ARCHAEOLOGY AND GEOPHYSICS IN WEST-SWEDEN

AGNE FURINGSTEN

Central Board of National Antiquities, Department of Archaeological investigations, Box 5405, S-114 84 Stockholm

Since 1977 a collaboration has been carried through with archaeologists and geophysicists in West-Sweden. In this representatives from the Central Board of National Antiquities, the Chalmers University of Technology in Gothenburg and the National Geologic Survey have been participants. The aim of this collaboration has been to develop new methods for locating sub-surface ancient monuments. The necessity of this is obvious considering the accelerating land-exploitation for high-way-building projects and industrial buildings, as well as projects in the field of forestry and agriculture.

Methodology

The research has been carried out in five steps: 1) geophysical survey; 2) archaelogical excavation; 3) evaluation of the geophysical survey (independently of the archaeological evaluation); 4) evaluation of the archaeological excavation (independently of the geophysical evaluation); 5) synthesis.

Two types of geophysical methods have been used, the resistivity method and the magnetic method. Besides some experiments with subsurface radar equipment have taken place, but these have not yet been definitively evaluated. These methods have been used in archaeological surveying for some years, both on the European mainland, in the British Isles and in America (e.g. Atkinson 1963; Bevan and Kenyon 1975; Bjelm and Larsson 1980; Clark 1975; Clark and Haddon-Reece 1973; Linington 1973; Scollar 1971; Vickers and Dolphin 1975; Wihlborg and Romberg 1980).

The Resistivity Method. In electrical resistivity surveys four electrodes are connected to the ground. Current is transmitted by two electrodes while the potential difference is measured between two potential electrodes. Application of Ohm's law together with knowledge of the geometry of the electrodes, allow calculation of the bulk resistivity of the ground. If there are no, or only gradual variations of ground resistivity, archaeological remains with a resistivity different from that of the ground can be detected.

The possibility of detecting remains under a soil cover is dependent on many factors. The most important ones are: (1) Depth and extent of remains; (2) Difference in resistivity between the remains and the surrounding soil; (3) The electrode configuration.

The electrode configuration used in this investigation was the twin configuration (fig. 1). This configuration has one current and one potential electrode fixed at two points outside the investigation area, while the other two electrodes are moved in profiles across the area. The resistivity data from the profiles are compiled on a map. The advantages of the twin configuration compared with the more widely used Wenner con-

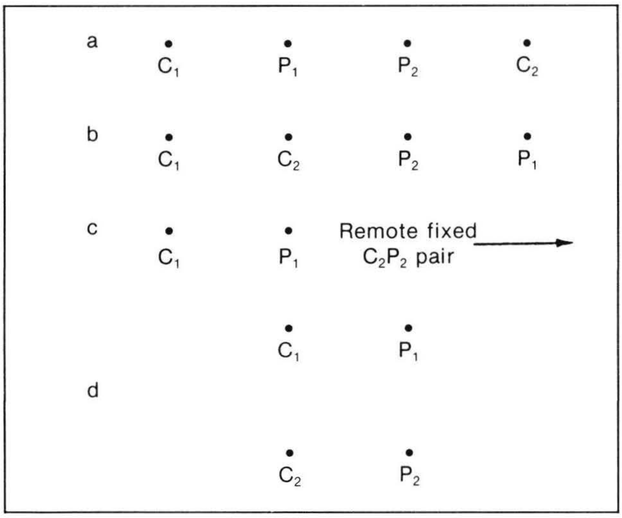


Fig. 1. Resistivity-mapping can be accomplished by different electrode-configurations: a) Wenner, b) double dipole, c) Twin, d) sqare.

figuration are that only two electrodes have to be moved and only one anomaly occurs over the remains.

It is important to select the most suitable distance between the moving electrodes. If the measured volume of the ground is too great (i.e. long distance between electrodes), small remains would not perceptibly influence the measurements. With a short distance between the electrodes, the current will not penetrate deep enough into the ground for remains to be detected. An electrode distance of one (1) meter is often considered appropriate. However, in a detailed investigation of small and shallow remains an electrode distance of 0.5 meter will probably give more information.

The Magnetic Method. Minor changes in the earth's magnetic field over an investigation area are caused either by variations in geological formations, or by objects produced by human activity. There are also slight daily variations in the magnetic field.

