information would be obtained by setting more stations in the contoured region. This means that the geologic features producing the observed anomalies must be at depths greater than the station spacing.

Interpretation:

It was originally hoped that the gravity survey would provide information as to the quantity of iron ore present and at least a rough idea of the shape of the deposit. It was also hoped that if nonmagnetic hematite were present that it would be present in sufficient quantities to produce a gravity high. Ideally, the gravity high produced by both the magnetite and the hematite should be on a smooth, and gentle, regional gravity slope. The anomalous mass (the iron ore) could then be found by applying Gauss's theorem to the anomaly after removing the regional gradient. Performing the required numerical integration would then yield the size of the deposit directly. The depth and horizontal extent of the deposit would then be determined by approximating the ore body by some simple geometric form, such as a sphere or cylinder, or by using some graphical method involving trial and error computations with a gravity graticule.

Unfortunately, a casual look at the Gravity Map shows the following sad fact. It is difficult, if not impossible, to determine anything about the quantity of the ore from the gravity anomalies. The ore zones simply do not produce recognizable gravity highs. In fact, the magnetic high on the Piute North claims coincides with a gravity low. There are two rather obvious reasons for this lack of a good high due to ore.

The chief reason is that all local gravity anomalies in this region are masked by a steep gravity gradient, probably due to basin-and-range type faulting. This steep gradient continues basinward for some distance, as evidenced by the road traverse northeast of the Piute North claims and the gravity station at the y-intersection of the power lines. Ordinary interpretive procedures call for locating the fault trace along the maximum gravity gradient, which is probably not mapped in this case. Carson Sink shows up as a gravity low because of the relatively light basin sediments and volcanics as compared to the heavier "basement" rocks exposed in the surrounding hills and ranges.

The "basement" in this region is usually considered to be the pre-Tertiary complex of Mesozoic metamorphic and igneous rocks. These are the heavy rocks with densities on the order of 2.70 g/cc. The Tertiary rocks in this area, as well as in many areas in the western Great Basin, are predominantly light lacustrine sediments and pyroclastics, welded and non-welded tuffs with some interbedded siliceous flows. The downfaulted basin contains great thicknesses of these light rocks, undoubtedly greater thicknesses than are exposed in the bordering ranges, as well as unconsolidated Tertiary and Quaternary debris, and Lahontan sediments. The gravity gradient here on the northern margin of Carson Sink is as steep as that observed in Honey Lake Valley, California. There, the total anomaly amounted to some 50 mgal, and the estimated depth to "basement" over 5000 ft, which places "basement" floor below sea level.

The actual mechanism of basin and range faulting is still unknown. In most instances it is not known whether the faulting takes place along one trace, several traces (step faulting) or along rather wide shear zones.

Also, any fault surfaces exposed to the air will have been modified by erosion. The gravity method will ordinarily not resolve this problem. Thus, it is best to refer to the dip of the bedrock surface rather than to the dip of the fault. Using a density contrast of 0.51 g/cc, as computed below, the dip of the bedrock surface in the area of the uniform gravity gradient was determined to be 24°.

The other reason for the lack of gravity highs associated with the magnetic highs can be found by making a detailed study of the density and the geometry involved. If the ore is assumed to consist of magnetite in diorite, such that there is 32% Fe in the rock, then the density of the ore plus rock is about 3.74 g/cc. A five million tonne magnetite ore body would produce a gravity anomaly of only 0.40 mgal if centered at 744ft. The 744 ft of light volcanics would produce a negative anomaly of 4.85 mgal with respect to the surrounding bedrock. A 65 ft step in the "basement" at this depth would produce an anomaly of the same size as that due to the hypothetical ore body.

A gravity survey in the area of the Piute claims will not yield any direct information concerning iron deposits. When applied successfully in the past in this part of the state, the gravity survey was run in areas with no or very little Tertiary and Quaternary cover, i.e. right on the "basement". The rocks of the "basement" complex, though varying a great deal in composition, have nearly the same densities. Thus, gravity anomalies measured on the "basement" surface can be interpreted in terms of iron ore.

Though direct information about iron ore can not be obtained, quite a bit of useful geologic information can be abstracted from the gravity data.

As mentioned before, the steep gravity gradient on the east side of both groups of claims corresponds to the steep dip of the "basement" rocks beneath the volcanics and the valley fill. Iron ore is not found in the Tertiary section in this region. Thus, iron in areas much to the southeast of the Piute claims would probably be too deep to be mined economically even if the quantity and quality of the mineralization were high.

The main fault bounding this, the southeast, side of the West Humboldt Range is farther basinward in the area of the Piute South than in the area of the Piute North claims. In fact the Piute South claims lie over a broad shelf of "basement" rock, which from the evidence of the one mile gravity traverse down the road must extend for some distance to the southwest. This shelf or bench is at a depth of 744 ft at D.D.H. No. 1. A little to the west the cover is evidently still thinner, probably amounting to less than 550 ft. This shelf should be investigated in detail with a magnetometer survey. From a strictly geomorphological point of view this shelf should not be termed a pediment. However, the surface of the Tertiary volcanics in this area might well constitute a pediment. The veneer is only 16 ft thick in D.D.H. No. 1.

There is a difference in gravity (including terrain corrections) of 4.82 mgal between the station at Wildhorse Pass, which is on metamorphics, and the station at the southeast corner of claim P, which is near D.D.H. No. 1. Assuming this anomaly to be due entirely to the 744 ft thickness of Tertiary volcanics, we find a density contrast of 0.51 g/cc for the volcanics. This figure is in agreement with measured densities and with density contrasts used elsewhere in the Great Basin.

