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Ahlbom, Kaj
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Archaeological Prospecting with Geophysical Methods at Svanesund, Orust, Sweden

By Kaj Ahlbom, Bengt Fridh and Agne Furingsten

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The article illustrates the possibility of using geophysical methods to detect areas of archaeological interest and large stones or accumulations of stones which may be hearths without removing the vegetation cover.

At a Stone Age site on the Island of Orust in western Sweden with rather faint archaeological remains all hearths were detected by the resistivity method. Owing to unfavourable geological conditions the magnetic method was less successful on this site; further tests at other sites will probably produce better results.

Kaj Ahlbom, Sveriges Geologiska Undersökning, Box 670, S-751 28 Uppsala; Bengt Fridh, Chalmers Tekniska Högskola, S-412 96 Göteborg; Agne Furingsten, Riksantikvarieämbetet, UV Väst, Box 10 259, S-434 01 Kungsbacka.

As a part of a research program for developing better and more exact prospecting methods in archaeology, an investigation was made on a Stone Age site at Svanesund in the eastern part of the Island of Orust in western Sweden. The aim was to check the reliability of geophysical prospecting methods on such faint remains as a Stone Age site.

The idea of using geophysical measurements for the detection of archaeological remains covered with soil is based on the fact that there is often a significant difference in physical properties between the remains and the surrounding soil. Remains like the walls of a Roman villa (Clark 1975) or various metal artefacts can usually be detected with resistivity, magnetic or electromagnetic methods. However, investigations of Stone Age remains are in this respect something of a challenge, since the finds from this period (stone axes, hearths etc.) are small, spread over vast areas and with physical properties little different from the surrounding soil. Another problem in glaciated areas is that the remains are often situated in moraine deposits. Moraine is an inhomogeneous material which contains a wide range of grain sizes. Since the remains often consist of different types of stone accumulations, naturally occurring stone clusters in the moraine can cause anomalies of the same magnitude as the remains themselves. It may therefore be difficult to distinguish between anomalies caused by geological phenomena and archaeological remains. However, some general rules can be applied in the interpretation:

1. If the anomalies present a characteristic pattern they are probably caused by archaeological remains, since "geological" abnormalities have random appearance.

2. Since Stone Age remains of the abovementioned type are situated at a shallow depth (0–0.5 m) the anomalies have a short wavelength, i. e. the disturbance is only measurable over a short distance at the surface. Variations over longer distances are

probably caused by a change of geological conditions.

Another type of interpretation divides the investigated area into smaller subareas which have different anomaly frequency. In subareas with random pattern and low frequency of anomalies, the chance of finding remains is adjudged small. In areas with high anomaly frequency the chances of finding remains are greater. These areas will therefore have a higher priority for excavation. Since the cost of excavation is much higher then that of geophysical survey, the selection of the most promising sites could to some extent be a task for geophysicists.

Geophysical Methods Used in Archaeological Prospecting

Two different geophysical methods were used in this investigation, the resistivity method and the magnetic method. Both methods have been used in archaeological surveying for some years, mainly on the European mainland and in the British Isles, but also in America. (For further reading, see e. g. Atkinson 1963; Clark 1975; Clark & Haddon-Reece 1973; Linington 1973 and Scollar 1971.)

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 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 (Clark 1975). This configuration has one current and one potential electrode fixed at two points outside the investigated 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 configuration are that only two electrodes have to be moved and only one anomaly occurs over 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 to detect remains. 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. In practice, the electrode distance is often a question of time and economy, since measuring in a grid of 0.5 m compared with one meter results in four times as many measurements for a specific area.

The Stone Age remains which are easiest to detect are hearths. The high resistivity of the stones in the hearths causes higher bulk resistivity. Anomalies with high resistivity may therefore be connected with hearths.

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 sufficiantly 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 a 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 this investigation. To avoid problems resulting from steep gradients of the magnetic field, the sensor was placed on a stick 0.3 meter above the ground. Magnetic changes due to diurnal variations or human activity were to some extent corrected by means of reference point which was measured after each profile. However, a sudden disturbance during the measurements of a profile could not be corrected. For instance, during the survey two cars arrived at a house near the investigation area, causing the distortion of two profiles.

The Site — a Description

The site is located on a slightly sloping cultivated field facing south to south-east. The adjoining ground consists of moraine. The relatively narrow strait of Svanesund, which separates the island of Orust from the mainland, lies approximately 300 m south and 250 m east of the site. The investigation area is surrounded by houses and summer cottages. 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.

