14 figures

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A PRELIMINARY GEOPHYSICAL INVESTIGATION OF CARNOTITE DEPOSITS IN MESA COUNTY, COLORADO

Trace Elements Investigations Report No. 66

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

OCT 19 1949

AEC-175/0

Dr. Phillip L. Merritt, Assistant Manager
Raw Materials Operations
U. S. Atomic Energy Commission
P. O. Box 30, Ansonia Station
New York 23, New York

OPEN FILE

Dear Phil:

Enclosed are copies 2 to 5 of Trace Elements Investigations Report 66, "A preliminary geophysical investigation of carnotite deposits of Mesa County, Colorado," by W. E. Davis, J. H. Swartz, and R. M. Shuler.

Copies 1 and 6 of this report are being forwarded to Dr. John K. Gustafson in accordance with his requests of February 25, and July 13, 1949.

Resistivity methods, particularly depth profiling methods, have shown definite anomalies associated with ore bodies in the Sage Flat area of Outlaw Mesa. Therefore, the results of the investigation as a whole are now under review for the purpose of determining a desirable course of action. As soon as this determination has been made we shall be glad to discuss it with you.

Sincerely yours,

Thomas B. Nolan

Assistant Director

Enclosures 4

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

A PRELIMINARY GEOPHYSICAL INVESTIGATION OF CARNOTITE DEPOSITS IN MESA COUNTY, COLORADO

by

W. E. Davis, J. H. Swartz, and R. M. Shuler

October 1949

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PRELIMINARY

GEOPHYSICAL INVESTIGATION OF CARNOTITE DEPOSITS

in

MESA COUNTY, COLORADO

by

W. E. Davis, J. H. Swartz, and R. M. Shuler

ABSTRACT

A preliminary investigation of the possibility of applying geophysical methods in the exploration for vanadium-uranium ore-bodies in the Colorado-Utah Plateau area was undertaken in southwestern Mesa County, Colorado, by the Geophysics Branch of the Geologic Division, U. S. Geological Survey. The project was in cooperation with the Mineral Deposits Branch and Trace Elements Unit of the Geological Survey and with the U. S. Atomic Energy Commission.

Time permitted the application of only a few of the available geophysical methods and techniques. Measurements were, therefore, restricted to those techniques which appeared most favorable or for which instruments, personnel, and equipment were immediately available. A major part of the time was devoted to electrical resistivity methods, particularly depth profiling, horizontal profiling, and azimuthal resistivity polarization measurements. Brief tests were also made by natural-potential, magnetic and geothermal methods.

Electrical resistivity methods, especially depth profiling methods, gave definite anomalies associated with the ore. Measurements by depth profiling over the newly discovered deposits in the Sage Flat area, Outlaw Mesa, showed well marked resistivity highs underlying and apparently outlining the ore bodies. Natural potential, magnetic, and geothermal measurements showed no observable correlation with ore occurrence.

Because of the short time available for the investigation, measurements had to be so restricted that these results cannot as yet be regarded as conclusive. Much more extensive measurements must be made in both barren and productive areas before they can be regarded as established. However, the results of the preliminary study are so encouraging as to warrant its continuation as a much more extensive investigation.

INTRODUCTION

A geophysical investigation was undertaken in the Colorado-Utah Plateau area to determine what possibilities might exist of detecting carnotite ore deposits or of mapping areas favorable to ore occurrence by geophysical methods. The present study in Mesa County, Colorado, constituted only an initial attack to determine whether geophysical methods would prove applicable. A much more extensive investigation would be required to test adequately the various methods which might be applied and to determine and develop the most effective techniques.

Investigations were made of ore deposits on Outlaw and Calamity Mesas during the period of April 21 to June 24, 1949. Electrical resistivity methods appeared the most promising and attention was concentrated to a large extent on these methods. In addition, brief measurements were made by natural-potential, magnetometer, and geothermal methods.

The work was done by the Geophysics Branch of the Geologic Division in cooperation with the Trace Elements Unit of the Geochemistry and Petrography Branch and the Mineral Deposits Branch as part of a joint project undertaken by the Geological Survey in cooperation with the Atomic Energy Commission.

LOCATION

Outlaw and Calamity Mesas are situated in the southwestern part of Mesa County, approximately sixty-five miles south of Grand Junction and nine miles southeast of Gateway (fig. 1).

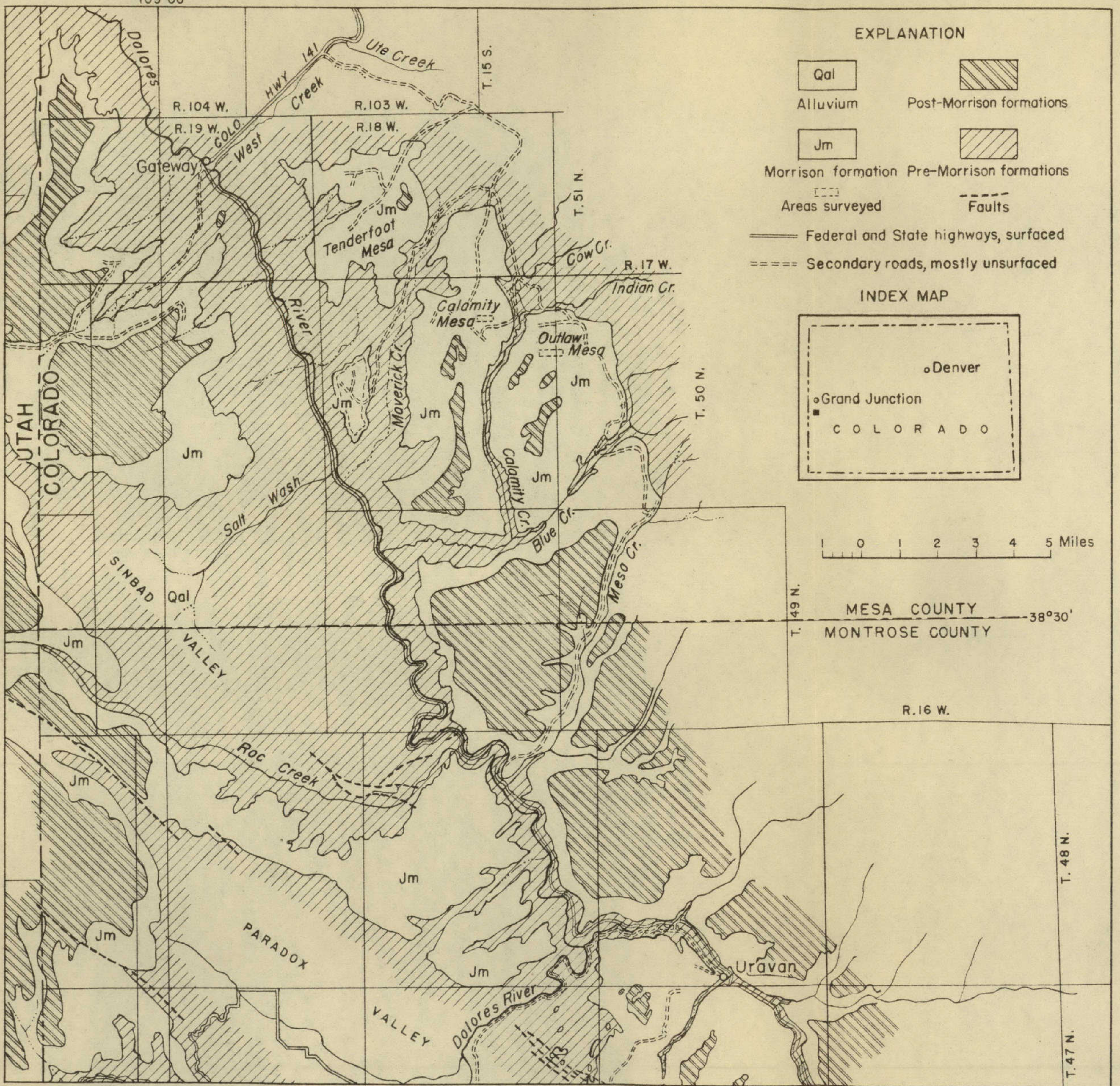

Figure 1.- Geologic map of Vanadium-Uranium district, southwestern Mesa County, Colorado.

They may be reached by way of the "Calamity Hill" road, which branches off from Colorado Highway 141, four miles northeast of Gateway, and the Mesa Creek road which joins the same highway nine and one-half miles northwest of Uravan, Colorado.

The mesas are separated by Calamity Creek Canyon, which carries the drainage of Cow, Calamity, and Indian Creeks. Outlaw Mesa lies to the east at an approximate elevation of 6,500 feet. It is bordered by Indian Creek Canyon on the north and by Blue Creek Canyon on the east and south. Calamity Mesa lies to the west at about the same elevation as Outlaw Mesa and is bounded by Calamity Creek on the east, Blue Creek Canyon on the south, and Maverick Creek Canyon on the west.

The topography of the areas is rough, comprising sandstone hills and ridges having a maximum relief of approximately 500 feet. These features are sparsely timbered with pinion-pine and cedar. Sage brush covers most of the flat areas wherever a thick mantle of soil and weathered shale overlies the country rock.

GEOLOGY

Rock strata of Jurassic age are exposed in the walls of canyons bordering the areas and on slopes of the higher ridges. They reveal the following geologic column.[1/]

1/ cf. Fischer, Richard P., Vanadium deposits of Colorado and Utah; U. S. Geological Survey Bull. 936-P, pp. 368-370, 1942.

