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REPORT ON
INDUCED POLARIZATION SURVEY
PRINCETON, BRITISH COLUMBIA
(49°, 121°, S.E.)

for

CLIMAX COPPER MINES LIMITED N. P. L.

by

HUNTING SURVEY CORPORATION LIMITED

Toronto, Canada

July, 1963

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1. INTRODUCTION

From May 27th to June 25th, 1963, an Induced Polarization (I.P.) survey was carried out by Hunting Survey Corporation Limited over part of the G.E. group of claims owned and operated by Climax Copper Mines Limited, N.P.L.

The G.E. Group of claims is located 2-1/2 to 3 miles northeast of Princeton (49, 121, S.E.) in the Similkameen Mining Division, British Columbia. The survey was carried out over the following claims:

G.E. # 1, 2, 3 and 4	G.E. # 46
6	
# 7	# 47
8	
#16	#104
#30	#108
#34	#111

The survey was performed by a five-man crew. The project geophysicist in charge of the survey and technician-operator were E. L. Gregotski and F. H. Faulkner, respectively, of Hunting Survey Corporation Limited. Climax Copper Mines Limited, N.P.L. provided ^{seven} ~~six~~ helpers for handling the electrodes on the lines during the course of the survey.

They were:

W. Waugh

J. Scharpegge

E. Mullin

K. Nilsen

W. Mullin

D. Ryla

E. Green

The geophysical survey was carried out along pre-cut and chained picket lines. These lines are grouped into two grid systems, and designated

"south zone" and "main grid". These grids although independent of each other are close enough to be considered as one system for the purpose of interpretation. Each grid consists of parallel lines turned off at right angles to the base line of that grid system. The stations are labelled north and south from these base lines.

2. SURVEY AND INSTRUMENT DATA

2.1. GRID SYSTEMS

The "main grid" system consists of eleven lines at intervals of 400 feet, numbered as follows:

Lines 0+00; 4+00 E; 8+00 E; 12+00 E, 16+00 E; 20+00 E;
24+00 E; 28+00 E; 32+00 E; 36+00 E; 40+00 E.

The I.P. survey of the "main grid" system provided 23,050 feet or approximately 4.63 miles of I.P. profiles.

The "south zone" grid consists of six lines with an azimuth of approximately S 5° E. From east to west these lines are: Lines 12+00 E, 8+00 E, 4+00 E, 0+00 E, 4+00 W and 8+00 W. The interval between these lines is 400 feet. The survey of the "south zone" provided 21,500 feet or approximately 4.06 miles of I.P. profiles.

The basic coverage of the survey consisted of readings at 100-foot intervals along the grid systems described above. The relative locations and orientations of those systems are shown on the map provided with this report. Thus, a total of 44,550 feet or approximately 8.7 miles of lines were surveyed.

2.2. ELECTRODE ARRAYS

The data were obtained using the "three electrode array". This array consists of one current electrode (C_1), two potential electrodes (P_1 and P_2), the second electrode (C_2) remaining fixed at "infinity";

Electrode spacings of 200 and 400 feet were used. Additional data were obtained where required with electrode spacings of 50, 100 and 800 feet. The basic station or reading interval was 100 feet. This interval varies from 100 to 200 feet for the 800-foot electrode spacing which was surveyed using the "W-3 array", a variation of the three-electrode array in which the position of C_2 can be changed from a point close to P_2 out to infinity. The station location and resistivity constant are functions of the ratio of the total distance from C_1 to C_2 to the electrode separations between C_1 and P_1 or P_1 and P_2 .

2.3. I. P. INSTRUMENT

The Hunting pulse-type instrument is similar in design and operation to those described by R. W. Baldwin in "A Decade of Development in Overvoltage Survey", A. I. M. E. Transactions, Vol. 214, 1959. Power is obtained from a Briggs and Stratton motor coupled to a 900 c. p. s. generator which provides a maximum of 2,000 watts d. c. to the ground. The cycling rate is 1.5 seconds current on and 0.5 seconds current off, the pulses reversing continuously in polarity. The data collected in the field consists of careful measurement of the current (I) in amperes flowing through electrodes C_1 and C_2 , and of the primary voltage (V_p) in volts appearing between P_1 and P_2 during the "current on" part of the cycle. Also, the

secondary voltage or overvoltage appearing between electrodes P₁ and P₂ during the "current off" part of the cycle is integrated electronically with respect to time, to provide a measurement of polarization (Vs) in milliseconds. The "apparent chargeability" in milliseconds is calculated by dividing the polarization (Vs) by the primary voltage (V_p). The "apparent resistivity" in ohm-meters is proportional to the primary voltage (V_p) divided by the measured current (I), the proportionality factor depending on the geometry of the array used.

The resistivity and chargeability obtained are called "apparent" as they are values which that portion of the earth sampled by the array must have if it were homogeneous. As earth sampled is usually inhomogeneous, the calculated "apparent resistivity" and "apparent chargeability" are functions of the "true" resistivities and chargeabilities of the various sections of the earth sampled and of the geometry of those sections.

2.4. DATA

The results of the survey are shown on the individual profiles. These profiles have a horizontal scale of one inch to one hundred feet. The "apparent chargeability" is plotted at a vertical scale of 1.0 milliseconds per inch. The "apparent resistivity" is plotted on a vertical logarithmic scale of two inches per logarithmic cycle.

The interpretation of the I. P. survey is presented in the form of an Interpretation Map, scale 1" - 200', showing the two grid systems used and the lines surveyed by the I. P. method. This map also shows a generalized vertical projection to the surface of the more interesting zones. These profiles and map are presented with this report.

This report constitutes a review of the Preliminary Report submitted by E. L. Gregotski to Climax Copper Mines Limited in June, 1963. The interpretation and recommendations herein are made after a careful re-examination of the I.P. results and are of a more specific and restricted nature than the general remarks made at the conclusion of the field work.

3. INTERPRETATION

3.1. METHODS

Due to the geometry of the mineralized zones which are the target of I.P. surveys in the Highland Valley, the usual approach to quantitative interpretation assuming a horizontally layered earth can seldom be applied. The complex problem of the combined effects of depth of burial, width, dip and true chargeability of a vertically mineralized zone plus the physical characteristics of the overburden and country rock have not been solved practically. However, certain rule-of-thumb plus the experience gained from test surveys over known ore bodies permit certain estimates to be made. Thus the maximum possible width of the causative bodies are indicated on the accompanying profiles, with the understanding that the body most probably is narrower than indicated. Rough depth estimates are possible in some cases, but it is necessary to know the electrode spacings at which maximum response is obtained; thus a minimum of three electrode spacings across the anomaly are usually required.

The interpretation of the survey data consists of a careful analysis of each individual profile. The results of this analysis are shown by

appropriate symbols on the I.P. profiles in the Appendix of this report. These results are also transferred to the interpretation map in the pocket at the end of this report, using the same symbols. Due to the high degree of complexity of the interpreted I.P. results and to the absence of geological data in certain parts of the area, caused by the presence of overburden, no attempt was made to outline in plan form the various zones by use of contact or similar symbols.

In addition the technique based on the assumption of a layer earth was used: The set of curves for the two layer response using the Wenner or four-electrode array are also valid for the three-electrode array used in this survey. This technique involves plotting the measurements made with the different electrode spacings at a given station against the electrode spacing. These curves are then fitted to the type curves similar to those published by Seigel. These calculations were carried out over anomalous zones on which the assumption of a layered earth is assumed.

As only two, or at the most three, points are available, the depth curves at the stations are incompletely defined giving rise to a certain degree of uncertainty in the determinations.

Thus, an intermediate layer may be overlooked or the bottom effect of the lowest layer may not be recognized. In all cases, an attempt has been made to accept the solution which will give the lowest chargeabilities so that the chargeabilities shown on the map are minimum values. The calculated depths can be in error to some degree although the overall picture will not be affected too significantly. Thus at a calculated depth of 100 feet, the actual depth may vary from 50 to 200 feet, and at a calculated depth of

800 feet, the uncertainty could be in the order of ± 200 feet.

