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1	Report		Magnetic Survey of MDA A, Los Alamos National Laboratory, New Mexico by Kaj M. Johnson (Purdue University) SAGE 1999, Santa Fe, NM N/A N/A N/A		

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Magnetic Survey of MDA A, Los Alamos National Laboratory, New Mexico

Kaj M. Johnson
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SAGE 1999
Sante Fe, NM

Introduction

This magnetic survey is a major component of a larger environmental geophysical study of the Materials Disposal Area A (MDA A) at Los Alamos National Laboratories, New Mexico. MDA A was actively used for waste disposal from 1945 to 1949 and again from 1969 to 1977 and was decommissioned in May 1978 (RFI Work Plan, 1991).

MDA A is a 5000 m^2 fenced area as shown in Fig. 1. The site is believed to contain two underground tanks in the western end (Fig. 2.) referred to as the General's Tanks. The tanks are ~50,000 gallon steel tanks about 4 m in diameter and 19 m in length. They were designed to hold solution containing plutonium. The plutonium has never been completely recovered from the tanks. A large disposal pit the extends from the southern to northern fence is located in the center of MDA A and was designed to hold debris from demolition work. The contents of the pit are not well known. Two long, narrow pits lie in the eastern end of MDAA (Fig. 2). The pits are believed to contain "laboratory equipment, building construction material, paper, rubber gloves, filters from air cleaning systems, and contaminated toxic chemicals" (Meyer, 1952, quote taken from RFI Work Plan).

The purpose of the geophysical study of MDA A was two fold: 1. To use non-invasive techniques to obtain subsurface information about the location of buried containers that may or may not contain contaminents, and 2. To use refraction seismic lines to locate a possible paleochannel near MDA A that may surve as a conduit for leaked contaminents from MDA A. The non-invasive methods used include seismic refraction, ground penetrating radar (GPR), electrical resistivity surveys, and magnetic surveys. This paper focuses on the results and interpretations of the magnetic surveys.

Method

For the magnetic survey we used a cesium-vapor total field magnetometer (Geometrics) and recorded 141 lines of data covering most of the 5,000 m^2 area of MDA A (Fig. 3). We also recorded 15 lines of data covering a 110 by 75 m area just to the north of MDA A. The lines inside MDA A ran from the southern fence line perpendicular to the northern fence line at 1 meter spacings. The 15 lines outside of MDA A were also perpendicular to the northern fence but at 5 m spacings. The data from both areas were gridded and contoured in Matlab. No corrections were applied to the data. We did not correct for diurnal effects as we did not have available a base station required for this correction. Also, we did not apply a latitude correction because the survey area is quite small. All of the contoured data are shown in Fig. 3. We will provide more detailed maps of the data near the General's Tanks, the central pit, the eastern pits, and the area outside of MDA A.

Basic magnetics

A quick summary of the main concepts of magnetic data analysis is provided here. The total field magnetometer measures only the component of the local magnetic field that is in the direction of the earth's inducing magnetic field (dec. 13^0, inc. 60^0 for Santa Fe). An anomaly produced by an induced monopole or dipole is shown in Fig. 4A&B. Notice that it is not possible to distinguish between a monopole and dipole with the shown magnetic fields. Fig. 4C,D and E show the anomalies over a sphere, vertical sheet and wide rectangular body respectively. These are the essential anomaly shapes needed in the following analysis.

The depth to the buried object can be approximated with a graphical method. In Fig. 4F, measure the horizontal extent (d) of the approximately linear segment of the curve and this provides the depth to the object to within ±20%. This crude approximation is used in the following analyses to obtain a rough idea of the depths to buried objects.

Results

We will discuss the results of the magnetic survey at four locations: the General's Tanks, the central disposal pit, the eastern pits, and the area outside of MDA A.

General's Tanks

An enlargement of the magnetic anomaly contour map near the General's Tanks is provided in Fig. 5. Notice the large anomalies ranging from ~16000 nT to ~-4000 nT. A north-south profile through the western most anomaly is shown in Fig. 6. The anomalies have wavelengths on the order of ¾ the width of MDA A and are large and positive in the south and smaller and negative in the north. The anomalies are characteristic of the anomaly doublets shown in Fig. 4A&B that are formed over a small buried body.

The size of the anomaly is not surprising given that the anomaly is near the steel General's Tanks that may have large magnetic susceptibilities. What is surprising is the shape of the anomaly given the geometry of the tanks as provided by the RFI work plan. We modeled the anomaly for a buried rectangular prism with the dimensions of the General's Tanks using a 3-D magnetic modeling program, magmod (Fortran code by George Jiracek). We buried the prism 4 meters and assigned a large susceptibility

contrast of 8 in S.I. units (a typical susceptibility contrast in sedimentary rocks .025). The modeled anomaly is shown in Fig. 7. Notice that this modeled anomaly does not very well match the measured anomaly over the General's Tanks in Fig. 6. This disagreement suggests that the either the measured anomaly is not an expression of the General's Tanks or the dimensions of the tanks are not as believed. The measured anomaly in Fig. 6 is more typical of an anomaly obtained over a narrow object such as a buried sphere or thin dike.

Central pits

The magnetic anomalies in the central pit can be seen in Fig. 8. We have labeled three large anomalies and the approximate boundaries of the pit. Each anomaly is trending west of the magnetic declination (N13E) suggesting that each of the bodies creating the anomalies show remnant magnetization. Anomaly one trends about N10W, anomaly two about N-S, and anomaly three trends about N5W. Fig. 9 is a profile through anomalies one and two. Anomaly two is characteristic of an anomaly over a thin object such as a buried sphere or vertical sheet (Fig. 4). With the rough graphical method, we estimate the object to be 3-4 m deep (Fig. 9). Anomaly one is characteristic of an anomaly over a wide or tabular prism. The approximate outline (estimated quantitatively, not modeled) of the object is sketched in Fig. 8. The object creating anomaly three is also probably a thin body such as below anomaly two. We did not create profile in order to determine the depth to the object.

Eastern pits

Figure 10 is a map of the magnetic anomalies in the region of MDA A that is believed to contain the long, narrow eastern pits which trend roughly parallel to the north

and south fences. Figure 10 shows two linear anomaly trends (red) that correspond roughly with the proposed location of the eastern pits. Figure 11 is a profile through this region. The profile shows the low amplitude of the anomalies corresponding with the pits. If the anomalies are due to buried objects, then we can estimate the anomaly is about 1-2 meters deep. However, because of the relatively low amplitude of the anomalies, it is quite likely that we are observing a (susceptible) contrast with the filled material inside the pits and the host soil/rock surrounding the pits. Because of the low amplitude anomaly, we will suggest that there are no large metallic objects buried in the eastern pits.

Paleo-channel

Figure 12 is a magnetic contour map of part of the area outside of MDA A (Fig. 1), and Fig. 13 is a profile through this area along seismic line #8 (Fig. 3). Figure 13 shows an anomaly characteristic of a wide rectangular prism or tabular sheet with a fairly small amplitude of about 100 nT. The small amplitude suggests that the susceptibility contrast is quite small. This anomaly corresponds very well with a paleo-channel that was modeled with the seismic refraction data along line 8 shown in Fig. 14. The thin low velocity layer is Quaternary colluvium and disturbed fill. The higher velocity material below the colluvium is the Bandelier tuff. If the anomaly were due to the paleo-channel then this would require that the channel fill have a slightly higher susceptibility than the surrounding Bandelier tuff. It is possible that some volcanic clasts were deposited within the paleo-channel to give the higher susceptibility. It is not conclusive, however, that the anomaly reflects a paleo-channel. The anomaly occurs very near the edge of a paved road that is roughly parallel to the northern fence of MDA A. The anomaly could therefore correspond to pipes near the road, debris from the construction of the road, etc.

Conclusions

We were able to locate many magnetic anomalies inside and outside of MDA A. A large anomaly corresponds quite closely with the proposed General's Tanks in the western end of MDA A. However, we did not see the expected anomaly for steel tanks of the dimensions of the General's Tanks suggesting that there are other highly magnetic objects in these locations, or the General's Tanks are not the size that they are believed to be, or that the General's Tanks have highly corroded to give an unexpected anomaly shape. We found several large anomalies within the central pit suggesting that there are several large metallic objects buried here. We found small amplitude anomalies that correspond well with the location of the eastern pits. The small anomalies suggest that there are no major metallic objects buried in these pits. Finally, we may have located a paleo-channel, with an anomaly in the magnetic data, outside of MDA A that runs roughly parallel to the northern fence. The location of this anomaly corresponds with the location of the paleo-channel in the refraction data on line 8. The shape of the anomaly is also appropriate for the shape of the paleo-channel.