Since the magnetic high on the Piute North claims is in a region where the gravity pattern shows a gradient, it is difficult to determine an exact depth to "basement". Inasmuch as the gravity anomaly at D.D.H. No. 2 is lower than at D.D.H. No.1, it should be expected that the depth to bedrock is somewhat greater than the 744 ft encountered in No. 1. The actual depth is around 790 ft (Personal communication, I. F. Moore).

The northwest-southeast trending contours across the northeast corner of the Piute South claims would seem to indicate a structure transverse to the main faulting. The most obvious explanation is that there is a sizeable fault paralleling this trend. (The deposition of the ore may have been controlled by this fault.) If the proposed fault cuts the volcanics, then detailed surface geologic mapping should detect it. In fact the Tertiary stratigraphy of the West Humboldt Range will have to be thoroughly worked out before an accurate structural picture of the area can be obtained. The proposed fault, which would serve as an explanation for the benching, probably extends basinward for some distance, as evidenced by the bending of the contours.

The local gravity high and low immediately south of D.D.H. No. 1 could be due to irregularities in the "basement" surface, or, perhaps, to Tertiary volcanics with markedly higher densities, such as dense basic flows, in the predominantly light pyroclastic section. Local faulting is another possibility.

The nosing of the gravity contours in the Piute North claims P 12, 13, 14, 18, and 19 may have a similar origin. The gravity "noses" could be produced by undulations of amplitude less than 100 ft in the "basement" surface. Whether these undulations are structural or erosional (valleys, since filled with Tertiary volcanics) is problematical. The gravity pattern could have been produced by east-west faulting through the north edge of the magnetic high. The deposition of the ore, then, could have been controlled by the faulting.

Conclusions:

This gravity survey did not directly detect the iron ore at the Piute claims. (This, of course, could not have been predicted in advance of the survey.) The survey would tend to eliminate from consideration the area basinward from the Piute claims because of the major basin-and-range type faulting.

From a gravimetric point of view the most favorable area for prospecting is southwest from Piute South along the bedrock bench. Between the Piute claims and the West Humboldt Range proper is another likely area. If the ore is magnetite, a magnetometer survey should detect it. These areas would be recommended more highly if it were not for the fact that several companies have aeromagnetic coverage and have not acted.

In any case detailed geologic work should be done in the area to see if the structure can be determined. The Tertiary stratigraphic problem will be a difficult one to solve.

From both the magnetic and the gravity data the southwest corner of P 5 appears to be a good place to drill. It is on the bedrock shelf and is still on the magnetic high. There is always a possibility of hematite in the area, though it is doubtful if a gravity survey could detect it.

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APPENDIX A:

First, let us consider a magnetite orebody of 200 million tonnes; the ore is assumed to run 44% magnetite (32% Fe). Using 2.62 g/cc as the density of the host rock, the density of the ore plus host rock is 3.74, the radius of the sphere is 1000 ft. The gravity anomaly, shown in Figure 1, was drawn assuming the center of the sphere to be at a depth of 1744 ft, i.e. the top of the sphere is at the 744 ft depth indicated by D.D.H. No. 1. Two things should be noticed. One, the maximum of the anomaly is only 2.98 mgal. Two, a 500 ft grid is more than adequate to depict this anomaly, because for that depth of burial the anomaly does not drop to half of its peak value until 1150 ft from the center.

It might be noted here that, taking the susceptibility of magnetite to be 0.5 c.g.s., such an orebody would produce a vertical magnetic anomaly of 20,400 gammas. The observed 4200 gamma anomaly could be produced by a 14 million tonne spherical orebody centered at 1260 ft.

The great thickness of light rocks in Carson Sink will produce a negative anomaly of about 30 mgal. This is evidenced by the total anomaly of 13 mgal observed in this survey with the steep gradient still continuing basinward. Using a density contrast of 0.51 g/cc, a vertical step (fault) of 4600 ft could cause the 30 mgal anomaly. Figure 2 shows the anomaly over such a step, buried to a depth of 744 ft. The scale of Figure 2 is the same as that of Figure 1.

Gravimetric methods do not lend themselves, easily, to the determination of the dips of faults. In the area of the Piute claims the gravity gradient indicates a steeply dipping surface. In fact the observed maximum