The symbols used warrant some further discussion. The "zones of special interest" (cross-hatched) represent the causative bodies of specifically recognizable anomalies measured from profiles observed with the shortest electrode spacings. Thus, the width indicated is the probable width nearest to the bedrock surface and need not represent the true width of the body at depth. The "zones of possible interest" (single-hatched) are anomalous zones which cannot be broken down into individual bodies, or zones which show lower chargeability (less mineralization) or greater depth.

Estimated depth (h), or the limits thereof, are shown in feet. Where a maximum value of depth is shown, it is believed that more often than not the actual depth will be found to be one-half, or less, of the maximum shown. It is to be noted that these depths would be more properly called distances to the body, the distances being measured in a plane perpendicular to the line and to the ground surface. This is due to the fact that the I.P. method samples a certain volume of the earth and therefore the causative bodies do not necessarily lie beneath the lines surveyed but could be located to one or the other side of the line. Such an occurrence is called a "side effect".

As previously explained, the mathematical problem of the relationship between the width, the depth and the true chargeability is not solved in the case of bodies of limited vertical cross sections. Thus, only a minimum chargeability in milliseconds is shown. Past experience shows that one per cent sulphide by volume will cause a chargeability of 3 to 8

milliseconds. In other words, a minimum chargeability of 12 milliseconds indicates an absolute minimum sulphide content of 1.5%, but the sulphide content could also be greater than 4%. The sulphides may or may not be economical as the I.P. method does not differentiate between chalcopyrite and pyrite, for example.

The interpretation of the survey data consists of a careful analysis of every individual profile. The results of this analysis are shown by appropriate symbols on the I.P. interpretation maps presented with this report.

3.2. MAIN GRID - I.P.

No significant anomaly was detected throughout the "main grid". However a number of weak variations in the chargeabilities were observed, these indicate possible zones of very weak mineralization, or are associated with a geological contact, such as a change of rock type. If mineralization occurs the zones appear to be fairly narrow.

The zones located on Lines 0+00, 8+00 E, 12+00 E are not clearly defined, as the 400 foot and 800 foot electrode spacings were not extended sufficiently to the south to check whether or not a double peaked anomaly would be indicated. If the anomaly is double peaked then the zones would be relatively narrow, possibly a shear with mineralization, situated midway between the peaks. These zones appear to have some depth extent.

Calculations carried out on the results obtained over these three zones show that the true chargeabilities are 3 milliseconds, indicating 1% or less of sulphides by volume, and that the depths to the causative bodies

are between 100 and 200 feet.

3.3. SOUTH GRID - I.P.

The results obtained over this grid system show much higher chargeabilities than found over the "main grid". This may be caused by the presence of widely scattered mineralization throughout the area or the country rock may have an unusually high chargeability response. All lines surveyed on this grid show increasing chargeabilities with depth over the full length of the line. This is probably due to variations within the bedrock as would be expected when passing through a weathered formation into an unweathered rock. Superimposed on this rather high background are a number of minor variations which could be attributed to minor quantities of sulphides. The results obtained indicate that the mineralization may be in narrow zones or bands.

The chargeabilities obtained at the south end of the lines are in general lower than those found on all the lines. This may indicate a change in rock type to the south.

The main areas of interest are shown on the interpretation map. Of these zones, the one located across Lines 8+00 W and 12+00 W at 6+00 S appears to be the most significant. Calculations carried out on this anomaly show that the causative body is located at a depth of less than 100 feet with a true chargeability of 6 milliseconds indicating 1-2% of sulphides by volume.

The irregular pattern of the profiles shows the complexity of the geological structure and indicates that the responses may originate from intrusive contacts within the Nicola Formation.

3.4. MAIN AND SOUTH GRIDS - RESISTIVITY

The resistivity data obtained over the two grid systems vary from 10 ohm-meters to 3000 ohm-meters. The variations in the resistivity values obtained are ascribed mainly to changes in the overburden thickness, and in overburden and bedrock resistivities. The overburden appears to vary in resistivity values between 10 ohm-meters to 3000 ohm-meters. However, these extreme variations appear to have little influence on the resistivity values in general due to the relatively thin overburden covering throughout the survey area. It is understood that graphitic zones are to be found in the area and that the bedrock surface is formed by a weathered rock, and it is possible that these could be the cause of the low readings. The lower resistivity values of the range of variation (10-30 ohm-meters) are restricted to mainly the "main grid" area, and are more or less localized. These variations in the low values may be attributed to graphitic areas or zones of weathering of varying thickness. The increased conductivity may be attributed to the salinity. The high resistivity values of the range of variation (1000-3000 ohm-meters) is localized on Line 4+00 E of the South Zone between Stations 1+00 S and 6+00 N on the shallow 100 foot electrode separation. Trenching in this area indicated that the overburden consisted of a very dry powdery material. Since the variations were localized and shallow, the evaluation of the resistivity data was restricted to the larger electrode separations (i. e. $a = 200'$ & $400'$) in order to minimize the effects of the overburden.

The resistivity data has been grouped into three zones from which inferences are made as to the geological formations which more or less coincide with the limited known geology. Apparent resistivity values varying from 10 ohm-meters to 100 ohm-meters are inferred to originate from Tertiary rocks and their boundary is represented by a broken line. The Nicola Formation is inferred to exhibit apparent resistivity values varying from 100 ohm-meters to 200 ohm-meters and its boundary is represented by a solid line. The dotted line represents the limits of the intrusive and is inferred by apparent resistivity values as being greater than 200 ohm-meters. The pairing of any two of the above symbols infers a coming together of the relative rock types.

The Nicola/Tertiary contact appears mainly at the north end of the South Zone grid system and the south-west portion of the "main grid" system. It thus appears that most of the "main grid" system except east of L 32+00 E lies within the Tertiary formation.

It is to be noted that at the northwest end of the south zone two Nicola/Tertiary contact trends are represented. However, one is broken by question marks and the other (the Nicola boundary) appears solid. The former contact is outlined on basis of geology and the latter contact is outlined by the resistivity values. Two possible solutions readily present themselves at this time. The first being that the Nicola edge determined on the basis of geology may be only a thin layer overlaying the Tertiary rocks. The second solution is that the inferred lower limit of the Nicola formation exhibiting a resistivity of 100 ohm-meters is slightly too high.

Contacts between the Nicola and intrusive rocks appear more definite in the east end of the "main grid" area, than over the South Zone grid area.

The often-curved trend of the contact symbols in the South Zone grid area attempts to show the relationship of the resistivity data to the geology. Considering the complexity of both the geological and apparent resistivity data, it is quite apparent that the inter-relationships shown represent only one out of many possibilities. This uncertainty explains the "question marks" connected with the Nicola/Intrusive contact in the South Zone grid area.

3.5. GENERAL

The low resistivities encountered during the survey may indicate the presence of graphitic zones, particularly in the "main grid" area, or due to variations in the depths of weathering. On the south grid the increase in chargeability, on every line, with increase in electrode spacing may be indicative of the change from weathered rock to un-weathered formations. An increase is expected under these circumstances.

In conclusion, a number of trends appear to have been established by the survey of the two grids, however the individual bodies are difficult to assess due to the complexity of their patterns. The accompanying interpretation map shows possible trend patterns based on all available information. Although the trends appear fairly well established, their lateral extent and position is open to question due to the possibility of side effects. Thus, it must be remembered that bodies indicated may or

may not reach a specific line, and may become more or less significant in between lines.

It will be noted that a smaller number of zones are shown on the interpretation map than were on the preliminary map. This report has attempted to outline only the zones of highest chargeability, and therefore, the most likely areas of mineralization. The other zones would only be worth considering if those discussed in this report proved to be of major interest.