A more complete study of MDA A would require integration of other geophysical techniques with the magnetic data. We did not obtain any seismic data inside of MDA A. Refraction and reflection data here would help us constrain the location and dimensions of the buried objects that give magnetic anomalies. We are not able to resolve the dimensions of the objects with only magnetic data. Furthermore, with seismic data we may be able to locate other objects that do not have large susceptibility contrasts and therefore are not detected with the magnetometer.

Acknowledgements

I would like to thank my fellow ER group members at SAGE99: Greg Young, Mike Martin, Mike Quesada and advisor John Fergusson. I appreciate the hard work of each group member (especially Mike Q. who spent at least one sleepless night trying to model the difficult refraction data). This was perhaps the most efficient and pleasant group I have worked with. I would also like to thank Dayanthie, Eve, Gail, and Mike M. for their friendship throughout this three week ordeal. It was a lot of fun!

References

Breiner, S., 1973. Applications manual for portable magnetometers. Geometrics. Sunnyvale, California.

TA-21 Operable Unit RFI Work Plan ofr ER, 1991. (I was not able to obtain a more complete reference)

Fig. 1. Location map of environmental sites MDA T and MDA A on DP Mesa. Refraction lines in red. GPR lines labeled GPR. Ohm mapper lines labeled OM. Blue box north of MDA A indicates location of magnetic data outside of MDA A.

Fig.2 General base map of MDA A showing locations of General's Tanks, Central pit, and eastern pits. (Taken from RFI Work Plan)

Fig. 3. Magnetic contur map inside and outside MDA A. Coordinates or New Mexico Plane State coordinates.

Fig. 4 A an B. Anomaly doublets. C, D and E. Anomalies over a buried sphere, vertical sheet and rectangular prism. F. Illustration of graphical method for approximating depth to buried object.

Fig. 5. Magnetic anomalies near General's Tanks. Coordinates or New Mexico Plane State coordinates.

Fig. 6. Profile of Fig. 5. Profile line indicated on Fig. 5

Fig. 7. Modeled profile of a 20x4x4 meter rectangular prism buried 4 meters.

Fig. 8. Magnetic anomalies in central pit. Coordinates or New Mexico Plane State coordinates.

Fig. 9. Profile of central pit. Line of profile indicated in Fig. 8.

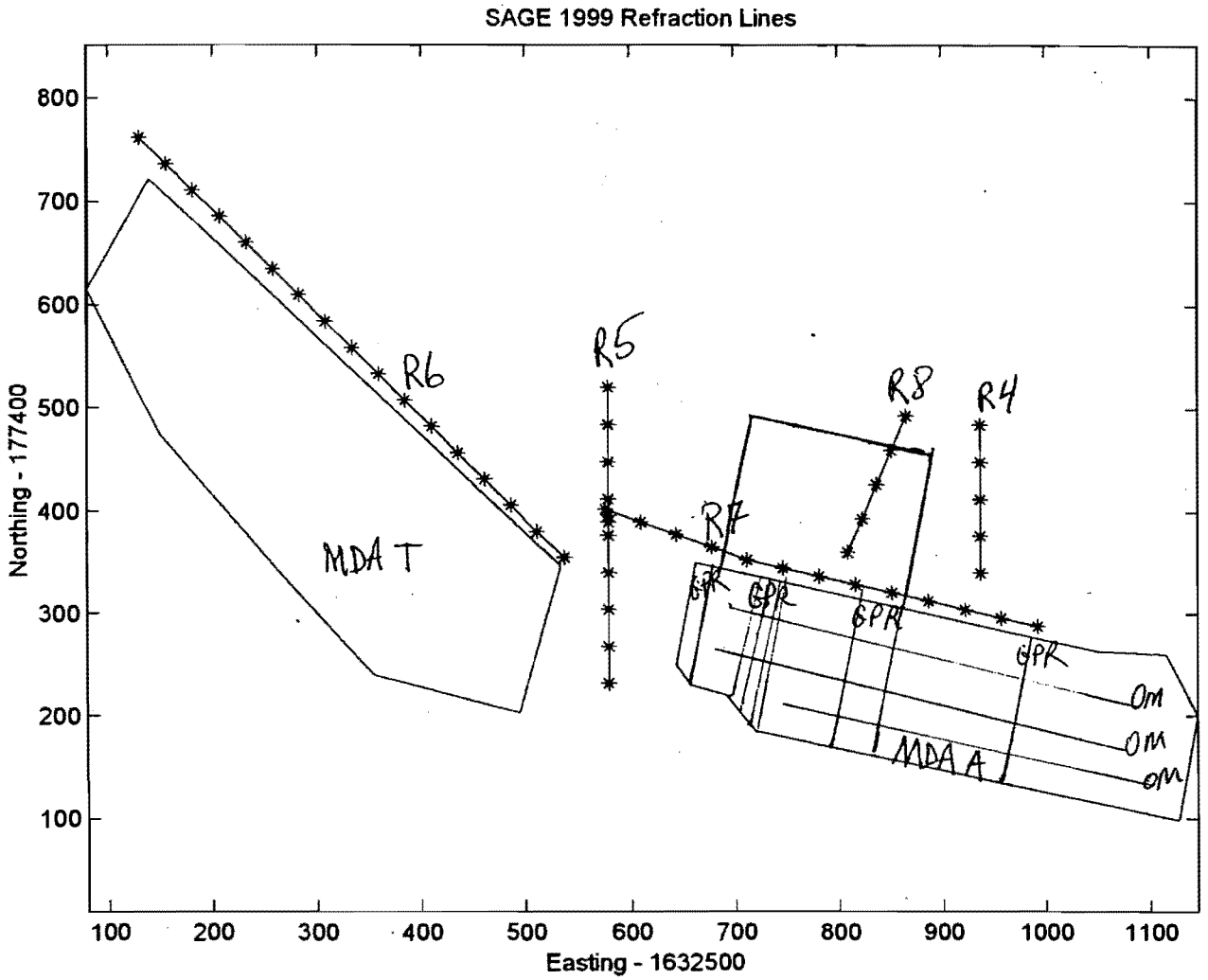
Fig. 10. Fig. 8. Magnetic anomalies near eastern pits. Coordinates or New Mexico Plane State coordinates.

Fig. 11. Profile through eastern pits. Line of profile indicated in Fig. 10

Fig. 12. Magnetic anomalies outside of MDA A. Coordinates or New Mexico Plane State coordinates.

Fig. 13. Profile through possible paleo-channel. Line of profile indicated in Fig. 12.

Fig. 14. Model of refraction data on line 8 (Fig. 1). Paleo-channel correlates with moderate magnetic anomaly in Figs. 12 and 13.



GPR - GPR line
OM - Ohm Mapper line
R# - refraction line and number

Fig 1.

