NM Mine File No. 3005

GEOPHYSICAL SURVEY
BROMIDE PROJECT
RIO ARRIBA COUNTY, NEW MEXICO

SEPTEMBER 1977

for

U.S. BORAX CORPORATION
1802 WEST GRANT ROAD, #108
TUCSON, ARIZONA 85705

APPLIED GEOPHYSICS, INC.
SALT LAKE CITY, UTAH

TABLE OF CONTENTS

ILLUSTRATIONS

I INTRODUCTION

DATES OF SURVEY: 10 AUG - 24 AUG, 9 SEP - 14 SEP 1977

The purpose of the survey was to test the Bromide Area for MAXMIN EM response, and to search for zones of massive sulfides along the strike of slightly mineralized outcrops.

The area has been tested with IP-resistivity techniques without very encouraging results. Because of the interesting mineralization seen on surface and in various prospect pits and shafts, two drill holes were sunk in the summer of 1977. The amount of mineralization, especially copper, seen in the holes, together with other geological considerations, led Borax personnel to believe that more enriched zones, or pods of massive sulfides, could lie within the area.

The minerology seen on surface and in the drill holes seems to constitute an IP type target, but the largely negative results of previous work suggested testing the ground with an EM system. MAXMIN horizontal loop surveying has produced good results in similar geologic environments, and thus was chosen for the survey.

INTRODUCTION (cont)

The complexity of the MAXMIN profiles prompted the writer to use a magnetometer to attempt to sort out the anomalies. It was seen that the EM anomalies had little or no correlation with the magnetics, consequently during the second phase of the survey a Crone Radem VLF EM unit was brought in. The VLF results helped considerably in analysing the MAXMIN profiles.

II DESCRIPTION OF SURVEY

SURVEY LINES

The survey lines were layed out by using the secant line chaining method described in the MAXMIN manual, and in-phase corrections were applied to the data.

The survey lines are shown on PLATE 1, PLAN MAP OF SURVEY LINES.

DESCRIPTION OF SURVEY (cont)

GEOPHYSICAL EQUIPMENT

ELECTROMAGNETIC (EM)

APEX PARAMETRICS MAXMIN II, serial number (SN) 789

CRONE RADEM VLF-EM (SN) 139

GEOMETRICS MODEL G-826 TOTAL FIELD MAGNETOMETER SN 987T
Used with sensor mounted on 8 foot staff

METHODS OF USE

The MAXMIN II was used exclusively in the maximum-coupled horizontal loop mode, with coil spacings, "a", of 800, 400 and 200 feet. Two lines of a=600 feet were run. The MAXMIN profiles are shown on PLATES 2 through 4.

The RADEM VLF-EM unit was used in the conventional manner to measure dip angle and field strength. The transmitter stations received are shown on the profile sheet, PLATE 5.

III INTERPRETATION OF RESULTS

The electromagnetic systems revealed a large number of anomalies amid considerable background fluctuation, commonly called noise. Most of the noise is geological, and is to be expected from the attitude and geological variation of the strata over which the measurements were made. The profiles of the magnetics are usually flat over the more interesting EM anomalies, and quite variable toward the south ends of the lines.

All the anomalies of the Bromide grid must be rated poor, as would be expected from the mineralogical description given to the writer. The fact that the anomalies are poor by conventional massive sulfide EM standards does not necessarily signify that values are not to be found in the zones. Some recrystallized sulfides are not massive electrically but are definitely so mineralogically.

Isolated EM anomalies are usually easy to analyse because the contrast between the anomaly and background values is apparent, as shown in Figure 1, Appendix. Closely spaced or multiple conductors produce complicated anomalies (Figure 2, Appendix), and if background values are erratic, interpretation is not unambiguous. The MAXMIN profiles at the west end of the survey area illustrate the complicated situation; the anomaly on Line 20W, at Station 16, illustrates a clear cut anomaly.

INTERPRETATION OF RESULTS (cont)

Often it is possible to differentiate between closely spaced, near surface, conductors, using moving coil EM systems such as the MAXMIN, by making traverses with small coil spacings (200 feet or less). In the case of those lines traversed with 200 foot coil separations in the Bromide survey, good conductor resolution was not obtained in all cases. The profiles were complicated by the profusion of conductors and by the roughness of the ground surface conditions. The in-phase response at the smaller coil spacings is more sensitive to variations in station interval than at larger spacings (by a factor of 1/interval cubed), and coincidentally the west end of the survey grid, where the anomalies are complicated, is also the roughest in ground surface and is covered with fallen timber and thick bush. The line surveying done in anticipation of 400 and 800 foot coil separations was not sufficiently accurate to produce noise-free in-phase response at the 200 foot separations.

The VLF EM unit used over the west end of the grid provided further resolution of some of the anomalies, and proved much more helpful than the magnetics, as can be seen by the plotted positions of the VLF anomalies vs. those of the MAXMIN. The VLF data was also filtered by Fraser's method to help determine line-to-line correlation. A contour map of the Fraser values is provided on PLATE 6.

INTERPRETATION OF RESULTS (cont)

The Fraser value contours do not necessarily provide positive anomaly correlation. In some cases more fill-in lines are needed to determine whether the anomaly trends are actually as shown, or whether the sources are really short strike length en-echelon conductors. For example, the poor correlation of anomaly (3), PLATE 7, with the Fraser contours, could indicate that the VLF trends are mapping surface features, while the MAXMIN sources are deeper.

The anomalies (1) through (8) are selected as the most interesting because of the presence of some in-phase (real) response, indicating a better grade conductor, and because of the anomaly width indicated at one or more coil spacings.

The survey area could be given a reasonable test of EM response versus mineral value by drilling the better anomalies: (1), (2), (3) and (4) for example, or by drilling those seen to lie in the more favorable rocks.

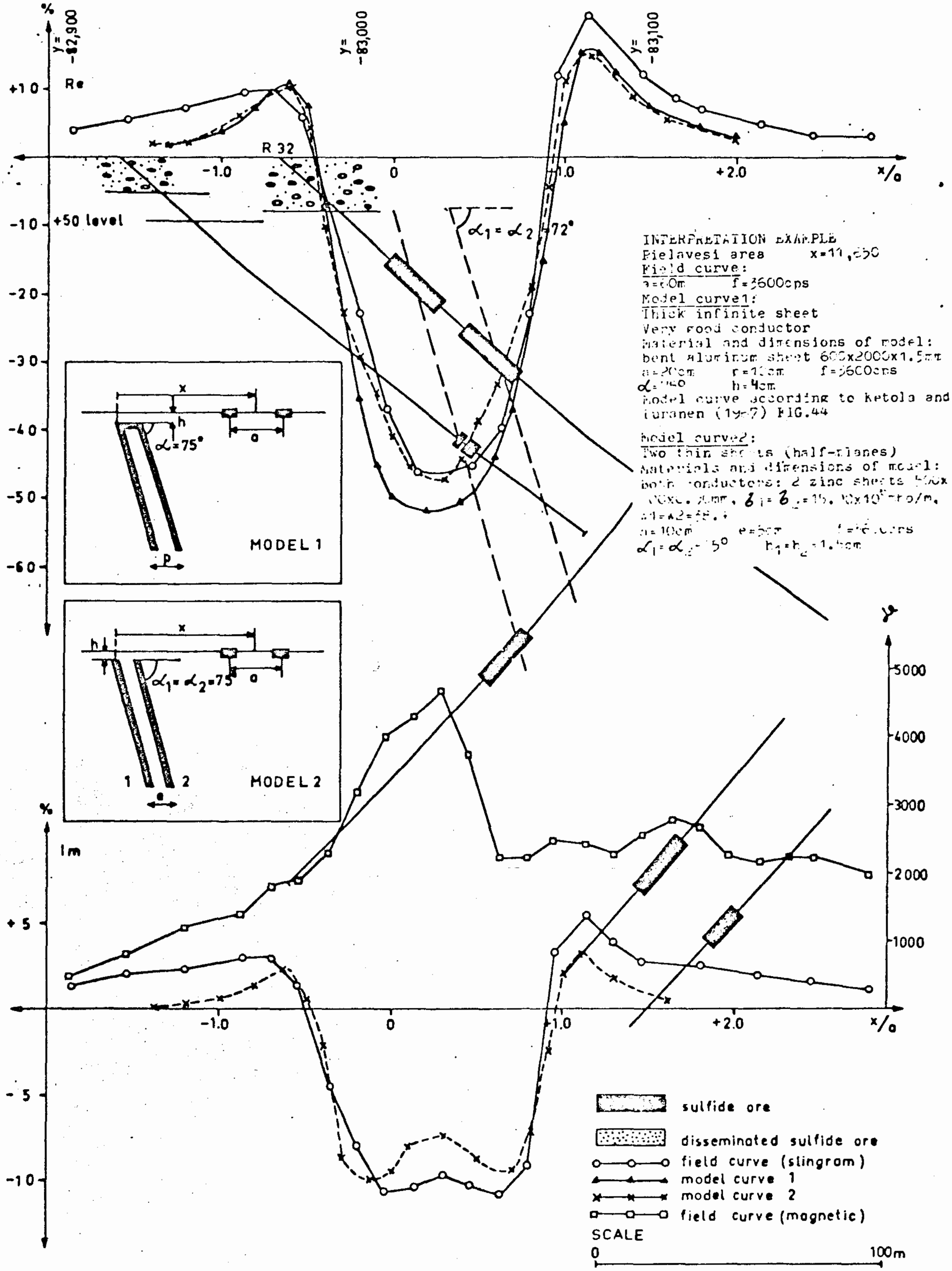
Less than half the survey area has been covered by 400 line spacing, and some 200 foot spacings would be necessary throughout the grid to provide complete coverage and check thoroughly for massive pods or wider, possibly economic zones.

The MAXMIN system has demonstrated its capacity to produce anomalies in the Bromide environment, and the area could be mapped thoroughly with more detailed application aided by VLF.