Formation	Thickness (feet)	Character
Dakota	100	Gray and brown conglomeratic sandstone and gray and brown shale; cliff forming.
Morrison:		
Brushy Basin	396	Variegated shale, mudstone, siltstone, and thin beds of hard sandstone. Cherty sandstone present in lower part. Conglomeratic sandstone present in lower and upper parts. Forms a steep slope.
Salt Wash	343	Sandstone, medium fine grained, white, gray, and red-brown, massive, interbedded with red and gray shale; ore bearing. Sandstone forms cliffs and benches.
Summerville	92	Red and white sandstone and red shale, thinly bedded. Forms steep slopes.
Entrada	198	Sandstone, medium fine grained, buff to light gray with reddish bands, thick-bedded to massive and cross-bedded, characteristically forms bare rounded cliffs to steep slopes.
Kayenta	132	Sandstone, sandy shale and conglomerate, thinly bedded, reddish or maroon.
Wingate	356	Sandstone, reddish-brown, massive, cross-bedded. Forms sheer vertical cliffs.

Outlaw Mesa lies on the eastern flank of a syncline that plunges to the southeast. Its axis strikes northwest-southeast across the southern boundary of the mesa near the confluence of Blue and Calamity Creeks and across the southern part of Calamity Mesa. The topography of the mesa is rough and elevations range from 6,740 feet to 7,152 feet above sea level. The highest point is situated in the extreme northeastern part of the mesa near the rim. Sandstones of the Salt Wash member of the Morrison formation are exposed near the edges of the mesa rim. The Salt Wash underlies most of the mesa except for the central part where sandstone and shales of the Brushy Basin member crop out along the slopes of hills and ridges. In this part of the mesa the highest features are capped with sandstone of the Dakota formation. The sediments have a regional dip of approximately 3° to the southwest.

Calamity Mesa is not as wide as Outlaw but extends approximately three miles farther north. The topography consists of sandstone hills and ridges with highest elevations ranging from 6,560 feet in the southern part to 6,920 feet above sea level in the northern part. Salt Wash sandstone underlies the northern part and the outer margins of the mesa. The Brushy Basin member of the Morrison underlies the south central portion and is overlain by Dakota sandstone on the higher hills and ridges. In the northern part of the mesa the sediments dip approximately 3° to the southwest and in the southern part 2° to the northeast.

ORE DEPOSITS

The ore deposits contain carnotite associated with vanadium bearing minerals and occur as scattered impregnations in the Salt Wash sandstone member of the Morrison formation. Most of the deposits are found in sandstone lenses occurring in the upper part of this member, apparently where the lenses are thicker and concentrations of argillaceous and carbonaceous materials are present in the sandstone. The deposits are spotty and form irregular tabular masses. Locally they occur in channel fills, but usually do not appear to be associated with any particular structural feature. Frequently the ore is found impregnating fossil logs. Mining operations have been confined to the mesa rims where the sandstone crops out and erosion has exposed small deposits.

AREAS OF INVESTIGATION

Investigations were made of three ore deposits discovered by drilling in the Sage Flat area on Outlaw Mesa (fig. 2). This area is situated east of Potatoe Mountain near the center of the northern part of the mesa. It is comparatively flat except for a low ridge that lies in the northeastern part. Low sandstone ridges border the area on the north and a broad, high ridge lies to the south. The flat is covered by a mantle of soil and weathered shale, through which erosion has cut a deep gully running diagonally across the area from northeast to southwest.

A large deposit of ore lies in the southern part of the Sage Flat between the gully and the base of the high ridge to the south. It has not been explored completely by drilling, but records of drill holes in the area show that the deposit strikes N26°E and dips to the southwest. It is approximately 1,000 feet long, and 150 feet across in the widest place. The ore occurs at depths ranging from 86 feet in the eastern part of the deposit, to 140 feet in the western part. It is approximately eight feet thick at the center of the deposit. The sandstone which carries the ore is overlain by a cherty sandstone followed by a thick section composed of interbedded mudstone, siltstone, sandstone, and shale. A geologic section along the strike of the deposit is shown in figure 3, which illustrates the complexity and variability of the stratigraphy

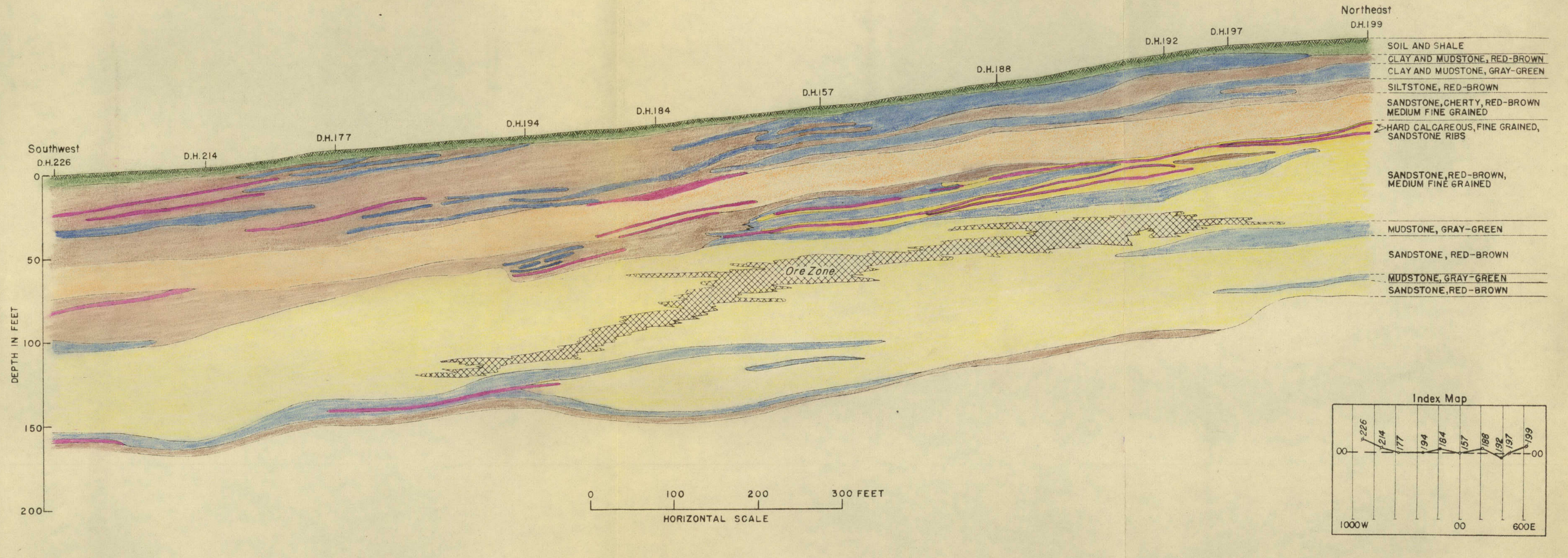

Figure 3.— Geologic section along strike of large ore deposit in Sage Flat area, Outlaw Mesa. (after Stager and Herbaly.)

in the area.

A smaller deposit lies north of the gully and northwest of the large deposit. Sandstone exposed at the limits of the mineralized area forms a gradual slope to the north and a low ridge to the west. The deposit is approximately 300 by 400 feet across. The ore occurs at depths ranging from 98 to 129 feet and is overlain by sandstone, and lenses of mudstone, siltstone, and shale.

A much smaller deposit lies in the western part of the Sage Flat area, a short distance north of the gully and approximately 400 feet east of the foot of Potatoe Mountain. Ore was encountered in four closely-spaced holes in this locality.

The other deposits included in this investigation lie in the northern part of Calamity Mesa in the vicinity of the Calamity group of claims. Two mineralized areas are located on a flat-crested ridge on Calamity Claims Nos. 21 and 27 (fig.4). Sandstone underlies the surface of the ridge, which is covered by a thin layer of soil and shale. The ore occurs at depths ranging approximately from 59 to 68 feet. The maximum thickness of the larger ore zone situated near the center of the ridge is approximately nine feet. The smaller zone lying to the west ranges in thickness from a trace to 3½ feet. Another ore-body lies to the east along a nose extending southward from a small hill in Claim No. 21. In this locality the ore occurs at shallower depths, ranging from 30 to 38 feet, but at about the same stratigraphic position. The ore zone is approximately six feet thick in the center of the deposit.

GEOPHYSICAL INVESTIGATIONS

Geophysical Methods Applied

Since time and available funds did not permit exhaustive tests of different geophysical methods, measurements were restricted to those methods which appeared to be most immediately applicable and to offer the best possibilities of success. These were supplemented by a few measurements made by other methods, which were considered for one reason or another to be applicable and which could be readily tested with available equipment.

Stratigraphic conditions indicated that electrical resistivity measurements offered the greatest chance for success. The measurements were, therefore, largely restricted to resistivity methods and particularly to three resistivity techniques: depth profiling, horizontal profiling, and azimuthal polarization measurements.

In depth profiling the center of the electrode configuration remains at a single station and the depth of measurement is varied. In horizontal profiling the depth of measurement is kept fixed at one particular value and the configuration moved from one point to another along a traverse line. Depth profiling may be considered analogous to drilling a hole at a given location. Horizontal profiling corresponds to trenching to a given depth along a certain traverse line.

In polarization measurements, the resistivities of underground rocks for direct and for reversed directions of current flow are compared and the effect of the direction of current flow determined. Conduction through the rocks is frequently polarized, that is, the resistivity differs with different directions of current flow. A series of such direct and reversed measurements along different azimuths have been found in certain oil-producing areas to be related to the direction of oil impregnation. It was thought quite possible that similar measurements in this area might give values related to ore occurrence.