4. SUMMARY AND RECOMMENDATIONS

An Induced Polarization survey was carried out over part of the property of Climax Copper Mines Limited. The resistivity results indicate the possible presence of graphitic zones and areas of weathering. The chargeability readings indicate a number of anomalous zones that may be due to the presence of sulphides. The high I.P. background found over the "south grid" may be due to widely scattered mineralization, which makes it difficult to assess the trends of the individual bodies due to the complexity of the pattern. Narrower zones are interpreted within this broad area which are probably due to a concentration of the mineralization. It is considered that the disseminated sulphides in unknown quantities (probably 1-2% sulphides by volume and in some instances less than 1%) are the cause of these narrow anomalies.

The economic significance of these mineralized zones must be determined by visual examination. Since overvoltage is essentially a surface phenomena, the I.P. effects from a given volume per cent of

metallic conductors generally increase as the individual partical size is decreased. In this manner the method tends to emphasize true disseminations of metallic conductors over the more massive interconnected metallic conductors with the same metallic content.

Further investigation by trenching and drilling is suggested as the next step to determine the nature of the causative bodies. The overburden appears to vary in thickness but in the vicinity of the main anomalies it is probably less than 100 feet and in some instances bedrock surface may be reached by trenching. In drilling, it must be remembered that it is possible that the causative body may not reach the particular line on which the anomaly is observed.

Due to the nature of the mineralization, it is possible that a drill hole may intersect an exceptionally good or bad section. In order to assess the zones it is recommended that the following anomalies be further investigated by trenching or drilling:

Line 12+00 E	to investigate anomaly	centered at	6+00 S
Line 8+00 E	"	"	" " "
Line 4+00 E	"	"	" " 10+00 N

Further drilling should depend on the results obtained from this initial programme.

It must be remembered that the anomalies are not very big and are probably caused by low percentages of narrow bands of sulphides, so should

the results of this drilling prove encouraging, further detail work should be undertaken to completely outline the zones.

HUNTING SURVEY CORPORATION LIMITED,

E. B. Nicholls

E. B. Nicholls,

Geophysicist

Toronto, Ontario,

July, 1963.

APPENDIX

I. P. PROFILES

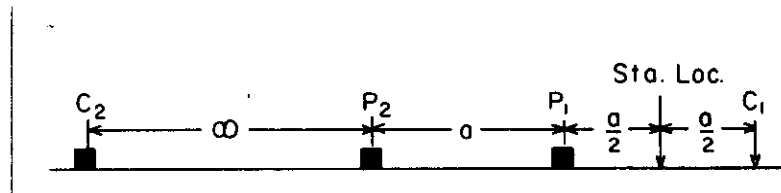
MAIN GRID:—

SOUTH ZONE:—

Lines - 0+00
 4+00 E
 8+00 E
 12+00 E
 16+00 E
 20+00 E
 24+00 E
 28+00 E
 32+00 E
 36+00 E
 40+00 E

Lines - 8+00 W
 4+00 W
 0+00
 4+00 E
 8+00 E
 12+00 E

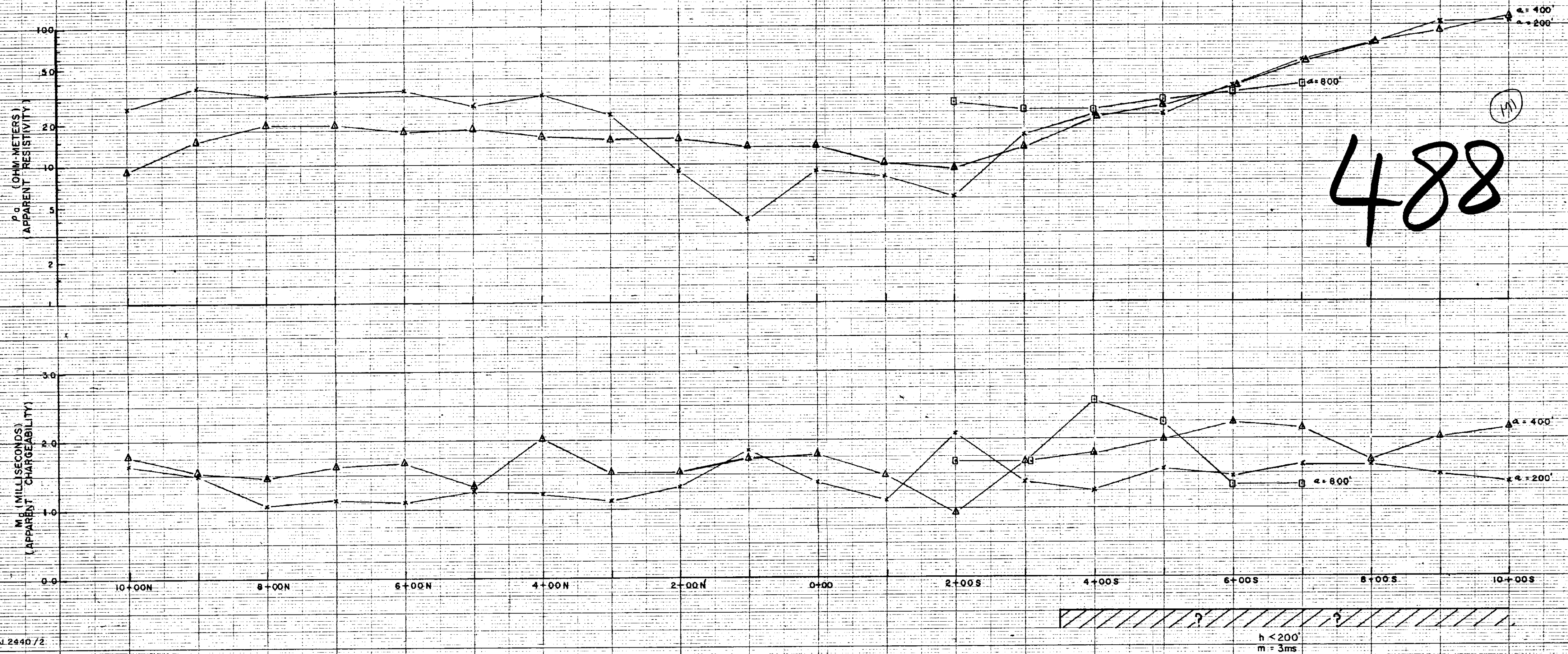
3-ELECTRODE ARRAY



INTERPRETATION LEGEND

- Area of interest
- Area of possible interest

I.P. PROFILE - LINE 0+00 E



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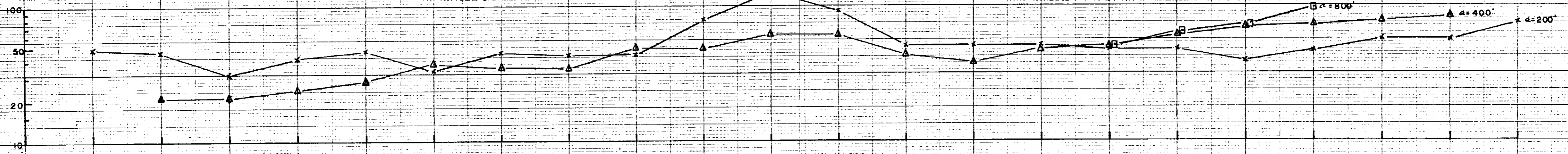
12440/2

$h < 200'$
 $m = 3ms$

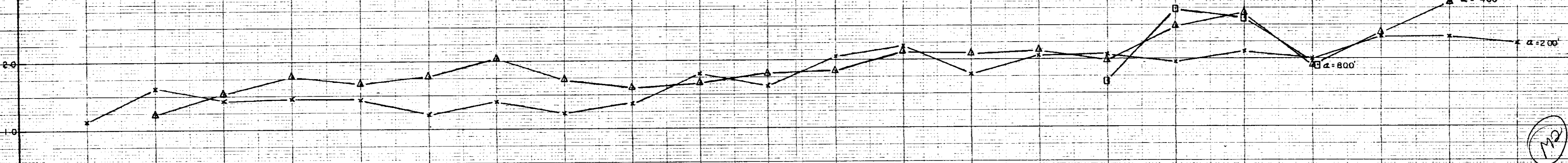
PKW

I.P. PROFILE - LINE 8+00 E

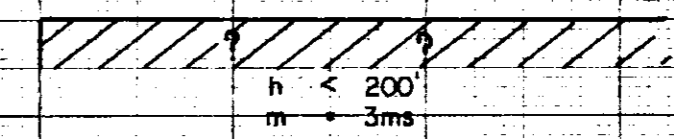
P_a (OHM-METERS)
(APPARENT RESISTIVITY)



