APPENDIX E

RADAR SURVEY OF THE DAWSON SITE

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A Ground-Penetrating Radar Survey at the Dawson House Site

The major findings of this survey are summarized in Figure 2; this figure can be compared to the features which are at the surface in Figure 1.

An earlier excavation at E50 N50 revealed a remanent of an 18th century house; the radar suggested that the feature could extend to the area marked with a dotted pattern in Figure 2. A more recent excavation has found the foundation of another house which stood in the area during this century; the radar also suggested the extent of that house, and it is marked by a hachure pattern in Figure 2. Two linear features were found 25 m to the east of that modern house; it is possible that these are filled ditches.

The Site

The Dawson House site is located on the southern side of Dover, Delaware. A modification of the nearby highways is planned by the Delaware Department of Transportation, and the goal of this survey has been one of assisting the archaeological evaluation of the area.

Historical evidence has indicated that the 18th-century Dawson House was on this site, and prior archaeological excavations have revealed a feature which may be a remanent of that house. Wells and a brewery are also possible in this area.

The site is located immediately east of US highway 13. It is on a rise in the land, and there is a dropoff of over 3 m at the west side of the site where a cut has been made for the highway. The total relief in the area of survey is about 2 m, and the highest point in the area is in the vicinity of E50 N50.

The surface is covered by grass and weeds. The soil has been churned up by groundhogs or other large rodents at the southern side of the area; this is marked in Figure 1. Outside that area, the vegetation has been mown and it may be as low as about 15 cm; no mowing has been done in the rodent area and the vegetation is taller there. There are no trees in the area. The soil appears to be quite sandy and there is no rock in the vicinity.

There are no heavy industries, transmitting antennas, or electrified railroads in the vicinity. There is a low voltage power line on the west side, and this is located in Figure 1 with a broken line. A water-monitoring well is on the east side of the area; this is cased with a plastic pipe.

Excavations were on-going during this geophysical survey. These

tests were 1 m square and placed at 10 m intervals at the site. Figure 1 locates some of these excavations; during this geophysical survey, excavations were being done along line E70 and another line. The black squares indicate where the excavations had been refilled at the time of this survey; the other squares show excavations which had not yet been completed or filled.

The field excavations at the site are directed by Henry Holt; I thank him for assisting my work with information and coordination also.

The Geophysical Survey

The radar survey was done with a model SIR System-7 radar, manufactured by Geophysical Survey Systems. Two different antennas were tested. A low resolution antenna (model 3105, 180 MHz) was found to be able to profile to a depth of greater than 5 m, but it was not very suitable for detecting features in the upper meter of the soil. A higher resolution radar antenna (model 3102, 315 MHz) was found to be more suitable; it could detect features as shallow as about 0.2 m, and as deep as about 3 m. This antenna was used for the entire survey. A sketch of the radar is given in Figure 13.

The lines which were profiled are mapped in Figure 7. The spacing between the parallel lines was 1.5 m; this was a compromise between the greater definition of a survey with lines spaced by 1 m and the greater speed of a survey with lines spaced by 2 m.

The field work of the survey was done on July 22 and 23, 1997. The weather was cloudy and cool both days; a light amount of rain fell during much of the second day (the total accumulation was less than 1 cm). There had been little rain in the area for a long period; this was revealed by the very dry soil in the excavations.

The depth scale of the radar profiles was determined by an estimate of the velocity of the radar pulse; this was done by a geometrical analysis of the hyperbolic echo arcs caused by small underground objects. From Figure 14, an average velocity of 0.14 m/ns has been assumed.

The different radar echoes were classified by their appearance into the categories shown in Figure 12. Undulating lines mark spans where the soil strata were unusual. A curlicue line indicates where the patterns were extremely complex; this typically locates where there is debris in the soil. Rather flat interfaces are marked with a straight line. Small objects are located with different circular symbols to indicate the clarity of the echo. Metal objects can cause

a reverberation of the radar pulse, and an asterisk is used to mark these echoes.

Figure 3 is a map of the radar echoes which were found by this survey. The estimated depth of the object or interface which causes each echo is listed next to the symbol; these depths are more likely to be too large than too small.

The results of a resistivity sounding at the site are given in Figure 15. The measurements were analyzed with the computer program Einvrt4 (by Stewart Sandberg, New Jersey Geological Survey open-file report 90-1). A 5-layer model is plotted in the figure; this shows that the soil may be rather like a loam in the upper 0.5 m, and that the sandy soil must contain a greater fraction of silt or clay below a depth of 1.5 m.

Findings of the Geophysical Survey

A summary of the results of the radar survey is shown in Figure 2. This is derived from the detailed map of radar echoes in Figure 3. The echo patterns at different depths are separated in Figures 4 through 6; the shallowest objects which were detected are plotted in Figure 4, while the deepest are in Figure 6.

In Figure 2, the dotted pattern at E50 N50 approximates the 4 by 6 m extent of a feature; this may be a reliable extrapolation of the feature which was discovered by the excavation there. The radar profile of Figure 8 crosses this feature, and it is revealed by an irregular white pattern at a very shallow depth on the profile. In principle, this echo could be caused by layer of excavated soil (perhaps over 15 cm thick) which has been smeared on the surface; this appears to be unlikely at this location, so the radar echo is probably caused by a shallow feature. It was detected most distinctly on line E52.5; while a similar pattern was also found on the two profiles to the west, the pattern was not as clear there.

The location of this feature has been estimated from the radar profiles; however, the radar data do not indicate anything of the material which causes the echo. While the radar cannot detect things which are as small as individual bricks, it can detect soil contrasts caused by accumulations of rubble and cultural debris.

The hachured pattern at the top of Figure 2 delineates another feature which was discovered by excavation before this survey was started. This probably marks the remanent of a 20th century house which stood on this site. Figure 1 shows the approximate alignment of

the concrete foundation found by the excavation at E60 N100; Figure 2 suggests that the structure may be rectangular, with a size of 6 by 9 m. A radar profile across this structure is shown as Figure 9; this profile was made 0.5 m to the east of the open excavation. A very thin white line between two black echo bands indicates that there was a strong echo from a shallow interface; this could possibly be the concrete slab which was discovered by probing south of the foundation.

The radar echo at a depth of 0.9 m at about N100.5 in Figure 9 may be caused by the bottom of the concrete foundation there. The excavation went to a depth of about 0.45 m and did not uncover the bottom of the foundation. However, similar echoes were not found at other locations around the perimeter of the rectangular feature.

A pair of linear features were found east of this modern house, and they are mapped at the upper right corner of Figure 2. An illustration of a radar profile across this area is given as Figure 10. This two linear features were traced for a span of over 15 m, and the two lines end abruptly near the north end of the survey area; a echo there may reveal a connection between the features that was not resolved by the radar survey. These features are fainter at the southern end and these features could extend outside the eastern side of the area of survey.

While the cause of these echoes is not known, it is most likely that they are the result of a pair of filled ditches. It is possible that these ditches are on the sides of a former road. It is unlikely that the echo patterns are caused by pipes in the soil, but drainage ditches containing are possible. These are almost surely cultural features, for they extend along the side of a slope, rather than going down a slope.

The radar profiles reveal a part of a feature just to the north of these two linear patterns; this feature was detected along line E82.5 at a depth of 0.5 m. The echo pattern there is complex, and it could result from a pit or lens of debris which contains metal.

Several other areas with irregular soil strata were also discovered; these are located in Figure 2. None of these patterns were distinct. The two areas to the southeast may be the most important, for they appear to be caused by features which are shallower than 0.3 m. The deeper patterns may be caused by changes in the natural stratification of the sediments. As seen in Figure 9, the strata are moderately complex below a depth of 1 m. This natural

complexity was greatest in one section of the site; the boundaries of this area are delineated by broken lines in Figure 2.

An examination of the radar echoes of Figures 3 or 5 reveals two lineaments of echoes which could be caused by segments of buried pipes or wires at a depth of 0.6 m; these lines are marked in Figure 2. These could, in principle, locate foundations or filled gullies also. The echoes which form the line near E60 N90 were detected on only three profiles, and the line could be coincidental.

A very distinct echo was detected north of the modern house. This is illustrated in the radar profile of Figure 11. Because of its proximity to that modern house, it is most likely caused by a feature associated with the house.