In addition to the resistivity measurements a few scattered determinations were made by natural-potential, magnetic, and geothermal techniques.

Resistivity Measurements

Outlaw Mesa

Drilling on Outlaw Mesa earlier in the spring of 1949 had discovered three ore-bodies in the Sage Flat area east of Potatoe Mountain. Since the drilling furnished valuable geologic calibration data and the area was largely free of geophysical interference, a considerable part of the field time was spent in this area.

Resistivity measurements were made along the traverses shown in figure 2. The Lee Partitioning configuration was employed throughout.

Depth Profiling

Depth profiles were run at 45 foot intervals along Traverse 00 from 304.5 S to 370.5 N, along Traverse 600 W from 270 S to 270 N, and along Traverse 900 W from 530 N to 1115 N (fig. 2). Measurements were made to a total depth of 200 feet at each station, using a depth interval of five feet.

The results of these measurements are shown in figures 5 and 6 where vertical sections are shown drawn through the resistivity stations along each traverse. Resistivity values have been plotted for each station and through these values iso-resistivity lines or contours have

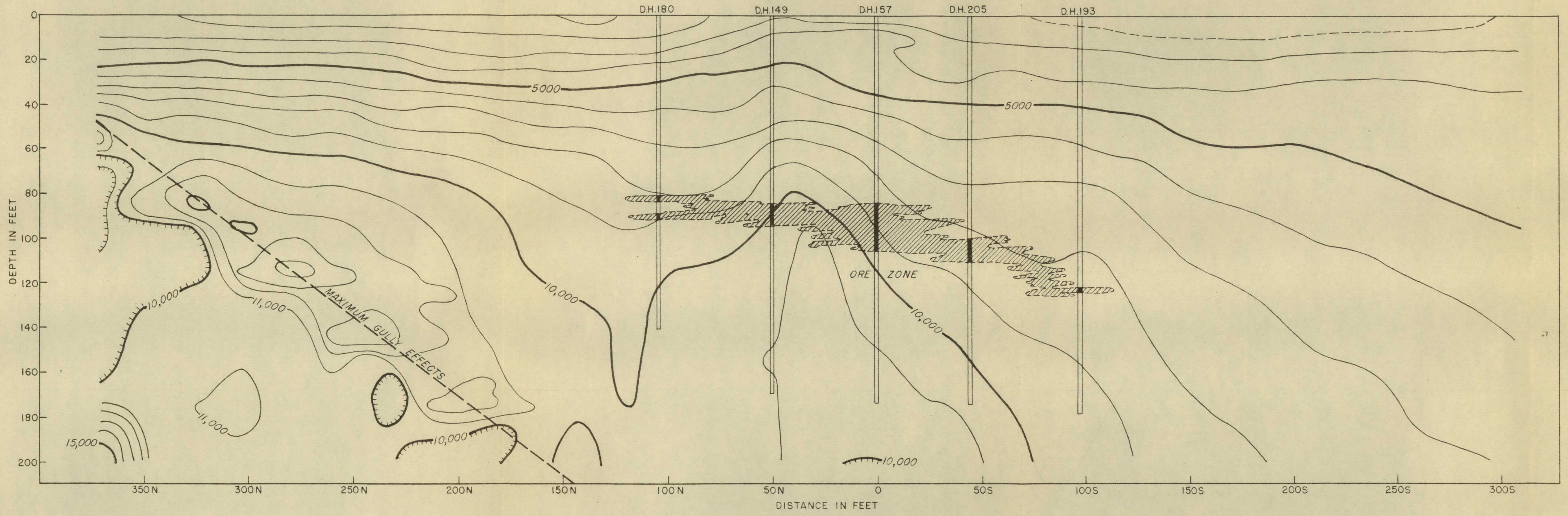

Figure 5. - Vertical iso-resistivity section along traverse 00, Sage Flat area, Outlaw Mesa.

been drawn with a contour interval of 1000 ohm-centimeters.

Figure 5 shows the vertical iso-resistivity section along Traverse 00, which passes through the thickest part of the ore-body as shown by drilling. The position of the ore-body in this section is shown by the cross-hatched area.

It is immediately apparent that the ore-body is accompanied by a sharp resistivity high affecting especially the 11,000 to 8,000 ohm-cm contours. These contours rise to a maximum under the approximate center of the ore-zone and drop off sharply at either end of the deposit. The disturbed area at the left of the section is due to the effects of the deep gully cutting across the northern end of the traverse as seen on the map, figure 2.

The discovery of an iso-resistivity high associated with the ore-body was encouraging, but, of course, a single profile while suggestive is not conclusive evidence. To check on the possible significance of this feature Traverse 600 W was investigated. D.H. 177 on this traverse found no ore, although there was some slight indication of mineralization. The vertical iso-resistivity section along this traverse is shown in figure 6B. It is interesting to note that while there is a slight resistivity terrace approximately at the position of D.H. 177, there is no such resistivity peak as that underlying the ore-body of Traverse 00, figure 6A. While this resistivity terrace may be related to the slight mineralization indicated in D.H. 177, it is much affected by the presence of the gully and may be caused to great extent by such gully effects. In any event, the absence of any well marked resistivity peak is in agreement with the absence of any concentrated mineralization along this traverse.

In figure 6C is shown the vertical iso-resistivity section along Traverse 900 W. This traverse crosses an ore deposit found by drilling

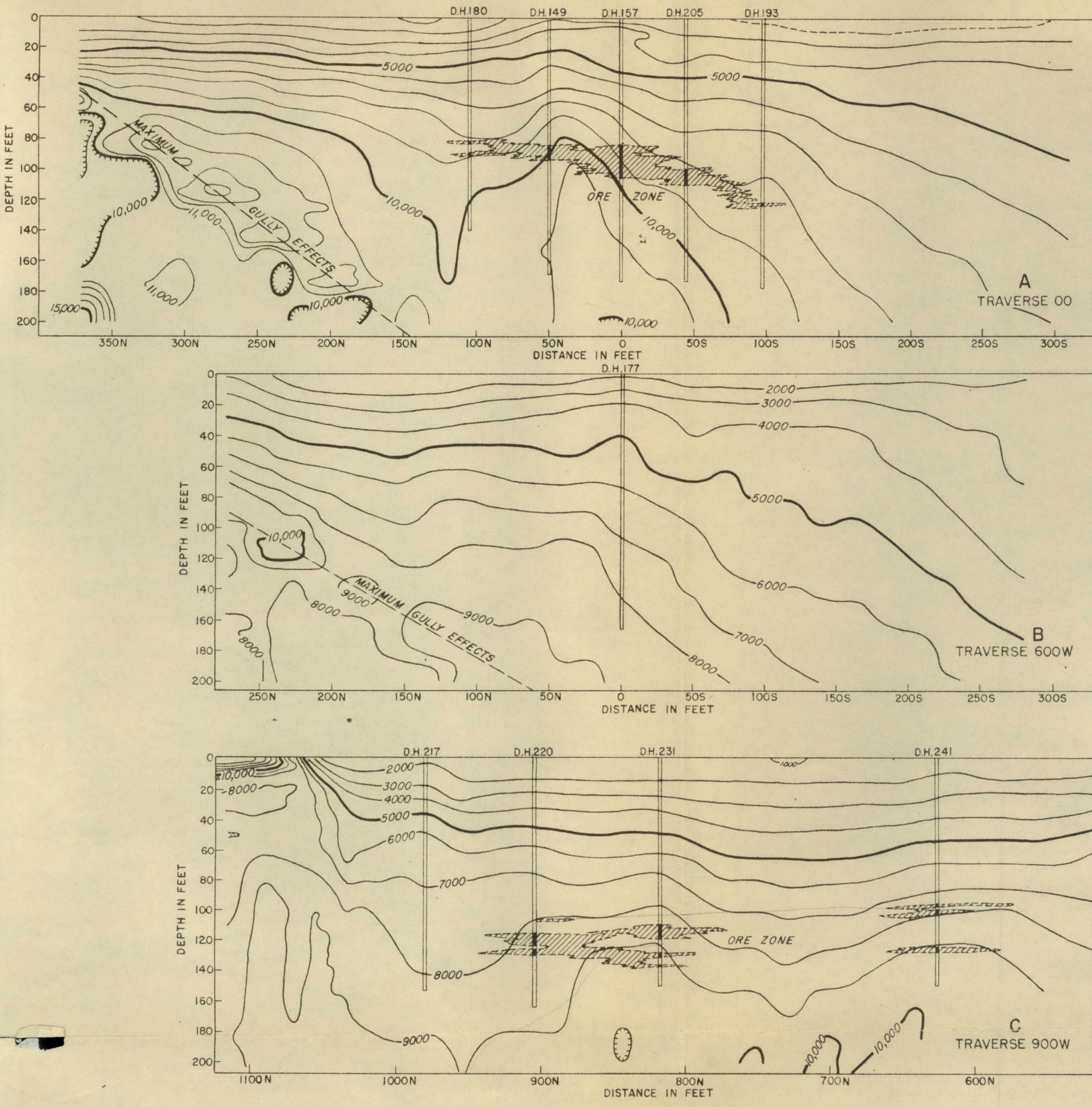

Figure 6. – Vertical iso-resistivity sections along traverses 00, 600W, and 900W in Sage Flat area, Outlaw Mesa.

north of the deep gully, as shown on the map, figure 2. The iso-resistivity section shows in the drilled area two well marked resistivity highs. Each resistivity peak appears to be associated with an ore concentration. The northernmost of these is wider and thicker and is accompanied by the more pronounced iso-resistivity high.

