Bergvesenet

Postboks 3021. 7002 Trondheim

Rapportarkivet

Bergvesenet rapport nr	Intern Journal nr	Internt arkiv nr	Rapport lokalisering	Gradering
BV 2201				Fortrolig
Kommer fra ..arkiv Sulitjelma Bergverk A/S	Ekstern rapport nr "542200002"	Oversendt fra	Fortrolig pga	Fortrolig fra dato:

Tittel

Audiomagnetotelluric (AMT) measurements in Ballangen for NGU.

Forfatter	Dato	Bedrift
PELKONEN R. CARSTENS C.	1979	Sulitjelma Gruber A/S

Kommune	Fylke	Bergdistrikt	1: 50 000 kartblad	1: 250 000 kartblad

Fagområde	Dokument type	Forekomster
Råstofftype	Emneord	

Sammendrag

I juli 1979 utførte Sulitjelma Gruber AMT mülinger for NGU i Ballangen, Nordland. Rapporten tar kort for seg utstyret som ble brukt og teorien bak mülingene. Tre områder ble undersökt og anomaliene i disse områdene er kort omtalt.

542.200.002

AUDIOMAGNETOTELLURIC (AMT) MEASUREMENTS IN BALLANGEN FOR NGU

Raimo Pelkonen
Carl Wilhelm Carstens
A/S Sulitjelma Gruber
8230 Sulitjelma
1979

CONTENTS

1. INTRODUCTION

A/S Sulitjelma Gruber performed audiomagnetotelluric (AMT) measurements in Ballangen for NGU from the 16th to the 20th of July. The measurements were carried out by C.W. Carstens and R. Pelkonen. A/S Sulitjelma Gruber had also two assistants and so did NGU. The measurements were done in two shifts: three men per shift.

2. EQUIPMENT

The measuring equipment was a French audiomagnetotelluric resistivity meter "Resistivimétre magnéto-tellurique" manufactured by Societe ECA in Paris.

The amplitudes of the telluric and magnetic fields are measured at nine fixed frequencies from 8 to 3700 Hz. Two coils are used to measure the magnetic field, one for the low (from 8 to 370 Hz) and one for the high (from 170 to 3700 Hz) frequencies. The telluric field is measured galvanically with steel electrodes. After integration and electronic division of the amplitudes the absolute value of the apparent resistivity at each frequency can be read directly from the scale of the resistivity meter.

3. INTERPRETATION

Apparent resistivity (ϱa) values obtained in sounding are plotted already in the field on nomograms (Figure 1) developed by Fournier (1970). With the help of this nomogram we can approximately determine the depth to a conducting layer. The so-called H-lines on the nomogram are related to the depth of penetration at a certain conductivity-frequency combination. The ascending lines correspondingly enable us to determine the S-values of the conductive layer (S= the conductivity-thickness product of a layer). From the intersection of the S-lines with the horizontal line $\varrho a = 1$ we can read the corresponding H-value. Since $\varrho a = 1$ the numerical H-value equals the S-value of the conductor. The problem of this kind of interpretation is the positioning of the true H- and S-lines in relation to the descending and ascending parts of the measured ϱa-curve.

If in the earth there is a perfect conductor, the ϱa-curve is descending parallel to the H-lines. The depth to a perfect conductor is then found by the formula (Porstendorfer, 1975).

$$H\ (m) = 356\ \sqrt{\varrho\ (\Omega m)\ /\ f\ (Hz)}$$

Provided the resistivity contrast between the resistive and conductive layers is great enough (exceeding 300), the maxima and minima of the ϱa-curve can be used for the determination of the depth to the conductor and S-value of the conductor (Berdichevskij, 1968):

$$H\ (m) = 520\ \sqrt{\varrho_{max}\ (\Omega m)\ /\ f_{max}\ (Hz)}$$

$$S\ (1/\Omega) \approx 520\ /\ \sqrt{\varrho_{min}\ (\Omega m)\ f_{min}\ (Hz)}$$

A more detailed layered model interpretation is based on curve fitting by master curves. The master curves have been published for instance by Cagniard (1953), Berdichevskij (1968) and Porstendorfer (1975).