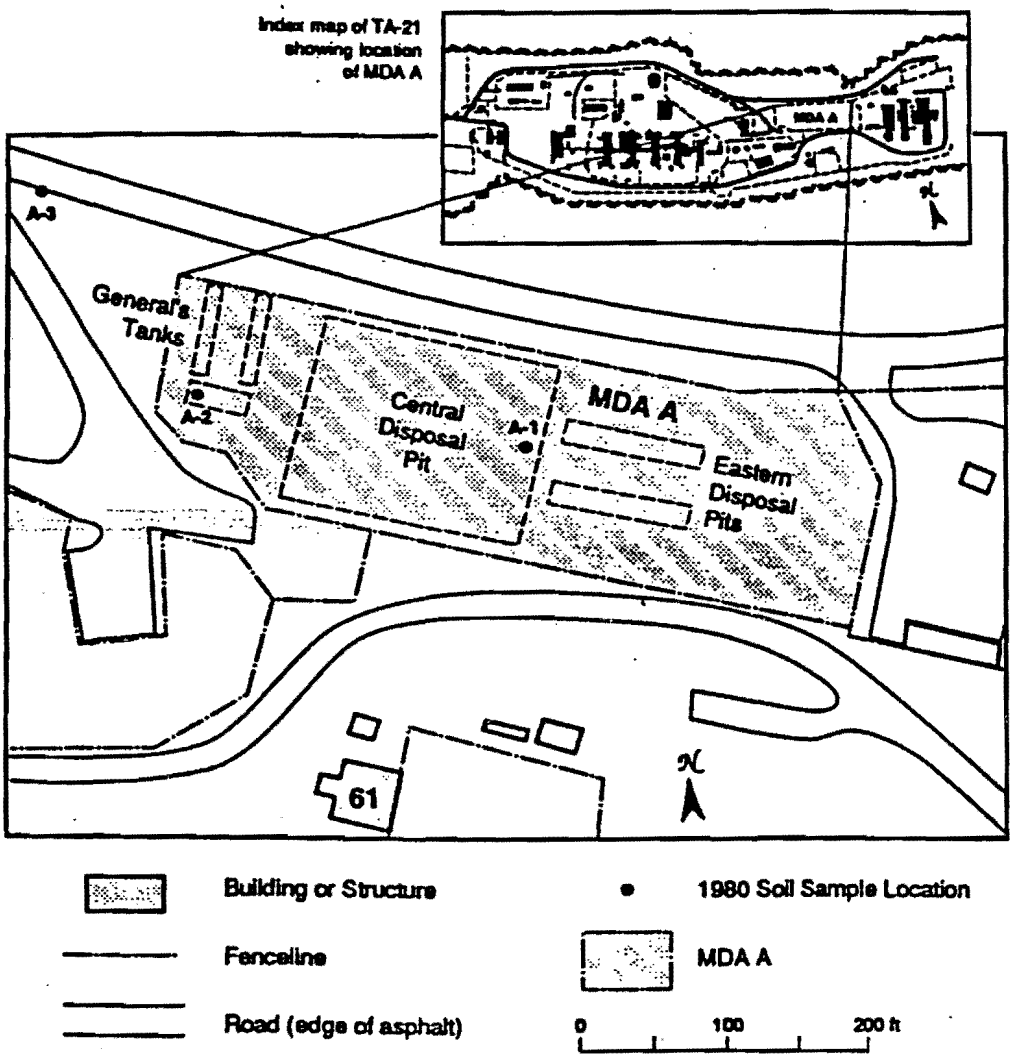
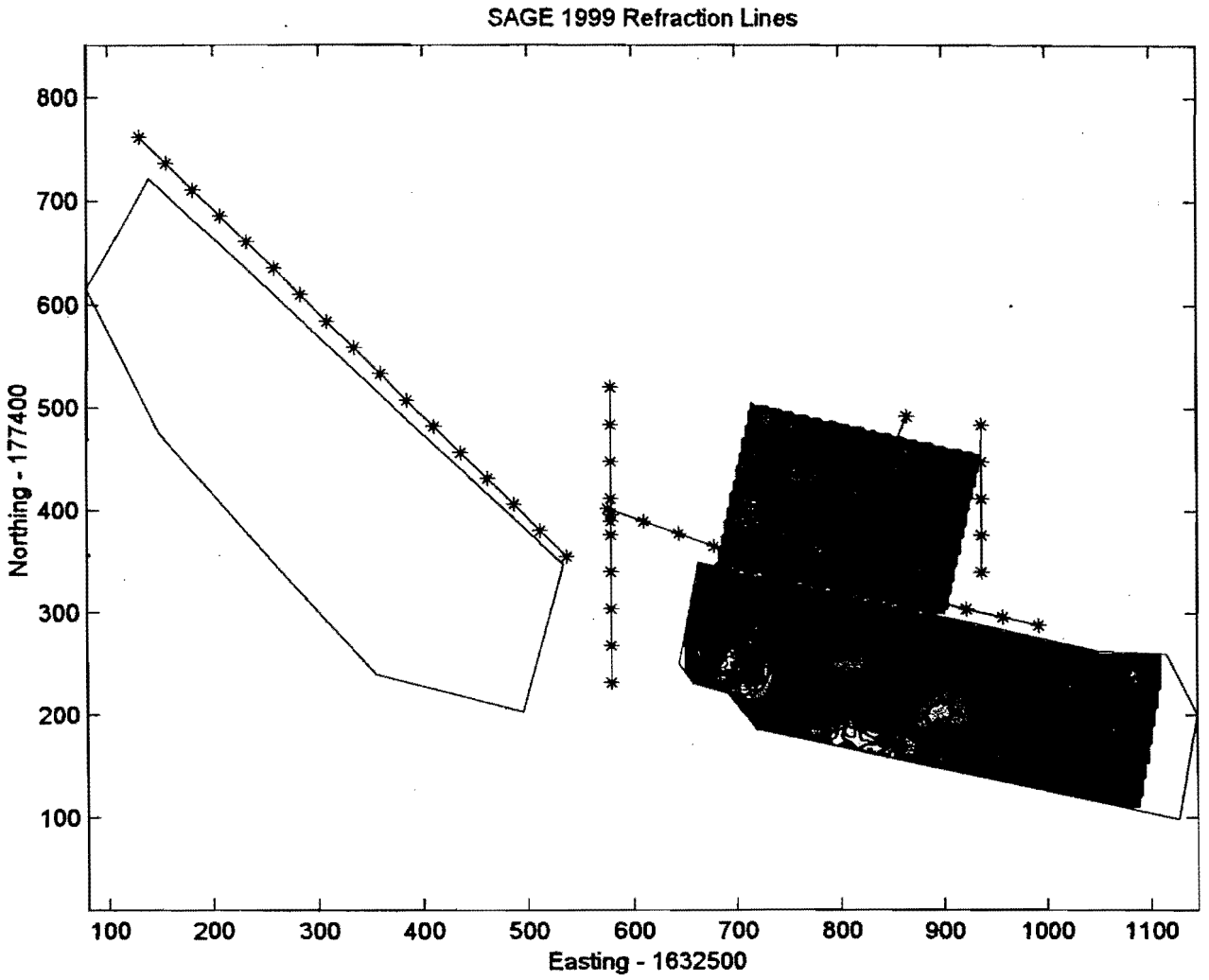


Fig. 16.8-1 General base map of MDA A showing location of 1980 soil samples.

Fig. 2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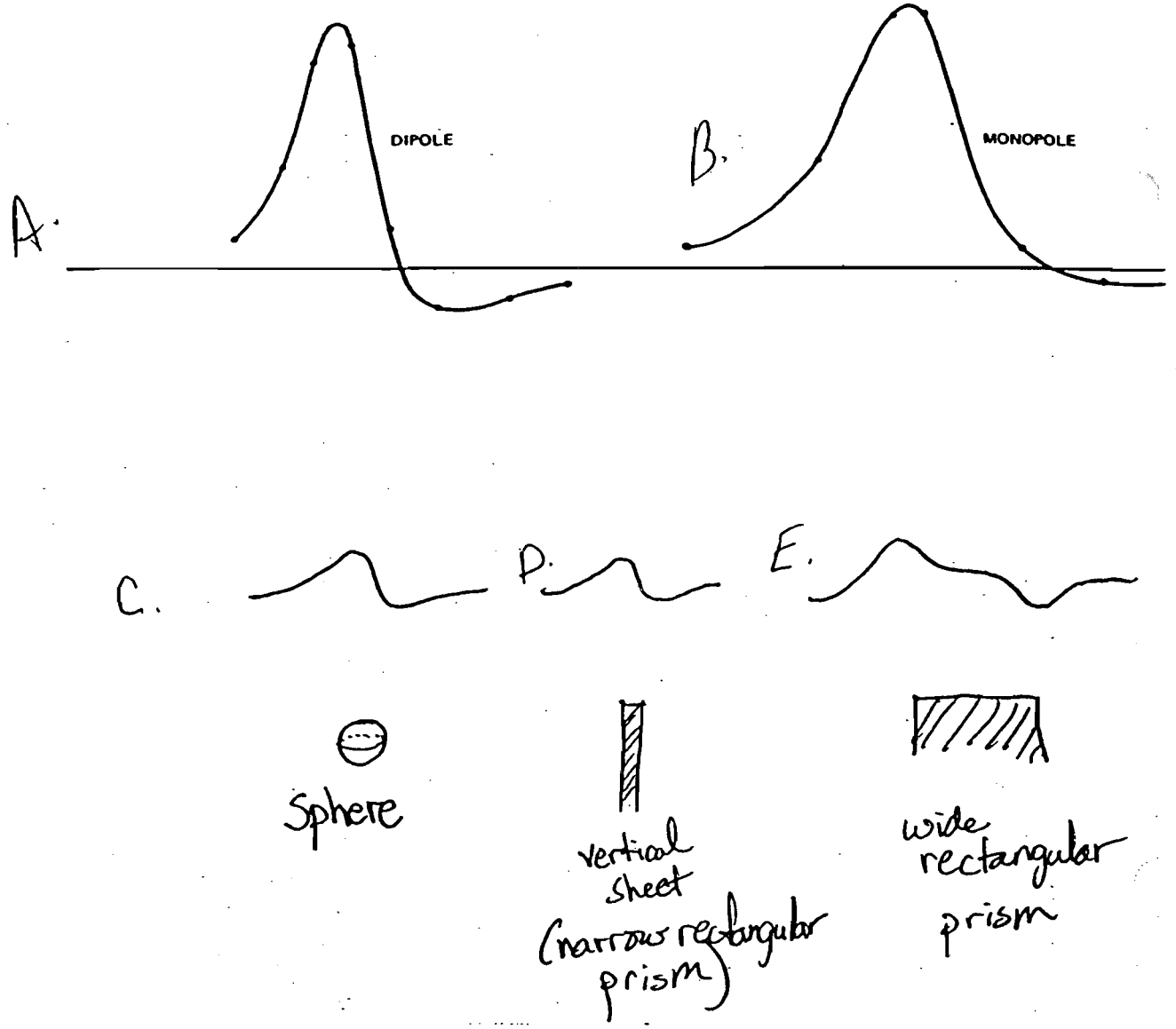
800
900
1000
1100