The iso-resistivity data so far obtained in this area are consistent in their indications and in their correlation with the drilling data. Their evidence is suggestive and encouraging. It cannot be regarded in any sense as conclusive, however, since it rests on too restricted a series of measurements. It does indicate that this method offers possibilities for ore exploration which should be further investigated. Only tests in numerous areas and under varied conditions can determine whether or not this method can be an effective and successful technique for ore exploration in the Colorado-Utah Plateau area. The results in the Sage Flat area are sufficiently encouraging, however, to warrant much more extensive testing.

Horizontal Profiling

Depth profiling is somewhat time consuming, although it can be considerably accelerated by using a longer depth interval, a procedure which other studies of these data have shown feasible.

Horizontal profiling or resistivity "trenching" to a fixed depth is a much more rapid method. To test the possible application of this technique horizontal resistivity profiles were run along traverses in the Sage Flat area of Outlaw Mesa (fig. 2). Measurements were made to an effective depth of 150 feet at intervals of 25 feet along these traverses. Two measurements, a north and a south partitioning half, were made over each partitioning zone.

Resistivity profiles of traverses crossing the large ore-body and a small deposit lying to the west in the Sage Flat area are shown in figure 7. A broad resistivity high extends over most of the eastern part of the area (upper profiles) diminishing gradually in magnitude to the west (lower profiles) where the curves are comparatively flat.

The large ore-body, as outlined by drilling, is shown in black on the profiles of Traverses 400 W to 400 E. A resistivity hump overlies the ore-body. It is a maximum over the center of the deposit on Traverse 00 and is well defined on the profiles of Traverses 190 E and 400 E. This feature is of low magnitude along Traverses 200 W and 400 W which cross the western part of the deposit where the ore occurs at greater depths. The small amount of ore encountered in holes drilled in the vicinity of Traverse 800 W between 50 S and 175 N appears to be indicated in the profile by a resistivity high at this locality. An extension of the small deposit in the western part of the area may be indicated by the small resistivity high shown between 50 S and 25 N in the profile of Traverse 1810 W.

The resistivity high associated with the large ore deposit is less clear cut in these profiles than in the vertical iso-resistivity sections. The horizontal profiles are more sensitive to resistivity disturbances so that the picture they present is considerably confused by various effects due to topographic and surface geologic features.

The effect of a topographic feature is shown in the profiles of traverses in the eastern part of the area where a prominent resistivity peak occurs at the location of the deep gully that trends diagonally across the flat. The peak is less pronounced along traverses in the

Figure 7.— Horizontal resistivity profiles along traverses in Sage Flat area, Outlaw Mesa

western part of the area where the gully is narrower and shallower.

The effect of a geologic surface feature is seen in the profiles of Traverses 400 E and 600 E where a resistivity high occurs at the edge of a sandstone outcrop that forms a ridge to the north. The resistivity feature extends westward developing into a broad dome-shaped high overlying most of the ridge, as shown in the profile of traverse 190 E. Another resistivity high occurs over a similar contact in the northern part of Traverses 1200 W, 1400 W and 1600 W.

In figure 8 are shown profiles of traverses crossing the ore-deposit located in the northern part of the Sage Flat. Resistivity highs occur over the mineralized area at positions where ore was encountered in drilling. A distinctive and prominent resistivity high occurs between 850 N and 975 N on Traverse 1200 W. It was observed along a sandstone ridge that lies west of the ore-deposit and occupies the approximate line of trend of the ore-body. It may represent a westward extension of the ore zone. A sharp resistivity drop to the north occurs in the profiles, where it marks the edge of a sandstone outcrop that forms a gradual topographic rise in that direction. Associated with it is also a well-marked resistivity high, which is thought to be an expression of the lateral distortion of the current field caused by this stratigraphic contact. While in these profiles resistivity highs are again shown associated with the ore, the correlation is less clear-cut and the most striking effect is produced by the sandstone-shale contact.

Because of the increased interference of topographic and surface geologic effects the horizontal profiling method, although faster, is less satisfactory than the depth profiling method, at least in the Sage Flat area. However, additional horizontal profiling measurements

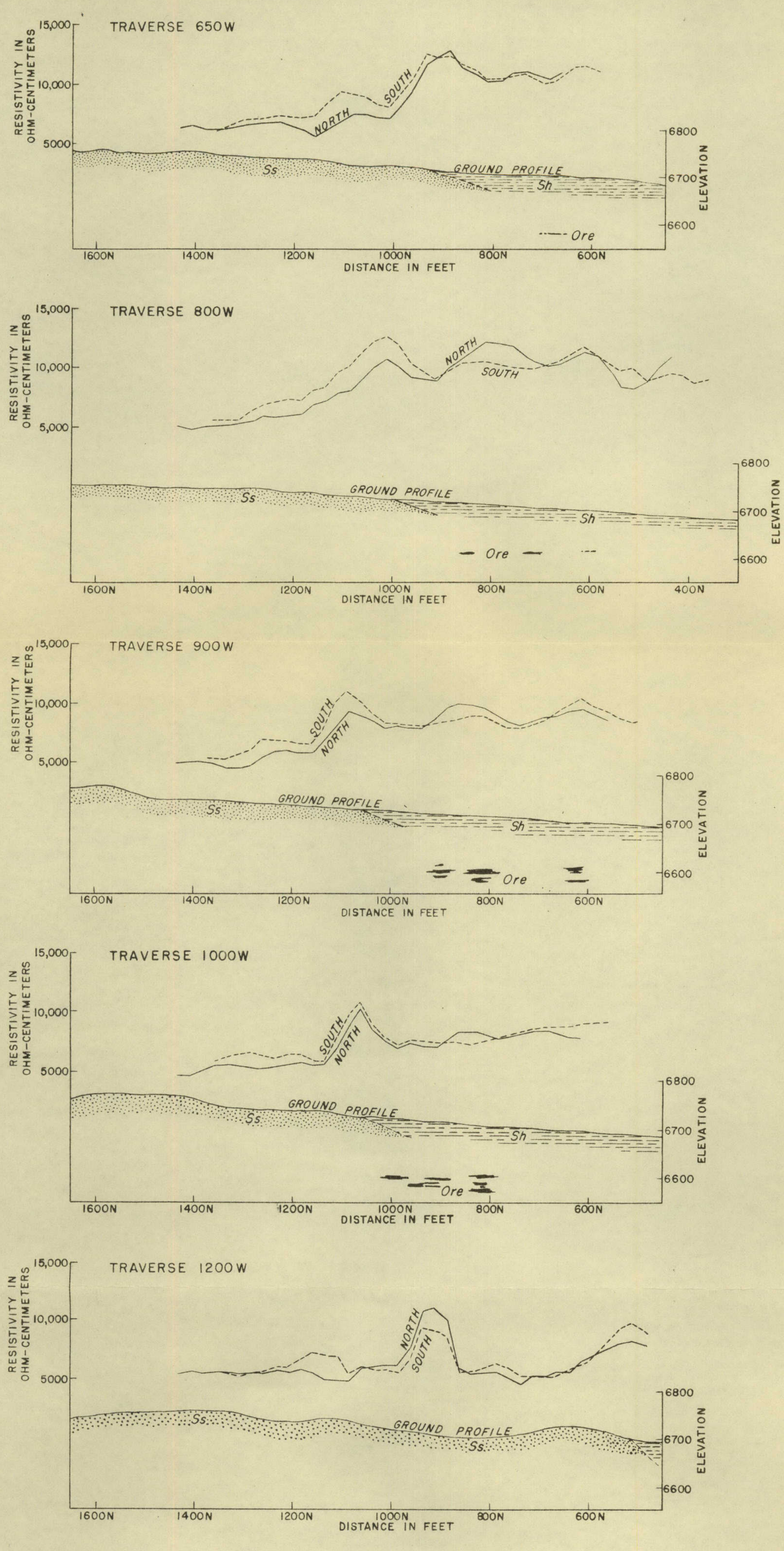

Figure 8.- Horizontal resistivity profiles along traverses in northern part of Sage Flat area, Outlaw Mesa.

should be run in other areas where topographic and geologic features are less disturbing before this technique is abandoned. At present it would seem to take second place with respect to depth profiling.

Azimuthal Polarization Measurements

It has been found in a number of areas that the apparent resistivity of the rocks changes when the current is reversed. In certain oil-bearing areas it has been found that such resistivity polarization is related to the direction of oil impregnation. It has frequently proved possible to tell in what direction to move from a dry hole in order to obtain production. This has been done by a technique, referred to as the sand extension method, developed by F. W. Lee[2/] of the Geophysics Branch. In this technique the central electrode of the Lee Partitioning configuration is lowered into the drill hole to the depth of the petroliferous horizon and a series of surface resistivity measurements made along traverses radially arranged in different azimuths about the drill hole, as shown in figure 9.

The electrode configuration for inhole measurement of polarization is shown in figure 10. The direction of current flow from C_1 to C_2 is first made positive, then negative, and the resistivity corresponding to each direction of current flow computed in standard fashion. The ratio of the two resistivities is a measure of the amount of resistivity polarization. The variations in the value of this ratio can be plotted along each azimuthal radius, very much as in a meteorological wind-rose of figure 11, to give a picture of the change of polarization with direction.