4. MEASUREMENTS AND RESULTS

4.1. GENERAL

The AMT measurements were performed in three areas (appendix 1). AMT soundings were done in 58 points. The meaning of the measurements in the areas 1 and 2 was to find out if there were conductors in the earth. In the area 3 we checked if the AMT method can find the known ore. The layered model interpretations were done mainly by eye ("curve fitting by eye"). Where it was possible the formulas of chapter 3 were used. Some points could not be interpreted.

4.2. AREA 1

The AMT sounding points of the area 1 are plotted on the map in the appendix 1. The strike was unsure, so the measurements were done so that the telluric line was N-S and/or W-E.

The interpretations of the profiles 4100 Ø, 2500 Ø and 1200 N are shown in the Figures 2, 3 and 4. As general there is a resistivity contrast at the level -400 ··· -1600 meters in all the profiles. In the profile 4100 Ø there are deep conductors at 2000 N ··· 3000 N. In the profile 1200 N there are shallow conductors at 2450 Ø ··· 2700 Ø.

4.3. AREA 2

The AMT sounding points of the area 2 are plotted on the map in the appendix 1. The strike was unsure, so the measurements were done so that the telluric line was N-S and/or W-E. In some points the telluric line was 135 degrees.

The interpretations of the profiles 1 and 2 are shown in the Figure 5. In the profile 1 there is a resistivity contrast at the level -400 ··· -1000 meters. In points 40 and 43 there are conductors at the level ~200 meters. In the profile 2 there are conductors at the level ~200 meters.

4.4. AREA 3

The AMT sounding points of the area 3 are plotted on the map in the appendix 1. The strike of the known ore is W-E and that´s why the measurements were performed in E-polarization (i.e. the telluric line parallel to the strike). In some points also H-polarization was used.

The interpretations of the profiles 2250 Ø, 2150 Ø and 1500 N (1400 N) are shown in the Figure 6. The points on the profile 1400 N are plotted at the same picture than the profile 1500 N. In the profiles 2250 Ø and 2150 Ø there are conductors at the level 200 ··· -100 meters. In the profile 1200 N of the area 1 there were conductors at 2000 N ... 3000 N. These belong probably to the same conducting zone than the conductors on the profiles 2250 Ø and 2150 Ø. In the profile 1500 N (1400 N) in the points 54-58 there are no conductors, only the resistivity contrast at the level ∿-1100 meters.

5. CONCLUSIONS

As general in the measured areas there is a resistivity contrast at the level -400 ··· -1600 meters. It is difficult to say what is the resistivity under this boundary surface. Only in some points in the areas 1 and 2 was found conductors at a "reasonable" depth.

In the area 3 the AMT method sees the known ore.

It would be interesting to compare AMT interpretations to other geophysical and geological information.

In the AMT interpretations there is an error marginal of 10-20 percent. The interpretations could be done more accurately with curve fitting by computer (Pelkonen, 1977). At least in some interesting points this should be done.

6. REFERENCES

Cagniard, L., 1953: Basic theory of the magnetotelluric method of geophysical prospecting. Geophysics, 18, 605-635.

Berdichevskij, M.N., 1968: Elektriseskaja razvedka metodom magnitotelluritseskogo profilirovanija. Nedra, Moskva, 255 pp.

Fournier, H.G., 1970: Contribution au developpement de la méthode magnetotellurique, notamment en vue de la détermination des structures profondes. Doctor's thesis, parts I, II and III. University of Paris, 122, 136 and 18 pp.

Pelkonen, R., 1977: About the layered model interpretation of magnetotelluric measurements (in Finnish). Graduate thesis, Department of Geophysics, University of Oulu, 76 + 32 pp.

Porstendorfer, G., 1975: Principles of magnetotelluric prospecting, Gebrüder Borntraeger, Horb, 118 pp.