The magnetic anomalies of geological objects are due to higher, or lower, content of the magnetic mineral magnetite compared with the surrounding soil or bedrock. Other iron ore minerals, such as limonite or haematite, are not sufficiently magnetic to cause anomalies. Iron in artefacts also gives rise to anomalies. The amount of iron (or magnetite) and the distance between the object and the magnetometer determine the magnitude of the anomaly. Distance in particular is crucial, since the magnetic field of an object decreases very rapidly with increasing distance.

A change in the topography of the bedrock covered with soil, can also cause variation in the magnetic field. However, this type of disturbance usually has a long wavelength compared with shallow remains and can be disregarded in the interpretation.

A proton magnetometer, which measures the total magnetic field was used in these investigations. To avoid problems ensuing from steep gradients of the magnetic field, the sensor was placed on a stick 0.3 m above the ground. Magnetic changes due to diurnal variations of human activity were to some extent corrected be means of a reference point which was measured after each profile. However, a sudden disturbance during the measurement of a profile could not be corrected.

Both these methods have been used with great success in the Mediterreanean area, the Near East, southern England and the southern USA, areas which have not been influenced, at least by the latest Glacial period. In the North European area, e.g. where the latest glaciation has affected the geological soil-conditions, there are difficulties to interpret the anomalies as a result of heterogenity in the soil. This means that a special effort must be made to minimize the errors of interpretation, e.g. by different types of data-filtering (Fridh, 1982: 17 f).

Results

So far four sites have been investigated within the frame of the cooperation between the regional office of the Central Board of National Antiquities and the Chalmers University of Technology/the National Geologic Survey. Another two sites have been investigated as a result of cooperation between the Chalmers/NGS and the county museums of Halland and Skaraborg. Three of these sites will be presented here.

Svanesund, Orust (Ahlbom et al. 1981)

In connection with some large-scale archaeological excavations of six settlement sites from the Mesolithic and the Neolithic in the island of Orust in the province of Bohuslän, directed by the author, the geophysical project was involved. The site chosen for geophysical prospecting was RAÄ no. 131 in Långelanda parish, earlier known as Enquist no. 180 (Enquist 1922). It is a mixed site yielding finds from both the Lihult period and the Neolithic. The site was located on a slightly sloping cultivated field facing south

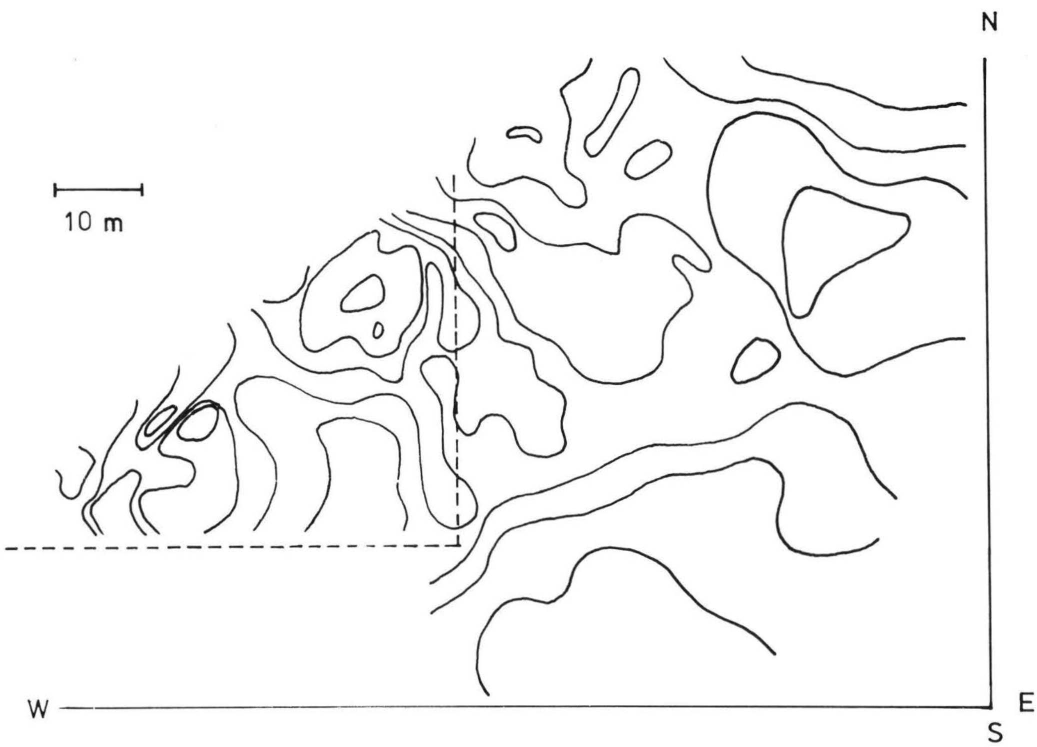


Fig. 2. Resistivity-map. Twin configuration 1 m. The dotted line shows the detailed investigated area. RAÄ 131, Långelanda parish, Bohuslän.