Respectfully submitted,

D.A. Smith

David A. Smith
Geophysicist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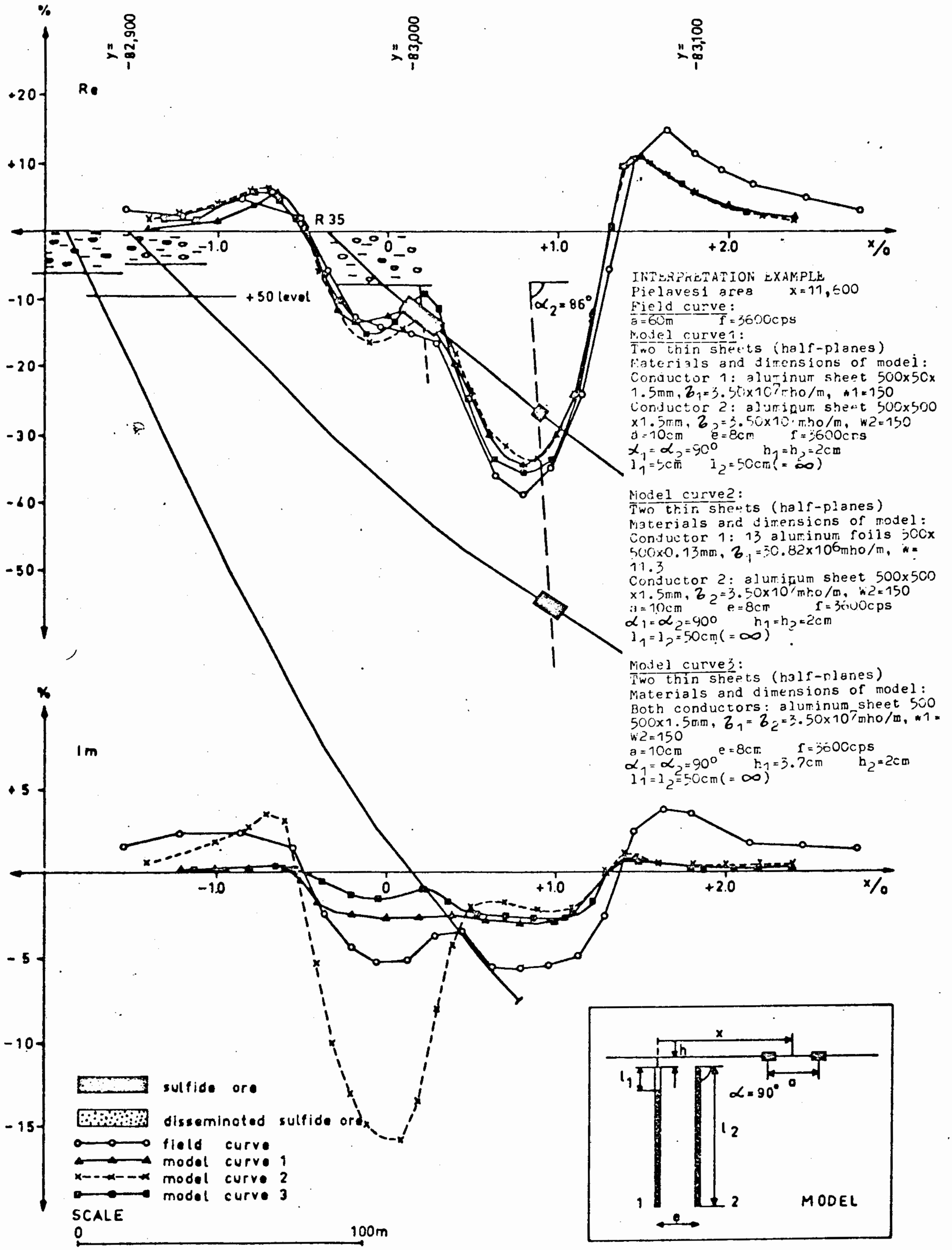
y= -83,000
y= -83,100
Re
R 32
+50 level
INTERPRETATION EXAMPLE
Pielavesi area
Field curve:
Model curve1:
Thick infinite sheet
Very good conductor
Material and dimensions of model:
bent aluminum sheet
h=4cm
Model curve according to Ketola and
Puranen FIG.44
Model curve2:
Two thin sheets (half-planes)
Materials and dimensions of model:
both conductors: 2 zinc sheets
MODEL 1
MODEL 2
Im
sulfide ore
disseminated sulfide ore
field curve (slingram)
model curve 1
model curve 2
field curve (magnetic)
SCALE
0
100m


%
y= -82,900
y= -83,000
y= -83,100
Re
+20
+10
-10
-20
-30
-40
-50
R 35
-1.0
0
+1.0
+2.0
x/o
+50 level
α2 = 86°
INTERPRETATION EXAMPLE
Pielavesi area x=11,600
Field curve:
a=60m f=3600cps
Model curve1:
Two thin sheets (half-planes)
Materials and dimensions of model:
Conductor 1: aluminum sheet 500x50x
1.5mm, σ1=3.50x10^7 mho/m, w1=150
Conductor 2: aluminum sheet 500x500
x1.5mm, σ2=3.50x10^7 mho/m, w2=150
a=10cm e=8cm f=3600cps
α1=α2=90° h1=h2=2cm
l1=5cm l2=50cm(=∞)
Model curve2:
Two thin sheets (half-planes)
Materials and dimensions of model:
Conductor 1: 13 aluminum foils 500x
500x0.13mm, σ1=30.82x10^6 mho/m, w=
11.3
Conductor 2: aluminum sheet 500x500
x1.5mm, σ2=3.50x10^7 mho/m, w2=150
a=10cm e=8cm f=3600cps
α1=α2=90° h1=h2=2cm
l1=l2=50cm(=∞)
Model curve3:
Two thin sheets (half-planes)
Materials and dimensions of model:
Both conductors: aluminum sheet 500
500x1.5mm, σ1=σ2=3.50x10^7 mho/m, w1=
w2=150
a=10cm e=8cm f=3600cps
α1=α2=90° h1=3.7cm h2=2cm
l1=l2=50cm(=∞)
%
Im
+5
-5
-10
-15
-1.0
0
+1.0
+2.0
x/o
sulfide ore
disseminated sulfide ore
field curve
model curve 1
model curve 2
model curve 3
SCALE
0
100m
x
h
l1
α=90°
a
l2
1
2
e
MODEL

APPENDIX 2

5. SECANT CHAINING AND SUBSEQUENT DATA REDUCTION

5.1. This secant method of chaining has been devised for acquiring clean in-phase data in choppy and mountainous terrain, i.e. in terrain where marks on a taut cable will no longer serve as a guide to an accurate coil spacing. Secant chaining is done with a Suunto PM5/SPC inclinometer, which has a "%grade" and a "Modified Secant" scale (secant x 100) -- hereafter called the "Secant" scale. The latter scale states the number of units along a slope per 100 units of horizontal distance. The "%grade" scale is visible simultaneously with the "Secant", and it states the number of units along the vertical per 100 units of horizontal distance. Other features of this inclinometer are that it is very small, single-hand-held, self-levelling, and oil-damped, with an optically magnified scale.

5.2. The Suunto inclinometer is not a precision instrument in the sense of a surveyor's level. The true "zero" position is usually within ¼% grade of "zero" on the scale, but each operator introduces his own bias to the instrument. This bias relates to superimposing the horizontal reading line, seen with one eye, onto an object seen with the other eye. Even with both eyes on the same horizontal plane, superimposition errors still occur. These errors vary from person to person.

It has been found that the cumulative error is generally in the positive direction at the rate of ½ to 1 unit per 100. In the light of this, any inclinometer operator using one of these inclinometers for the first time should make a reversed - position shot on his chaining partner over the distance of a station interval. With this, the inclinometer operator will know whether or not he should be aiming above or below the equi-height mark on his chaining partner.

5.3. The specific procedure in the secant method of chaining depends upon the desired end result. For an accurate MaxMin II survey, it is only necessary to secant chain along the traverse lines. If an accurate plan of the grid with topo contours is desired, then it is necessary to secant chain between the ends of the lines. No specifics will be given here on making topographic contour maps from chaining data, other than to say that the chaining must be done in closed loops and accumulated errors corrected back through the loops. Infact, the procedure is akin to that for a controlled magnetic or gravimetric survey, except that corrections are pro rated by distance rather than time.

5.4. The in-phase accuracy of the MaxMin II results depend upon the accuracy of the chaining along the traverse lines; whereas, the accuracy of the grid plan depends also on the accuracy of the chaining between the ends of the lines. A random chaining error of a percent or two will have a perceptible effect on the MaxMin II in-phase results, whereas it will not on the grid picture. So, the chaining along the traverse lines must be quite accurate while the chaining between them can be less accurate. In fact, cut lines are not required for chaining between traverse lines. With a good compass course, it is easy to keep the chain reasonably straight. However, the inclinometer operator does require a line of sight to his helper on the chain.

5.5. A good compass course between the ends of the traverse lines will permit back-chaining without large misclosures at the other end of the line. In fact, misclosures of greater than one meter will not be due to deficiencies in the secant chaining method but to errors in the course followed between the lines. Nonetheless, misclosures at the end of a line -- or in the center, if the baseline is located there -- need not be a cause for subsequent mapping problems if shown in plan as they occur in the field. As far as accurate MaxMin II data is concerned, it is only necessary to know the horizontal-plane position and the elevation of each station along the traverse line.

5.6. A practical example of using the Suunto PM5/SPC inclinometer follows: The inclinometer operator sighting on his helper up a slope reads "105" on the "Secant" scale. This means that he should pay out 1.05 times the desired chaining interval. If this interval is 100 feet, he should simply pay out 105 feet of chain. He holds the "105" mark vertically above the "0" mark on the chain. The picket should be driven well or there's little point to this type of chaining. While the helper is writing co-ordinate information on the picket, the inclinometer operator records in his note-book both the secant reading and the corresponding % grade reading (+32).

In this way there is no "dead time and the chaining goes quickly. Recording each secant reading may appear redundant after it has been applied to the chain. However, a quick visual check of the two recorded readings in the book, against a reference "secant - %grade" table clipped into the book, will alert the operator to the inevitable reading error. An example of this type of table is shown below:

Secant:	%Grade:	Secant:	%Grade:
100	0	118	63
100½	10	119	64½
101	14	120	66½
102	20	122	69
103	24½	124	73
104	28½	126	77
105	32	128	80
106	35	130	83
107	38	132	86
108	41	134	89
109	43½	136	92
110	46	138	95
111	48½	140	98
112	50½	142	101
113	52½	144	104
114	55	146	107
115	57	148	109
116	59	150	112
117	61		

5.7. During the distance measurement, the chain is always held parallel to the slope, e.g. head-to-head, waist-to-waist, hip-to-hip, boot top-to-boot top, at a constant tension.
On steep slopes, a piece of talus dropped from the mark on the chain will improve the precision of the measurement on the ground.