APPENDIX 1

ARNES

AREA 1

AREA 2

AREA 3

E6

STØVELHOLA

Rånelva

Kringelvann

PROFILE 1

PROFILE 2

ARNESHESTEN

STORVATNET

4000 N

3000 N

2000 N

3000 Ø

4000 Ø

AREA 3: PROFILE 2250 Ø

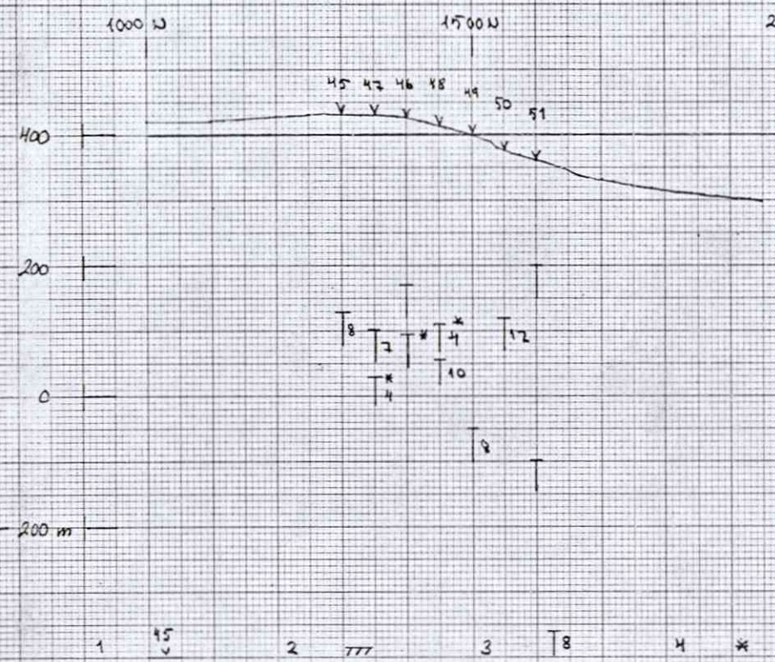


FIGURE 6a. AMT-interpretation of the profile 2250Ø / area 3.
1 = AMT sounding point
2 = resistivity contrast, E-polarization
3 = upper surface of conductor (and its S-value), E-polarization
4 = as 2 and 3, but H-polarization
Scale 1:10000.

AREA 3: PROFILE 2150 Ø

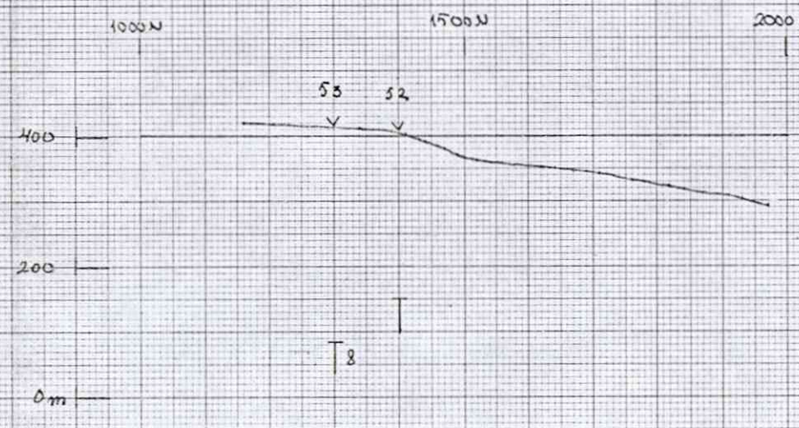


FIGURE 6b. AMT-interpretation of the profile 2150Ø / area 3.
For notations, cf. Figure 6a.
Scale 1:10000.