to south-east. The adjoining ground consists of moraine. The investigation area is surrounded by permanent settled houses and summer houses. The north-western part of the area borders on a slightly sloping rock-face. Across the northern part of the site runs a minor road, which divides the site into two sections. The site is approximately 170 × 60 m, located at a height of 28—35 m above the present sea level. The vegetation is mainly meadow plants and some trees.

The geophysical investigation was carried out in two steps. First a twin configuration resistivity survey was made on a large, c. 3500 m^2, area where remains were expected. The distance between the electrodes was one (1) meter. The results of this investigation are presented on a map (fig. 2). From the map it is evident that the north-western part of the investigated area contains many more small anomalies than the rest. The chances of finding remains here were therefore considered more favourable. This assumption was confirmed during the archaeological excavation where no constructions were found in trenches outside the anomalous area. The next step was to concentrate all further work to the anomalous area.

To obtain more detailed information on the anomalous area, a resistivity survey with a twin configuration distance of 0.5 m in a 0.5 m grid was carried out inside the dotted line in fig. 2. The results from this survey are shown on a map (fig. 3). The anomaly pattern obtained by means of the 0.5 m resistivity survey is more detailed, with many small anomalies, compared with the one meter survey. The 0.5 m survey is also more sensivite to shallow disturbancies, and the one meter survey to variations in bedrock topography.

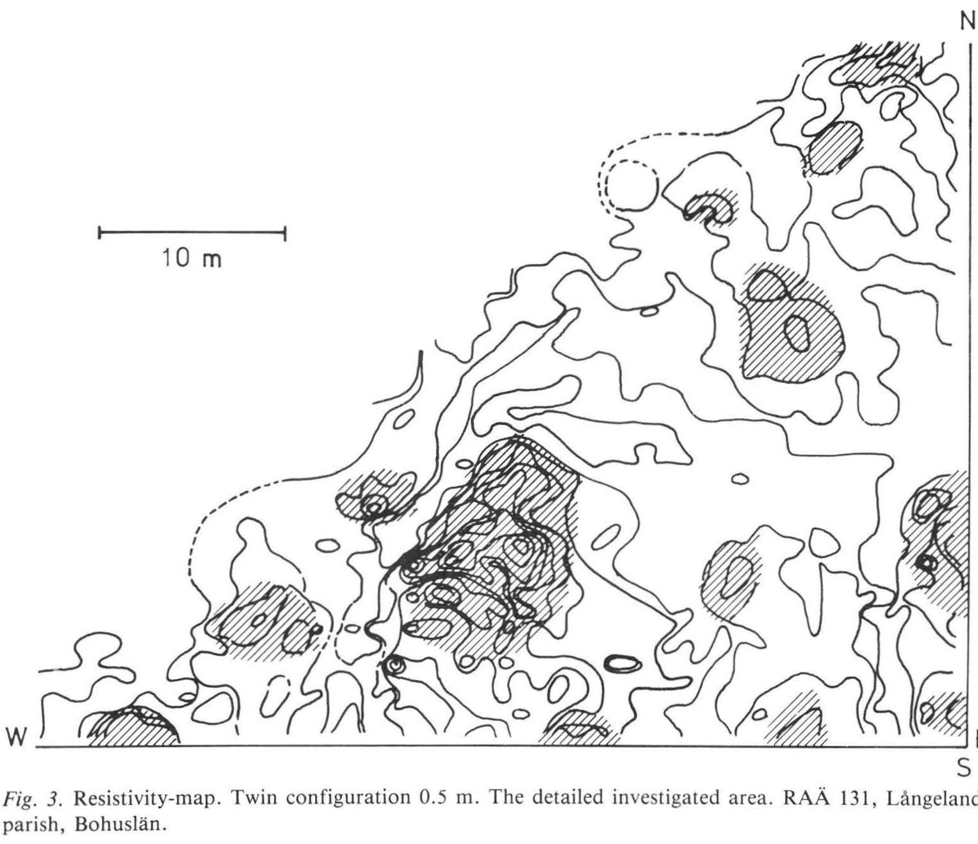


Fig. 3. Resistivity-map. Twin configuration 0.5 m. The detailed investigated area. RAÄ 131, Långelanda parish, Bohuslän.