Fig. 3


A.
DIPOLE
B.
MONOPOLE
C.
D.
E.
Sphere
vertical sheet (narrow rectangular prism)
wide rectangular prism

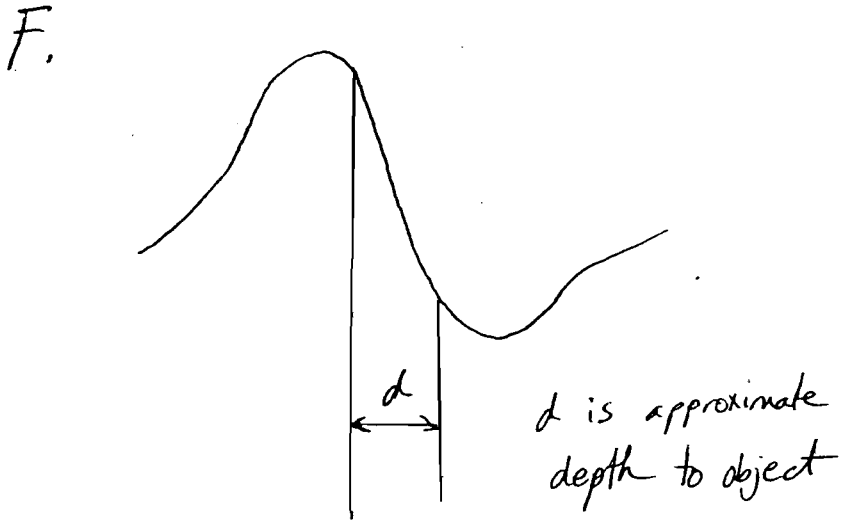

F.
d
d is approximate depth to object

Fig. 4

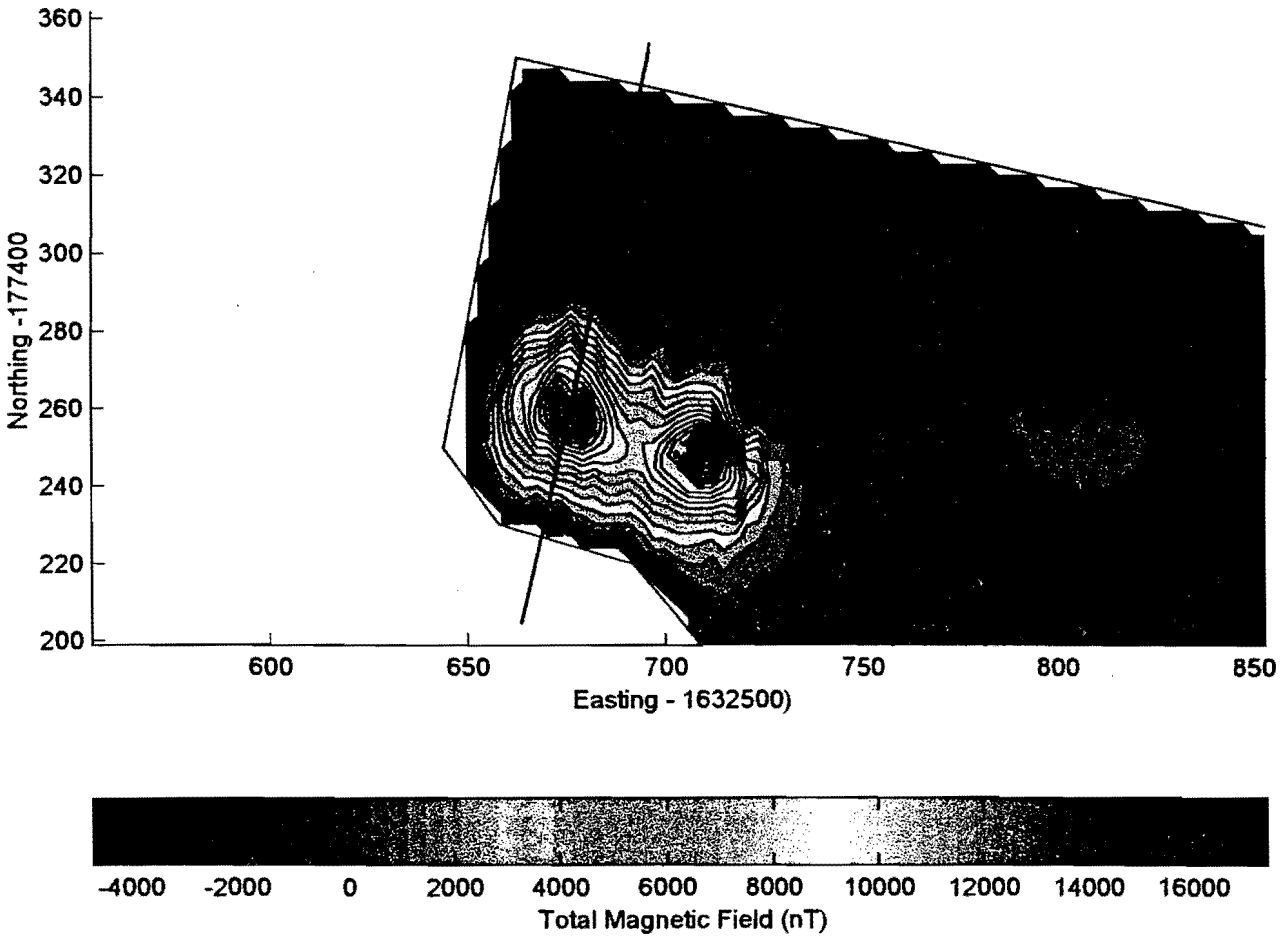

360
340
320
300
280
260
240
220
200
Northing -177400
600
650
700
750
800
850
Easting - 1632500)
-4000
-2000
0
2000
4000
6000
8000
10000
12000
14000
16000
Total Magnetic Field (nT)