M_a (MILLISECONDS)
(APPARENT CHARGEABILITY)



J 2440/2

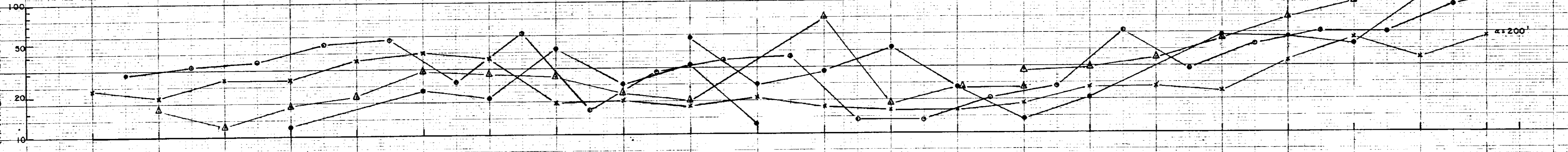


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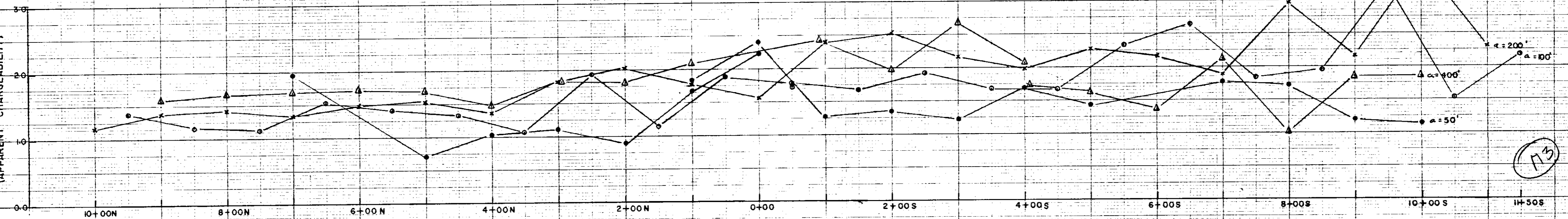
EB Nicholls

I.P. PROFILE - LINE 4+00 E

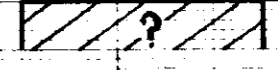
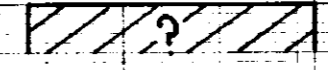
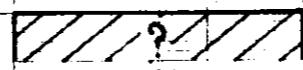
P_0 (OHM-METERS)
(APPARENT RESISTIVITY)



M_0 (MILLISECONDS)
(APPARENT CHARGEABILITY)

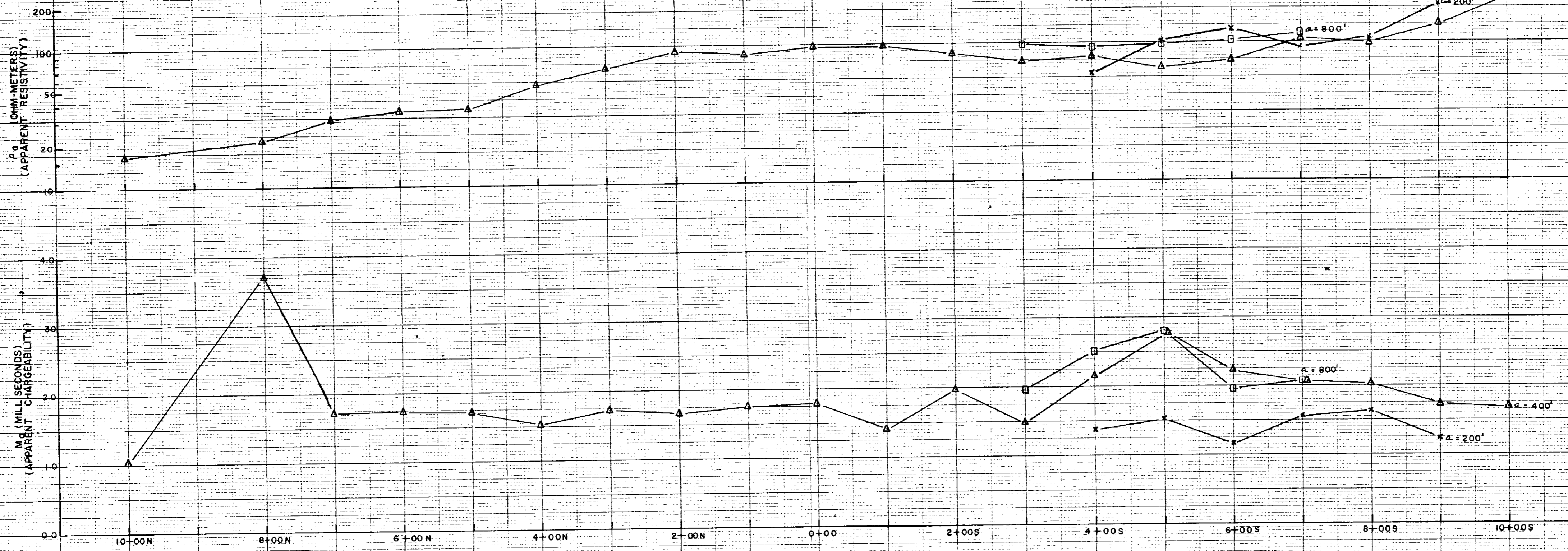


10+00N 8+00N 6+00N 4+00N 2+00N 0+00 2+00S 4+00S 6+00S 8+00S 10+00S 11+50S



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I.P. PROFILE - LINE 12+00 E



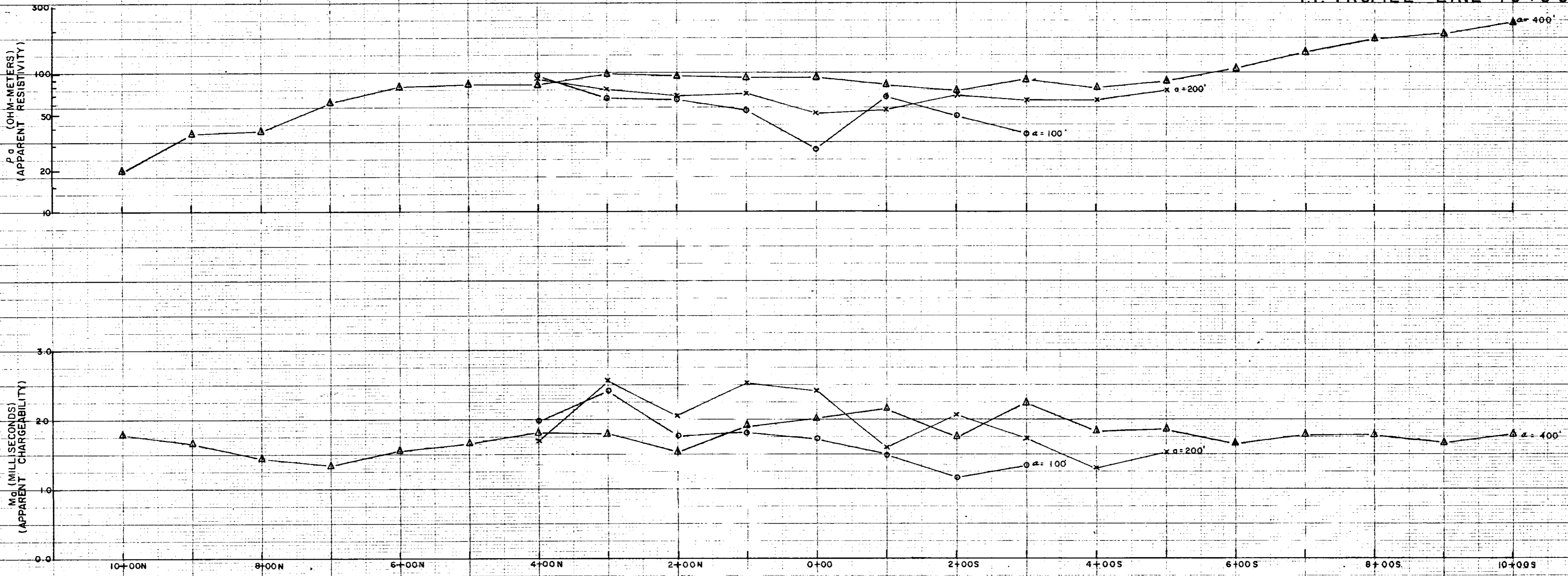
J 2440/2

h = 150
m = 3ms

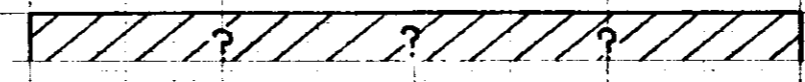
CBN *[Signature]*

[Handwritten mark]