5.8. Where obstructions in the line impede a full 100ft measurement with the chain, then only a fraction of the secant value seen on the inclinometer scale should be given on the chain. Suppose for instance, that the operator at the "0" end of the chain can only get 3/4 of the way to his next position before passing out of sight, and at this time the secant scale reads "105"; then, the trailing operator should hold the chain at "105 x 0.75 = 78.8", making for an exact 75ft (horizontal) shot. The corresponding %grade value (i.e. +32) seen on the inclinometer scale is recorded directly into the book, as well as the horizontal distance of the shot. The following measurement would then be only 25ft (horizontally).

5.9. If when backchaining to the base line, the final shot from picket 1+00 (N,S,E or W) to the base line picket is on a slope, then an inverse calculation is required to get the horizontal distance to the base line. For example, if the distance on the chain is 128.5ft, and the inclinometer shows secant and %grade values of 107 and -38 respectively, then the true horizontal distance is given by the expression 128.5/1.07 = 120ft, and the elevation difference is given by the expression -38 x 1.2 = -46ft. Of course, the foregoing calculations are only necessary when closing a chaining loop at the base line.

When chaining past the base line, it is best to continue the chaining from the "0" picket and not the base line picket, so that all stations are 100ft apart. Although the base line picket would not be used during the EM coverage in a situation like this, it is a good practice to note its location on the way by. With this, the stations on the line can be accurately plotted with respect to to the base line.

5.10 In the metric system, there are usually 25 meters horizontally between stations, which means that an extra calculation must be made on the inclinometer data. One way around this is to subdivide 25 meters of distance on the chain into 100 equal parts numbered 1 to 100. So, a 50 meter chain would be subdivided into 200 equal parts numbered 1 to 200. With this, the inclinometer is used directly, and the operator turns grey less rapidly.

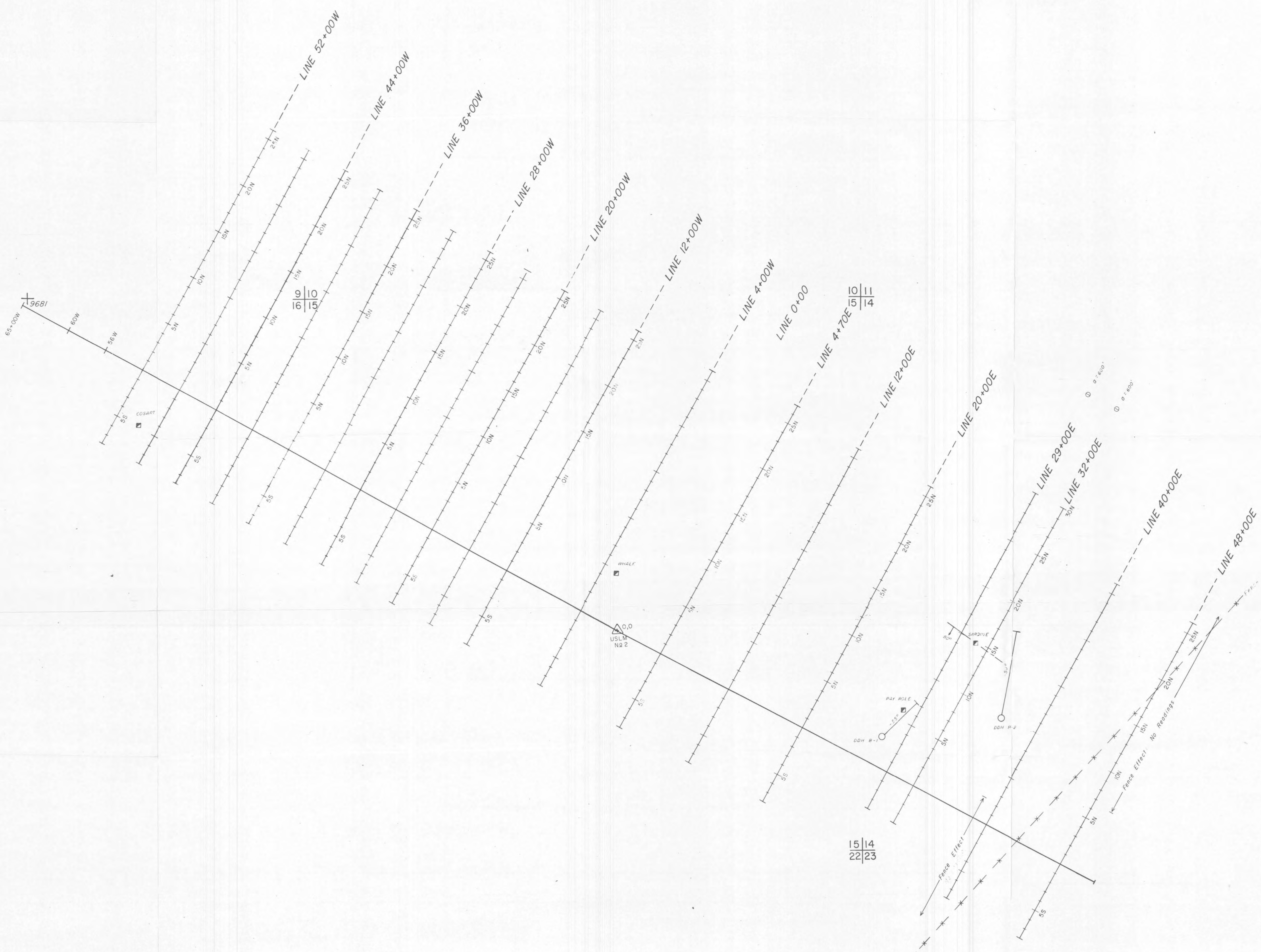
5.11 The most efficient way to reduce the chaining notes is to calculate first the topographic elevations from the % grade values. To start with, a quick perusal should first be made through the notes for all chaining intervals of other than 100 feet before any other calculations are made. For instance, the +32% grade figure of subsection 5.8. would convert to +24 feet over the 75 feet horizontal distance of the shot. Of course, when the shots are a full 100 ft , the % grade figure is the vertical distance between stations in feet, and the % grade can be used without conversion.

5.12 It is an easy matter to derive the mean slope between the coils from the topo elevations. If a nominal coil spacing of 600ft. is to be used, then the elevation difference between stations 600ft apart is divided by "6". For instance if the leading coil in the procession is at station 6+00N on a line while the trailing coil is at the base line station, and the elevation of station 6+00N is 54 ft while that of the base line station is 100ft, then the mean slope between the coils is given by the expression (54-100)/6 = -8 % grade.

5.13 If due to a back-chaining error, the distance between the base line and station 1+00 (N,S,E, or W) is 120ft --- and the chaining has been continued to the other side of the base line from the base line picket rather than the "0" picket --- then the distance between the coils will be 620ft when they are straddling the chaining error. This distance will have to be taken into account when calculating the mean slope between coils, and also in correcting for the large-coil-spacing error. The calculation for the mean slope in the section above becomes (54-100)/6.2= -7% grade.

5.14 The corrections to the in-phase reading, for the slope of -7% grade and the 620ft horizontal distance between the coils, are +0.5% and +9.5%, respectively. These values are taken from the correction table on the following page.

5.15. THe widely varying in-phase readings, associated with a widely varying secant chained slope, will reflect in the out-of-phase reading, if there is appreciable phase mixing in the system. This course can be corrected arithmetically. But, it's much less time consuming to open the receiver and remove the problem as per subsection 2.4.3., than to correct the out-of-phase readings.



N

SCALE 1" = 500'

PLATE I

U S BORAX CORPORATION

PLAN MAP

BROMIDE PROJECT

RIO ARRIBA COUNTY, NEW MEXICO

by

applied geophysics inc

SALT LAKE CITY, UTAH

August 1977

LEGEND

UNITS ARE THE SECONDARY FIELD COMPONENTS PLOTTED AS PERCENTAGES OF THE PRIMARY FIELD

REAL (IN PHASE)

IMAGINARY (OUT OF PHASE)

ANOMALY

THIN CONDUCTOR, a=800, INDICATED BY REAL AND IMAGINARY PHASES

CONDUCTOR OF INDICATED WIDTH SHOWN

CONDUCTOR INDICATED BY IMAGINARY PHASE ONLY.

SCALE 1"=500'