Archaeological Environment. The investigation area is situated in an region relatively rich in Stone Age sites and finds. As early as 1907 a research project was undertaken for the purpose of illustrating Stone Age settlement in central Bohuslän. The two islands of Tjörn and Orust were selected for an intensive investigation. The field work was carried out partly as excavations and partly as a survey. As a result of this survey in the first decades of this century it was possible to recognize 189 Stone Age sites on the Island of Orust and 222 on Tjörn (Enquist 1922). These sites were discovered in cultivated ground. A more thorough study was made in a rescue investigation in the vicinity of Svanesund, in which eight sites were revealed. Only three of these were known through the survey at the beginning of the 20th century. Other thorough investigations in different parts of Bohuslän yielded the same result, i. e., only 1/3 of the total number of sites came to light at conventional surveys.

The investigation area is situated in the parish of Långelanda. In this parish 28 Stone Age sites were previously known, excluding the megalithic tombs. It is possible, by typology, to make a chronological classification of 23 of these. Eleven date from an earlier phase of the Mesolithic (–5000 B.C.), 8 from the so-called Lihult period (*c.* 5000–3000 B.C.) and 2 from the Neolithic (*c.* 3000–1500 B.C.) Another two have material both from the Lihult period and the Neolithic. From a geophysical point of view, it is easier to detect anomalies caused by sites from younger phases because settlement development is directed towards more stable forms. The most promising results could therefore be expected in sites from the Neolithic and the Lihult period.

Through the intensive investigation in the exploitation area of Svanesund it was possible to discover another five Stone Age sites in addition to the three already known. Of these eight sites, only six were directly involved in the exploitation. These six sites could be chronologically grouped as follows; one from the Sandarna culture, one from a period between the Sandarna and the Lihult cultures, three from the Lihult culture and one with finds from both the Lihult period and the Neolithic.

The site chosen for geophysical prospecting was RAÄ no. 131, which corresponds to Enquist no. 180 (Enquist 1922). It is a mixed site, yielding finds from both the Lihult period and the Neolithic. The finds from the former, however, were in the majority. Nothing in the excavation contradicted the interpretation that the site is mixed.

The Site — Archaeological Interpretation

A total area of approximately 1750 m^2 was uncovered by a small bulldozer. The main part of the excavated area was in the south-western corner. Some small trenches measuring althogether 5 m^2 were also dug. The geophysical survey embraced approximately 1550 m^2 and included both magnetometer and resistivity measurements. The archaeological features were observed in an area of about 200 m^2 (see Fig. 4). Twenty-seven different types of disturbance were discovered. Fifteen of these consisted of diffuse dark-shaded constructions of various forms with very small amounts of stone. They are indicated with "MF" in Fig. 4, and varied in thickness between 1 and 7 cm. In all probability they are traces of decayed tree stumps and other vegetational phenomena.

Three stone groups were found, marked "SG" in Fig. 4. One of these was probably a sewer connected with the house previously situated north-west of the excavated area. The function of the other two could not be determined.

Four constructions from more recent times were present. Three of these were covered drains ("CD" in Fig. 4) and the fourth a telephone cable ("TC" in Fig. 4).

Finds of more direct prehistoric character were four hearths situated in the eastern and north-eastern corner ("H" in Fig. 4). They consisted of stones with filling of sooty moraine with various amounts of charcoal. Their sizes were; $1 \times 1.35 \times 0.19$ m, $1.5 \times 1.8 \times 0.22$ m, $2.5 \times 2.7 \times 0.24$ m and $0.9 \times 1.2 \times 0.3$ m. The hearths have not yet been subjected to chronological analysis. Some charcoal will be submitted to radiocarbon dating. They will also go through a wood-anatomical investigation. Some samples were also taken for analyses of plant remains.

These analyses and the archaeological analysis of the excavation material are of no interest for the development of the geophysical surveying technique, hence the results will not be presented in this context. Publication of these parts of the investigation ,is in preparation.

The Site — Geophysical Interpretation

The geophysical investigation was carried out in two steps. First a twin configuration resistivity survey was made on a large 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. 1. 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 were therefore here 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 meter in a 9.5 meter grid was carried out inside the dotted line in Fig. 1. The results from this survey are shown on a map, Fig. 2. 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 sensitive to shallow disturbances, and the one meter survey to variations in bedrock topography.