2/ Lee, F. W. Preliminary report to the U.S. Bureau of Mines on the results of sand extension surveys in Southern Ohio. U.S. Geol. Survey unpublished manuscript.

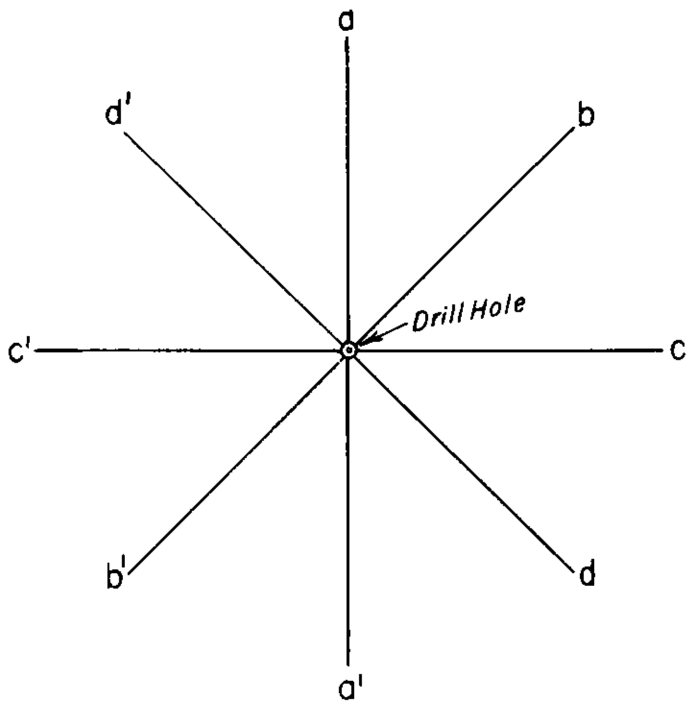

Figure 9.–Radial azimuthal traverses for resistivity-polarization method.

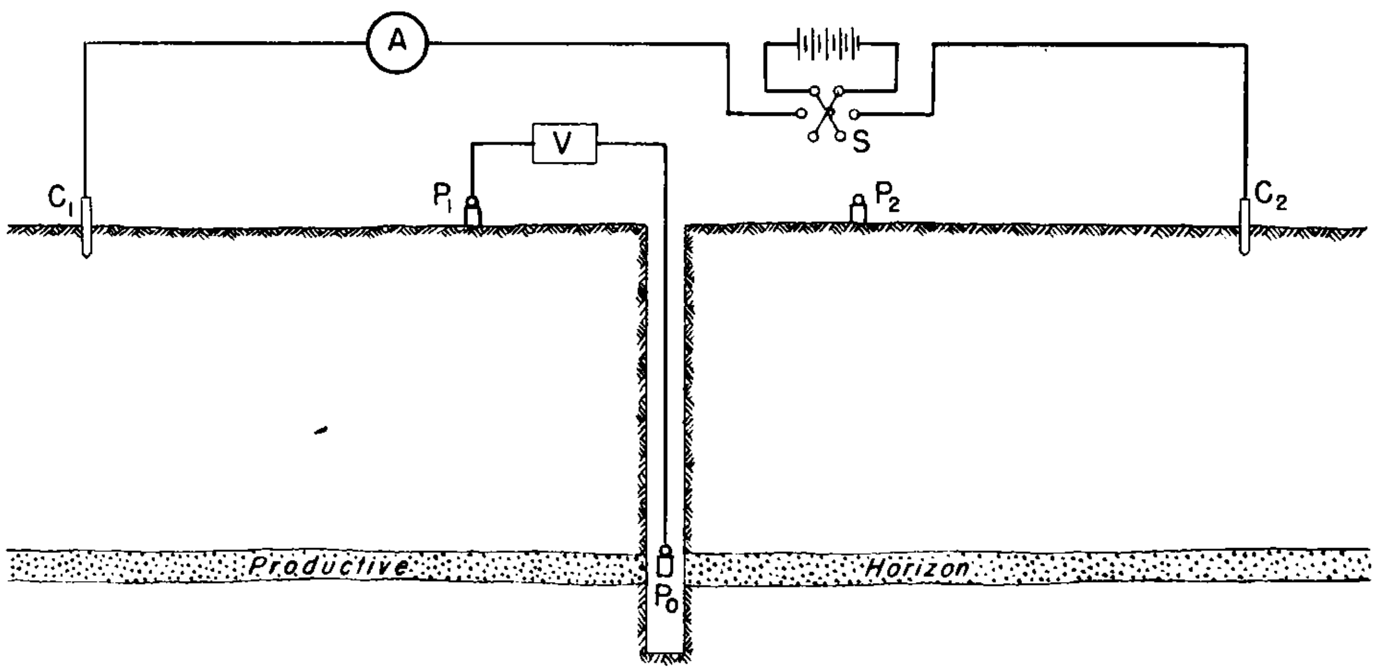

Figure 10.–Electrode configuration for inhole measurement of resistivity-polarization. C_1 and C_2 current stakes; P_0, P_1 and P_2 potential electrodes; S current reversing switch; A current measuring device; V potentiometer for measuring voltage.

In the case of oil-bearing areas a relationship has been found between these variations and the directions to adjacent productive and dry areas. It was thought possible that some similar relationship might be found for the Colorado-Utah Plateau carnotite deposits. To check this possibility measurements by this technique were undertaken about a few of the Sage Flat drill holes. Measurements were made to an effective depth of 95 feet with the electrodes aligned in directions N-S, N60°E-S60°W and S60°E-N60°W at drill holes 177, 213, 219, and 251.

The resultant data were tested in a number of possible ways. The most significant results were found to come from a determination of the departure of the polarization from the average. The results of this computation are shown in figure 11 in which the circle about each drill hole represents the average value of the polarization in the different azimuths about that hole. The single cross-hatching represents values less than the average, the double cross-hatching values greater than the average. The broken lines represent the approximate outlines of the ore deposits as disclosed by drilling. It is quite striking that the greater-than-average values point in the direction of these ore-bodies.

Only a few such measurements could be run in the available time. The data are, therefore, too few to permit any final conclusions. However, the results appear promising and warrant more extensive investigation.

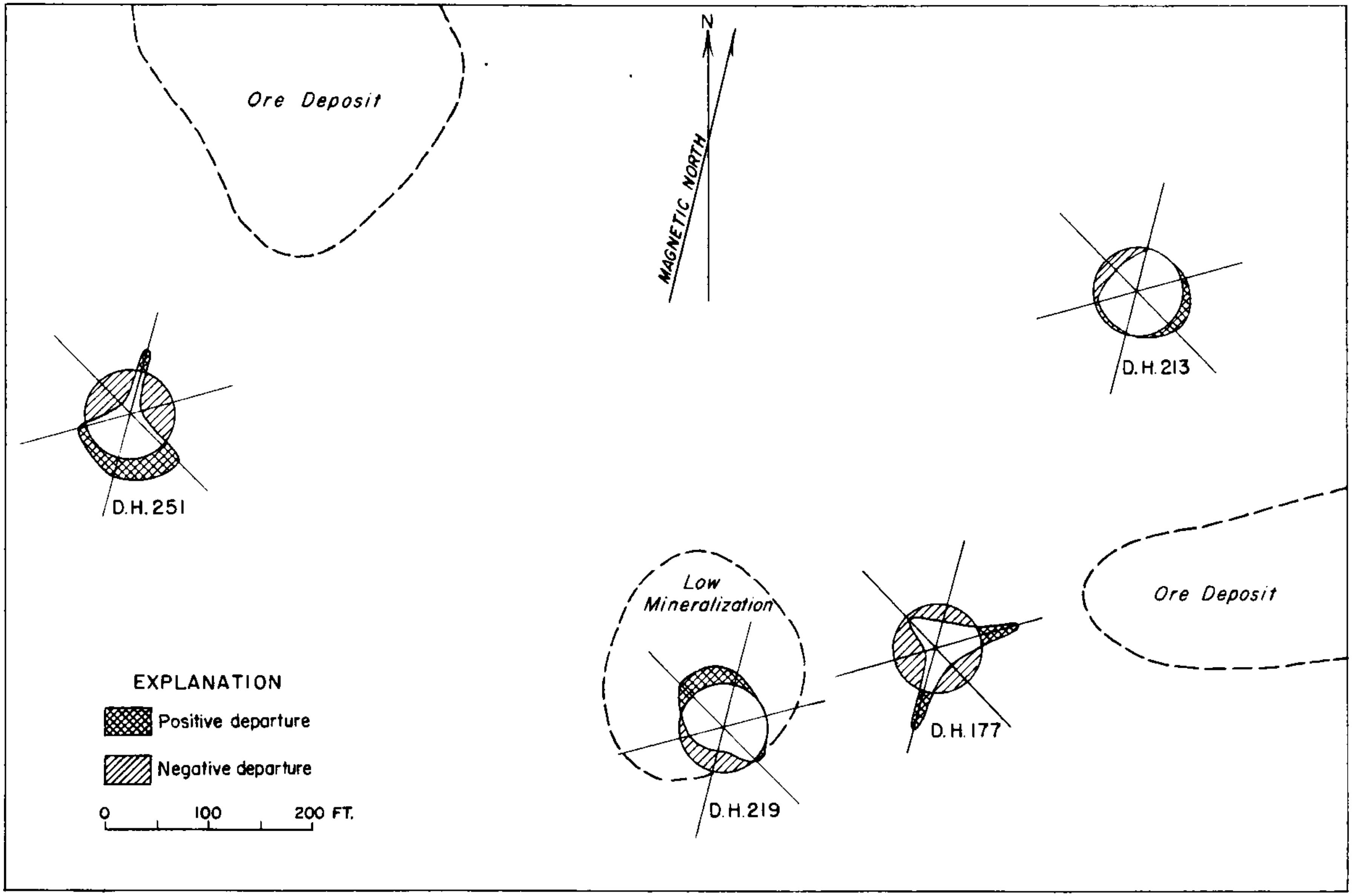

Figure 11.— Resistivity–polarization curves around drill holes in the Sage Flat area, Outlaw Mesa, showing departures from the average.