PLATE 4

U S BORAX CORPORATION

EM PROFILES

BROMIDE PROJECT

RIO ARRIBA COUNTY, NEW MEXICO

by

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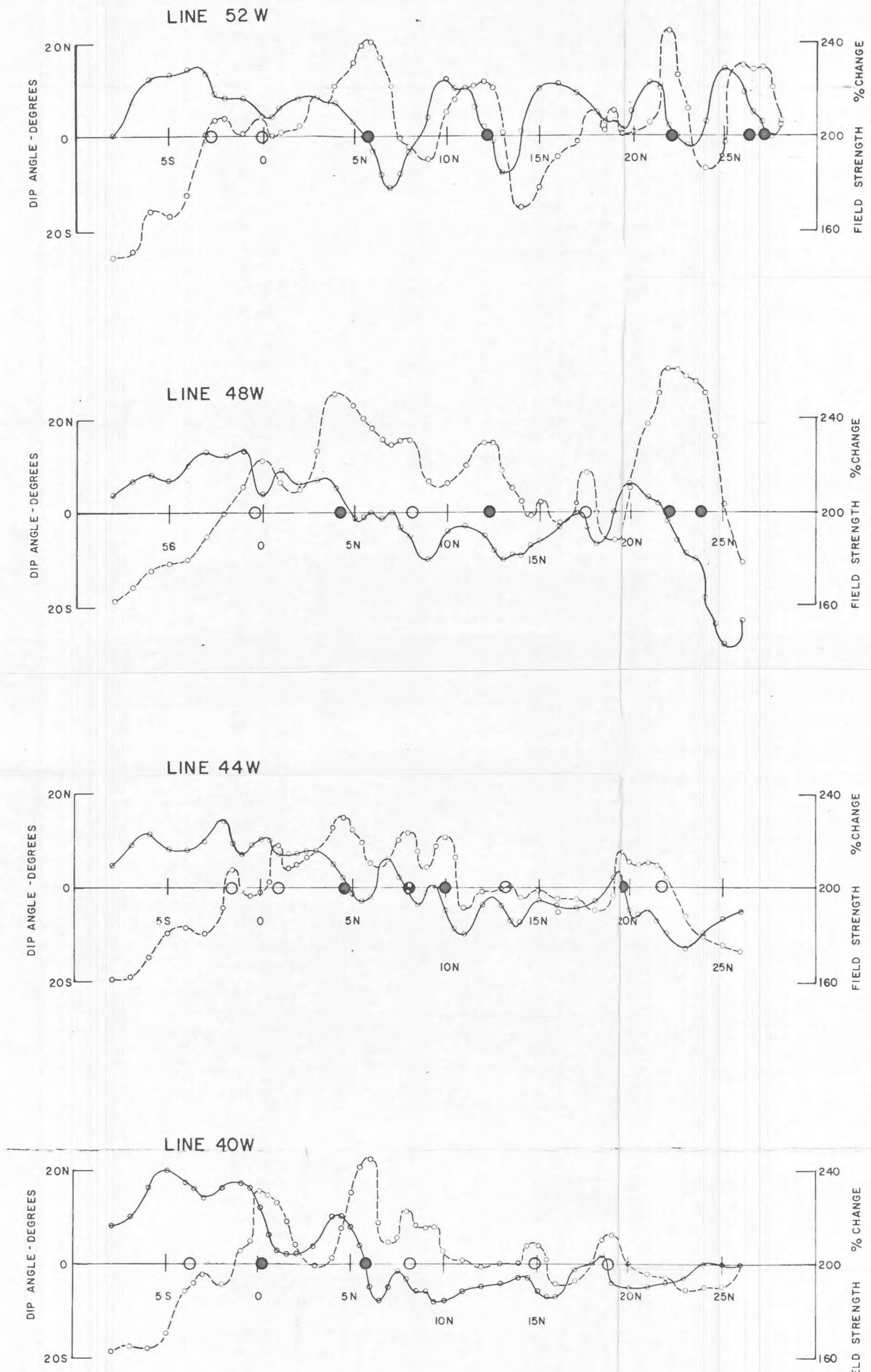
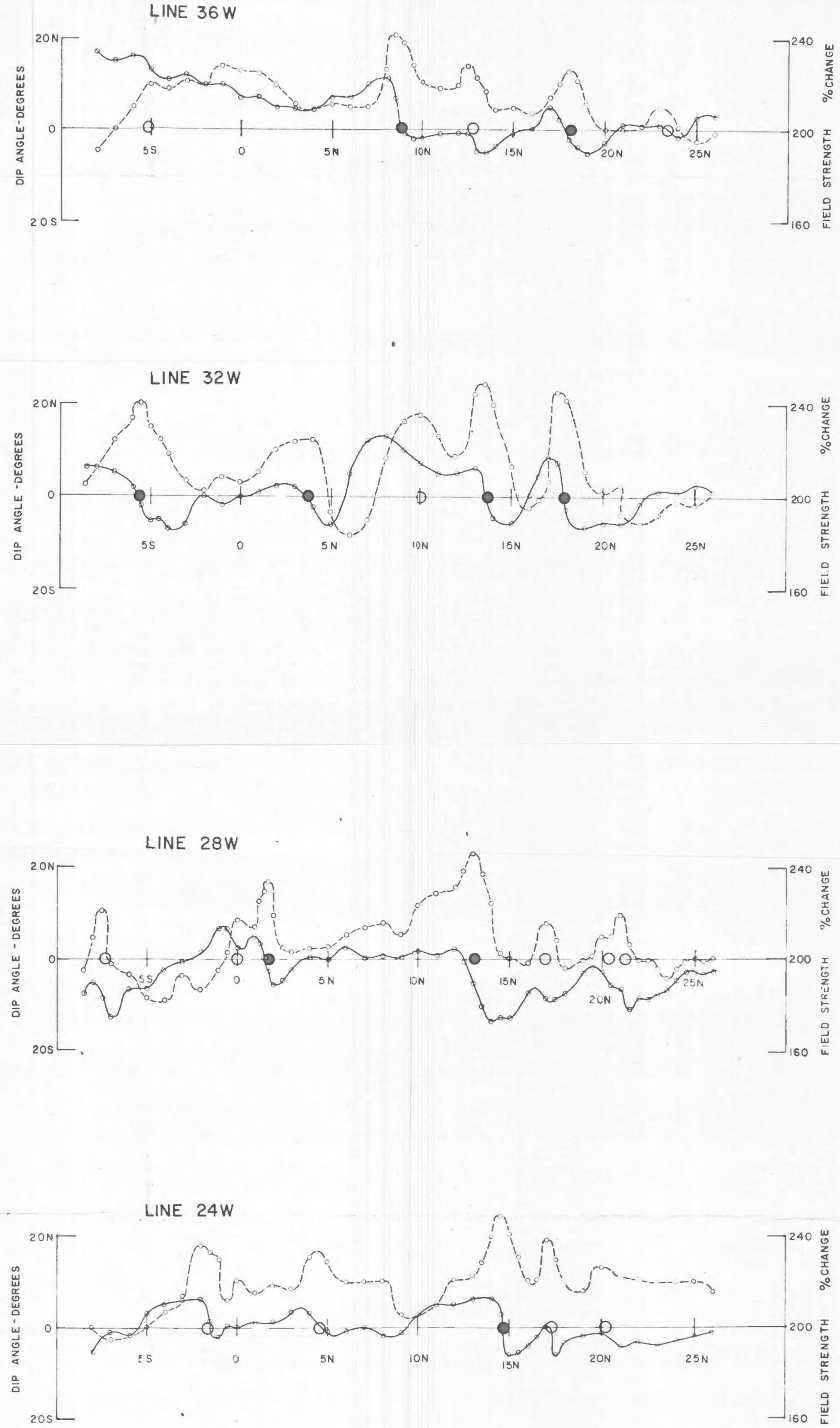
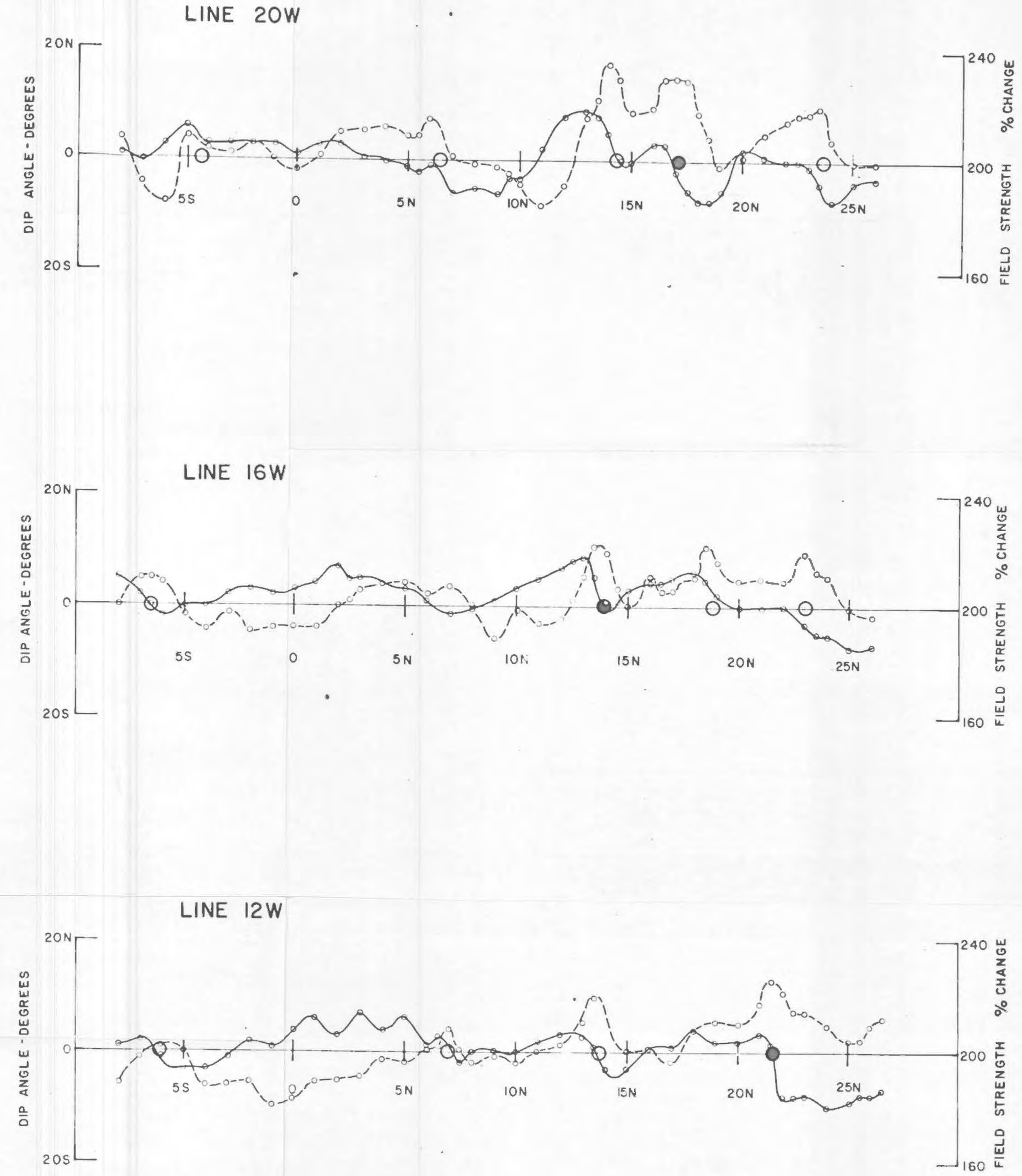
SALT LAKE CITY, UTAH

September 1977

PLATE 4







LEGEND

TRANSMITTER STATION RECEIVED: SEATTLE, WASHINGTON

● ANOMALY

○ POSSIBLE ANOMALY

FIELD STRENGTH AS PERCENT OF AN ARBITRARY BASE VALUE

DIP ANGLES - DEGREES

SCALE 1" = 500'