Fig. 5

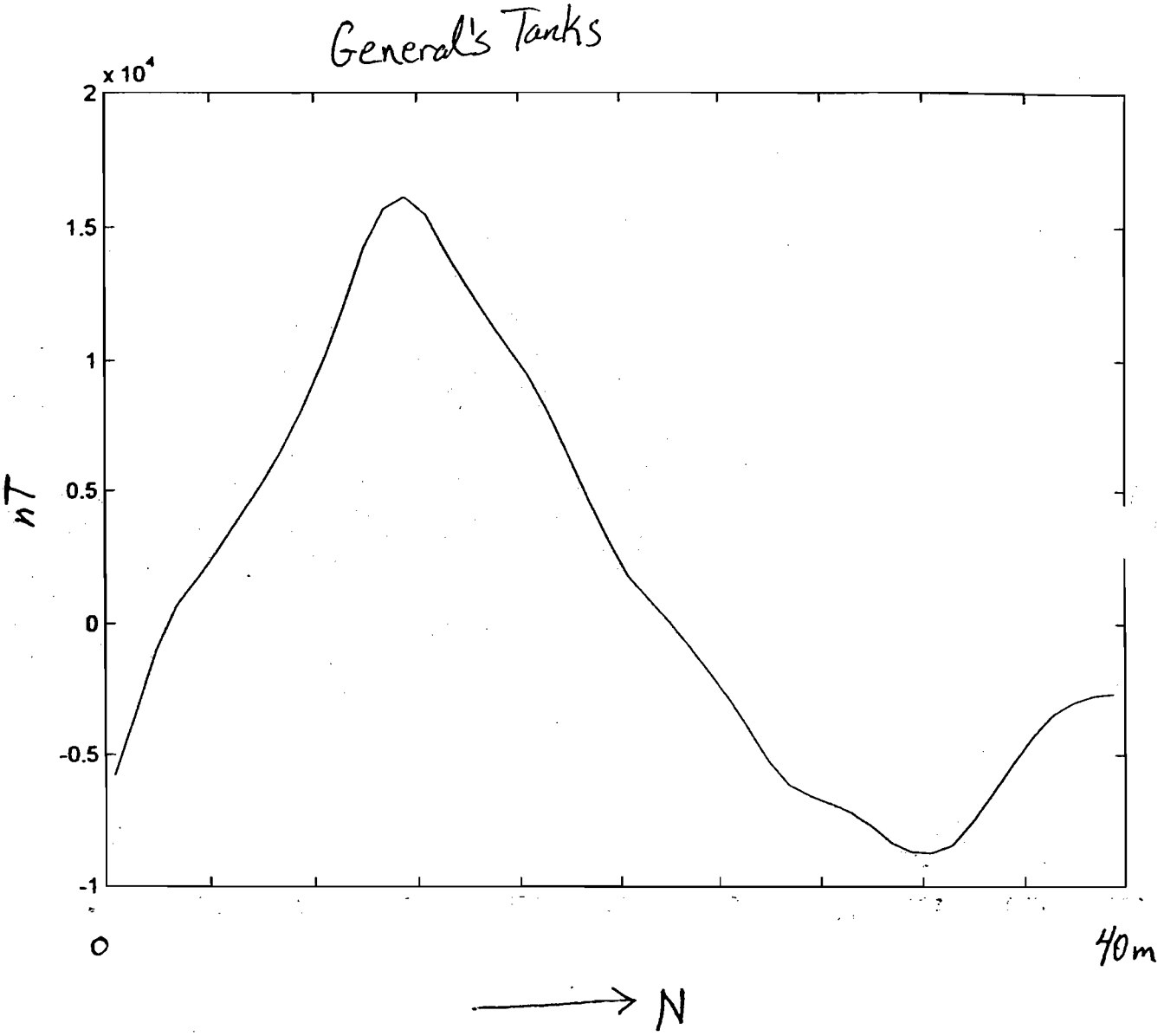


Fig. 6

Profile - buried prism (20x4x4)

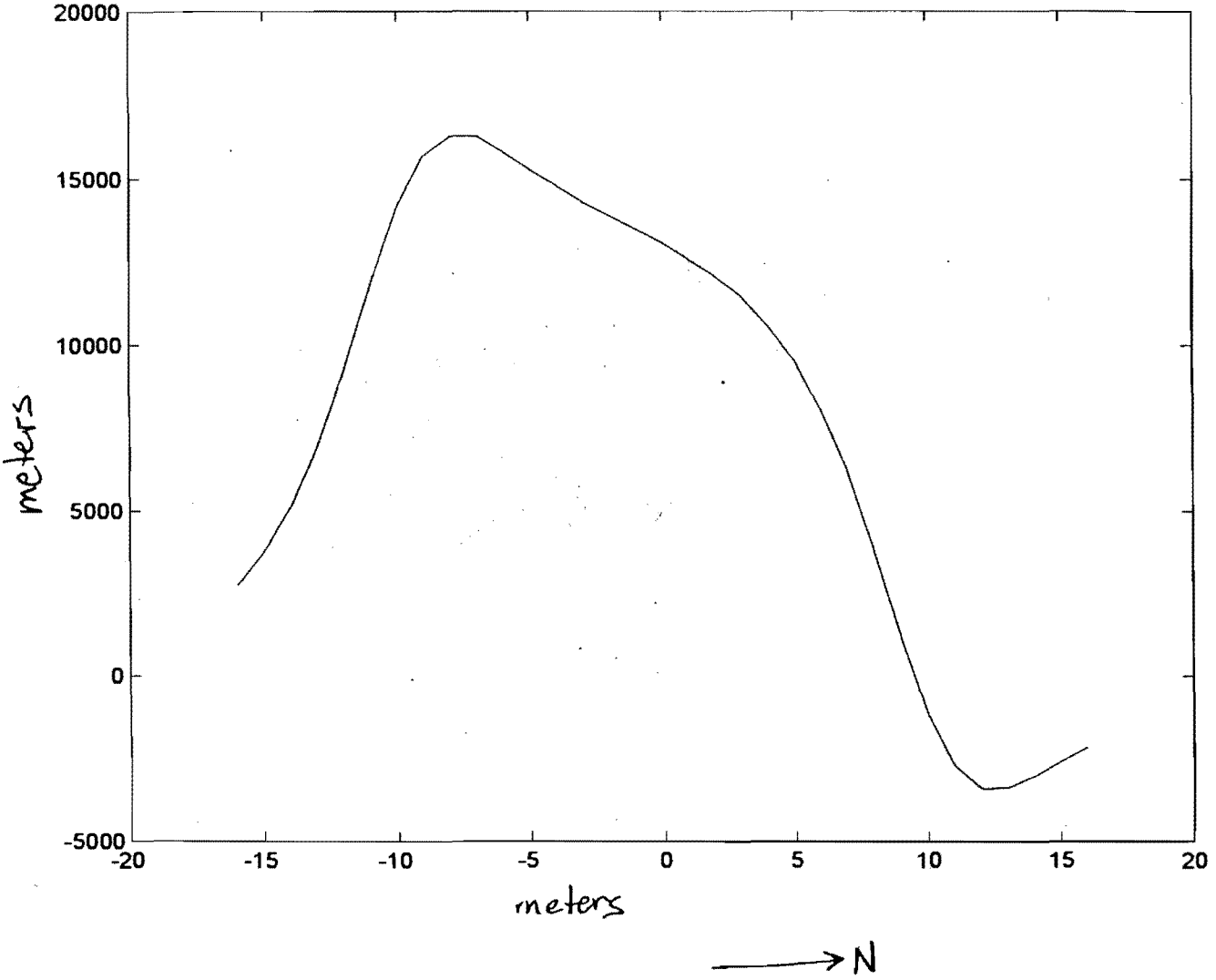
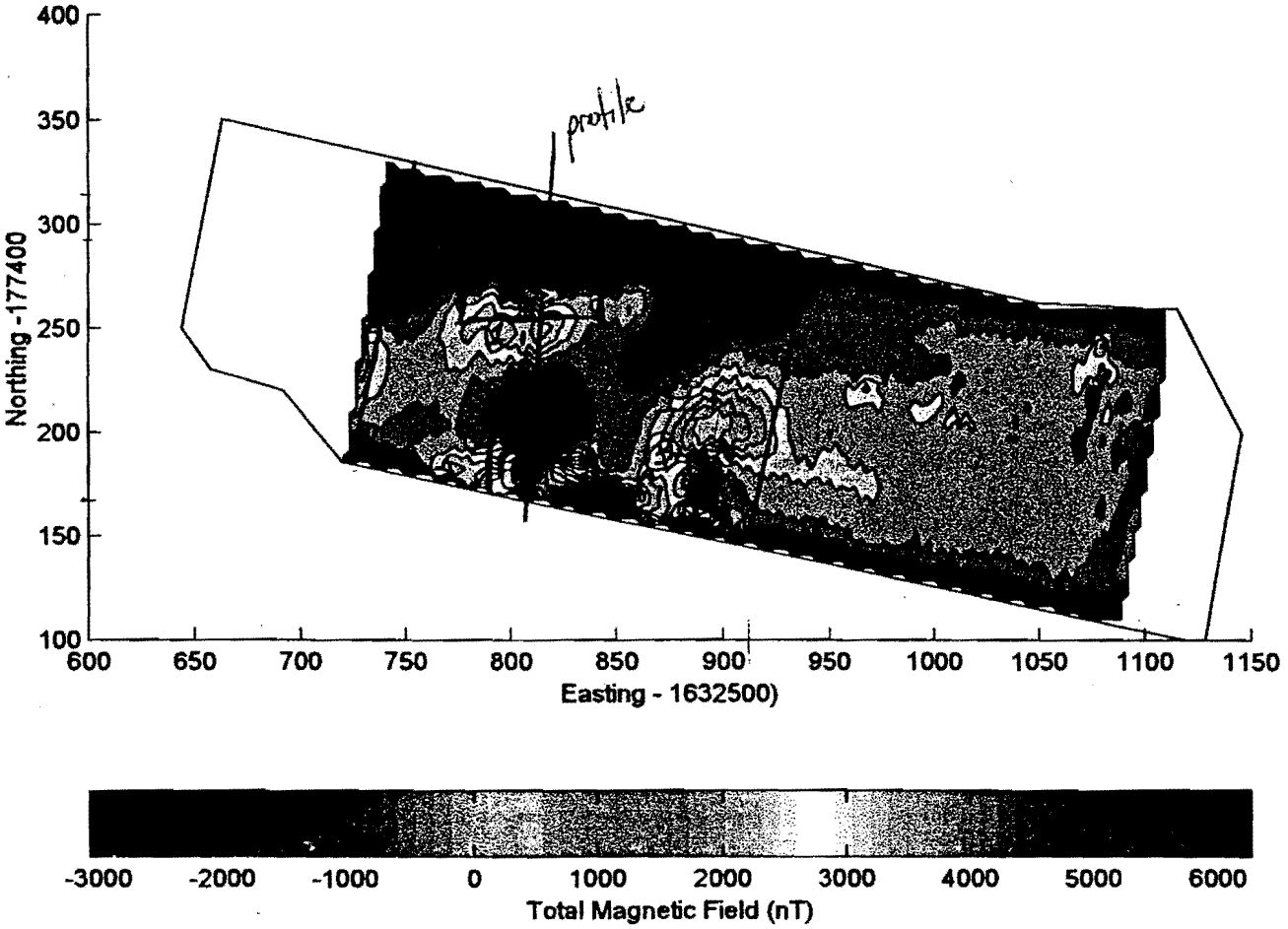