I.P. PROFILE - LINE 16+00E

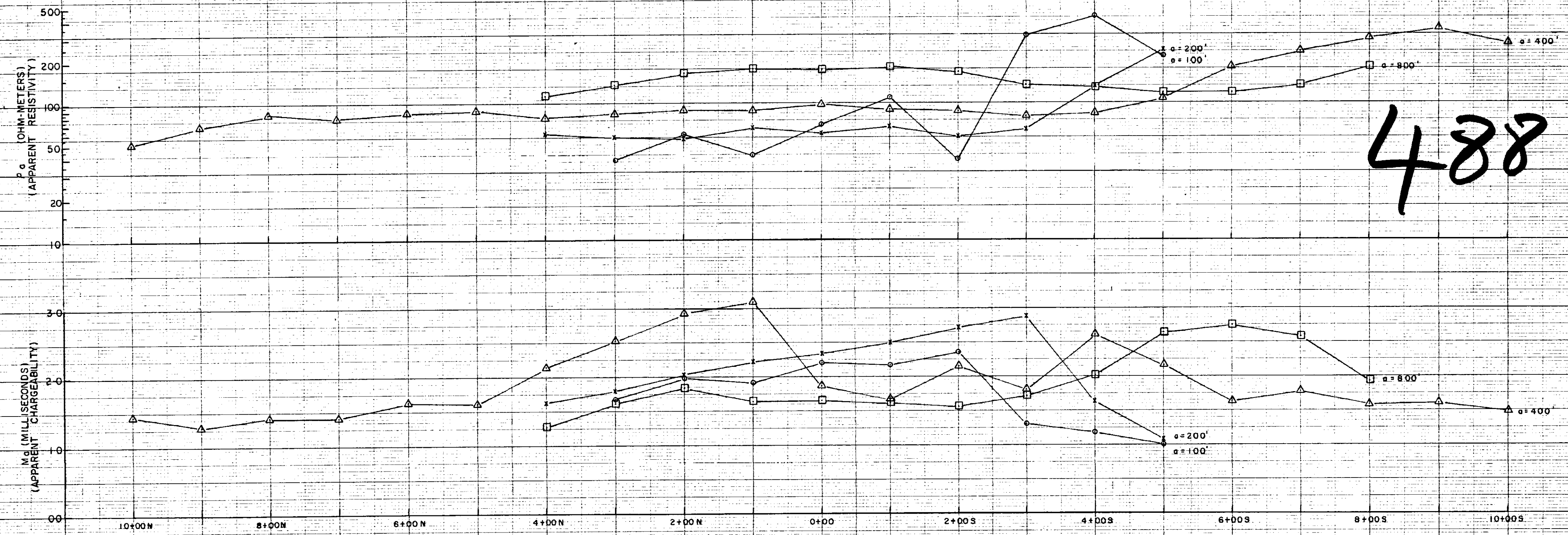


J 2440/2



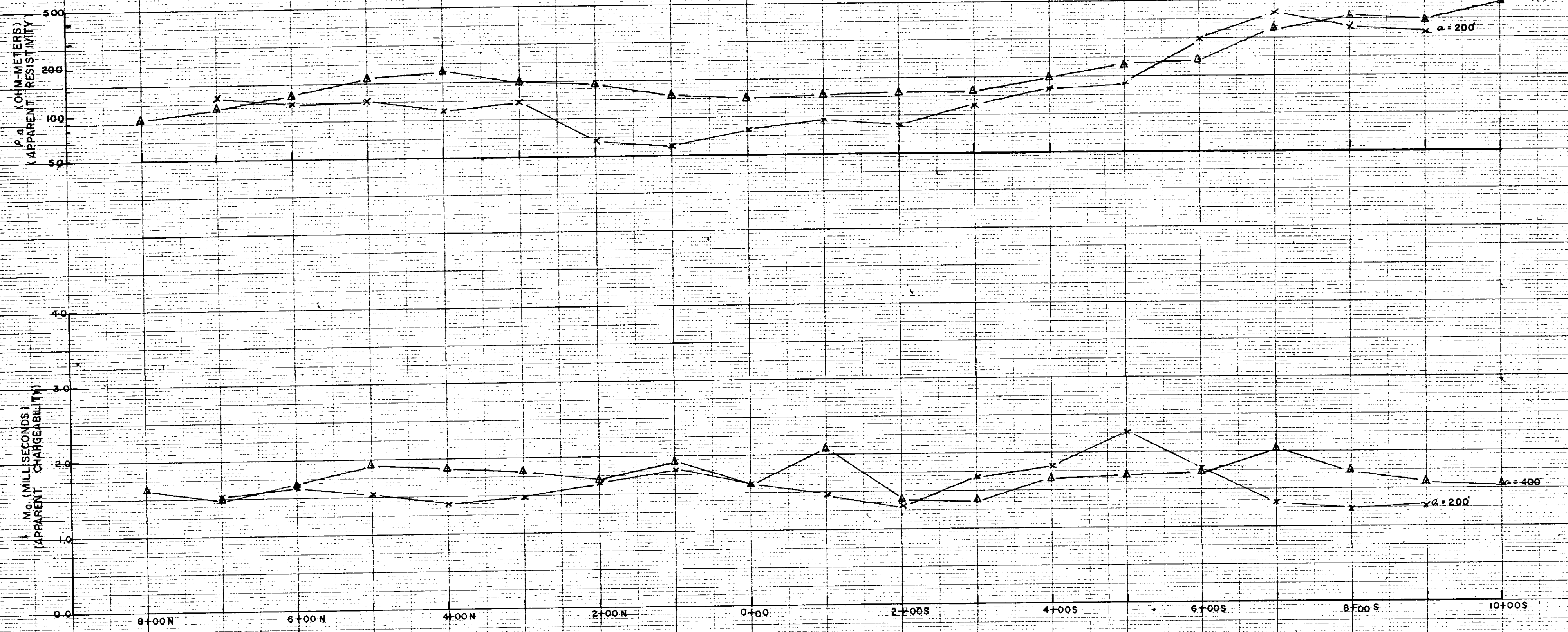
15

CBW



488

I.P. PROFILE - LINE 28+00E

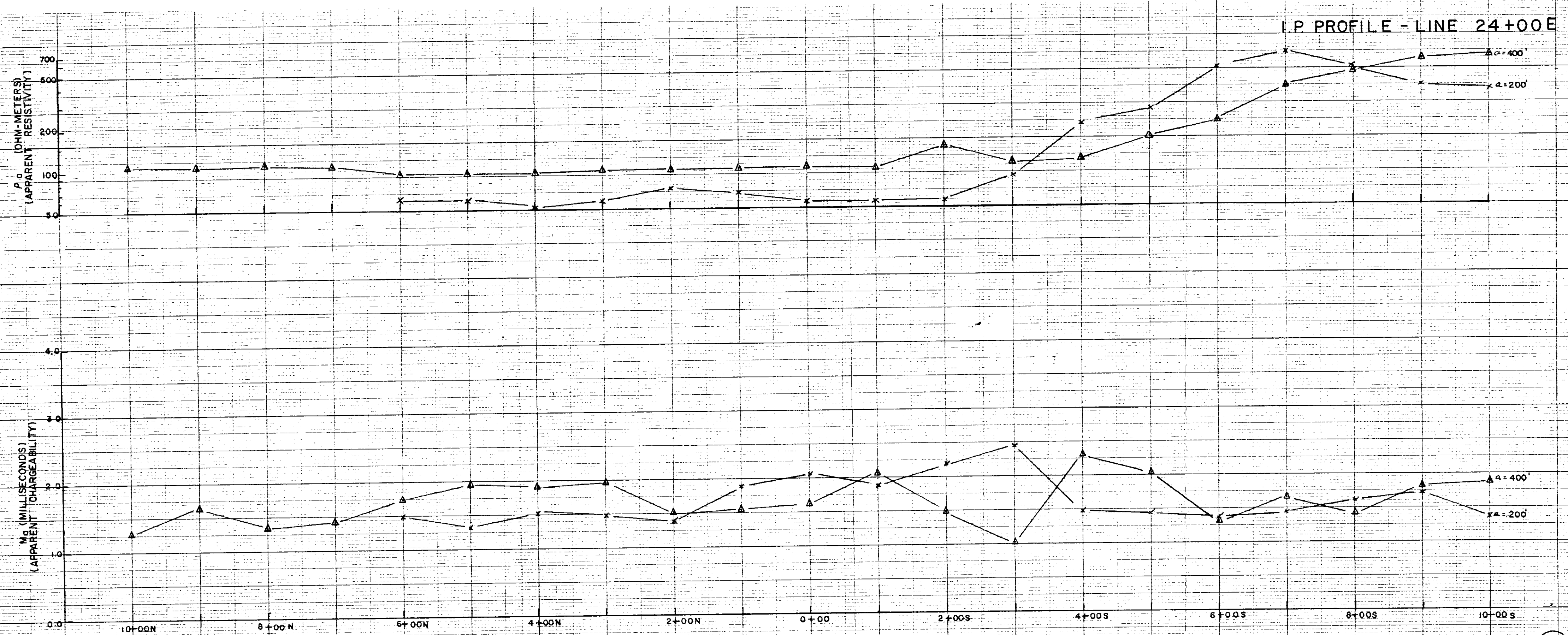


J 2440/2

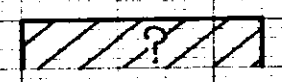
EB Nicholls

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I.P. PROFILE - LINE 24+00E