PLATE 5

U S BORAX CORPORATION

VLF PROFILES

BROMIDE PROJECT

RIO ARRIBA COUNTY, NEW MEXICO

by

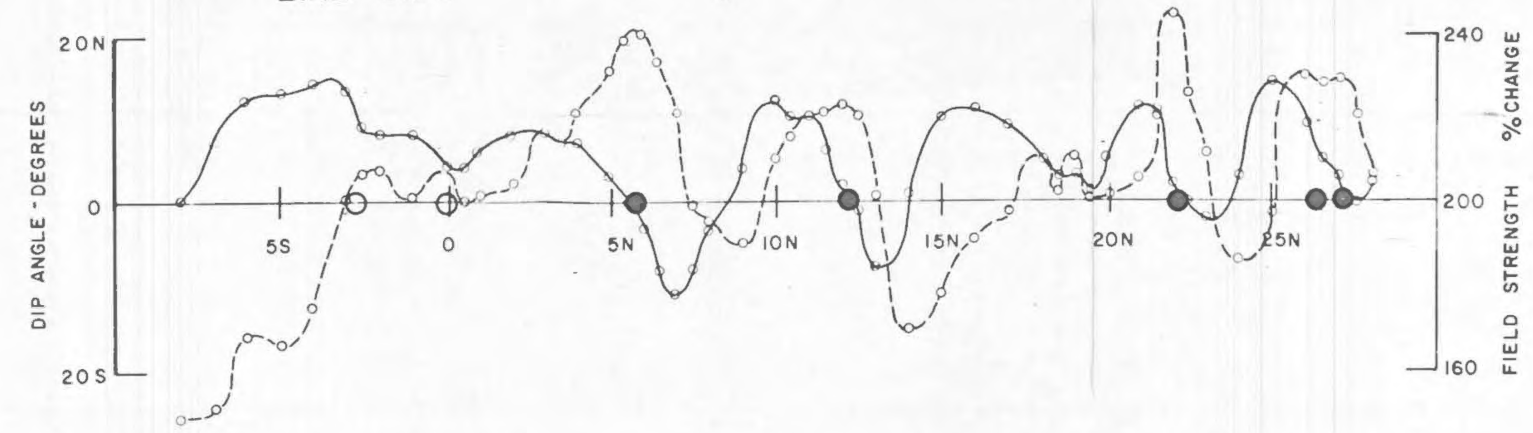
applied geophysics inc

SALT LAKE CITY, UTAH

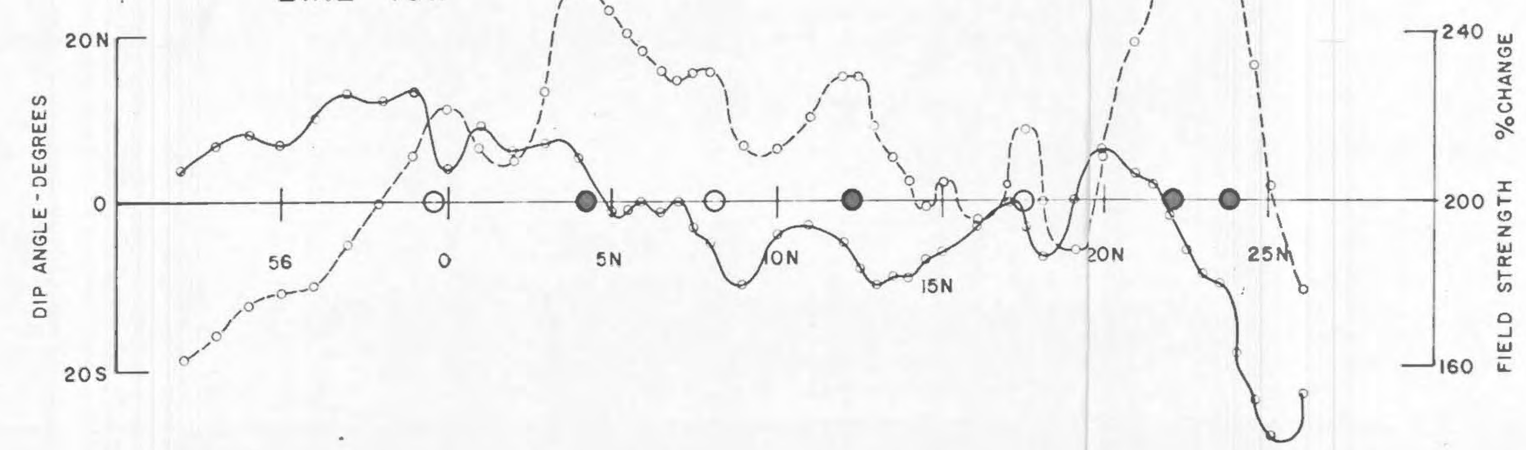
August 1977

PLATE 5

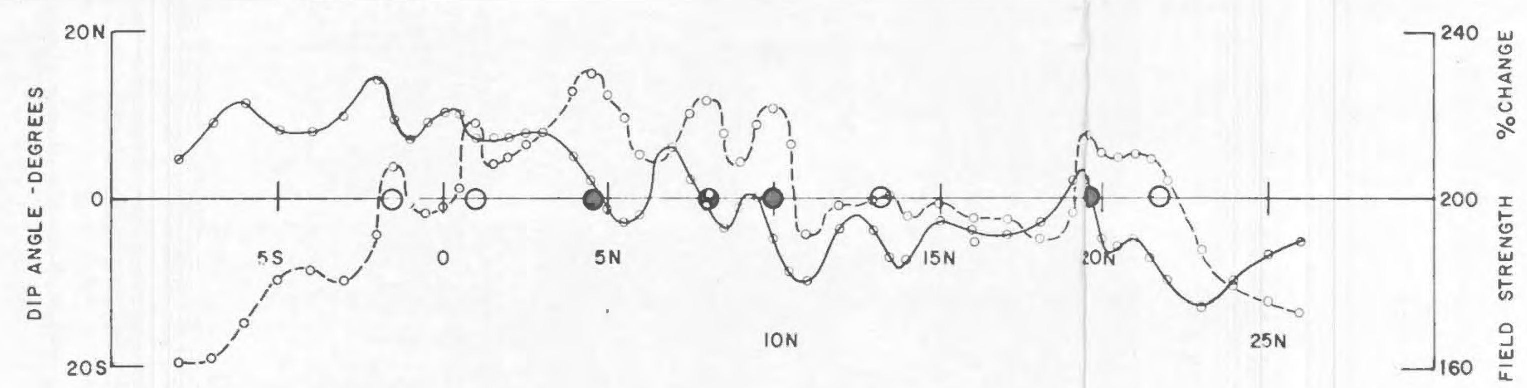
LINE 52 W



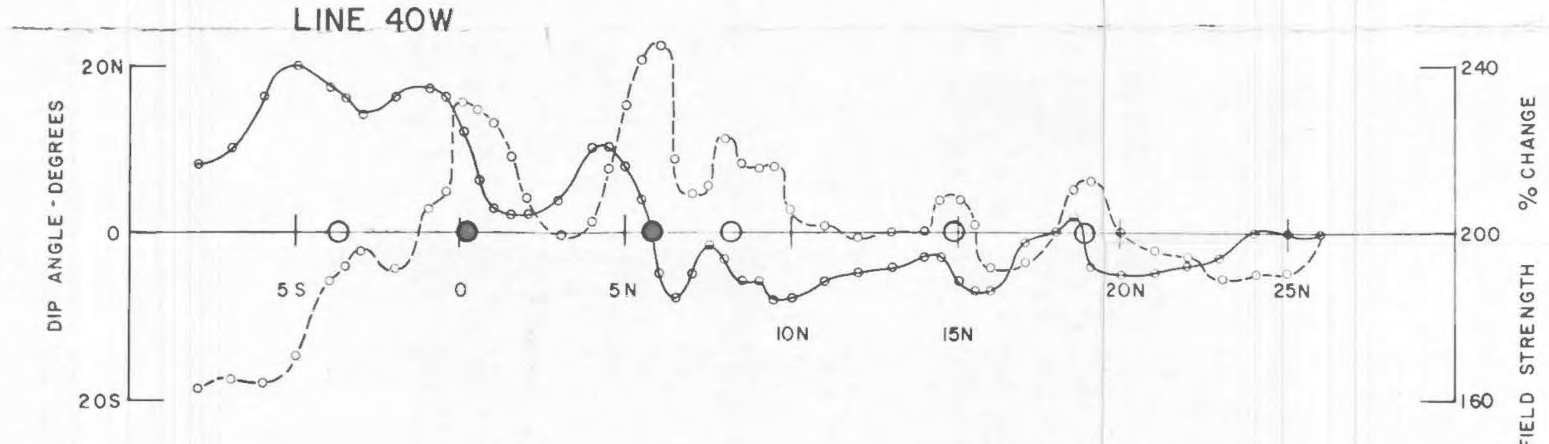
LINE 48W