In the 0.5 m survey, eight anomalies within the excavation trenches with high resistivity values were interpreted as possible hearths. These anomalies are shaded on the map in fig. 3.

During the excavation phase, four hearths were found within the investigation area. Furthermore, many accumulations of stones were detected.

Comparison between the results of the excavation (fig. 4) and the 0.5 m resistivity map (fig. 3) shows that all four hearths had resistivity anomalies in common. Three anomalies were caused by clusters of stones, while no explanation was found at the excavation depth for one of the abnormalities.

The anomalous area measured with the 0.5 m resistivity survey was also investigated with a magnetic survey in a 0.5 m grid. The results are shown in fig. 5. Unfortunately two profiles were distorted. These profiles are indicated by arrows in fig. 5.

Comparison of the magnetic survey (fig. 5) with the excavation results (fig. 4) shows that no remains could be detected by magnetic measurements. A later geological and magnetic investigation of the local stones and rocks indicated that most of the stones in the hearth consisted of nonmagnetic gneisses. This low magnetic rock type, however, is not very common compared with other crystalline rocks. Magnetic surveys of other Stone Age sites in areas where the bedrock consists of magnetic rocks will have greater chances of detecting remains.

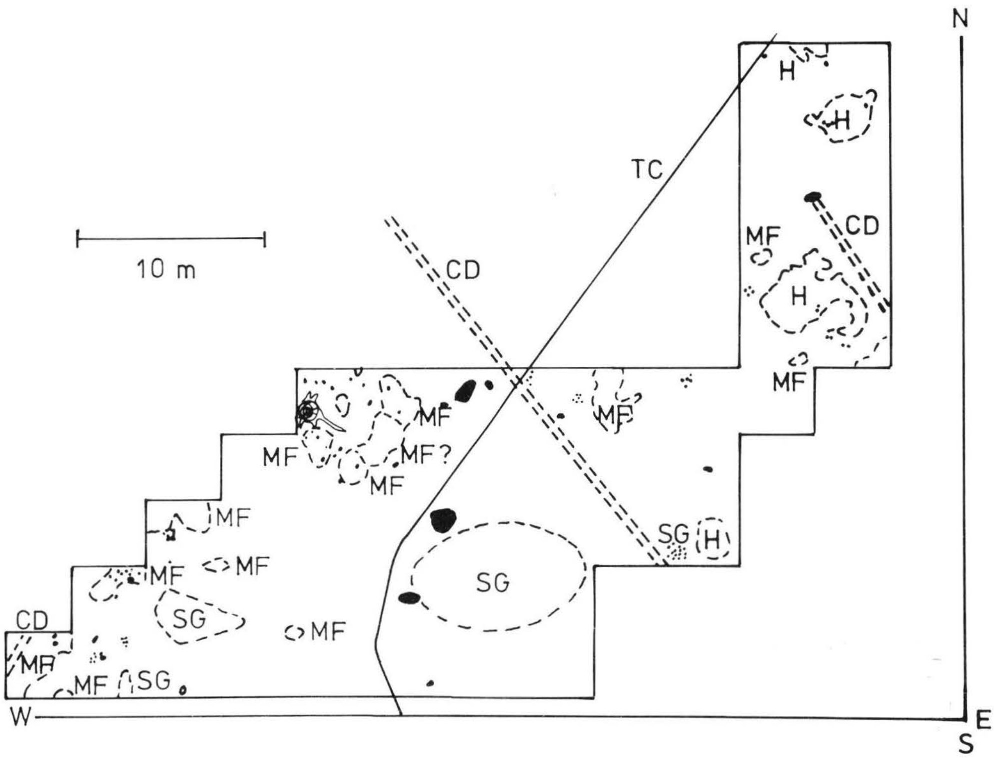


Fig. 4. Excavation map. H = hearths, SG = stone group, MF = dark shaded constructions, CD = covered drains, TC = telephone cable. RAÄ 131, Långelanda parish, Bohuslän.