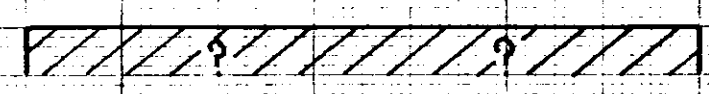
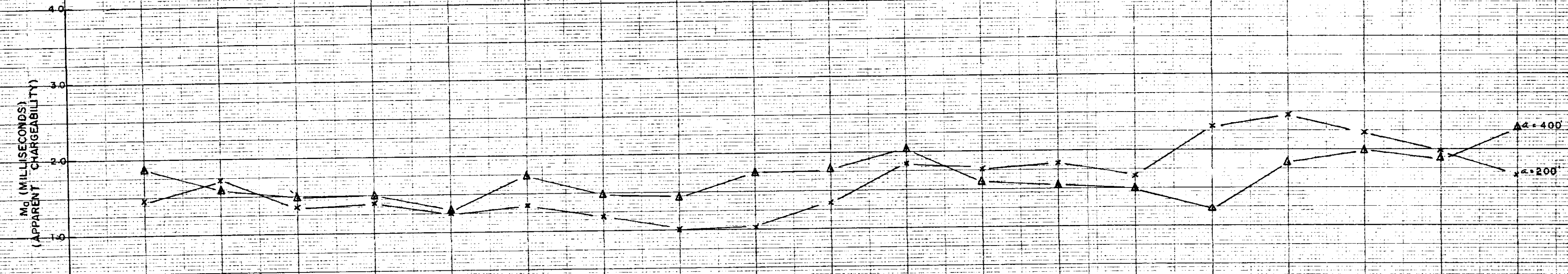
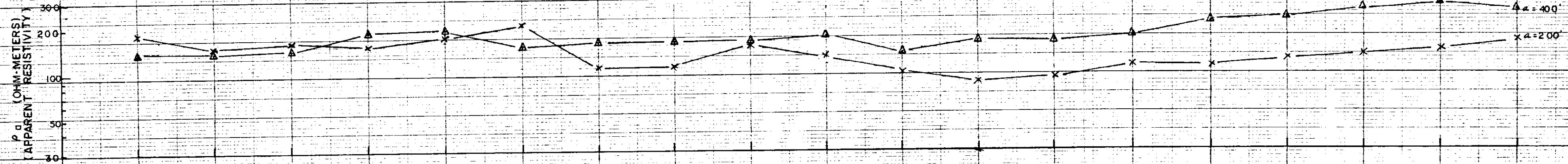
J 2440/2



(MP)

PBA/Whells

L.P. PROFILE - LINE - 32+00E

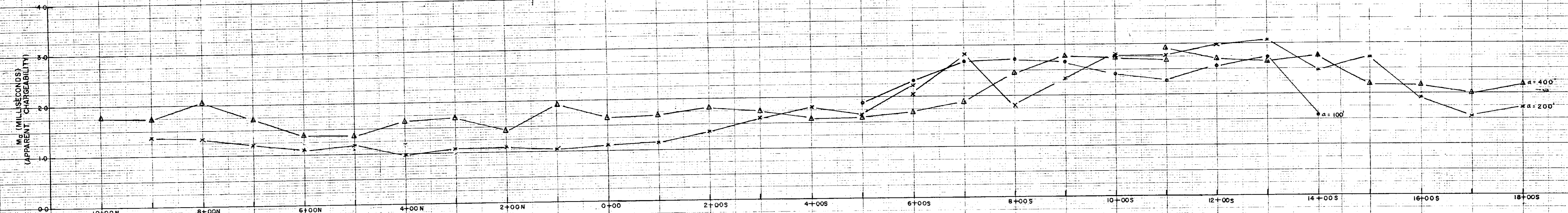
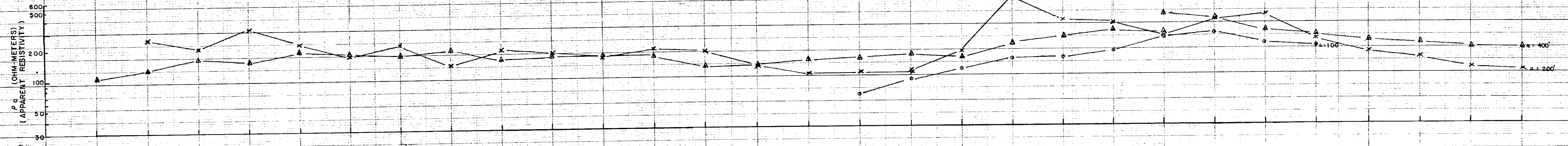


J. 2440/2

(Mg)