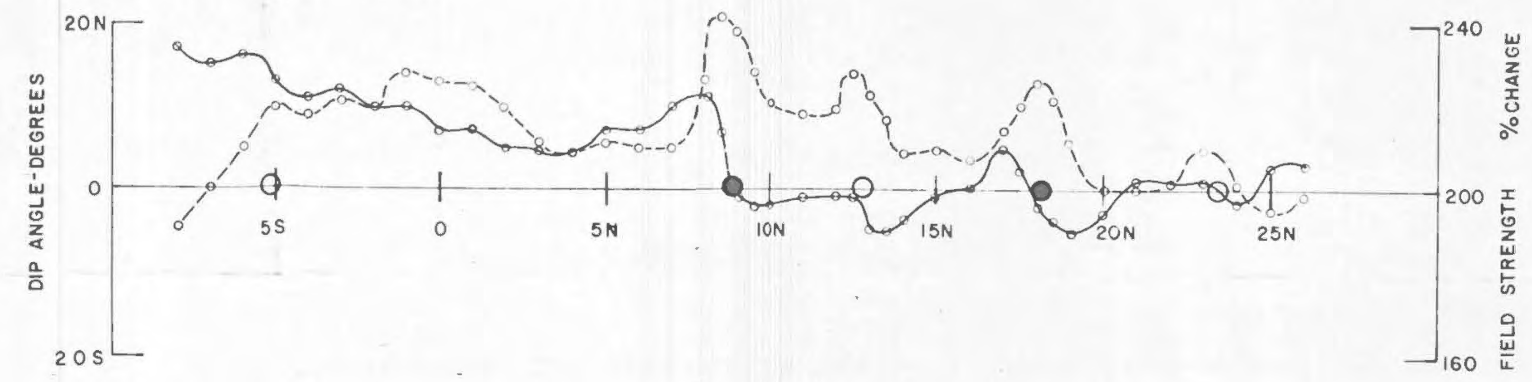
LINE 44W



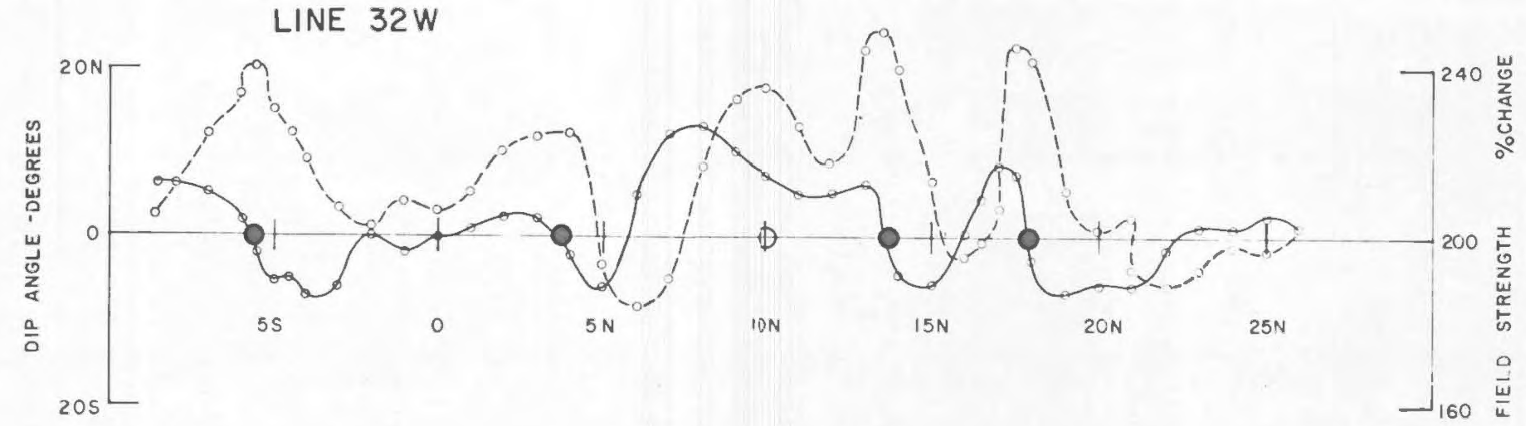
LINE 40W



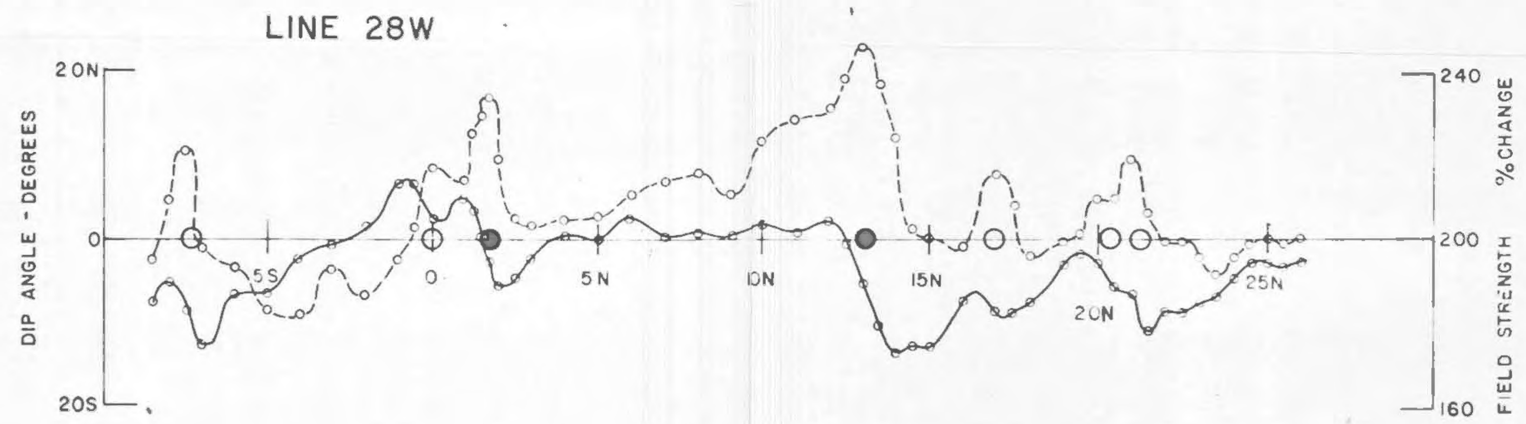
LINE 36 W



LINE 32W



LINE 28W



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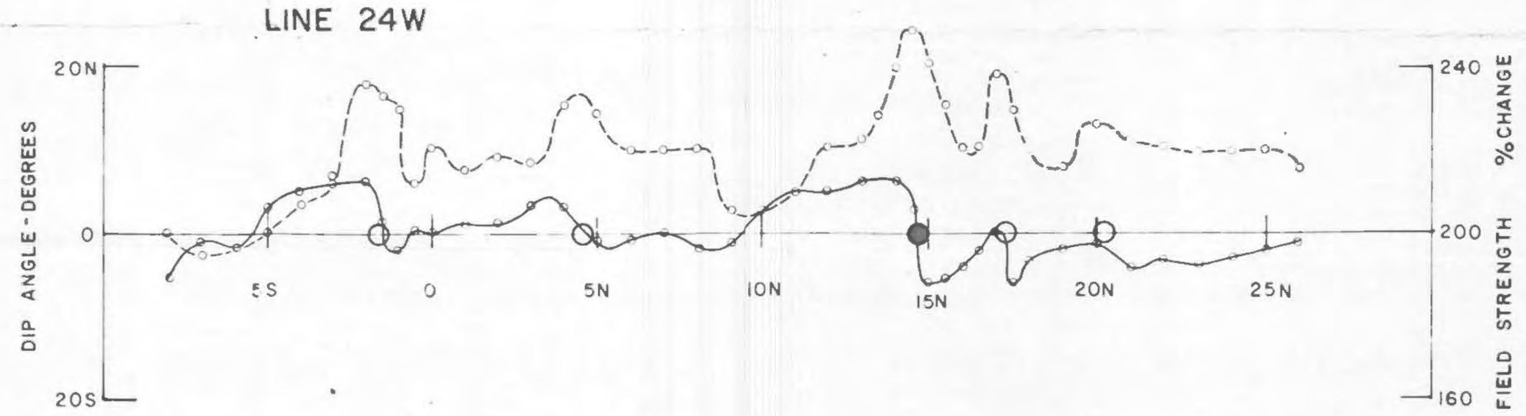
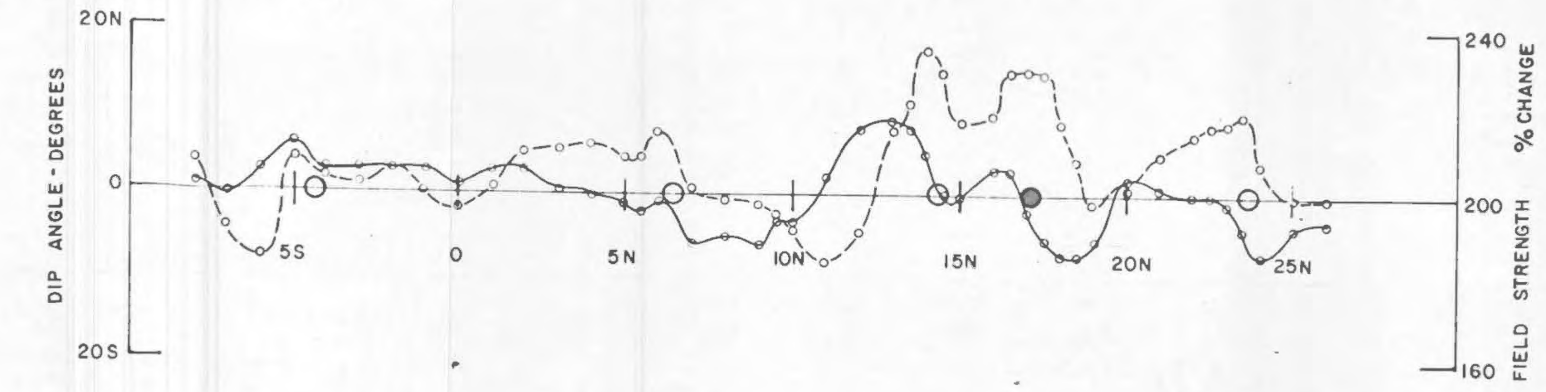
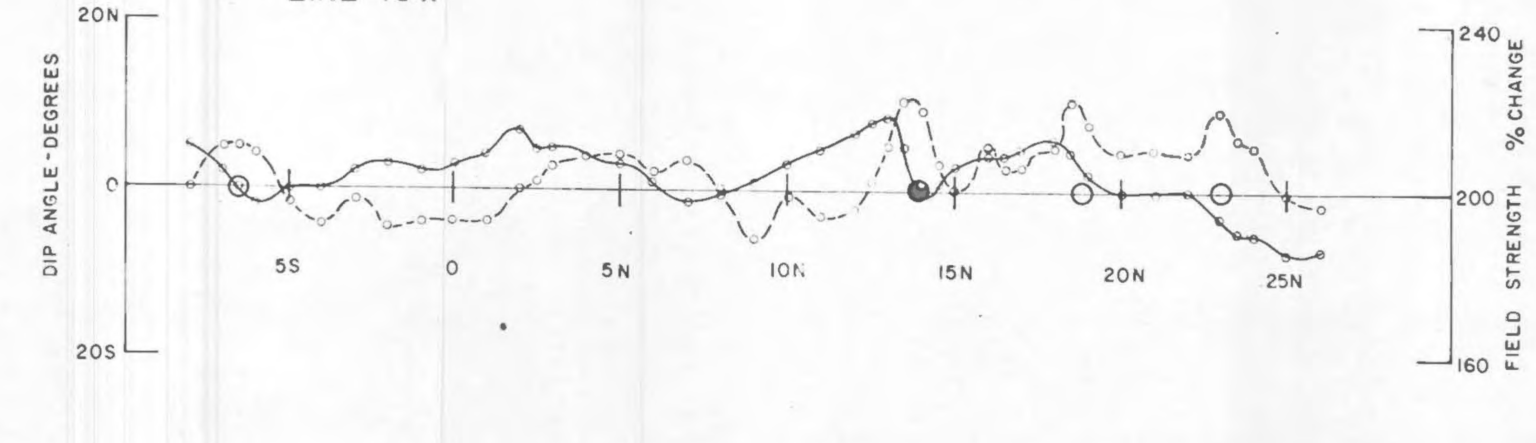