The radar is very good at detecting air-filled voids, and the tunnels and living chambers of the groundhogs which live at the southern end of the survey area were revealed. Figure 8 has an example. Over the decades, these rodents can churn the soil and the complex patterns which result can easily hide archaeological features of interest. The loose and destratified soil of a refilled excavation can also cause a radar echo, and several of the echoes in Figure 3 are caused by those excavations.

Conclusion

This survey has provided an extrapolation of two features which were discovered by excavation. The boundaries provided by the radar survey may approximate the extent of the major part of the feature; however, a thinner scatter of artifacts would not be detected by this survey. While some unexpected features were detected, there has been no identification of possible wells or the brewery which may have been at this site. The complexity of the deeper soil strata at this site makes it difficult to isolate deep archaeological features on the radar profiles.

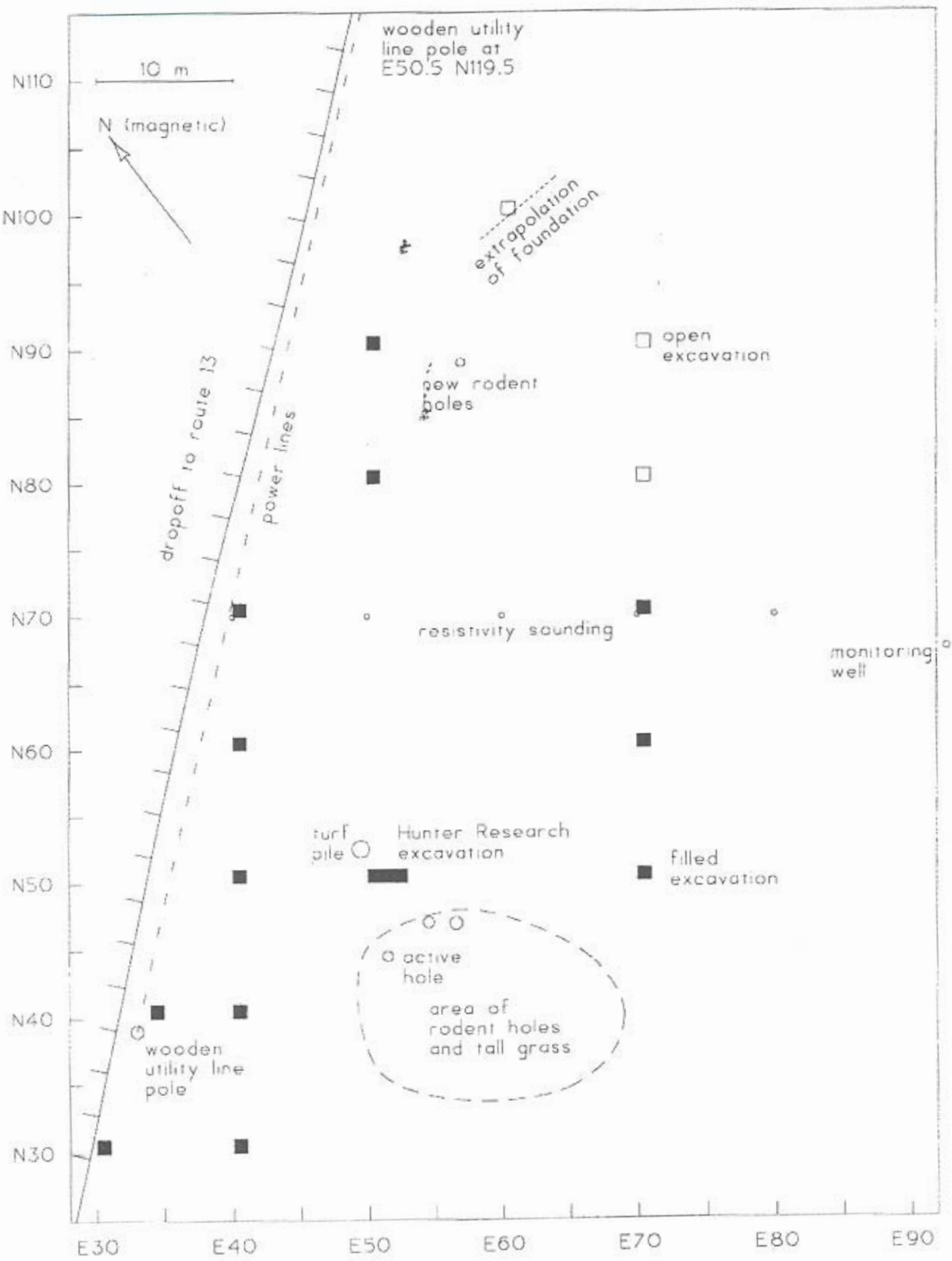

Figure 1: The site. Highway 13 is on the west, and highway 113 Alternate is to the east. Squares and a rectangle locate some of the excavations. Circles locate other features, but do not indicate the size of the features.

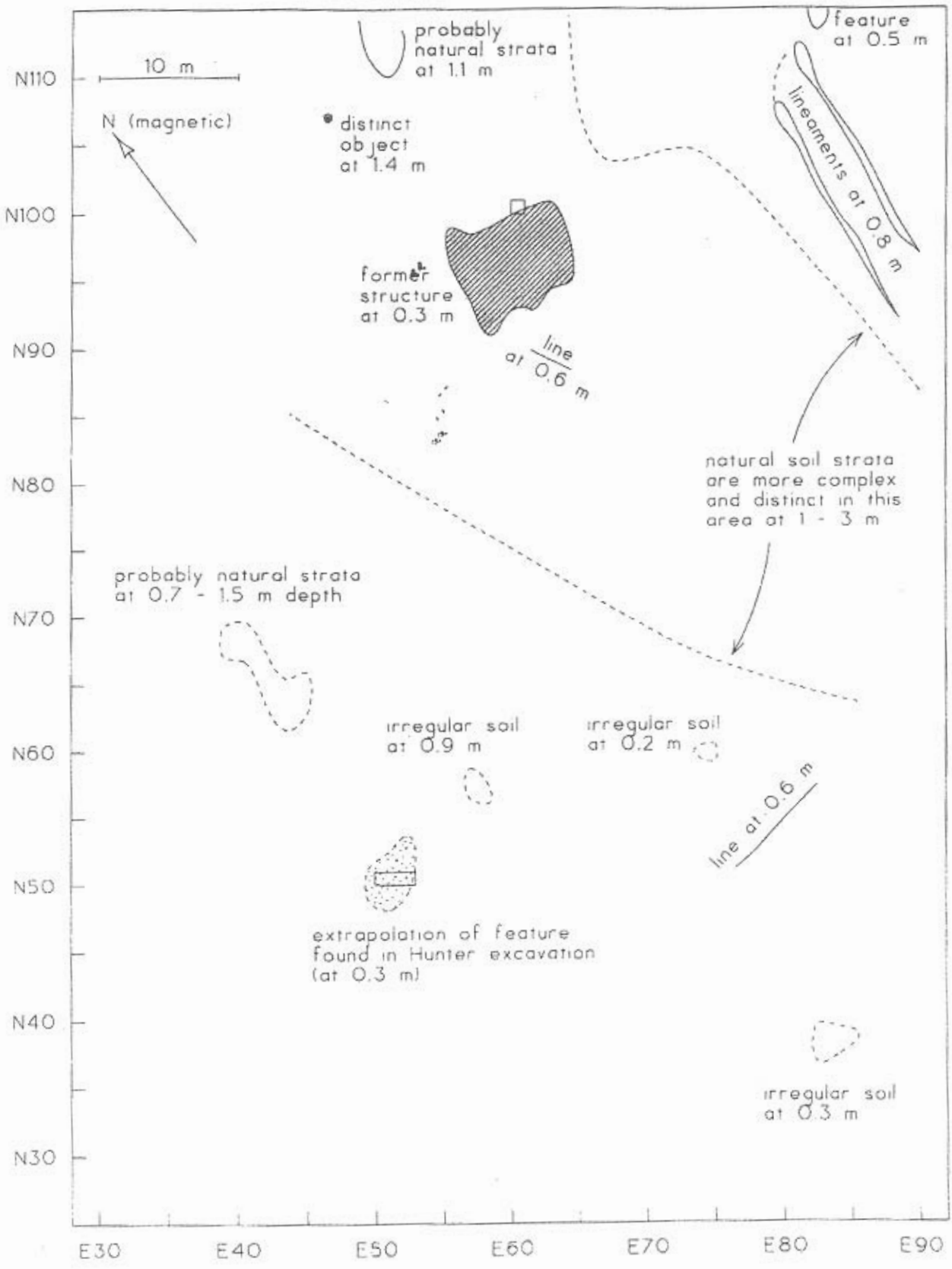

Figure 2: Findings of the radar survey. The extent of a two features found by former excavations (marked with a rectangle and a square) was estimated. Several other features were also detected.