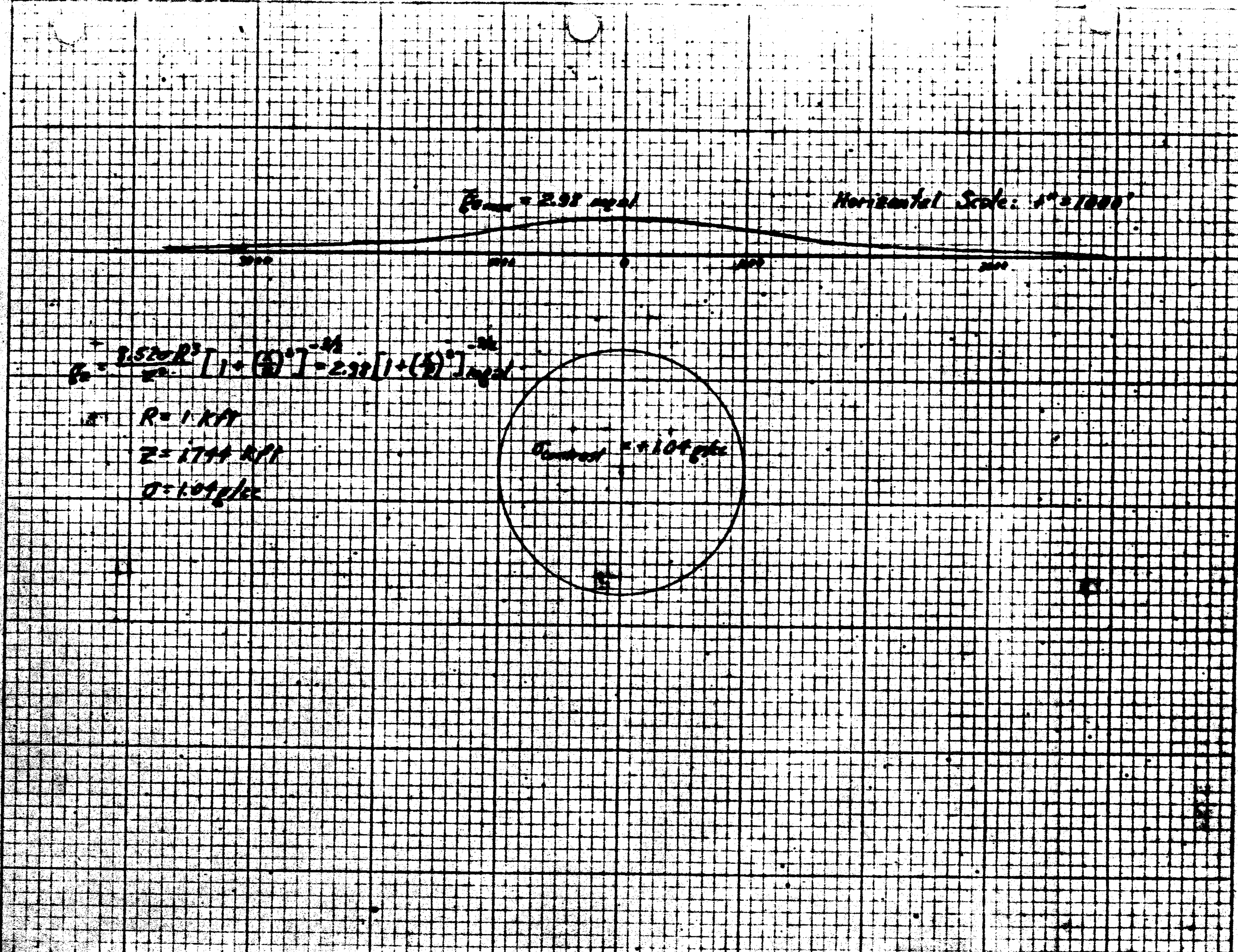


Figure 1 200 × 10⁶ ton Spherical Ore Body

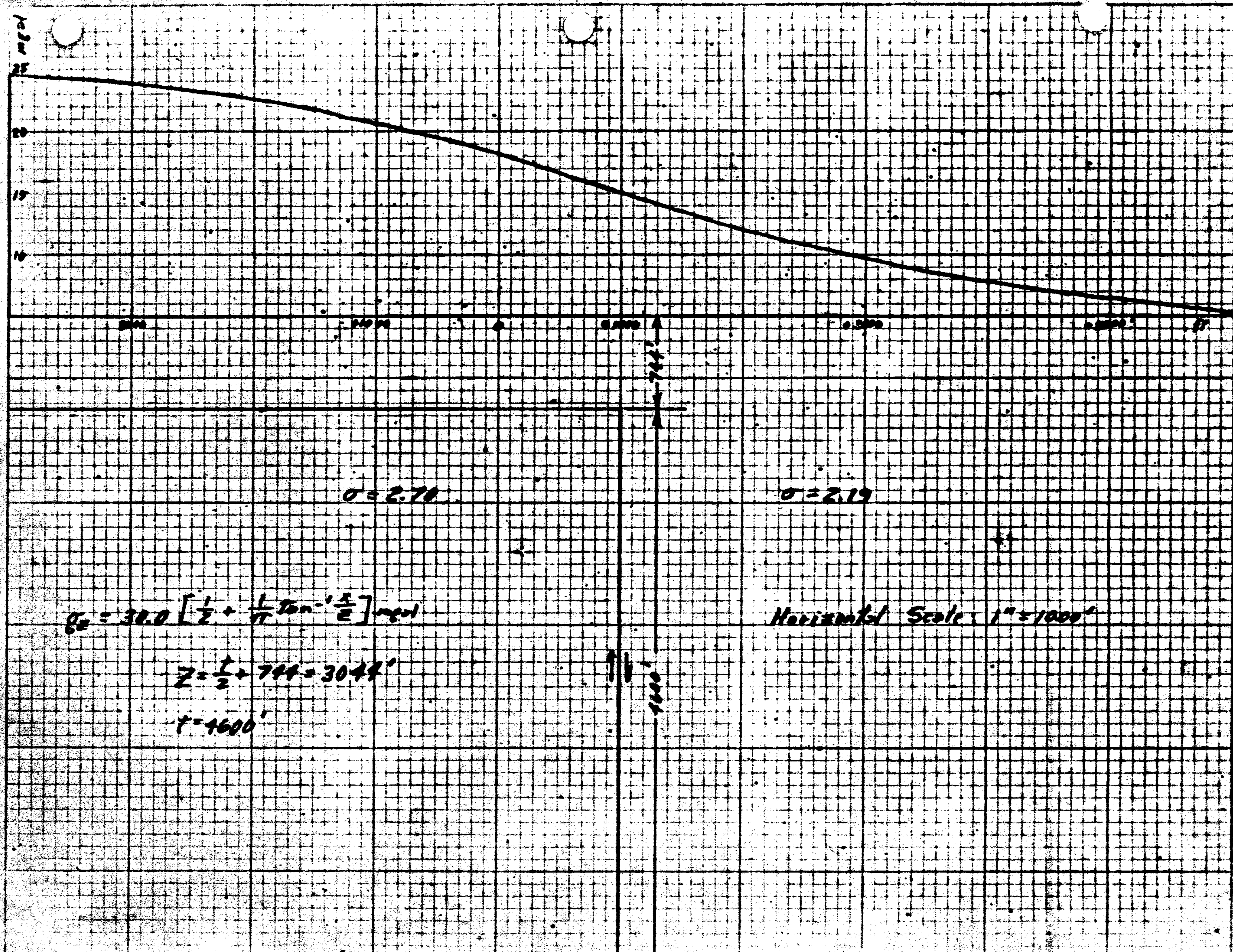


Figure 2 Vertical Fault

gradient of 2.9 mgal/kft is closely matched by the 3.0 maximum gradient of the theoretical geometry of Figure 2. The geologic probability of representing a fault by a smooth, vertical, plane surface should be considered in what follows.

Figure 3 is a composite of Figures 1 and 2 showing the anomaly of the sphere superposed on the anomaly of the fault. It is quite obvious that undulations in the fault and/or upper plane surface can mask the effect of even so large a sphere.

Figure 4 is the gravity profile along A-A' as shown on the accompanying map. This profile runs through D.D.H. No. 1, across the magnetic high roughly perpendicular to the regional strike. A north-south profile through D.D.H. No.1 would show more apparent closure. However, it is felt that the relatively steep gradient north of D.D.H. No.1 is due to the transverse fault postulated in the Interpretation section of this report.

If the smooth curve, shown dashed in Figure 4, is subtracted from the anomaly, the residual anomaly, plotted below, results. The dashed curve is a close approximation to the fault curve of Figure 2. The residual anomaly can be produced by a 30 million tonne spherical orebody centered at 900 ft. The residual high is located some 1000 ft southeast of the magnetic high. In view of the limiting nature of the assumptions involved, the 30 million figure should be regarded as being correct only to an order of magnitude, not as an exact tonnage.

Figures 5 and 6 are the gravity profiles B-B' and C-C', respectively, across the magnetic high in Piute North. Profile B-B' is perpendicular to the regional trend, while C-C' parallels it. The point on the profiles