Calamity Mesa

Horizontal resistivity profiles were run along traverses crossing ore deposits on Calamity Mesa (figure 4) but the data were not sufficiently reliable for correlation purposes because of serious electrical interference. In this area the applied electric current fields were greatly disturbed by irregular topography, old mine workings, large boulders and irregular surface conditions caused by bull-dozer and drilling operations. Available time did not permit the application of other resistivity techniques in this area.

Other Geophysical Measurements

In addition to the resistivity investigations outlined above a few measurements were made by other geophysical methods. The particular methods selected were determined by the immediate availability of equipment and personnel, and the shortness of the period of time available for making such measurements.

Natural-Potential Surveys

It seemed possible that ionization effects might produce natural-potential differences which could be observed by surface potential measurements. In figures 12 and 13 are shown natural-potential profiles measured along traverses crossing both ore-bearing and barren zones in the Sage Flat and Calamity Claims areas. There appears to be no correlation between the ore and potential anomalies shown in these profiles.

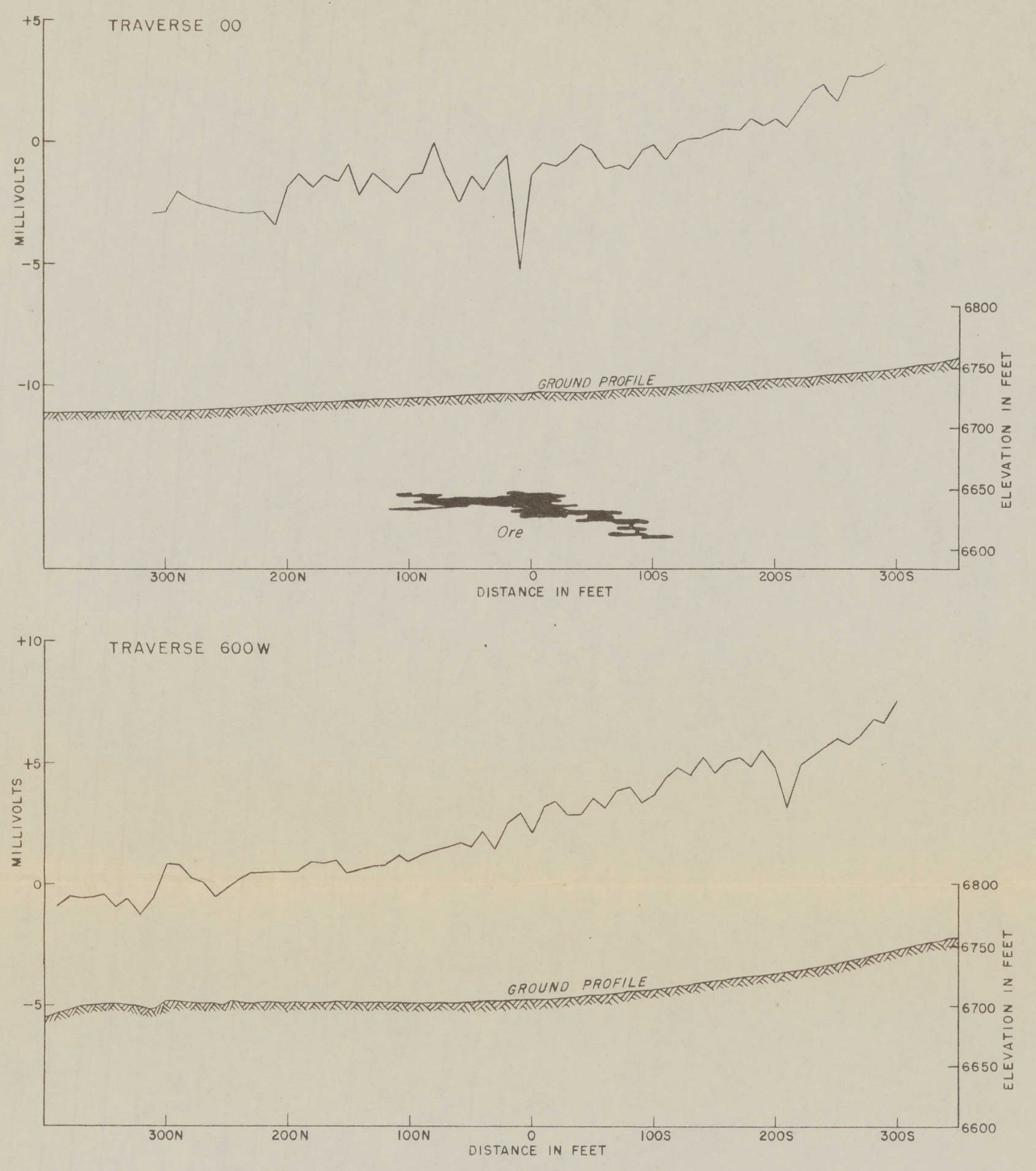

Figure 12.— Natural-potential profiles along traverses 00 and 600W in Sage Flat area, Outlaw Mesa.

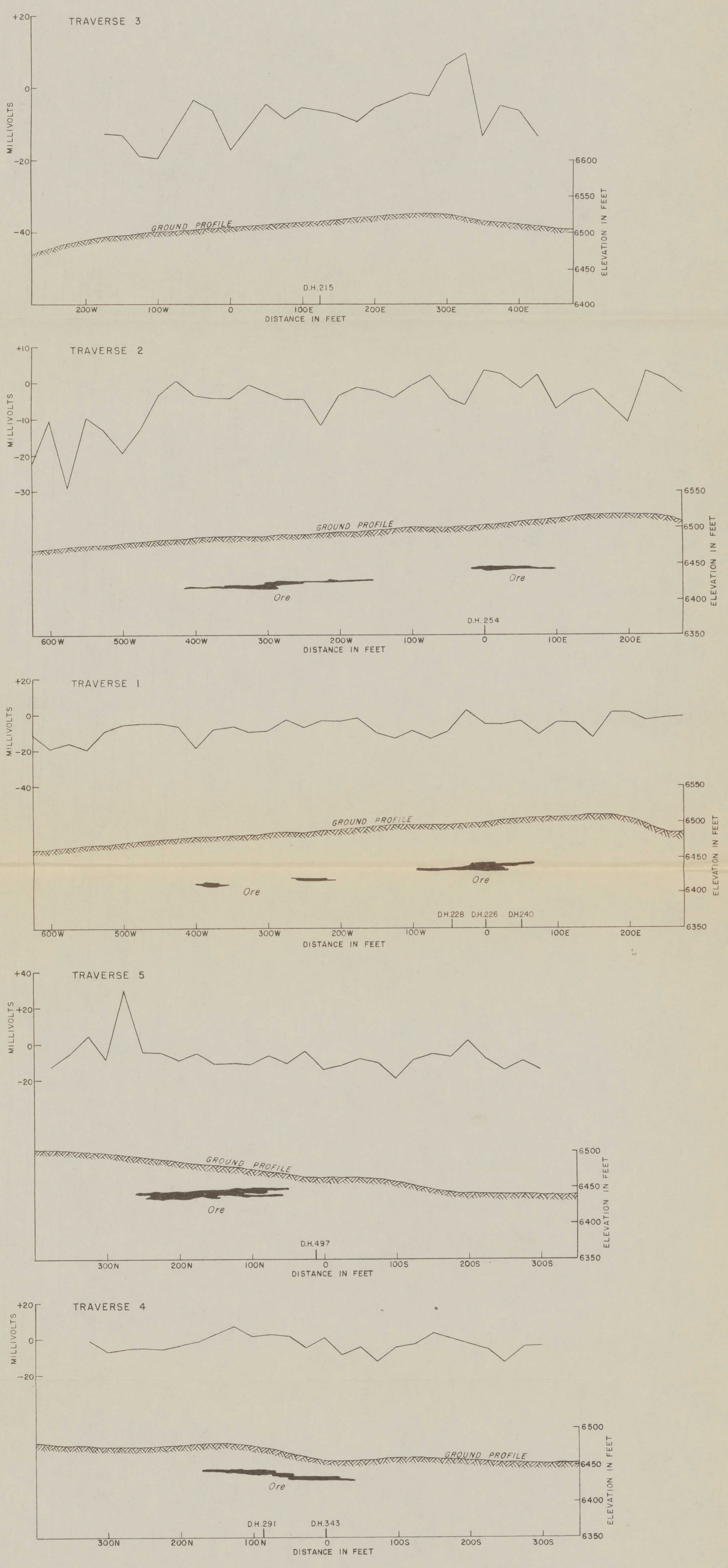

Figure 13.- Natural-potential profiles along traverses 1 to 5 in Calamity Claims area, Calamity Mesa.

Magnetic Surveys

Strong magnetic anomalies have been reported associated with an ore deposit in another part of the Plateau area. Although there is no known association between magnetite or other magnetic minerals and the ore it seemed worthwhile to check this possibility by running a few magnetic profiles.