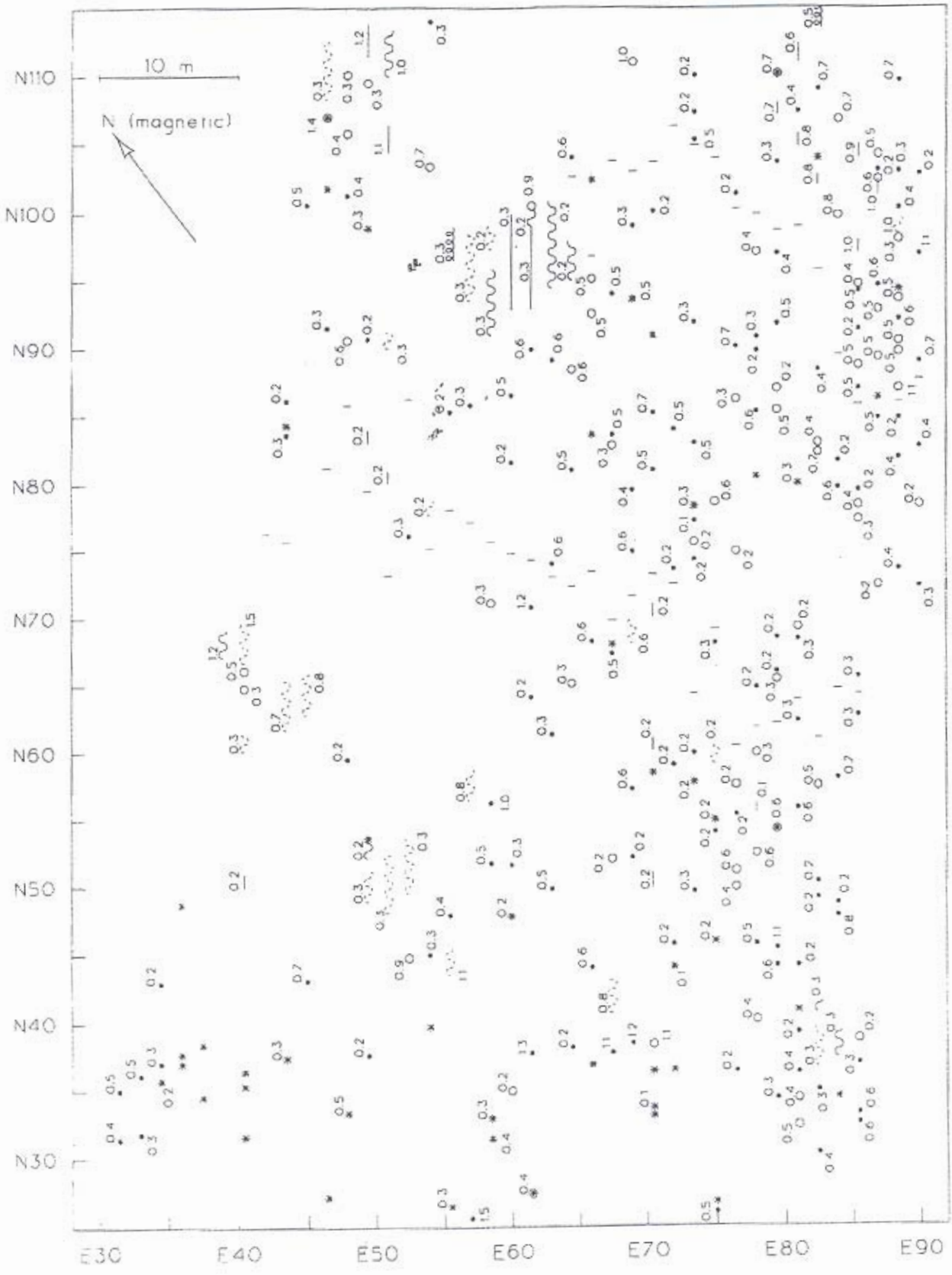

Figure 3: The radar echoes. The numbers indicate the estimated depth of the objects, in meters. A key to the different symbols is given in Figure 13. A total of 282 echoes are mapped.

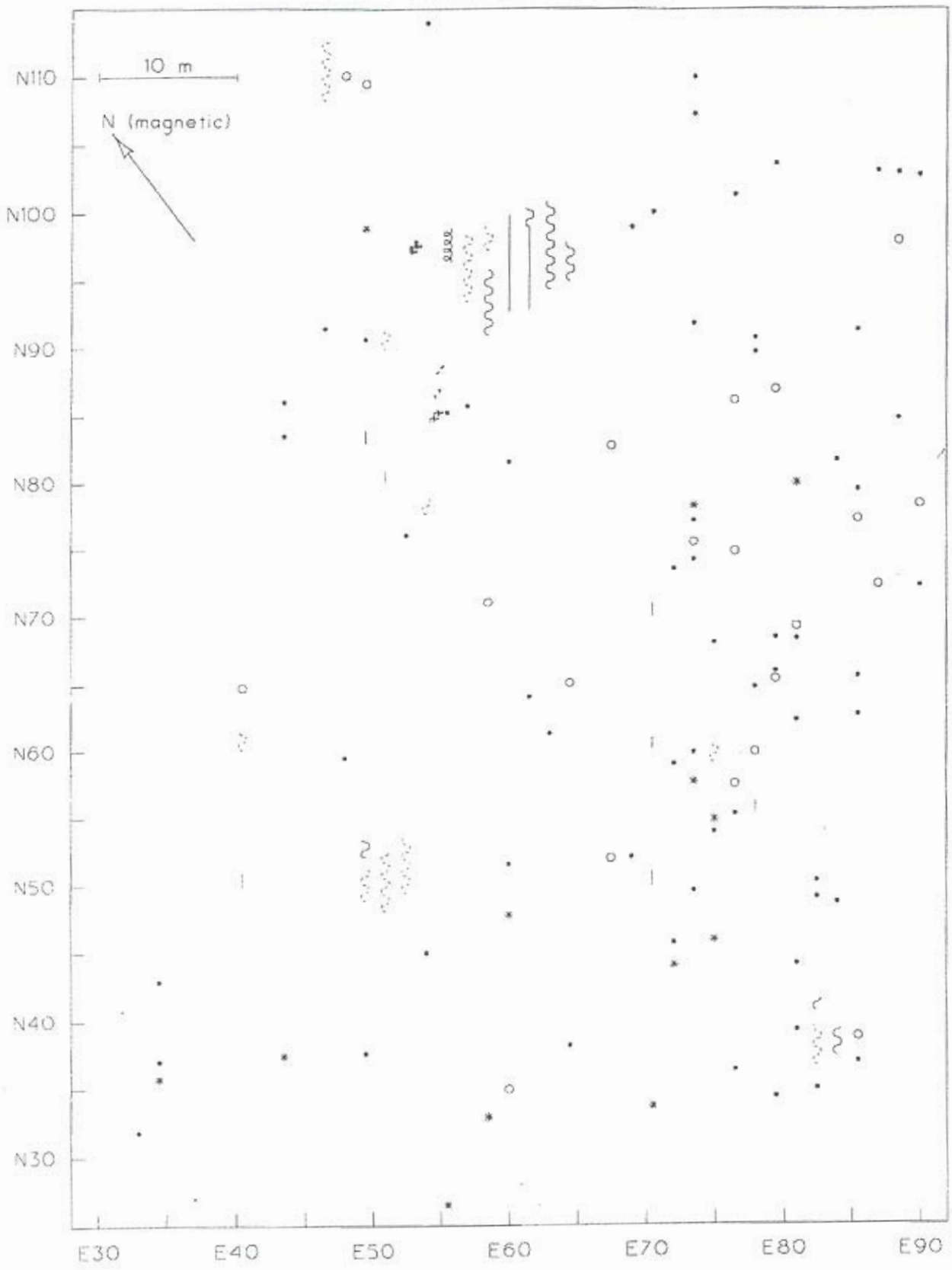

Figure 4: Shallow objects. Only echoes from a depth range from 0.1 through 0.3 m are included here.