Fig. 7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300
250
200
150
100
600
650
700
750
800
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900
950
1000
1050
1100
1150
Easting - 1632500)
-3000
-2000
-1000
0
1000
2000
3000
4000
5000
6000
Total Magnetic Field (nT)

Fig. 8

a2

Central Pit

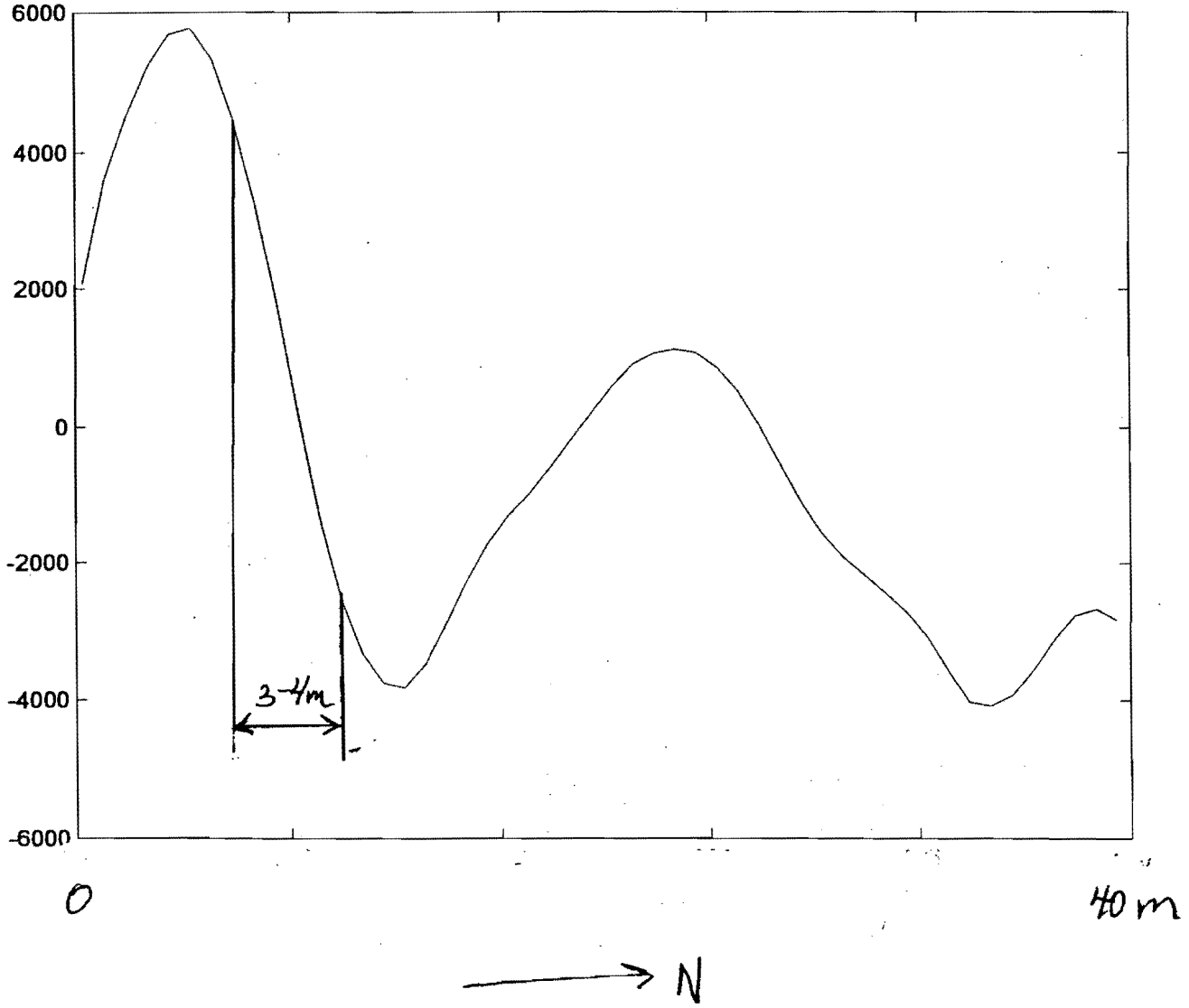