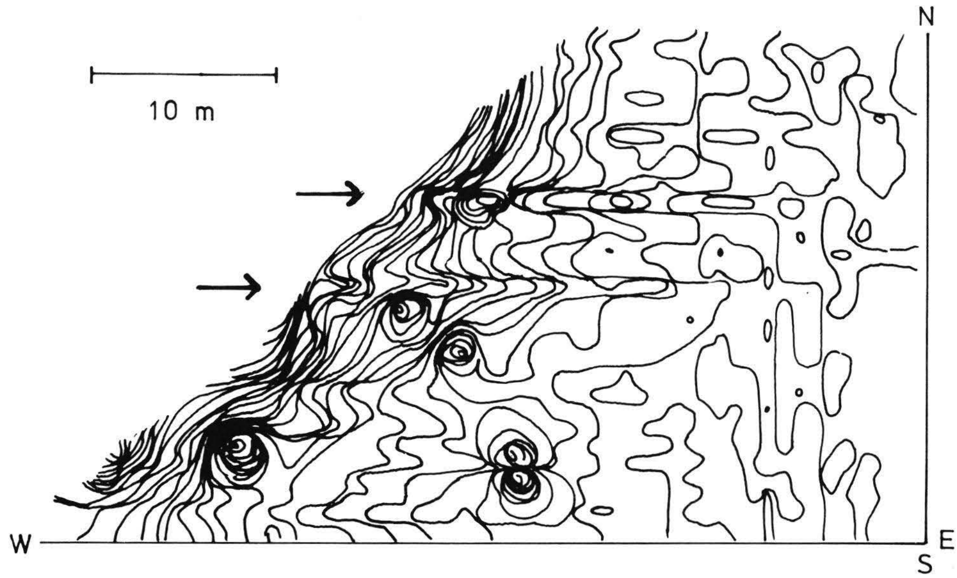


Fig. 5. Map of magnetic anomalies. Arrows indicate distorted profiles. Fornl 131, Långelanda parish, Bohuslän.

By, Stråvalla (Furingsten 1984)

In connection with an investigation, directed by the author, of a village site from the 16—19th centuries, geophysical surveying was executed. The site was situated c. 25 km north of the town Varberg. It was placed on a hilltop which was mainly covered with pasture-land vegetation. The place was of a specific character as it was partly situated almost directly on the bedrock. This caused some complications in the geophysical survey. Some of the constructions were however visible before the archaeological investigation and its character of a rapidly burnt down village, where very little could be saved from the fire caused reason to expect distinct anomalies on the geophysical equipment.

Approximately 1250 m^2 was surveyed both with the resistivity method and with the magnetic method. In the eastern area the distance between the electrodes of the resistivity method and the distance between the measuring points of the magnetic method was 1 m, and in the western area 0.5 m. The results are presented on fig. 6 a—c.

Of the 14 anomalies recorded by the resistivity method, the archaeological excavation showed that 12 were settlement reminiscenses. The other two were caused by the influence of the bedrock which was very shallow there. The bedrock caused also other problems, such as disturbancies of the anomalies of the settlement remains. For instance, the construction A 2 could not clearly be detected as a result of these disturbances (Frid 1982: 82 f).

The magnetic anomalies which could be registered indicated directly the house remains existing in the surveyed area. This is rather natural considering the amount of iron artefacts found in them.

As a summing up, both methods could register the existing house-remains on the site. However, the shallow bedrock caused some disturbances, especially on the resistivity method, so that some remains were "drowned" in the bedrock anomalies. Disregarding this site-specific disturbances, the investigation show that geophysical surveying on remains from medieval and later periods has good prospects.