AREA 3: PROFILE 1500 N, (1400 N)

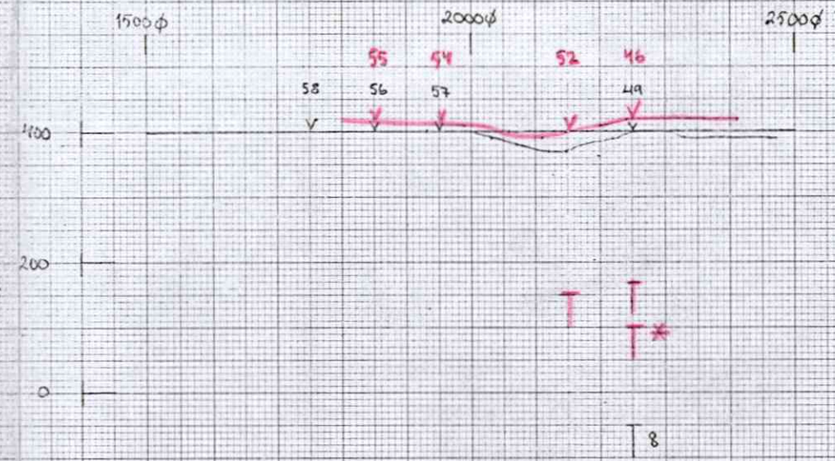


FIGURE 6c. AMT-interpretation of the profile 1500 N, (1400 N) / area 3.
For notations, cf. Figure 6a.
Scale 1:10000.