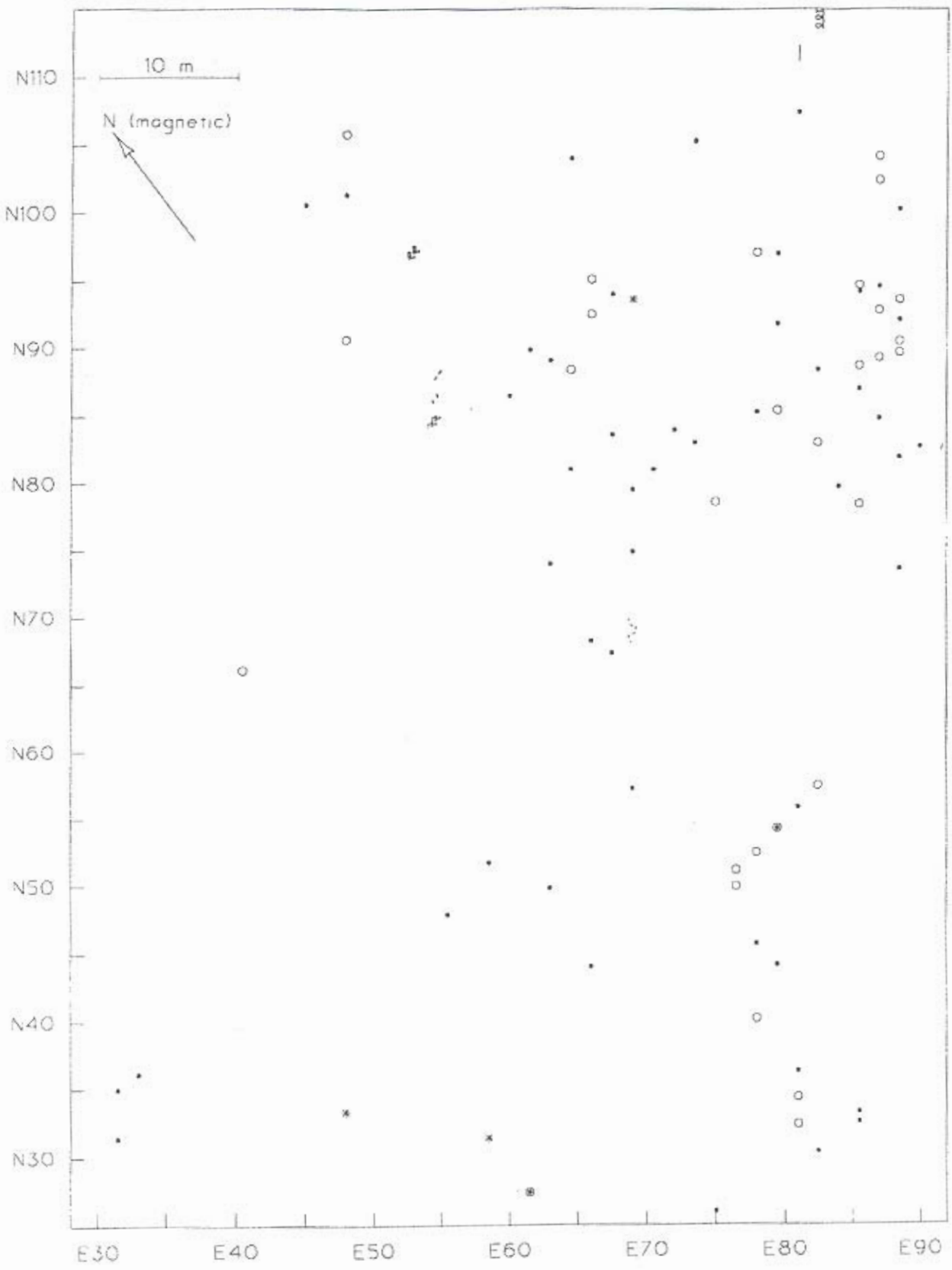

Figure 5: Objects at an intermediate depth. These echoes were detected in the depth range from 0.4 through 0.6 m.

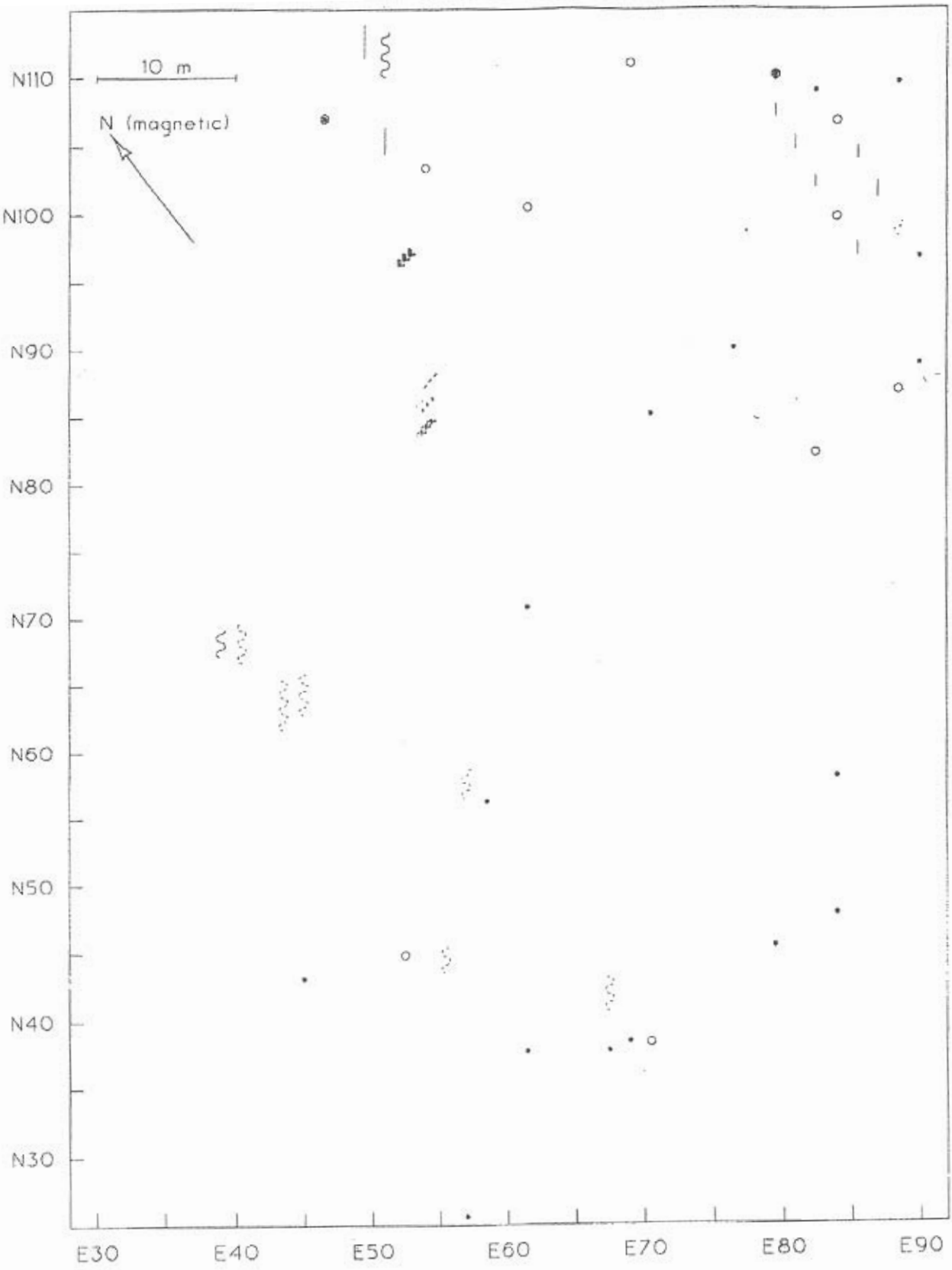

Figure 6: Deep objects. These echoes are from objects whose estimated depth is 0.7 m or greater. It is likely that geological features and rodent disturbances predominate.