EBD

I.P. PROFILE - LINE 36+00 E



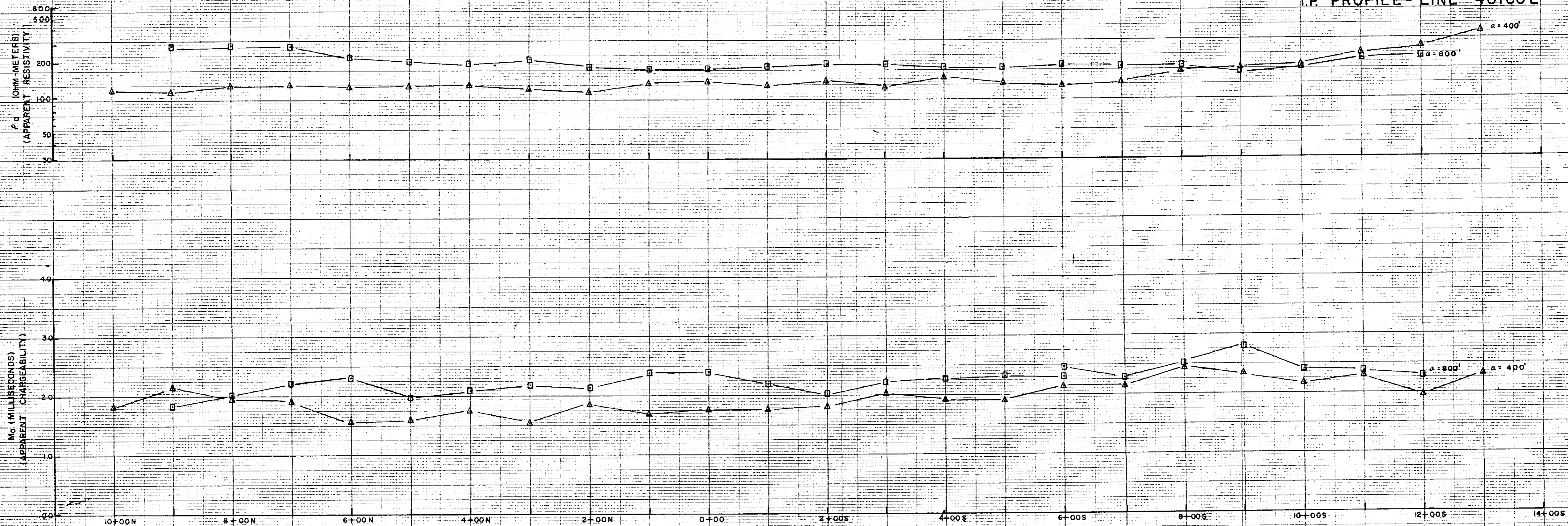
Possibly due to very weak mineralization

J 2440/2

M10

EBN

I.P. PROFILE - LINE 40+00E

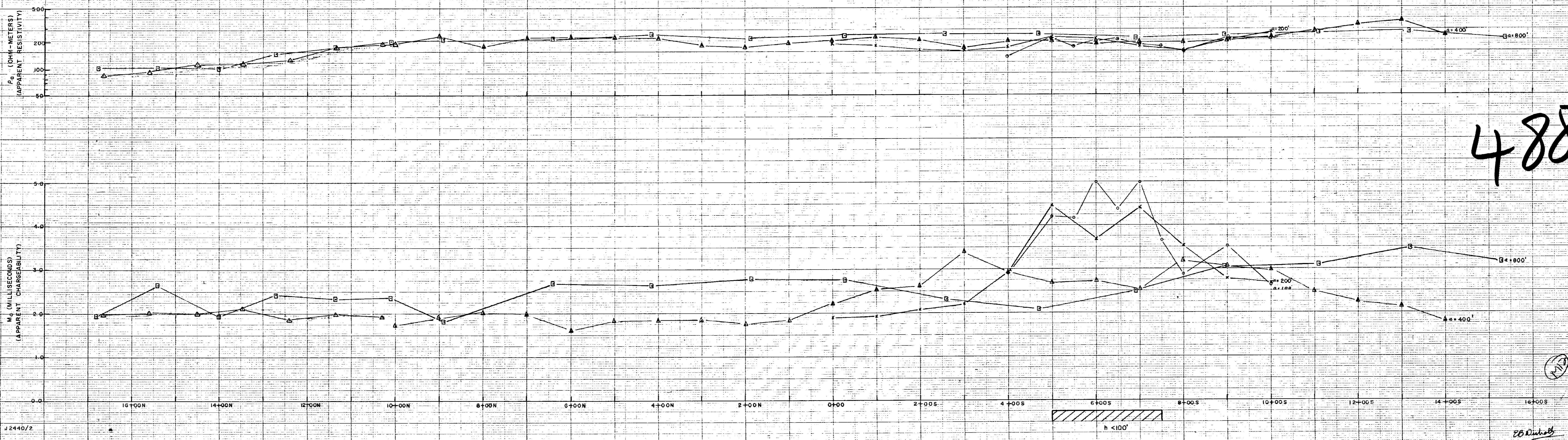


J 2440/2

Eb Nubaly

MII

I.P. PROFILE - LINE 12+00 E South Zone

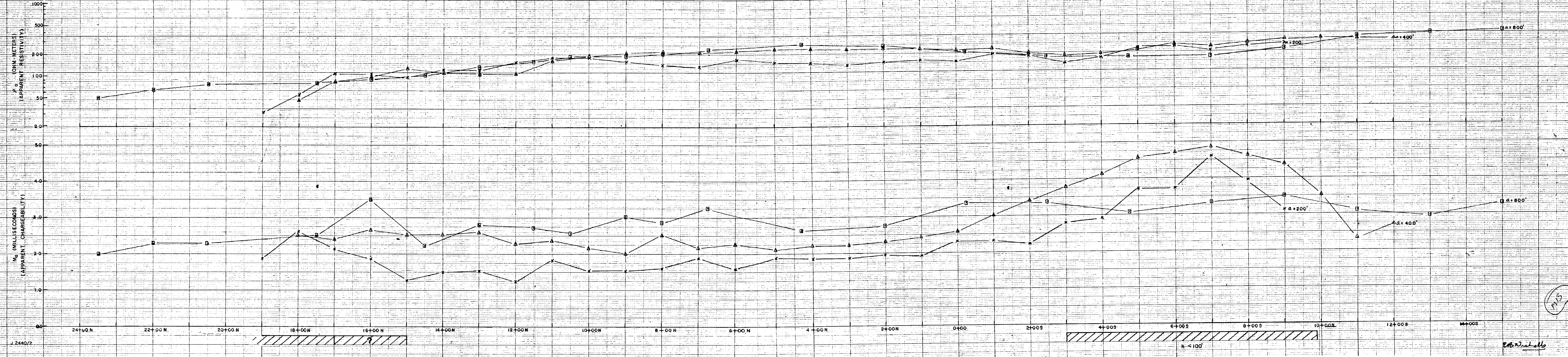


488

(M12)