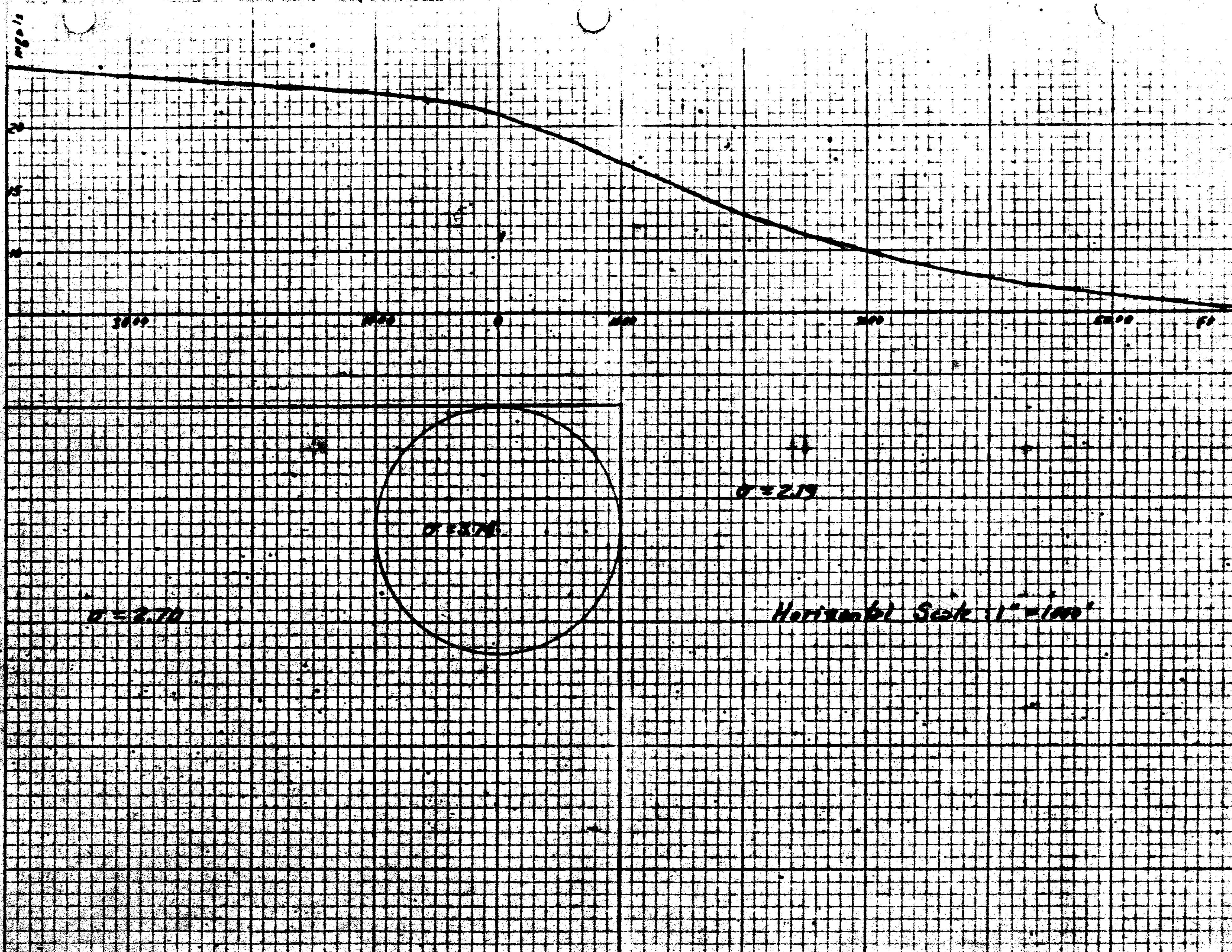


Figure 3 Vertical Fault + Spherical Ore Body

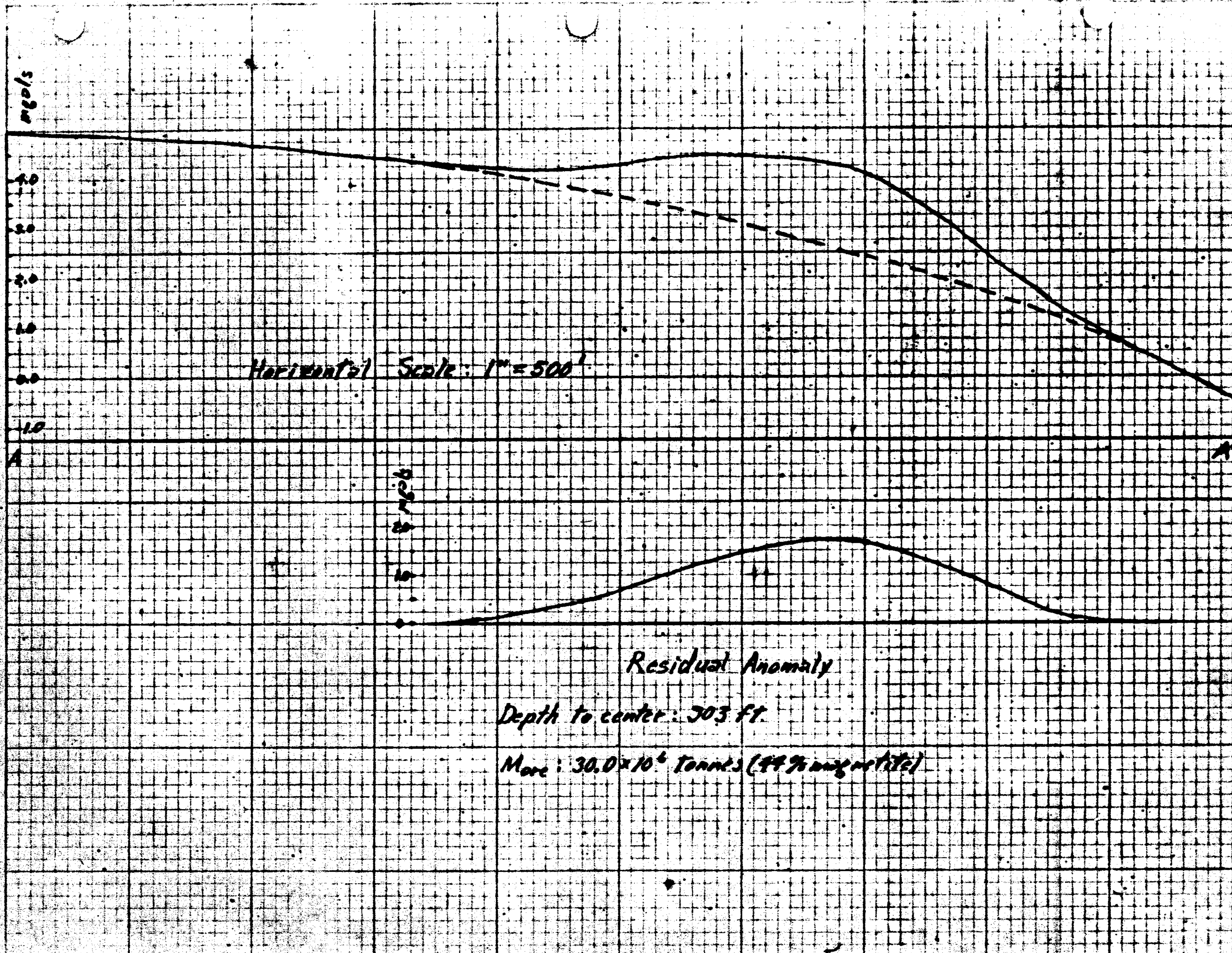


Figure 4 Profile A-A'

marked "I", the intersection of the two profiles, is very near to the center of the magnetic high.

Profile C-C', parallel to the strike, was drawn simply to show that the orebody evidently lies in a small gravity low when viewed in this direction. The undulations may be the expression of the transverse faulting postulated in the Interpretation section. They will, of course, limit the accuracy of depth estimates and tonnages obtained using the data of profile B-B'.

We can again remove the regional gradient (shown as the dashed curve in Figure 5) from gravity profile B-B' by assuming it to be the result of a vertical step fault of 4600 ft displacement. The resulting residual anomaly could be produced by a 18 million tonne orebody centered at 885 ft.