FABRICATION SUR

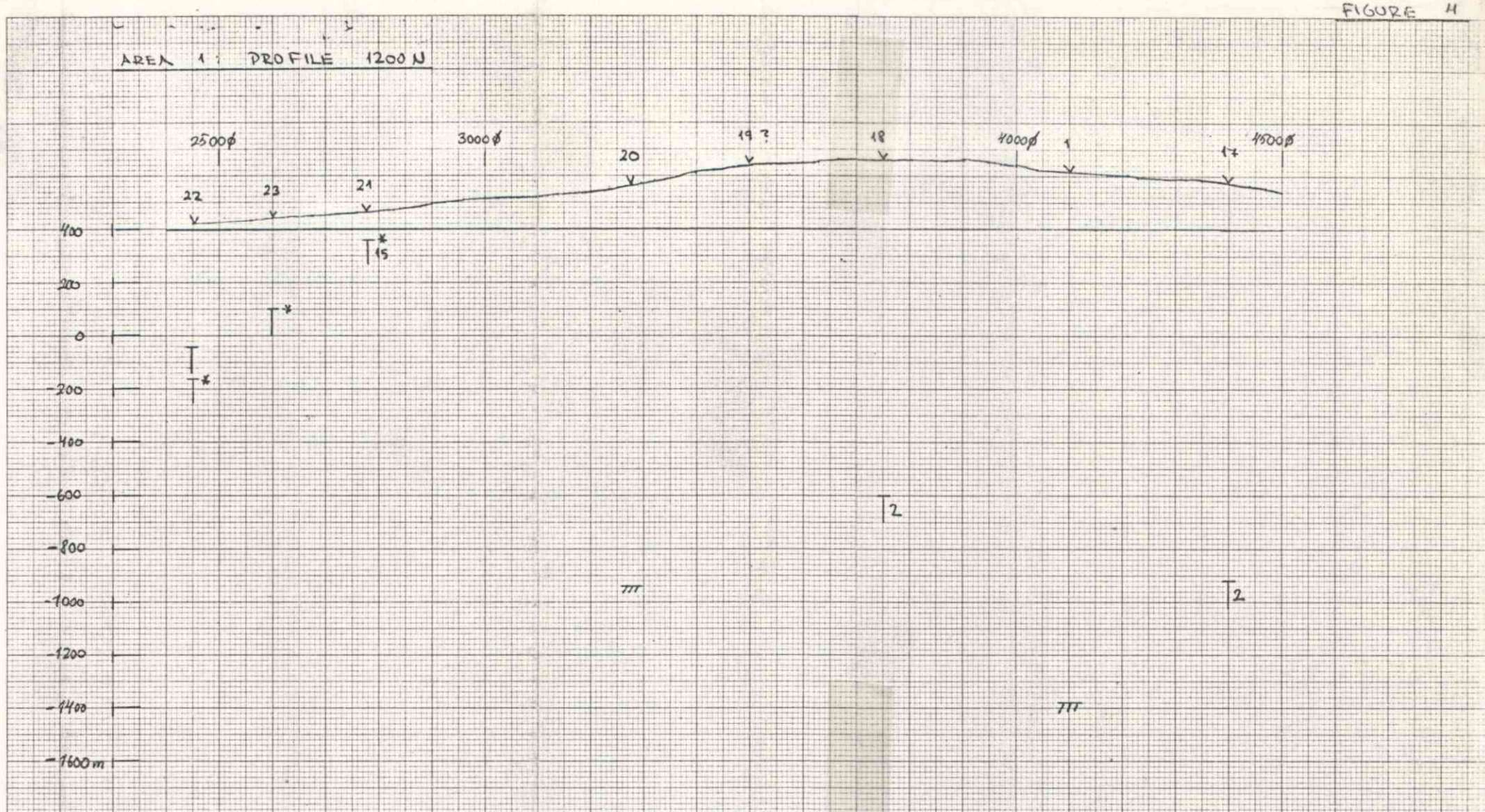


FIGURE 4. AMT - interpretation of the profile 1200 N / area 1
For notations, cf. Figure 2
Horizontal / vertical scale = 1:10000 / 1:20000.

AREA 2: PROFILE 1

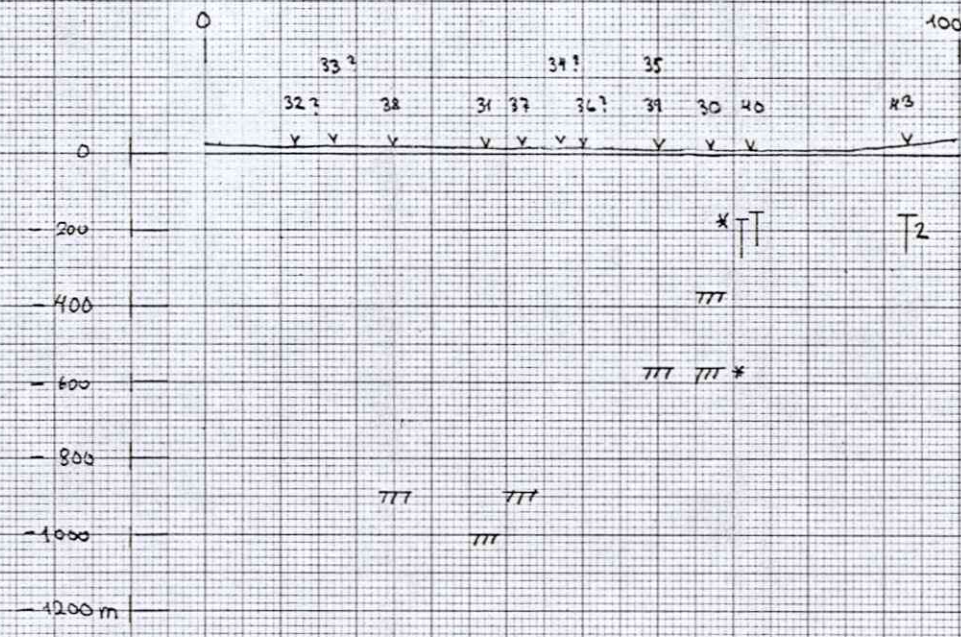


FIGURE 5a. AMT - interpretation of the profile 1 / area 2.
For notations, cf. Figure 2.
Horizontal / vertical scale = 1:10000 / 1:20000

AREA 2: PROFILE 2

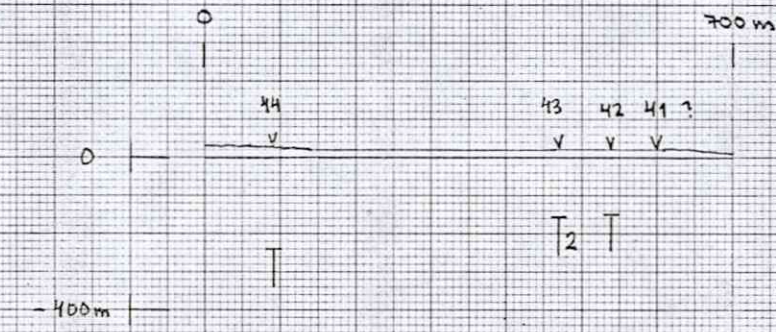


FIGURE 5b. AMT - interpretation of the profile 2 / area 2
For notations, cf. Figure 2
(The telluric line in points 41, 42 and 44 is 135 degrees)
Horizontal / vertical scale = 1:10000 / 1:20000.