EB Dubois

I.P. PROFILE - LINE 8+00E South Zone

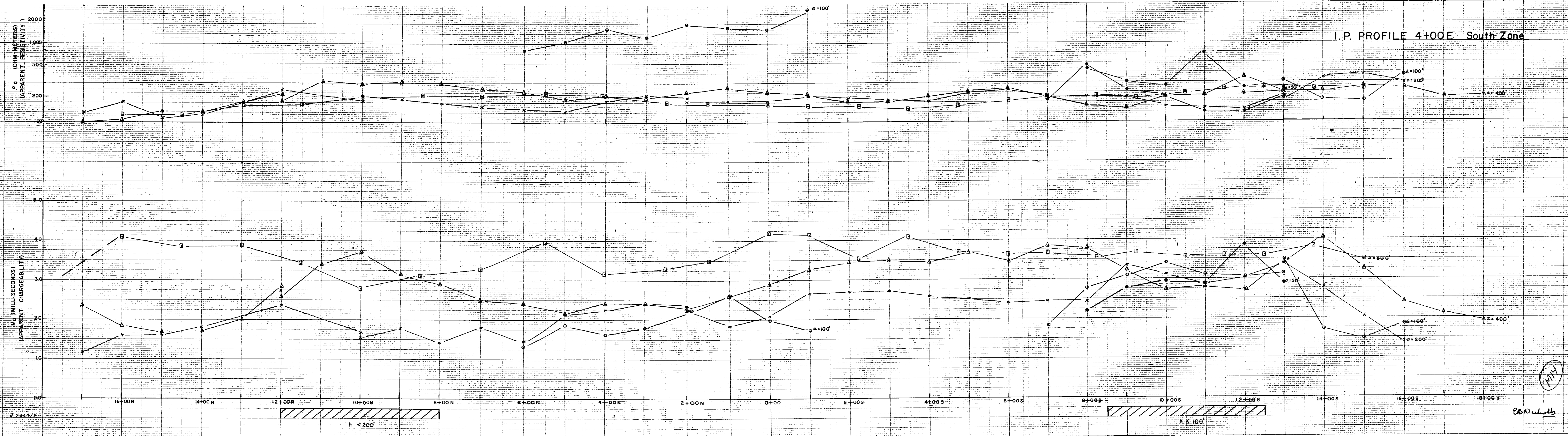


J. 2440/2

MIS

EBN 11/6

I.P. PROFILE 4+00E South Zone

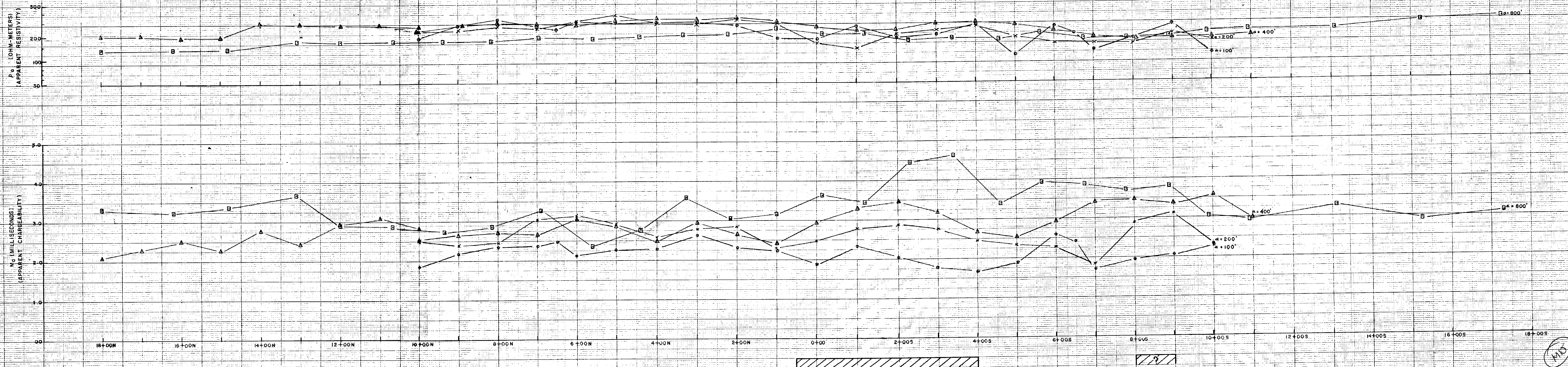


J 2440/2

MH

P.B. Schultz

I.P. PROFILE - LINE 0+00 South Zone



J. 2440/2

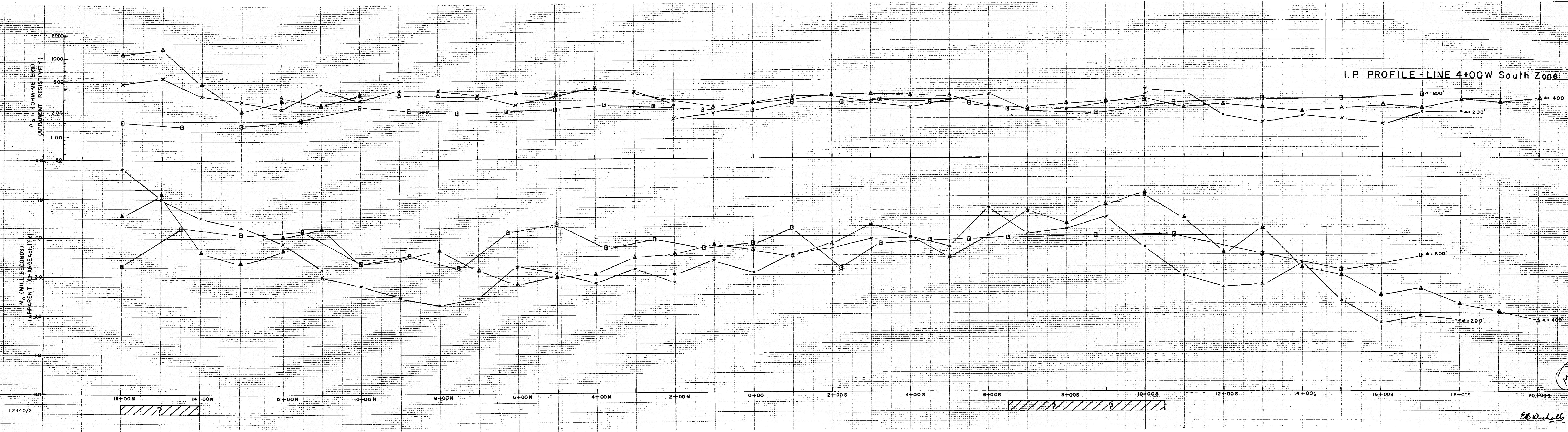
MIB

Edwards

P.P. (OHM-METERS)
(APPARENT RESISTIVITY)

M_a (MILLISECONDS)
(APPARENT CHARGEABILITY)

I.P. PROFILE - LINE 4+00W South Zone

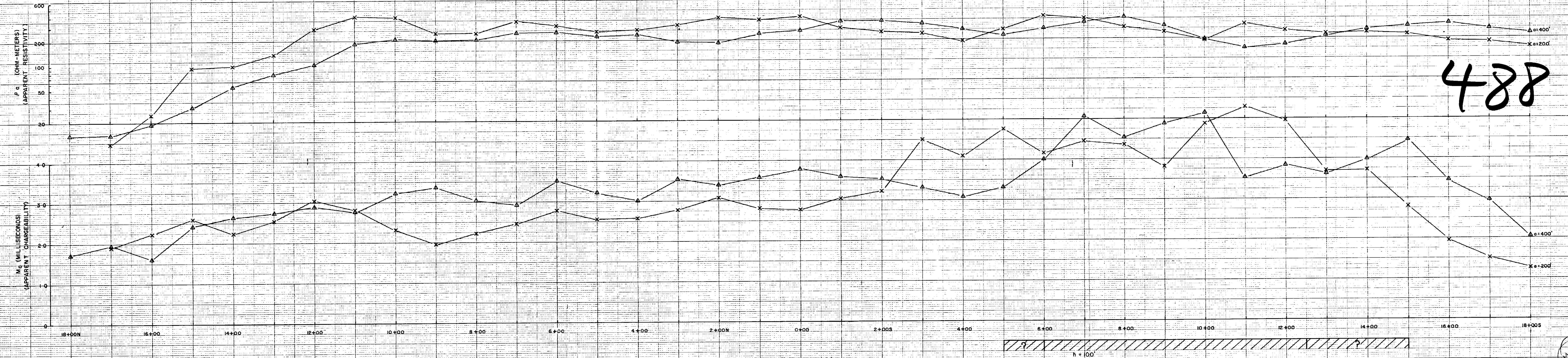


J 2440/2

MKB
E.B. Wickham

I.P. PROFILE - LINE 8+00W
SOUTH ZONE

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J 2440/2

EW Nichols



LEGEND

- h < 150' Estimated limits of depth in feet
- [Hatched] Area of interest
- [Hatched with ?] Area of possible interest
- [Solid line] Possible Nicola / Tertiary contact
- [Dashed line] Possible Nicola / Intrusive contact
- [Dotted line] Questionable Nicola / Intrusive contact correlation
- [Line with ?] Nicola / Tertiary contact plotted on basis of geology

CLIMAX COPPER MINES LIMITED (N.P.L.)
 G.E. GROUP OF CLAIMS
 NEAR PRINCETON, B.C. (49° 121' S.E.)
 INDUCED POLARIZATION SURVEY

Department of
 Mines and Petroleum Resources
 ASSESSMENT REPORT
 NO. 488 MAP 1

INTERPRETATION

SCALE: 1 inch = 200 feet

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