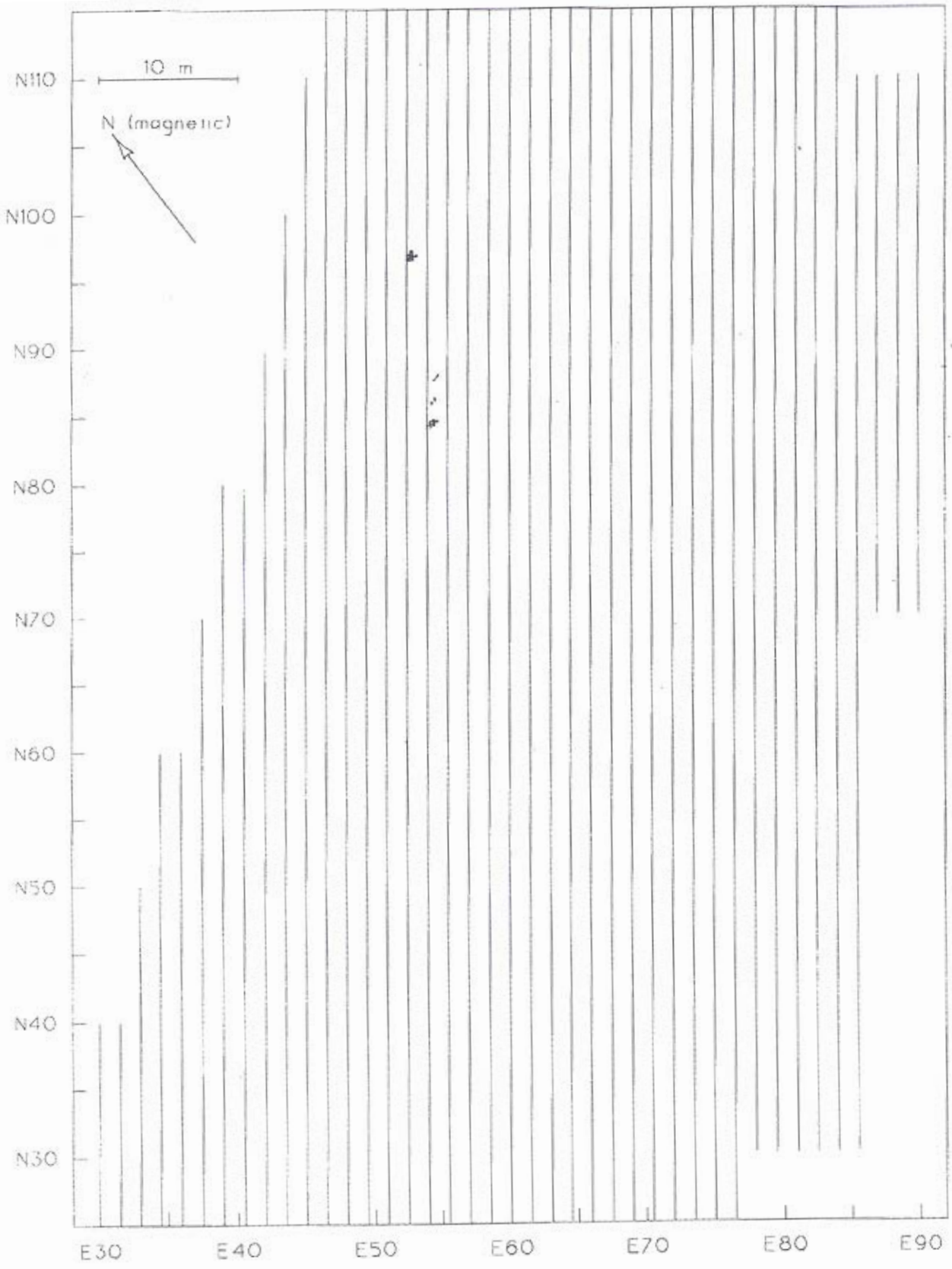

Figure 7: The lines of the radar traverses. Their spacing is 1.5 m. A total length of 3020 m was profiled on 41 lines.

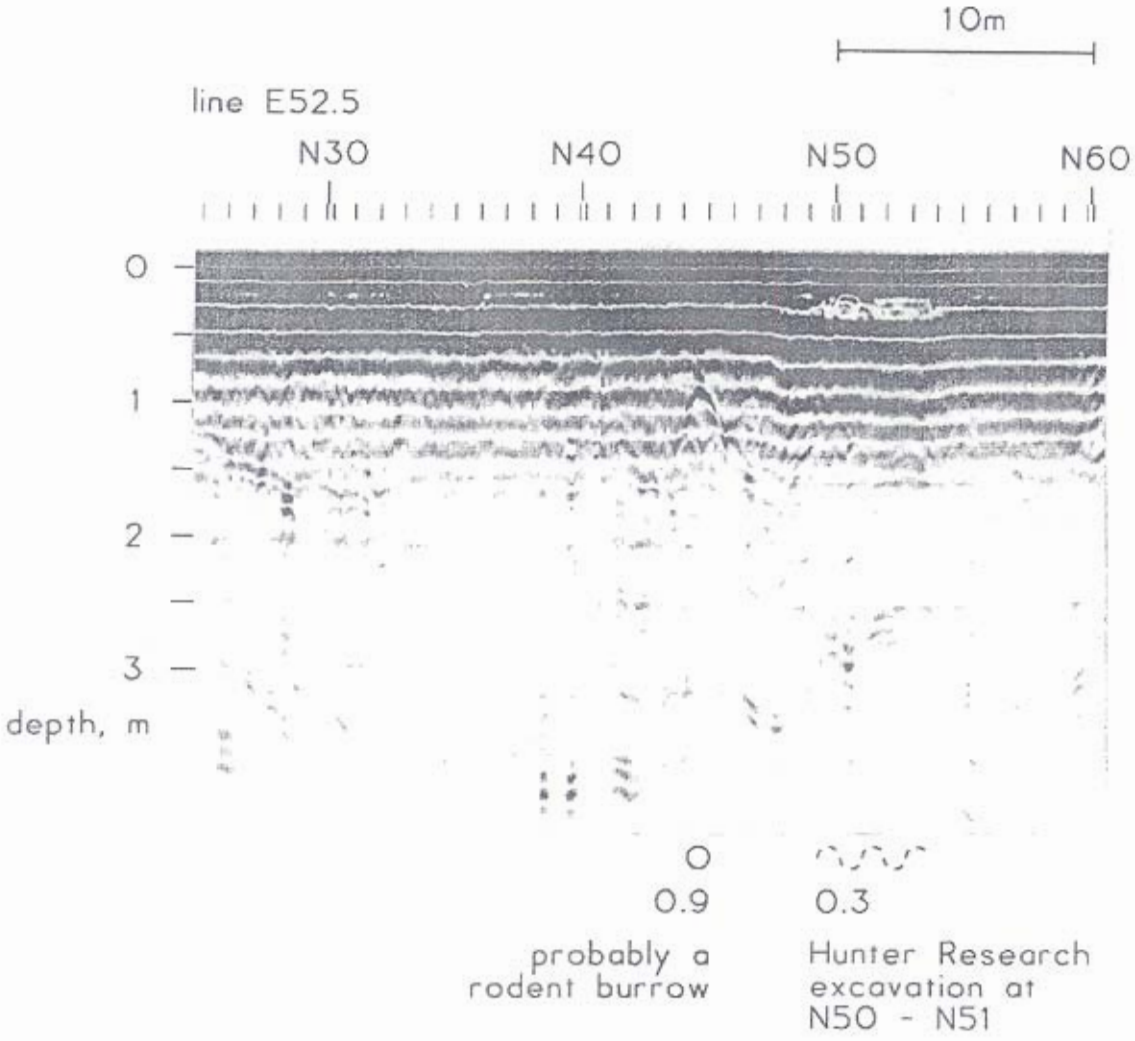

Figure 8: A radar profile. An archaeological feature which was revealed by an excavation at N50 appears to extend to N54 on the radar profile. The air void of a rodent burrow is the likely cause of the echo arc at N44.5 on the profile. The numbers at the bottom indicate the estimated depth of the features.