Fig 9

magmapa2

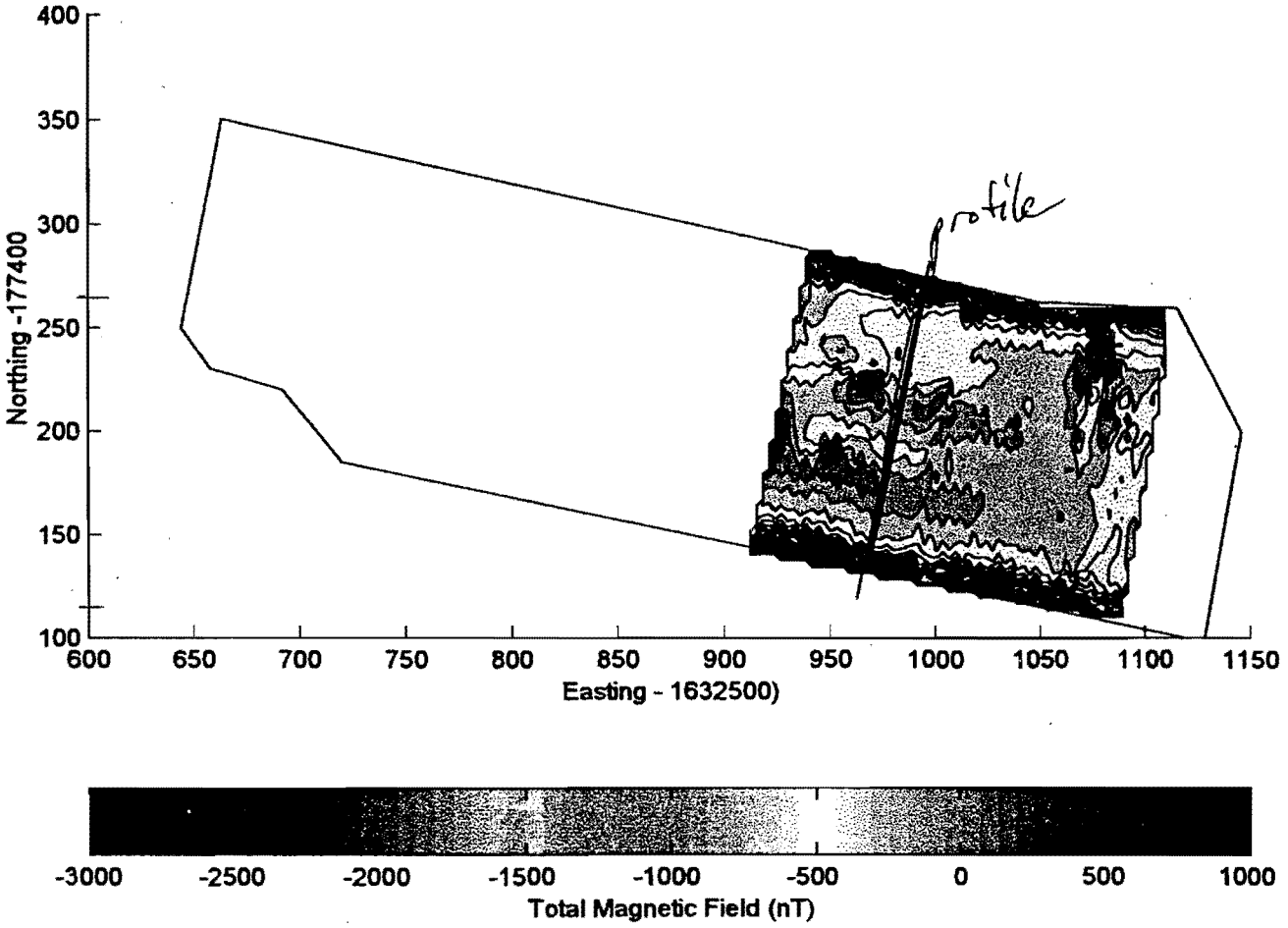


Fig 10

Eastern Pits

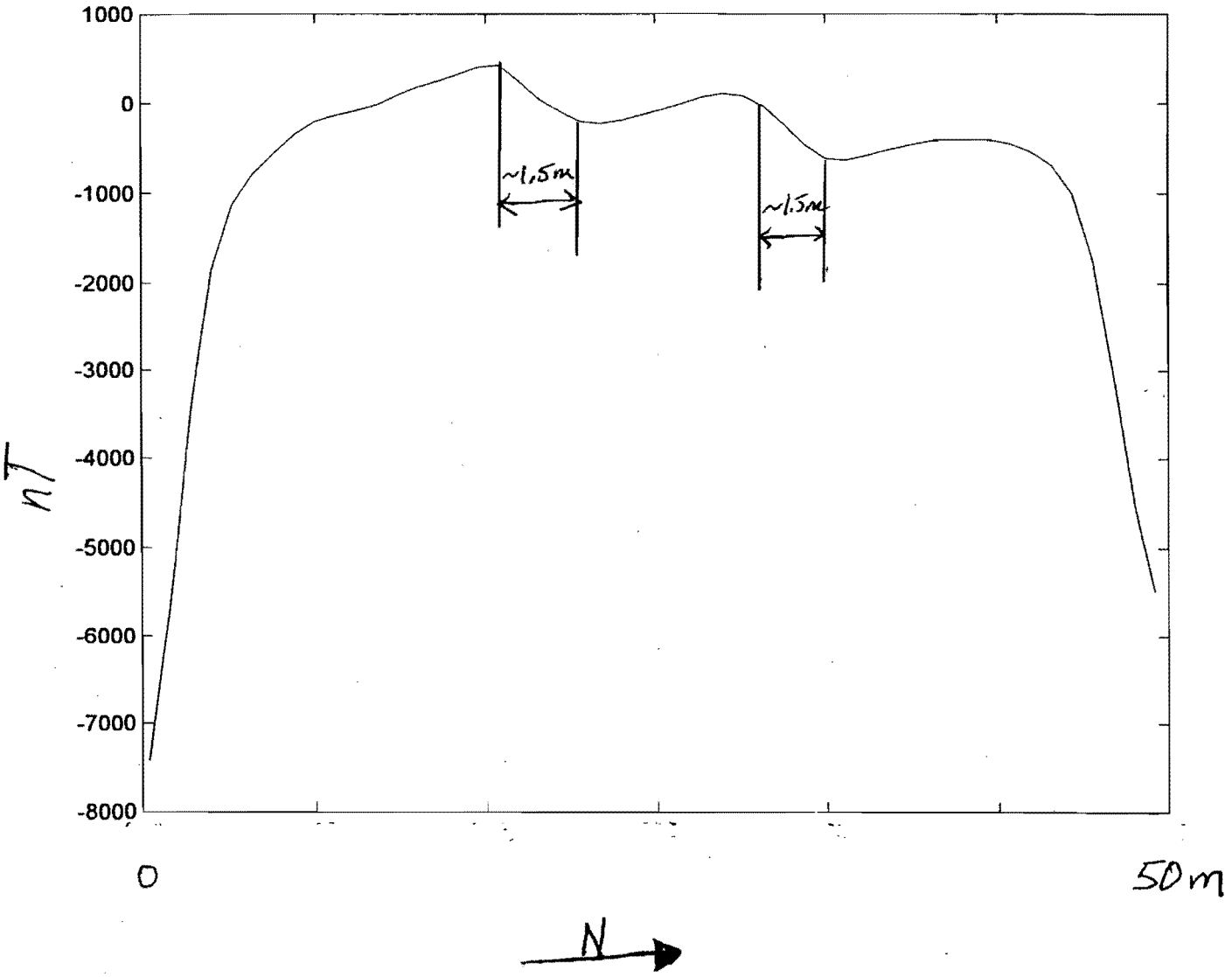


Fig. 11

magmap02

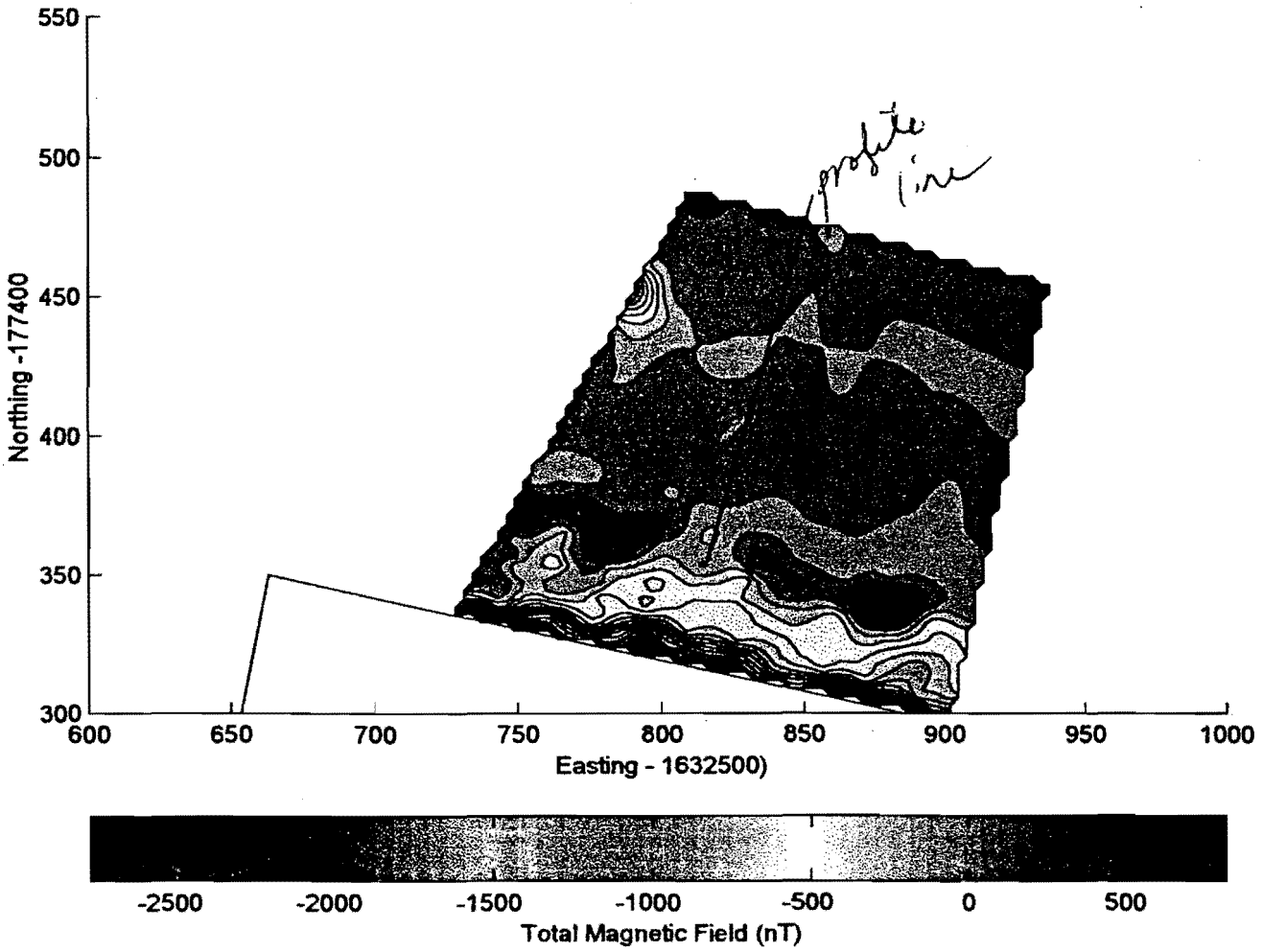
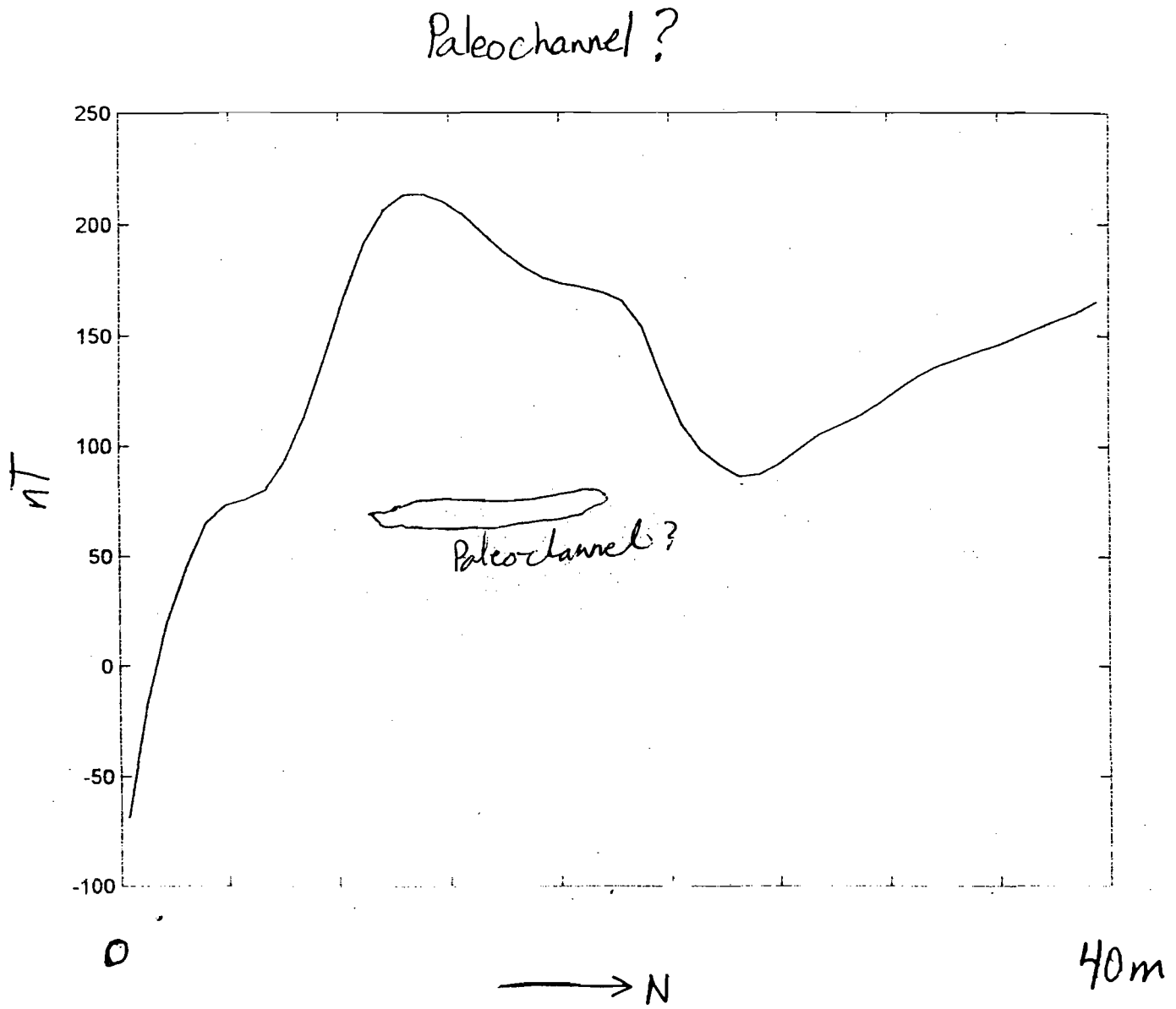


Fig. 12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100