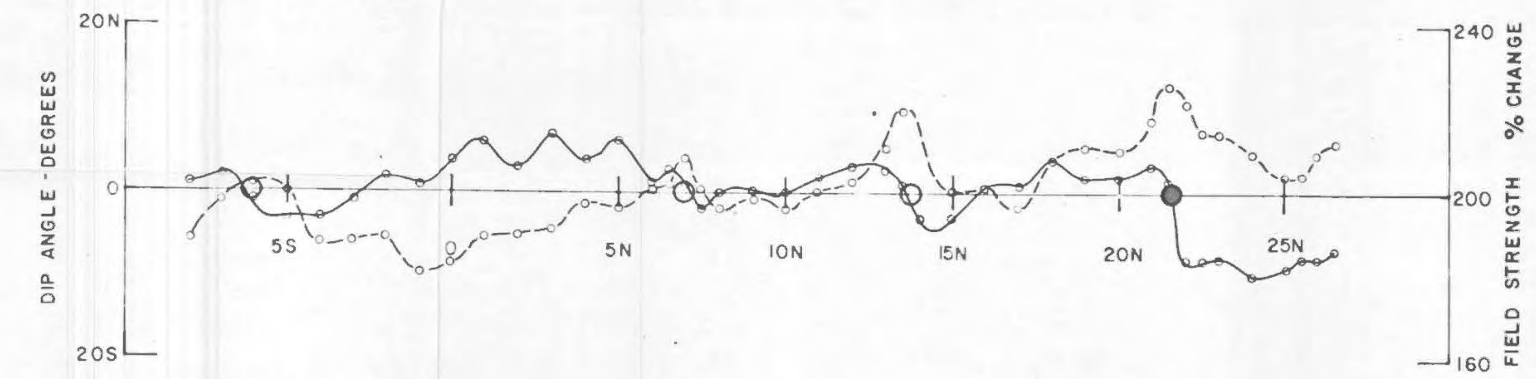
LINE 20W



LINE 16W



LINE 12W



LEGEND

TRANSMITTER STATION RECEIVED: SEATTLE, WASHINGTON

● ANOMALY

○ POSSIBLE ANOMALY

FIELD STRENGTH AS PERCENT OF AN ARBITRARY BASE VALUE

DIP ANGLES - DEGREES

SCALE 1" = 500'

PLATE 5

U S BORAX CORPORATION

VLF PROFILES

BROMIDE PROJECT

RIO ARRIBA COUNTY, NEW MEXICO

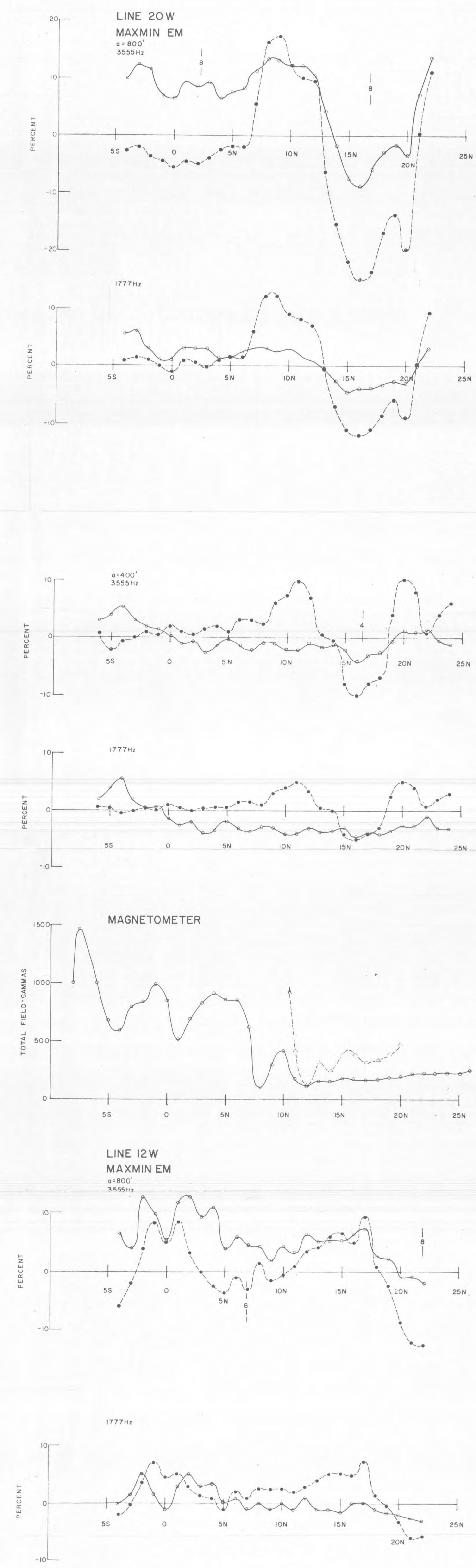
by

applied geophysics inc

SALT LAKE CITY, UTAH

August 1977

PLATE 5



LEGEND

MAXMIN II EM

UNITS ARE THE SECONDARY FIELD COMPONENTS PLOTTED AS PERCENTAGES OF THE PRIMARY FIELD

REAL (IN PHASE)

IMAGINARY (OUT OF PHASE)

ANOMALY

8 THIN CONDUCTOR, a=800', INDICATED BY REAL AND IMAGINARY PHASES

8 CONDUCTOR OF INDICATED WIDTH SHOWN

8 CONDUCTOR INDICATED BY IMAGINARY PHASE ONLY

VLF

TRANSMITTER STATION RECEIVED: SEATTLE, WASHINGTON

ANOMALY

POSSIBLE ANOMALY

FIELD STRENGTH AS PERCENT OF AN ARBITRARY BASE VALUE

DIP ANGLES-DEGREES

SCALE 1" = 500'

PLATE 2
U S BORAX CORPORATION
EM & MAGNETIC PROFILES
BROMIDE PROJECT

RIO ARRIBA COUNTY, NEW MEXICO

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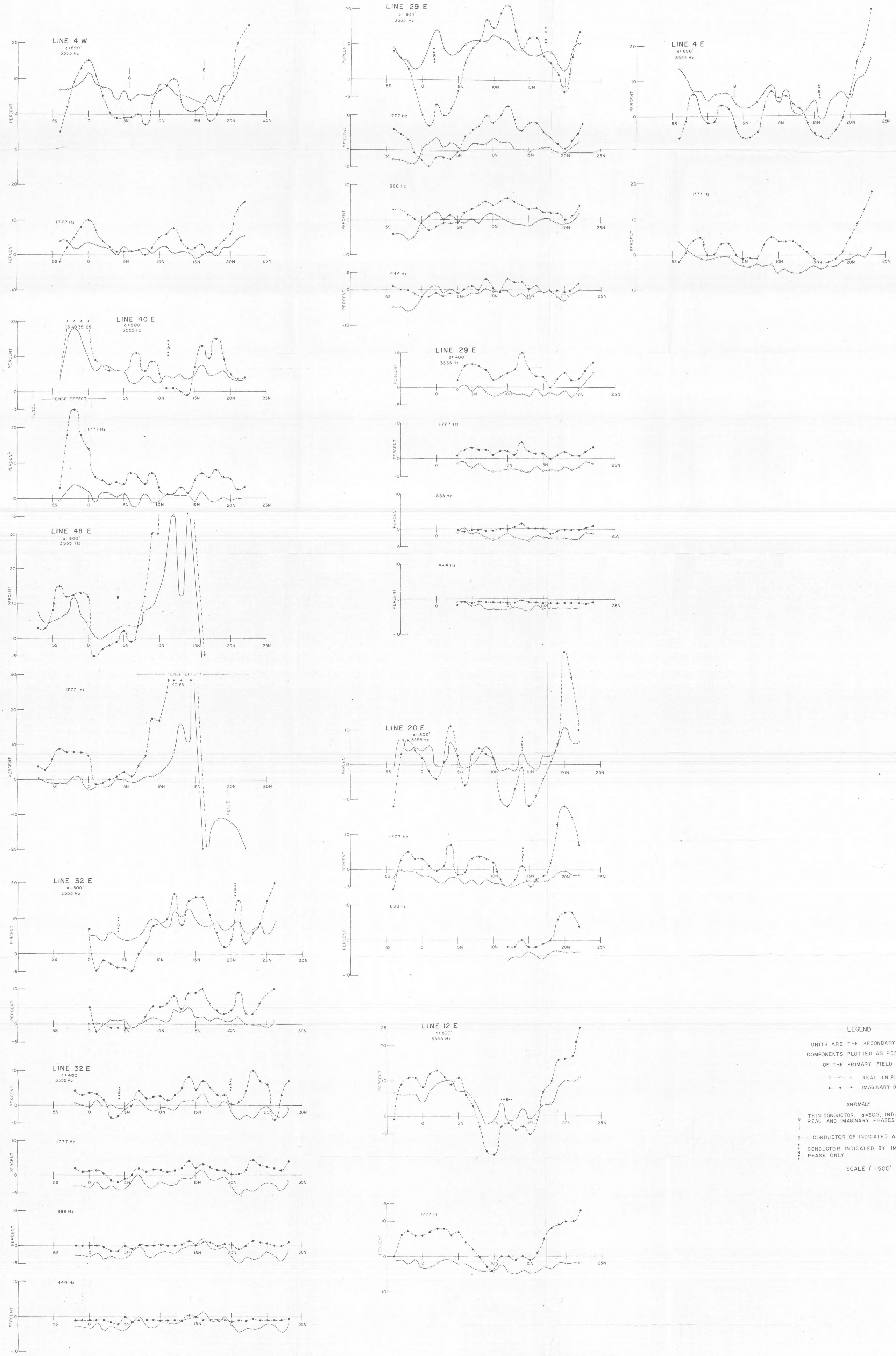
SALT LAKE CITY, UTAH