AREA 1: PROFILE 2500φ

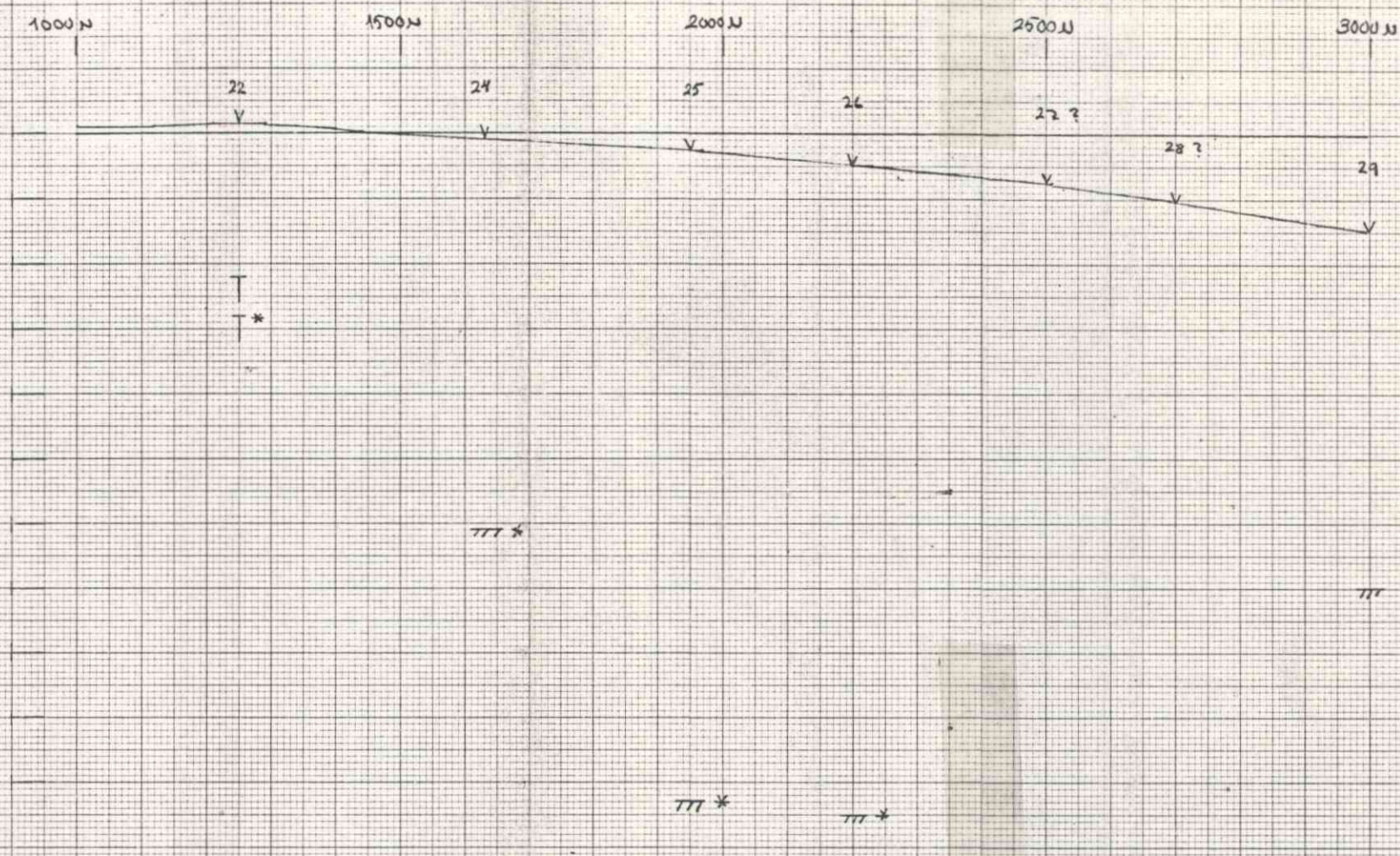
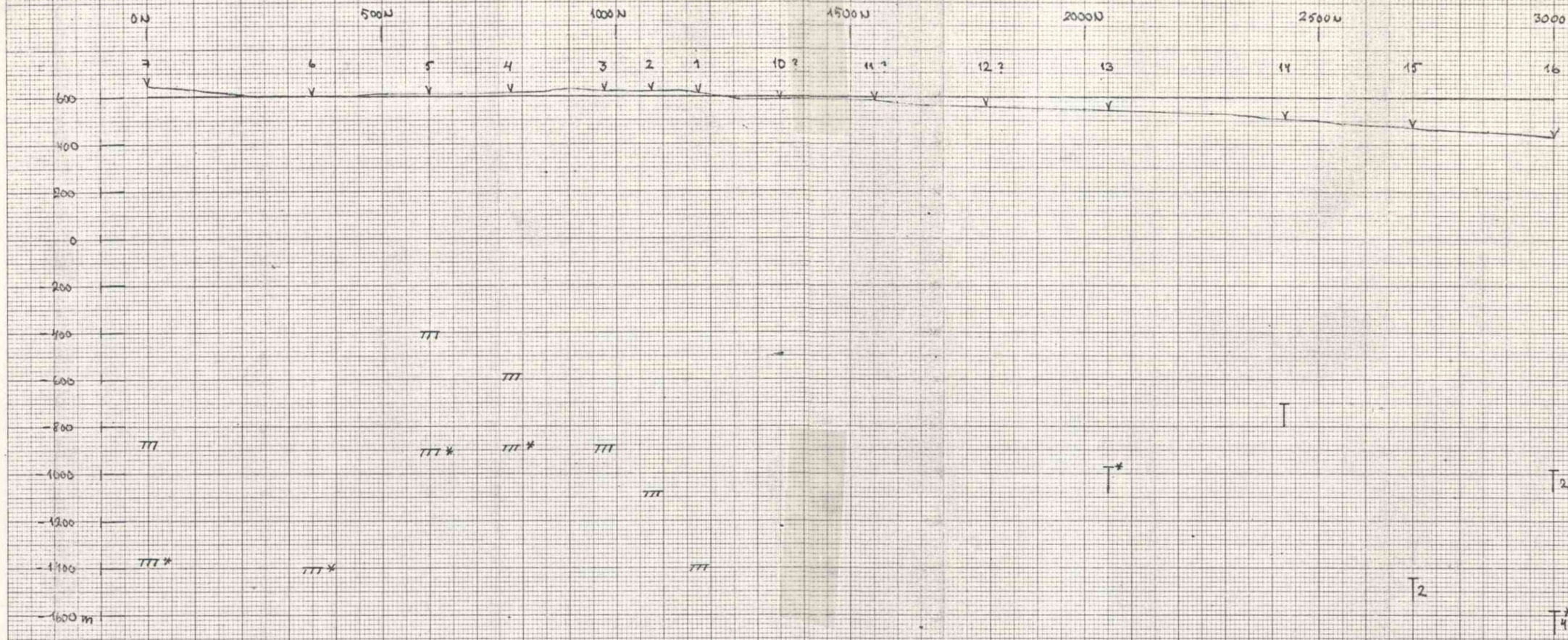


FIGURE 3 ΔMT - interpretation of the profile 2500φ / area 1.
For notations, cf. Figure 2.
Horizontal / vertical scale = 1:10000 / 1:20000.

AREA 1 : PROFILE 4100Φ



1 7 2 3 T2 4

FIGURE 2. AMT - interpretation of the profile 4100Φ / area 1.
1 = AMT sounding point,
2 = resistivity contrast, telluric line N-S,
3 = upper surface of conductor (and its S-value), telluric line N-S,
4 = as 2 and 3, but telluric line W-E
Horizontal / vertical scale = 1:10000 / 1:20000