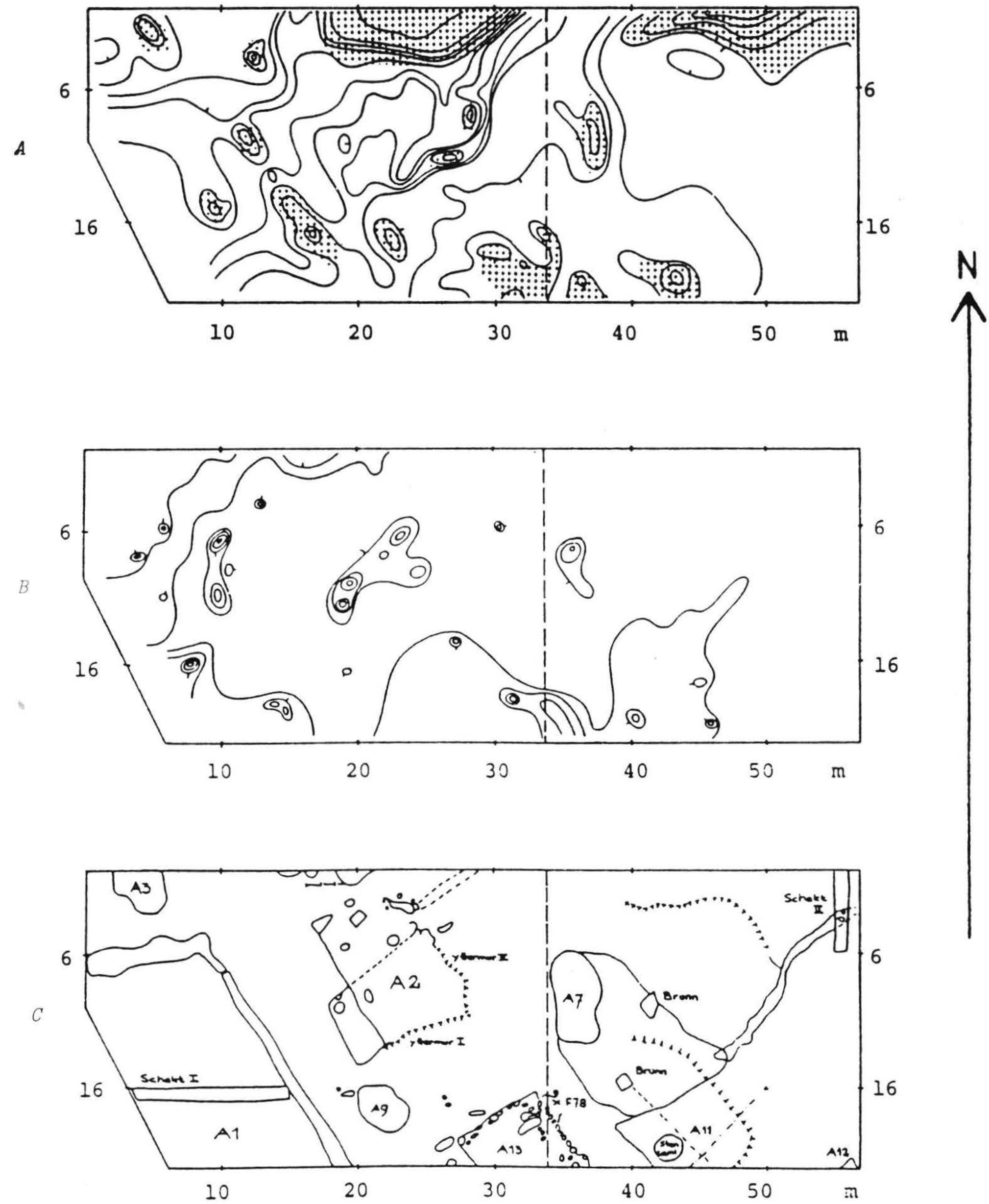
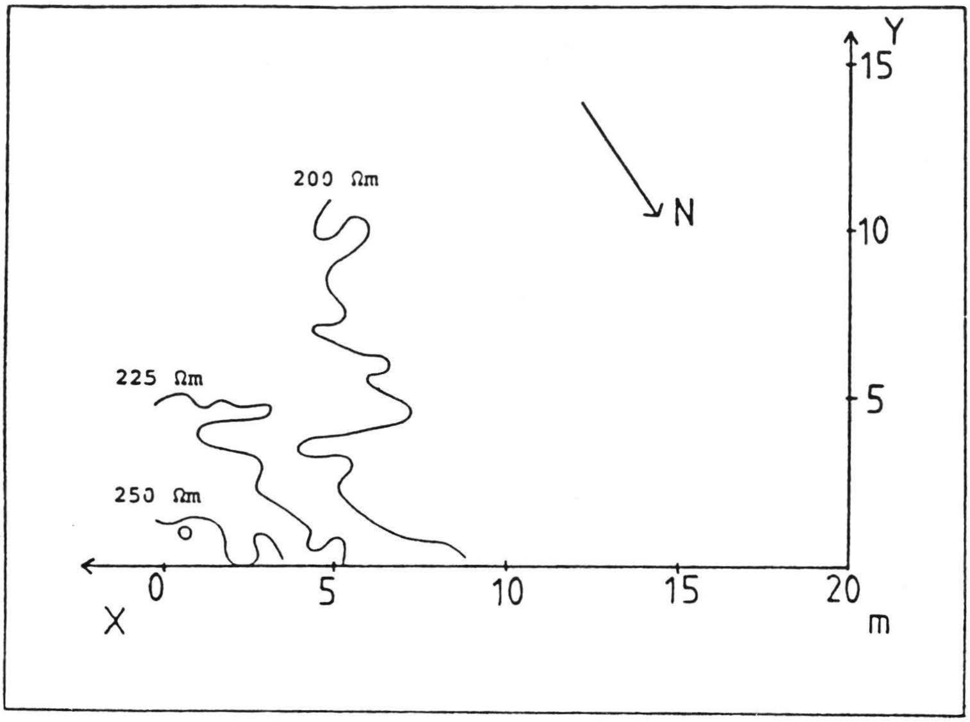