Conclusions:

In view of the many assumptions involved, the data obtained from profiles A-A' and B-B' show surprisingly good agreement with fact. The tonnages, 30 million tonnes for Piute South and 18 million tonnes for Piute North (both of 44% magnetite), agree quite closely with those obtained from the magnetic anomalies. This might indicate that little hematite is present. The theoretical depths are quite close to the depths where ore was encountered in the two drill holes, even to the extent that ore should be somewhat nearer the surface in Piute North than in Piute South. The lengths of the magnetic anomalies tends to invalidate the spherical assumption; the tonnages, above, are probably on the minimum side. Of course the grade decreases away from the magnetic high.

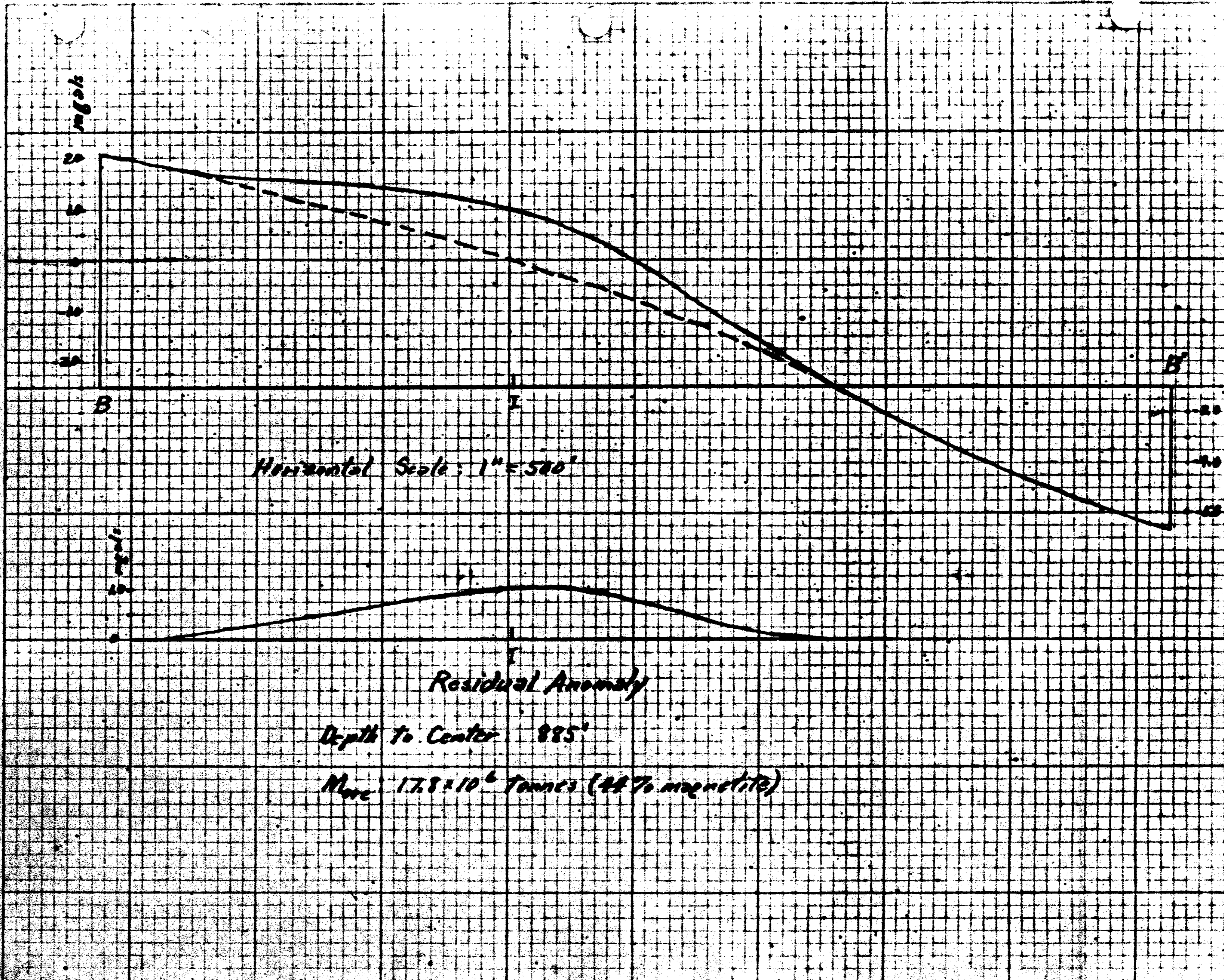


Figure 5. Profile B-B'