Five traverses were run across deposits in the Sage Flat and Calamity Claims areas. Magnetic measurements were made with an Askania, temperature-compensated, vertical magnetometer having a sensitivity of 32.4 gammas per scale division. Stations were occupied at intervals of 25 feet along the traverses and measurements were extended for some distance beyond the mineralized areas.

Magnetic profiles resulting from this work are shown in figures 14 and 15. These show no marked magnetic difference between mineralized and barren areas. Although magnetic highs overlie the deposits, similar features occur over areas lying outside of the ore zones. No definite correlation could be observed between the magnetic anomalies and ore occurrence.

Geothermal Measurements

It was thought possible that sufficient heat might be generated in the ore deposits to produce measurable thermal anomalies about the ore-bodies. To test this possibility geothermal measurements were made in five drill holes in the Sage Flat area: four in which ore had been found, one in which no mineralization had been observed.

Measurements were made with a 30-conductor vinylite cable in which a series of thermistors had been inserted, at two foot intervals, from 149 to 200 feet below the zero point of the cable. The thermistors had

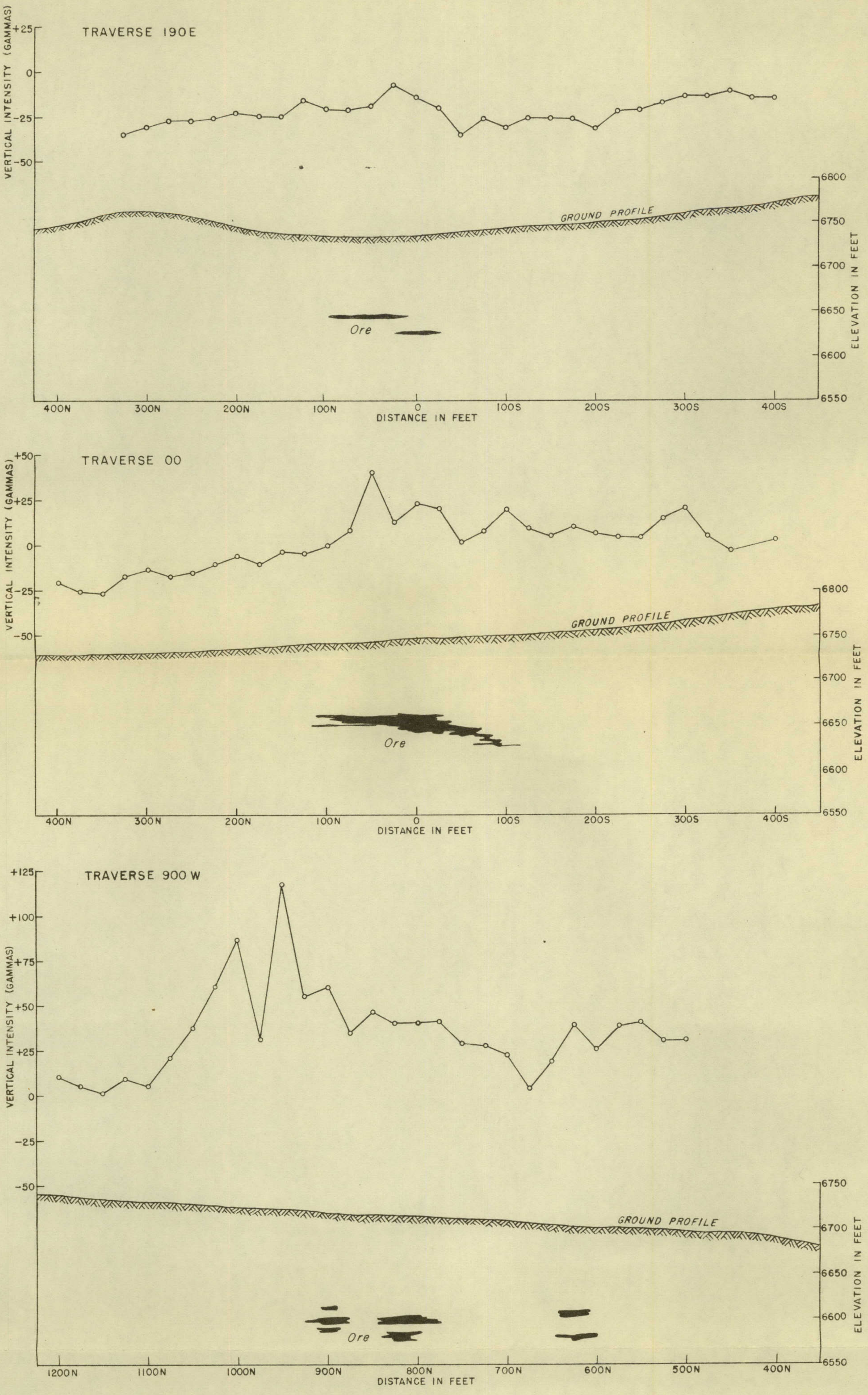

Figure 14.- Magnetic profiles along traverses 190E, 00, and 900W in Sage Flat area, Outlaw Mesa.

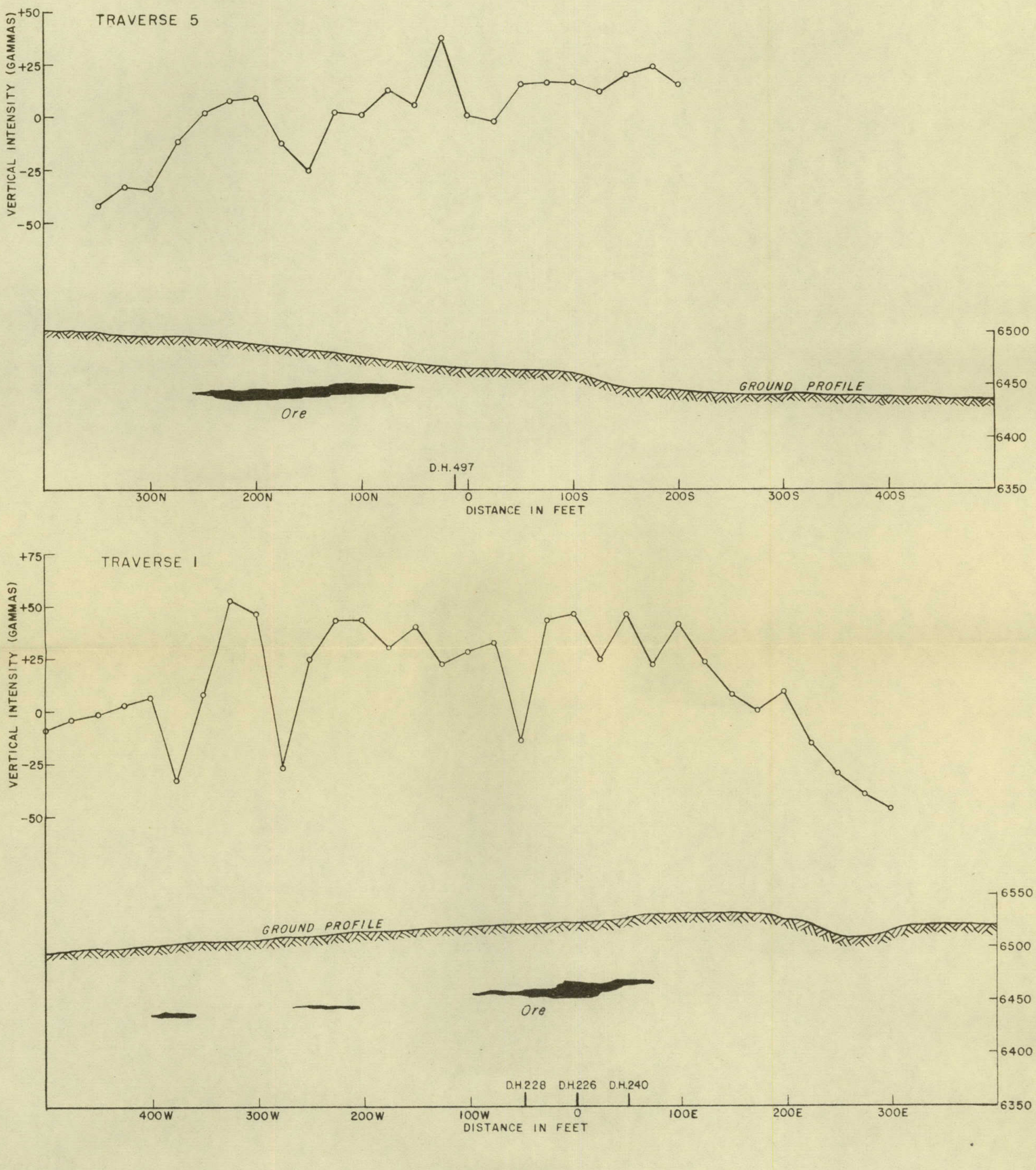

Figure 15. - Magnetic profiles along traverses 1 and 5 in Calamity Claims area, Calamity Mesa.

resistances averaging approximately 1000 ohms at 25°C and had a negative temperature coefficient of approximately 4.4% of their resistance per degree centigrade. Resistances were measured with a Wheatstone Bridge and temperatures determined from a series of calibration tables compiled for the specific thermistors used.