Fig. 6 A—C. Resistivity-map, map of magnetic anomalies and map of the results of the excavation. By, Strå-valla parish, Halland.

Herrgården, Hasslösa (Fridh 1982)

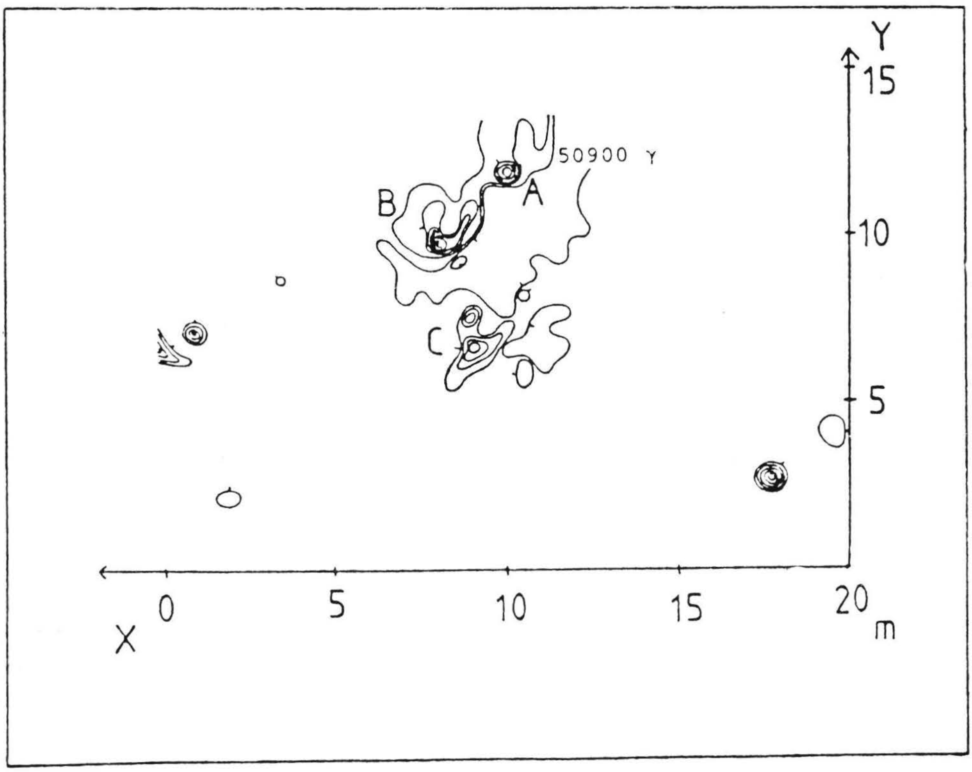
Within a large field area, where both an urn-field cemetery and settlement site remains had been found earlier, both resistivity and magnetic surveying were executed. The site was situated c. 10 km NW of the town of Skara. It was placed on a small elevation in an open landscape with arable land dominating. In the soil, sandy moraine was dominant with a very small element of stones (Frid 1982: 43 f).

A



200 Ωm
225 Ωm
250 Ωm
N
Y
15
10
5
0
5
10
15
20
m
X

B



50900 γ
A
B
C
Y
15
10
5
0
5
10
15
20
m
X

Approximately 300 m² was surveyed with both the resistivity and the magnetic method. The electrode distance was 0.5 m, as was the distance between the measuring points in the magnetic method. The results are presented on fig. 7 a—b.