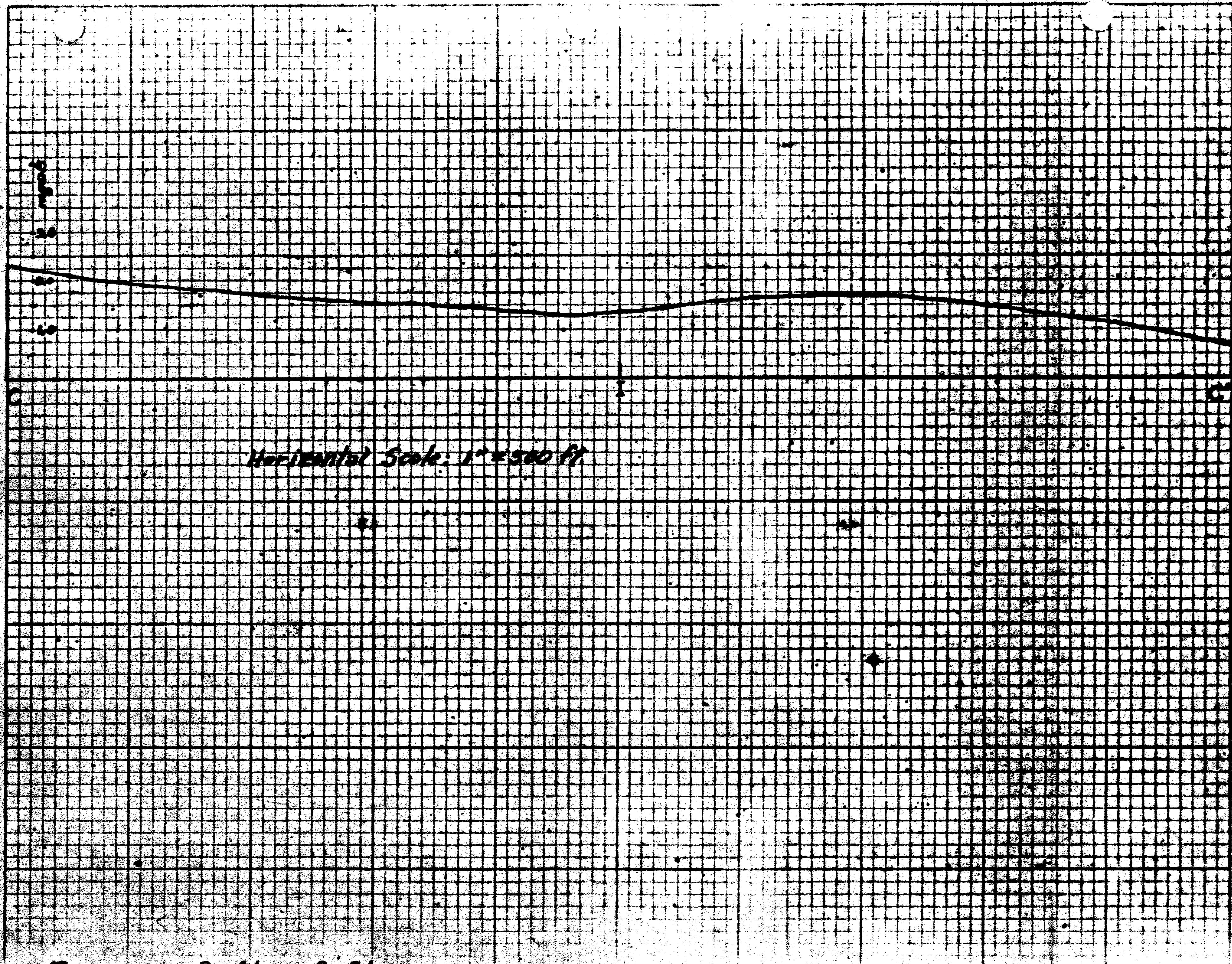
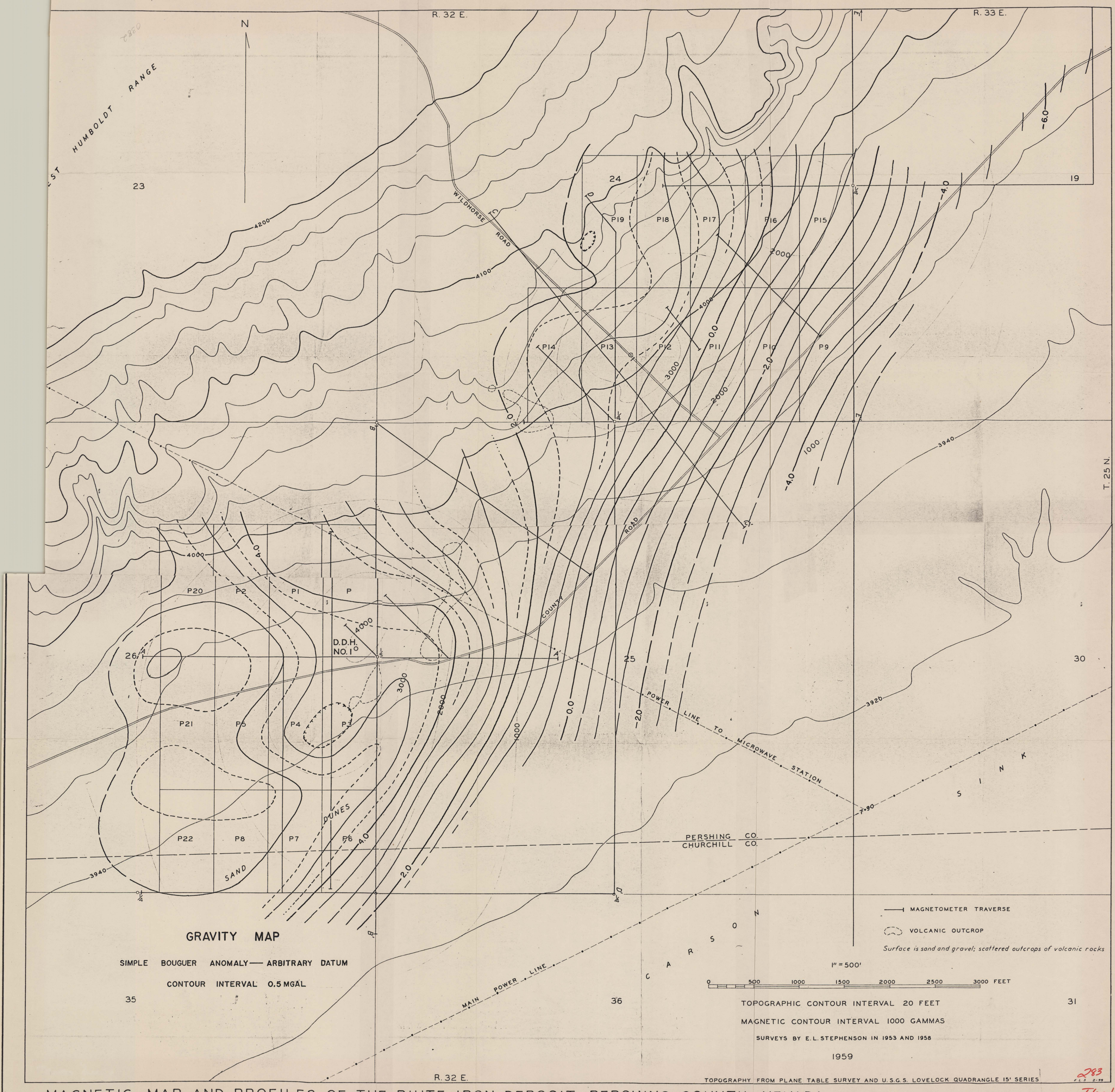