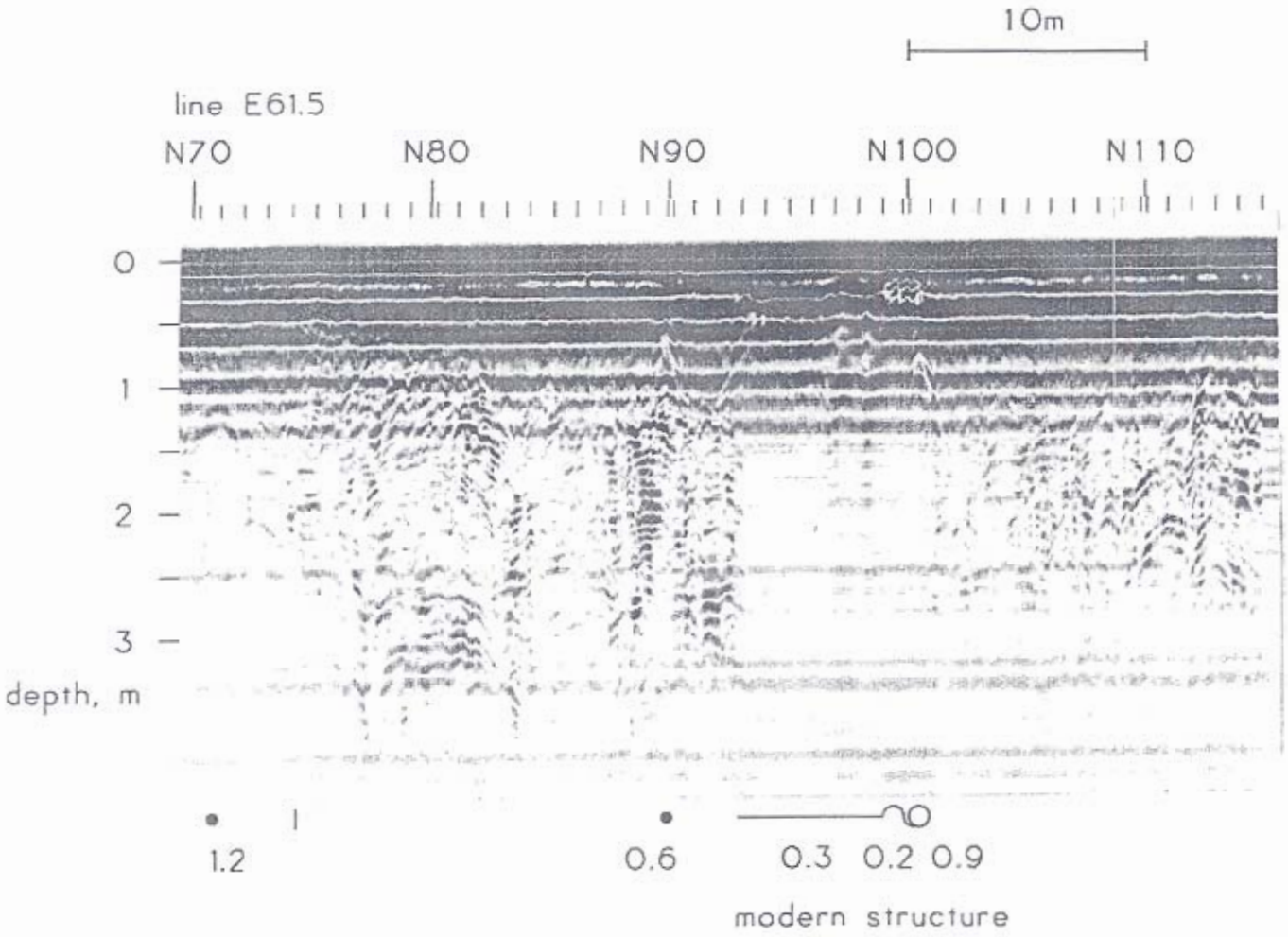

Figure 9: The extent of a modern structure. An excavation at N100 revealed the foundation of this structure, and the radar suggests that it extends south to about N93 along this line. The irregular patterns below a depth of 1 m are primarily caused by natural stratification of the soil.

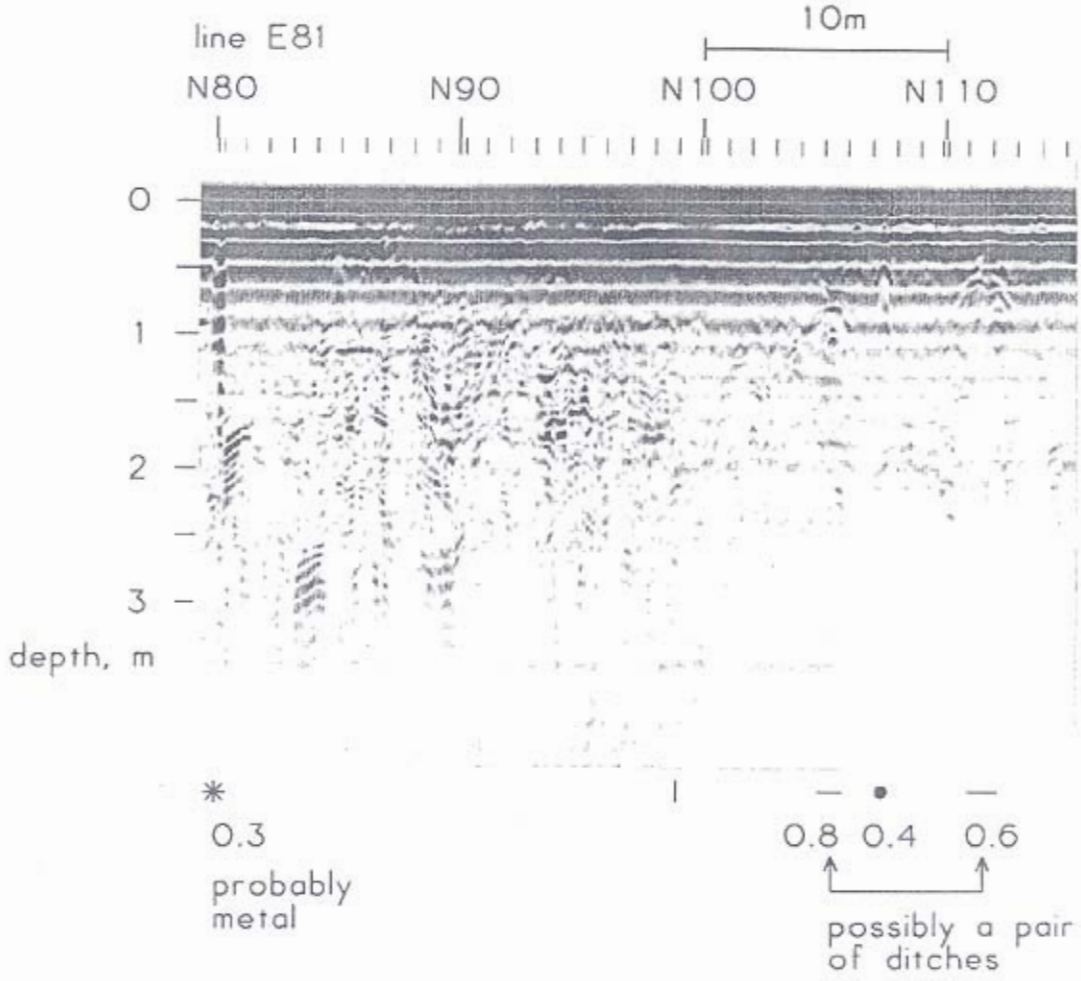

Figure 10: Two possible ditches. The two broad echo arcs at the right side of this profile are caused by two linear features which are separated by 4 m. Their path is illustrated in Figure 2.