The drill holes were air filled so that convection effects and disturbance of the air in the holes during lowering and raising of the cable, prevented the obtainal of very satisfactory determinations of rock temperatures. Time did not permit the use of baffles or other devices to help obviate these effects, nor did it permit the cable to remain in the drill holes long enough to reach satisfactory thermal equilibrium. This is indicated by the offsets between the curves (figure 16) for different cable positions in the holes. The results shown in figure 16 cannot, therefore, be regarded as too significant. The absence, however, of any obvious temperature anomaly suggests that heat production is probably small or thermal dissipation rapid in these ore-bodies.

CONCLUSIONS

The measurements so far completed in this brief preliminary investigation indicate that electrical resistivity methods offer considerable possibilities of success in the location of carnotite deposits in the Colorado-Utah Plateau area. Encouraging results were obtained by both resistivity depth-profiling and azimuthal resistivity-polarization measurements in the Sage Flat area, Outlaw Mesa. Horizontal profiling measurements also gave indications correlatable with the ore, but were less clear-cut and more affected by lateral topographic and stratigraphic variations.

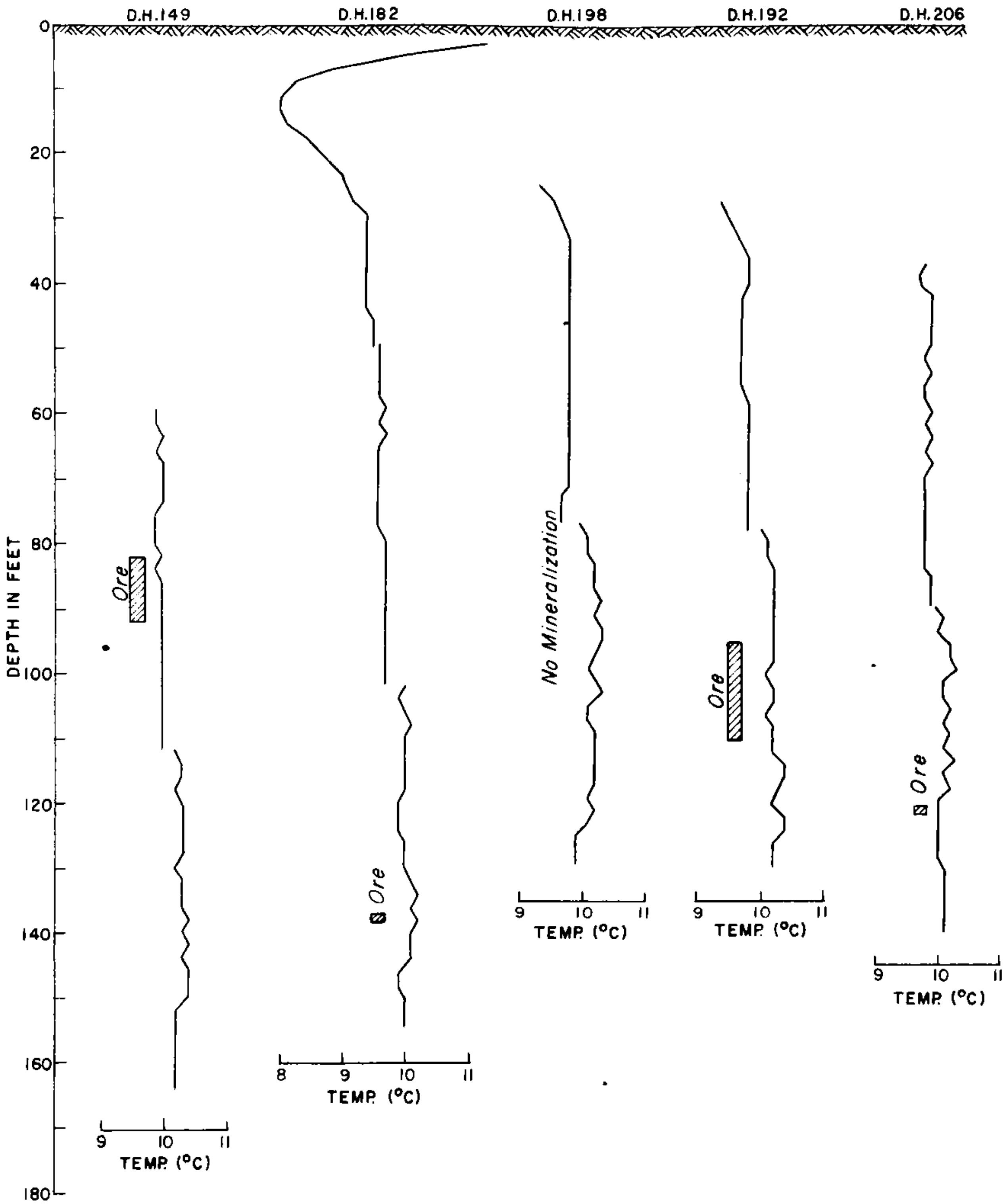

Figure 16.-Depth-temperature curves of drill holes in Sage Flat area, Outlaw Mesa.

Brief measurements by self-potential, magnetic and geothermal methods showed no observable correlation with ore occurrence. It appears unlikely that they can be of assistance in the exploration for ore.

Since this survey was purely preliminary in character, time did not permit a test of other geophysical methods and techniques which might be of assistance.

The results obtained are very encouraging. They were, however, too restricted to be conclusive. Many more measurements in both barren and productive areas must be obtained before the methods can be regarded as thoroughly established, or the best techniques developed. In addition, studies should be made of other techniques which could not be tested in the short period of time available but which offer possibilities for the detection of these deposits. The results so far obtained, however, warrant the continuation of a much more extensive investigation.

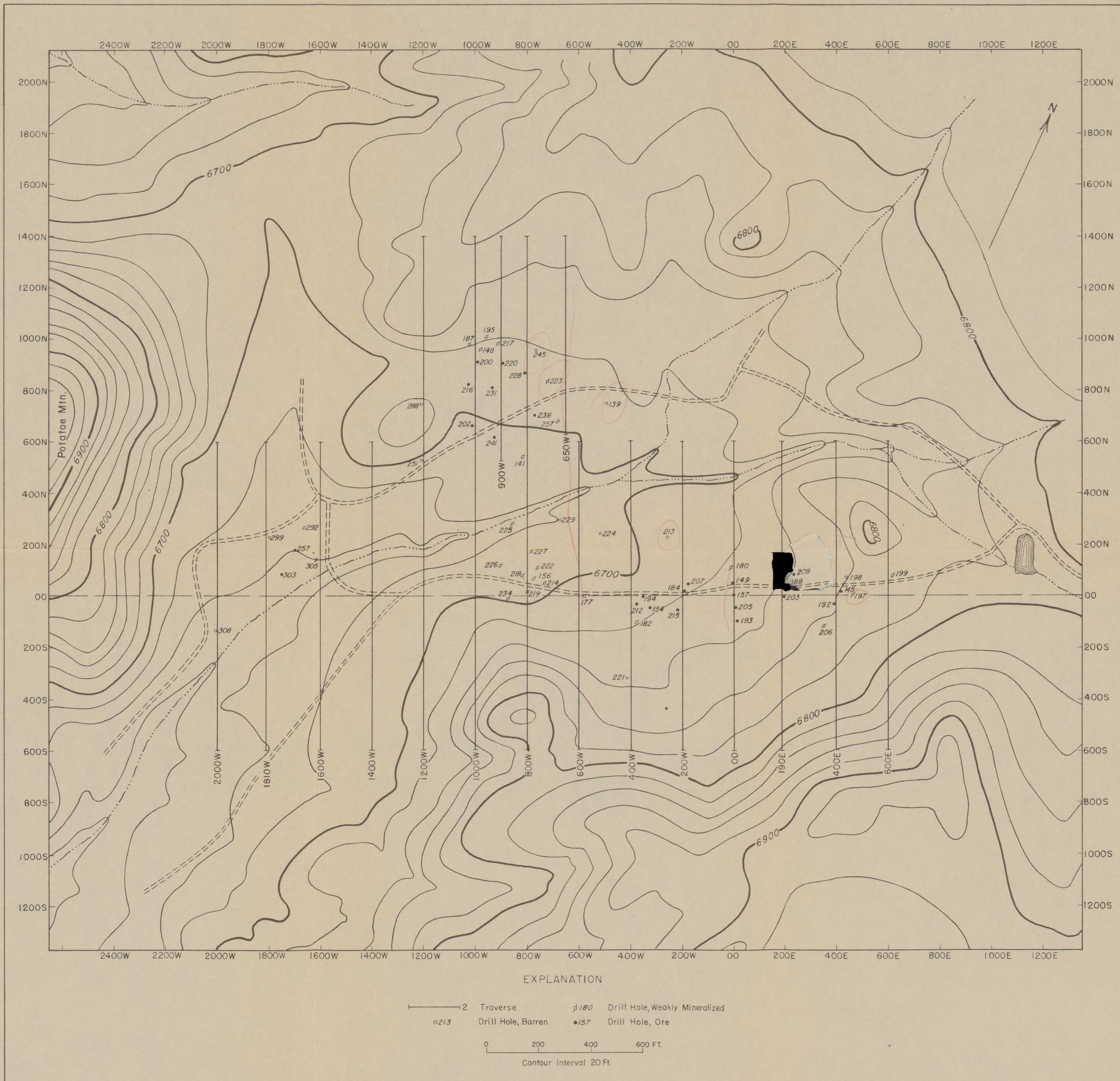

Figure 2.- Topographic map of Sage Flat area showing location of geophysical traverses, Outlaw Mesa.

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Figure 4.- Topographic map of Calamity Claims area showing location of geophysical traverses, Calamity Mesa.