Figure 6 Profile C-C'

For further exploration it might be advisable to fill in the magnetic survey. Then, using magnetic susceptibilities obtained from the two drill cores it should be possible to make a good estimate as to the amount of magnetite present.

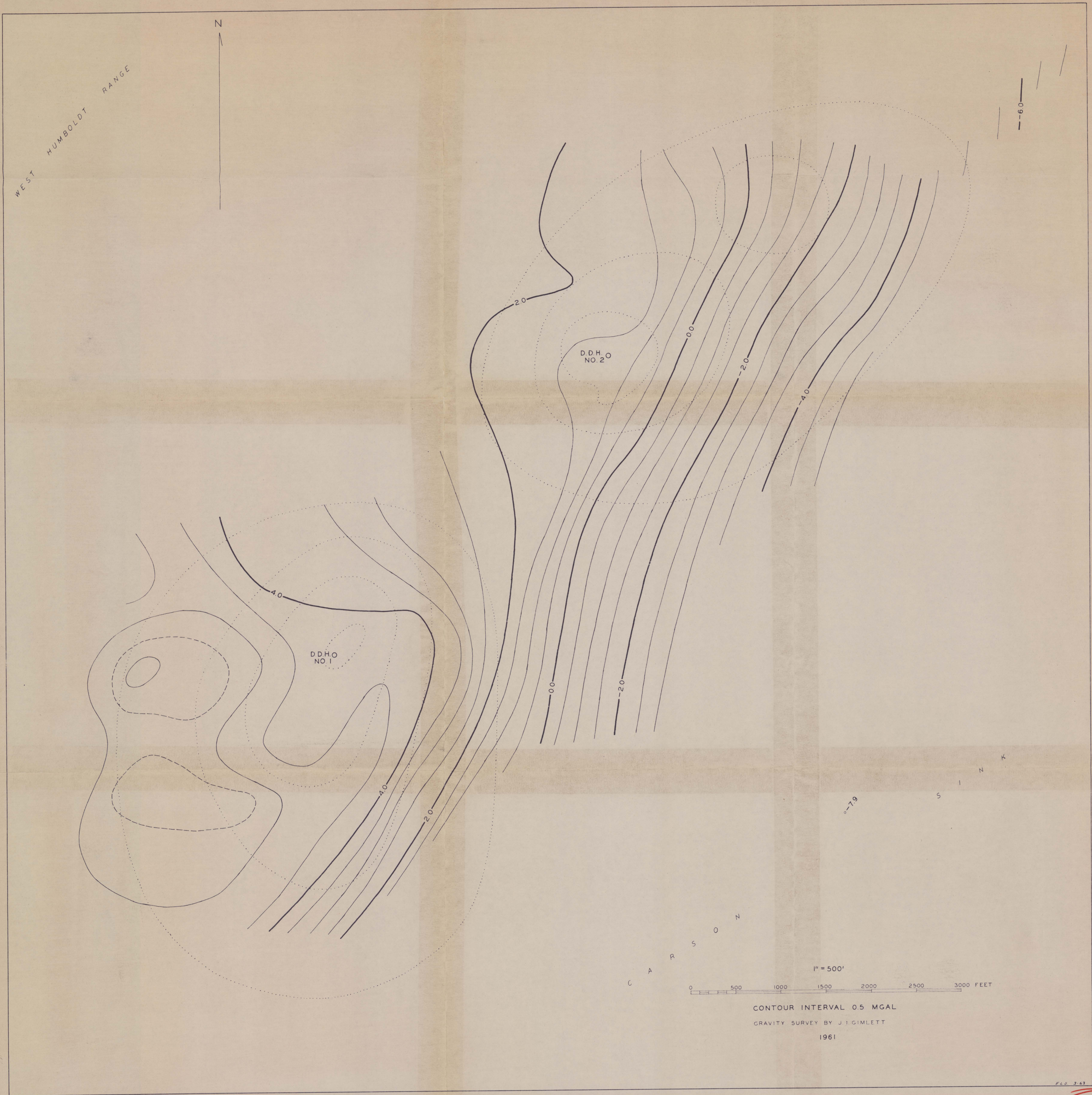


MAGNETIC MAP AND PROFILES OF THE PIUTE IRON DEPOSIT, PERSHING COUNTY, NEVADA

032-027-0382

283

Item 11



GRAVITY MAP OF THE PIUTE IRON DEPOSIT, PERSHING COUNTY, NEVADA

032-027-0382 283
Item 11