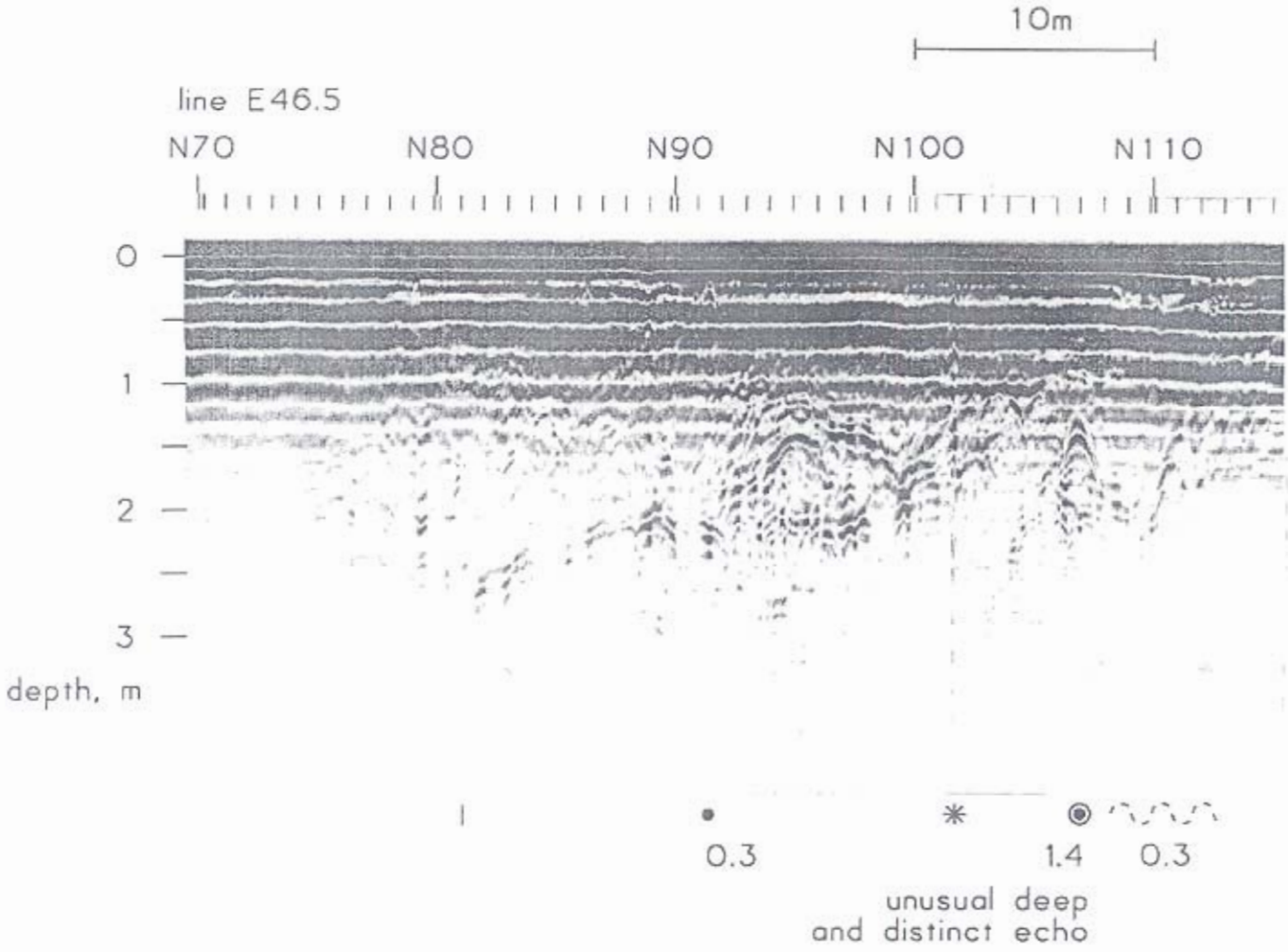

Figure 11: A distinct echo arc. While the cause of the echo at N107 is not known, it is more likely to have a cultural origin than a natural origin.

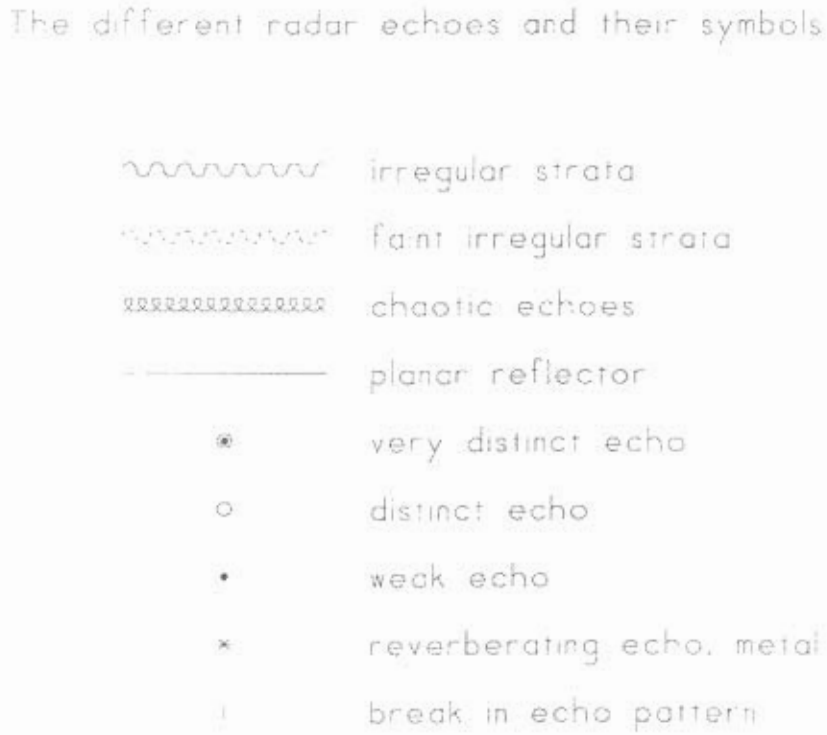

Figure 12: A key to the radar echoes. The different types of echoes are classified with these symbols.

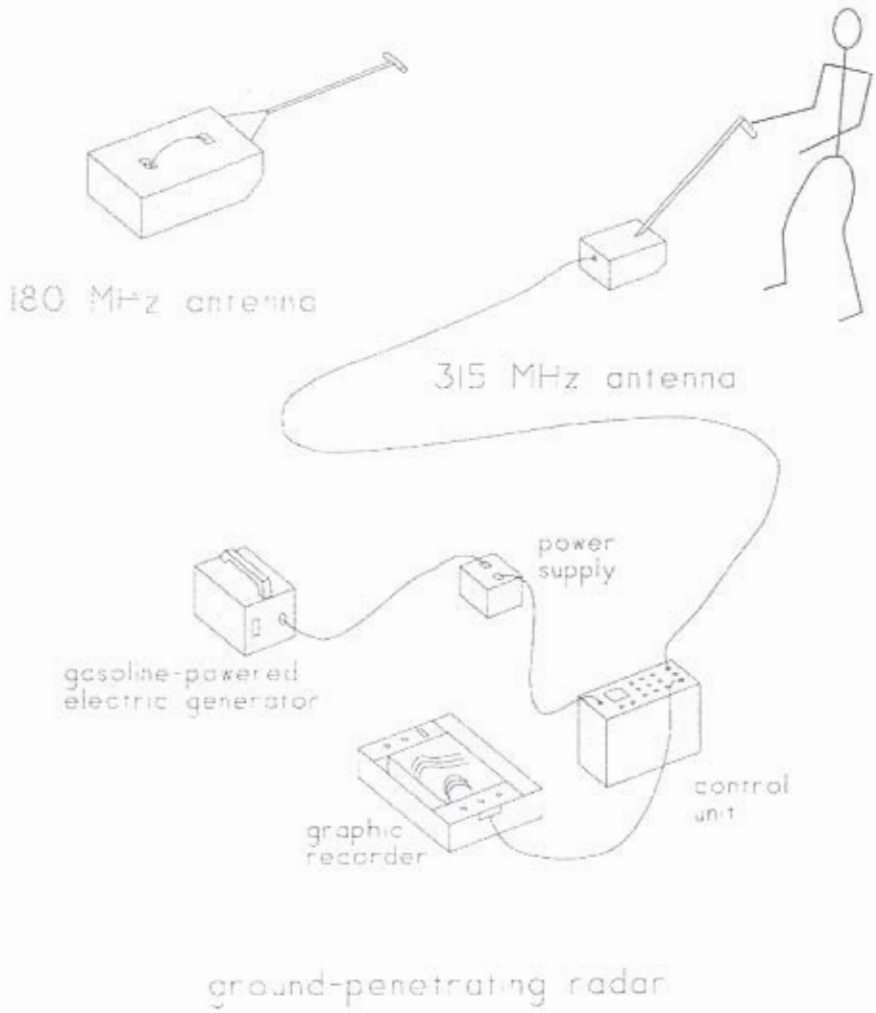

Figure 13: The radar equipment. A high resolution antenna was found to be most suitable for this site; it was a model 3102 antenna with a predominant frequency of 315 MHz.