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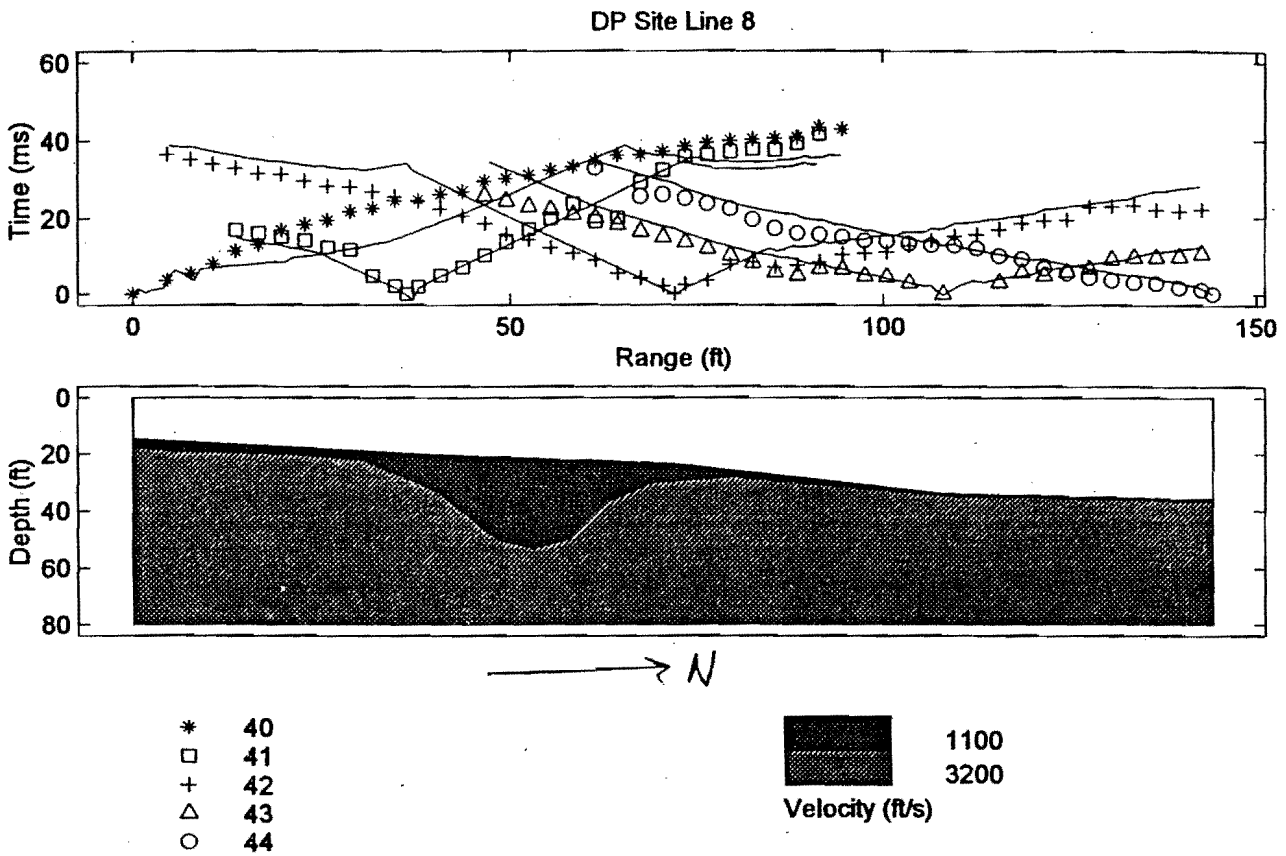
-100
nT
Paleochannel ?
0
40m
N

Fig. 13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50
100
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Range (ft)
Depth (ft)
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40
60
80
N
40
41
42
43
44
1100
3200
Velocity (ft/s)

Fig. 14