With the magnetic method five anomalies could be registered. Three of these were the results of settlement remains (A—C), and contained burnt clay and iron slag. The other two were caused by iron objects such as iron nails. The resistivity method could not detect any of the settlement remains.

To summarize, the magnetic method was excellent in this type of site, where iron objects and iron slag were at hand. In this case, the resistivity method did not function because of the lack of stones in the constructions (Fridh 1982: 44 f).

Summary

Above, only three of the six sites surveyed so far, have been more thoroughly described. It depends on the fact that they are of greater methodical value than the others. This summary will however also include the basic results from the other three sites.

The investigations so far have showed that the resistivity method has a greater degree of reliance, because it is less dependent on circumstances like telephone cables, power-lines, parked cars etc, than the magnetic method. On the other hand the resistivity method is less suitable for remains with no stones in lighter soils.

If one studies the connection site/method, there is a clear tendency in the material. The younger a site, the greater the possibilities for the magnetic method to function. This depends naturally on the rising content of metal objects on the site. Medieval or later village sites and iron-producing sites have good pre-requisites for the magnetic method. To these can also be added medieval town remains, if there are no disturbances from e.g. power-lines and telephone cables. Sites with a rather good prognosis are settlement sites, especially from the later part of the Iron Age. Ancient monuments with less good prognosis are settlement sites and work-shop sites without metal objects.

The resistivity method has its best pre-requisites on sites with clear and distinct constructions, above all of stone, such as houses and hearths. Remains with larger parts of e.g. burnt clay and with distinct pits containing material separable from the surrounding layer, have a moderately favourable prognosis. Remains where the resistivity method can be less successful are small constructions with no stones such as small post-holes.

Finally, these geophysical methods can be of great help in archaeological prospecting within certain limits. They should be used on sites up to c. 3500 or exceptionally 5000 m², and some facts of the geological conditions on the site must be known. Within these limits you can reduce the time spent on an archaeological investigation, without reducing the scientific output and get a satisfactory investigation result.

Acknowledgments

Thanks is due to Anders Anevik for revising the English in this article.

Fig. 7 A—B. Resistivity-map and map of magnetic anomalies. Herrgården, Hasslösa, Västergötland. A—C indicate settlement remains.

REFERENCES

Ahlbom, K., Fridh, B. & Furingsten, A. 1981. Archaeological Prospecting with Geophysical Methods at Svanesund, Orust, Sweden. *Fornvännen.*

Atkinson, R. J. C. 1963. Resistivity Surveying in Archaeology. In: E. Pyddoke, ed: *Scientist and Archaeology.* London.

Bevan, B. & Kenyon, J. 1975. Ground-penetrating Radar for Historical Archaeology. In: *MASCA Newsletter,* Vol. 11. No 2.

Bjelm, L. & Larsson, L. 1980. Georadar i arkeologiens tjänst. In: *META* nr 4.

Clark, A. 1975. Archaeological Prospecting: A progress report. In: *Journal of Archaeological Science* 1975: 2.

Clark, A. & Haddon-Reece, D. 1973. An Automatic Recording System Using a Plessey Fluxgate Gradiometer. In: *Prospezioni Archeologiche* No 7—8.

Enquist, A. 1922. Stenåldersbebyggelsen på Orust och Tjörn. Diss Uppsala.

Fridh, B. 1982. Geofysiska metoder vid arkeologisk prospektering i Sverige. In: *Geol. Inst. Publ.* B 187. Göteborg.

Furingsten, A. 1984. Geofysik och arkeologisk forskning i Västsverige. In: A. Furingsten, M. Jonsäter & E. Weiler: *Från flintverkstad till processindustri. — De första 9000 åren i Västsverige speglade av UV Västs undersökningar.* Stockholm & Kungälv.

Linington, R. L. 1973. A Summary of Simple Theory Applicable to Magnetic Prospecting in Archaeology. In: *Prospezioni Archeologiche* No 7—8.

Scollar, I. 1971. A Magnetometer Survey of the Colonia Ulpia Trajana near Xanten, West Germany. In: *Prospezioni Archeologiche* No 6.

Vickers, R. & Dolphin, L. T. 1975. A Communication on an Archaeological Radar Experiment at Chaco Canyon, New Mexico. In: *MASCA Newsletter,* Vol 11. No 2.

Wihlborg, A. & Romberg, T. 1980. Georadar för att spåra fornlämningar? In: *META* nr 4.