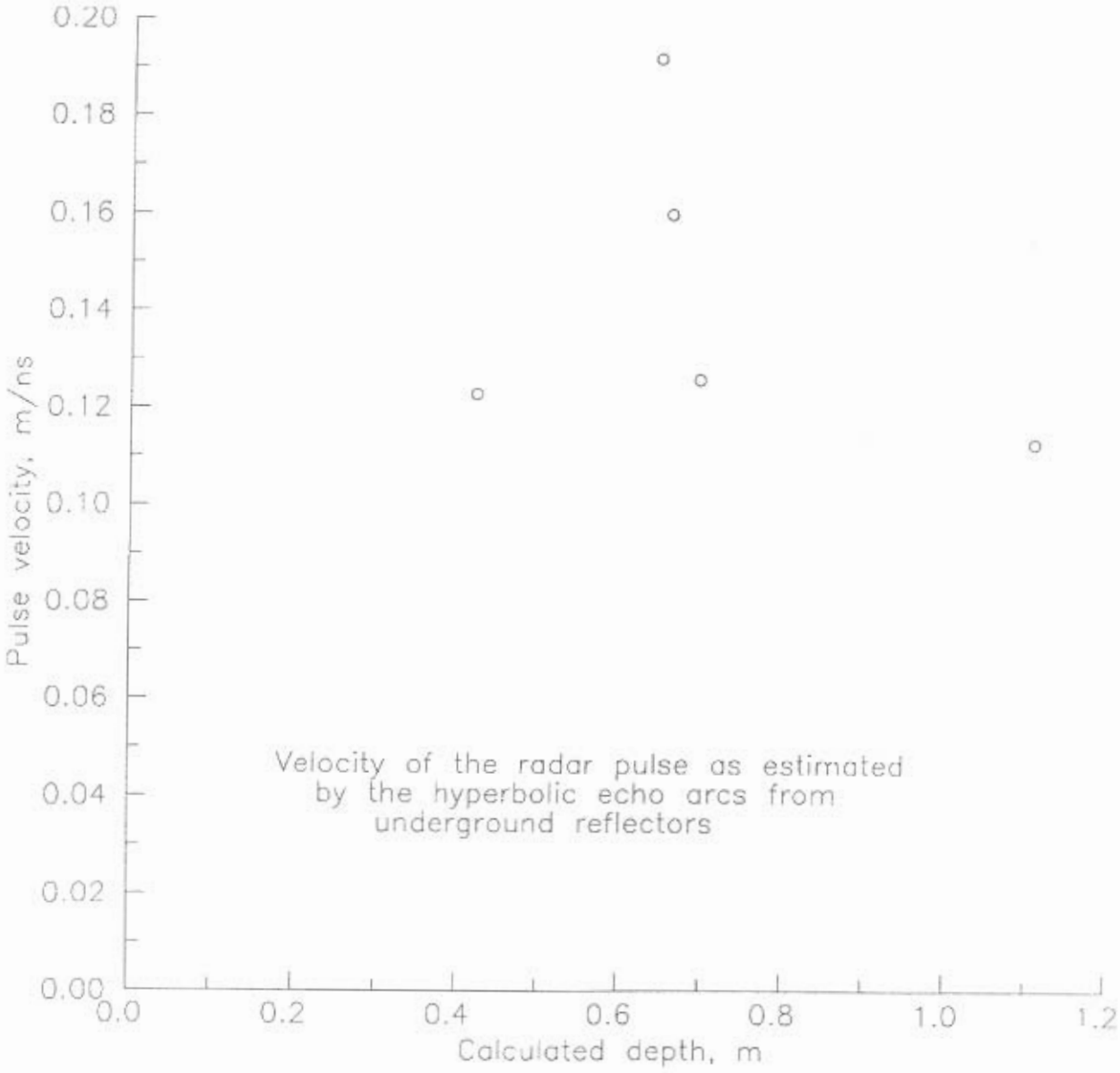

Figure 14: Estimates of the pulse velocity. An average value for the velocity of 0.14 m/ns has calibrated the depth scales on the radar profiles here.

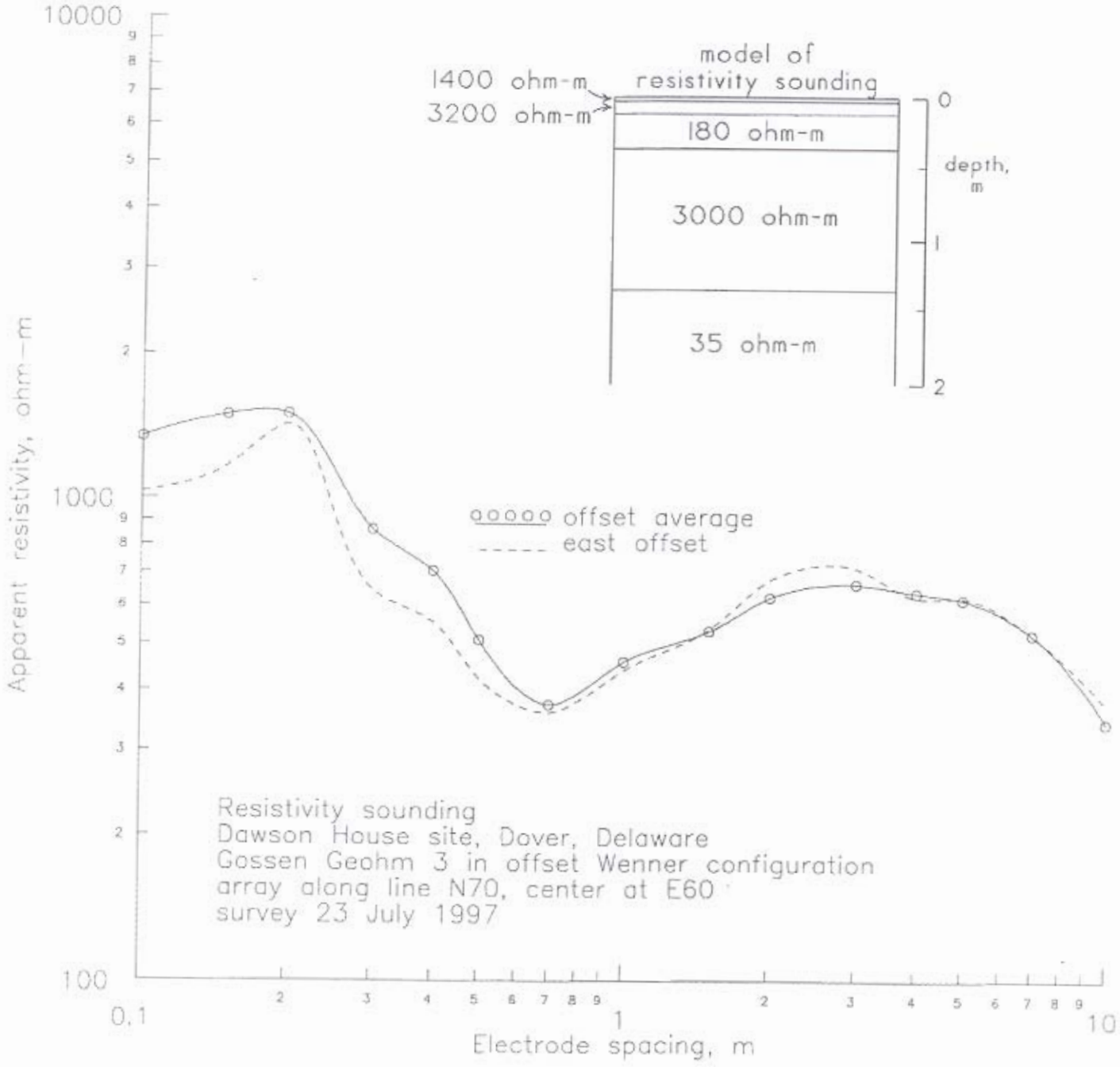

Figure 15: A resistivity sounding. This revealed that the soil is stratified and that it has a high electrical resistivity. The analysis of the sounding suggests that the soil may be silty below a depth of 1.5 m.