September 1977



LEGEND

UNITS ARE THE SECONDARY FIELD COMPONENTS PLOTTED AS PERCENTAGES OF THE PRIMARY FIELD

REAL (IN PHASE)

IMAGINARY (OUT OF PHASE)

ANOMALY

8 THIN CONDUCTOR, a=800', INDICATED BY REAL AND IMAGINARY PHASES

8 CONDUCTOR OF INDICATED WIDTH SHOWN

8 CONDUCTOR INDICATED BY IMAGINARY PHASE ONLY

SCALE 1" = 500'

PLATE 3

U S BORAX CORPORATION

EM PROFILES

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RIO ARRIBA COUNTY, NEW MEXICO

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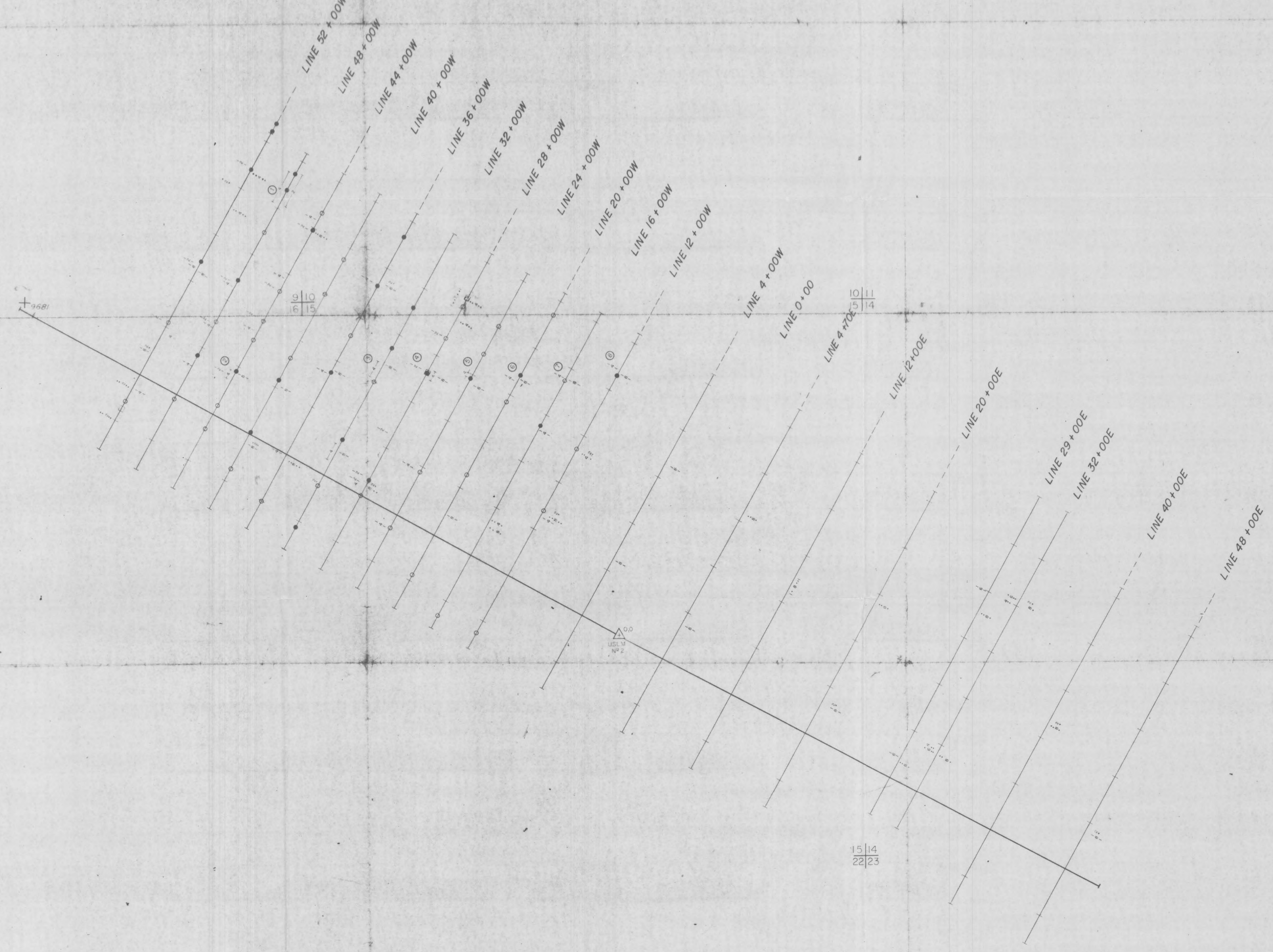
SALT LAKE CITY, UTAH

September 1977

PLATE 3



LEGEND

MAXMIN II EM

THIN CONDUCTOR AT 800' COIL SPACING WITH REAL AND IMAGINARY RESPONSE

CONDUCTOR WITH IMAGINARY RESPONSE ONLY

APPARENT WIDTH OF ANOMALY

ANOMALY NUMBERED FOR REFERENCE IN REPORT

VLF ANOMALY

POSSIBLE VLF ANOMALY

SCALE 1" = 500'

PLATE 7

U S BORAX CORPORATION

PLAN MAP OF ANOMALIES

BROMIDE PROJECT

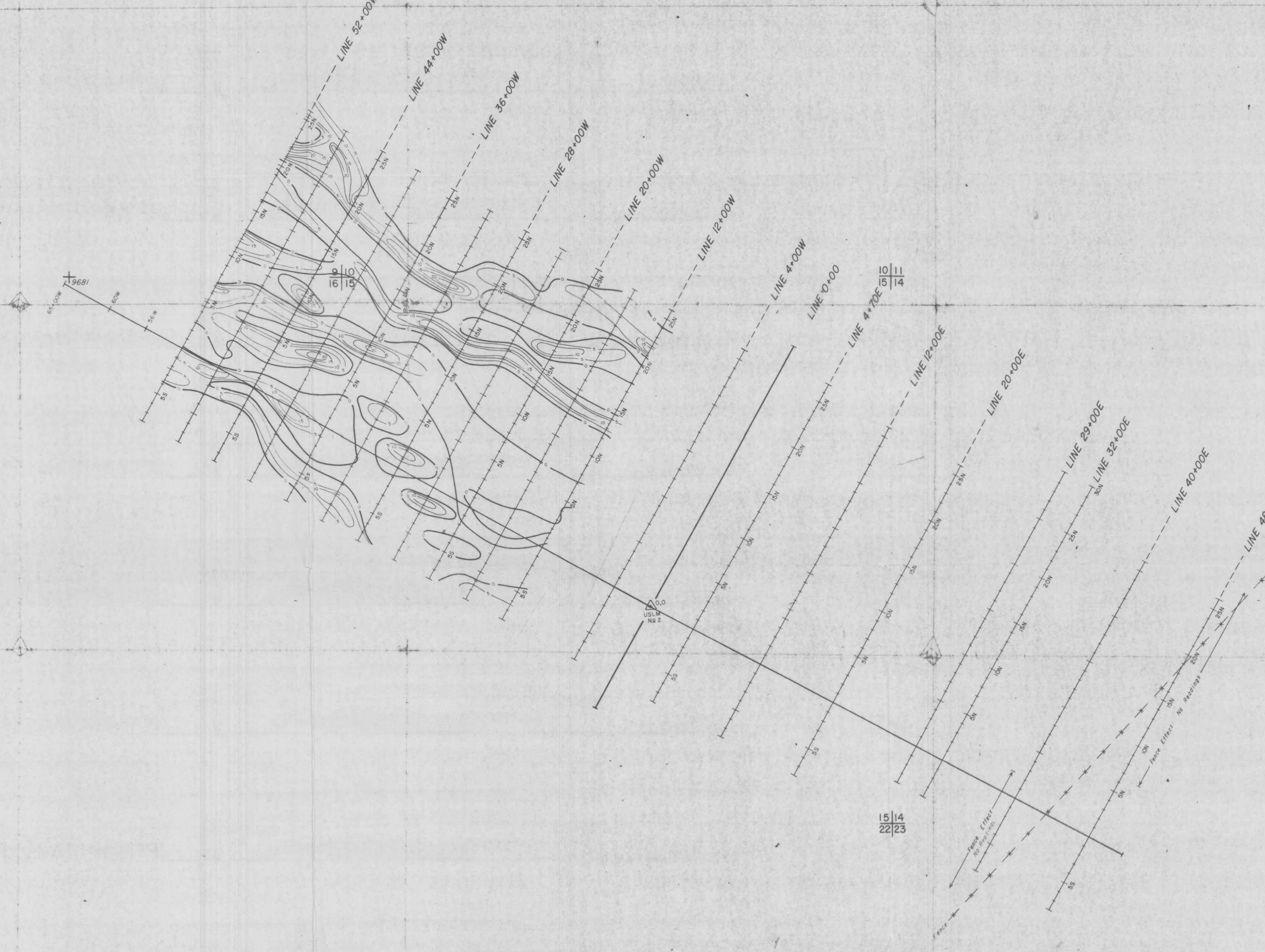
RIO ARRIBA COUNTY, NEW MEXICO

by

applied geophysics inc

SALT LAKE CITY, UTAH

August 1977



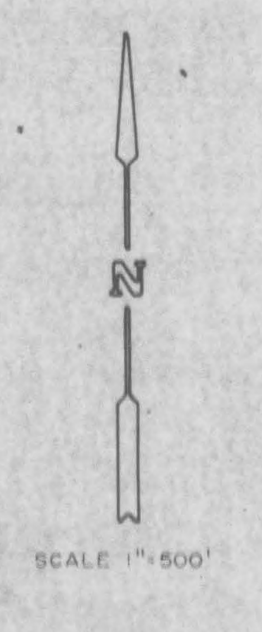


PLATE 6

U S BORAX CORPORATION

CONTOUR MAP OF FRASER VALUES

BROMIDE PROJECT

RIO ARRIBA COUNTY, NEW MEXICO

by

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SALT LAKE CITY, UTAH

August 1977