In the 0.5 meter survey, eight anomalies within the excavation area with high resistivity values were interpreted as possible hearths. These anomalies are marked with a darker tone on the map in Fig. 3.

During the excavation phase, three hearths and part of a fourth 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 meter resistivity map (Fig. 2) shows that all four hearths were connected with resistivity anomalies.

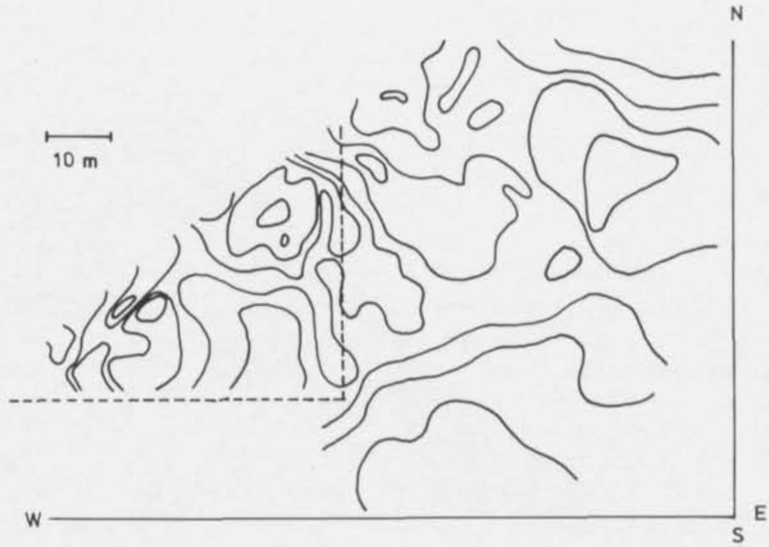

Fig. 1. Map of anomalies revealed by the resistivity method. Twinconfiguration 1 m. The dotted line shows the detailed investigation area. – Karta över anomalier från resistivitetskartering. Mätavstånd 1 m. Streckad linje visar det intensivundersökta området.

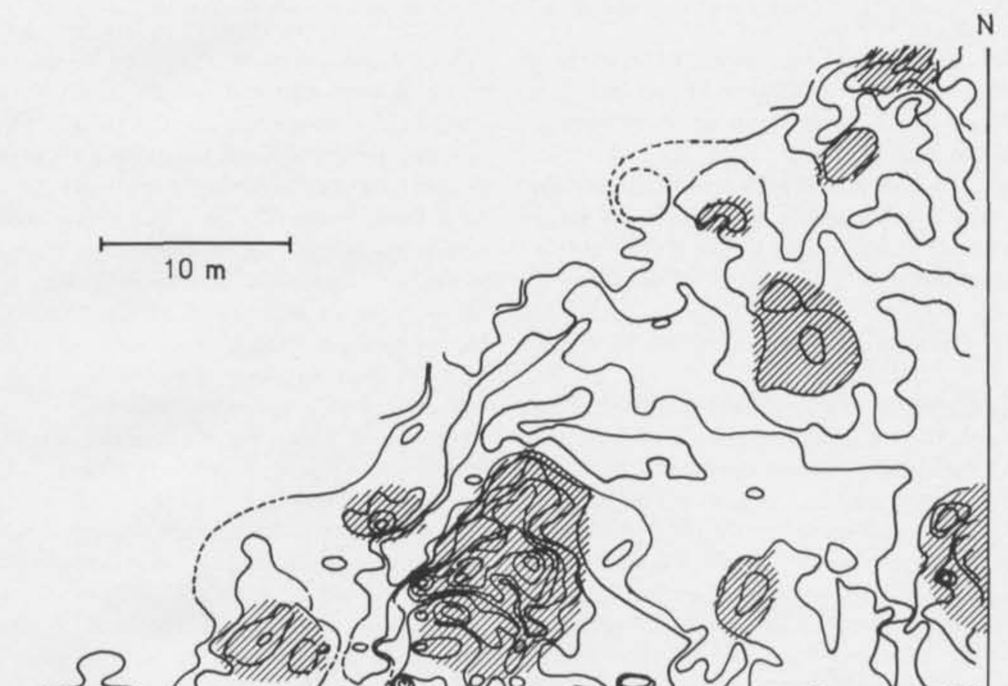

Fig. 2. Map of anomalies revealed by the resistivity method. Twinconfiguration 0.5 m. Darker areas represent high resistivity areas. – Karta över anomalier från resistivitetskartering. Mätavstånd 0,5 m. Skraffering visar områden med hög resistivitet.

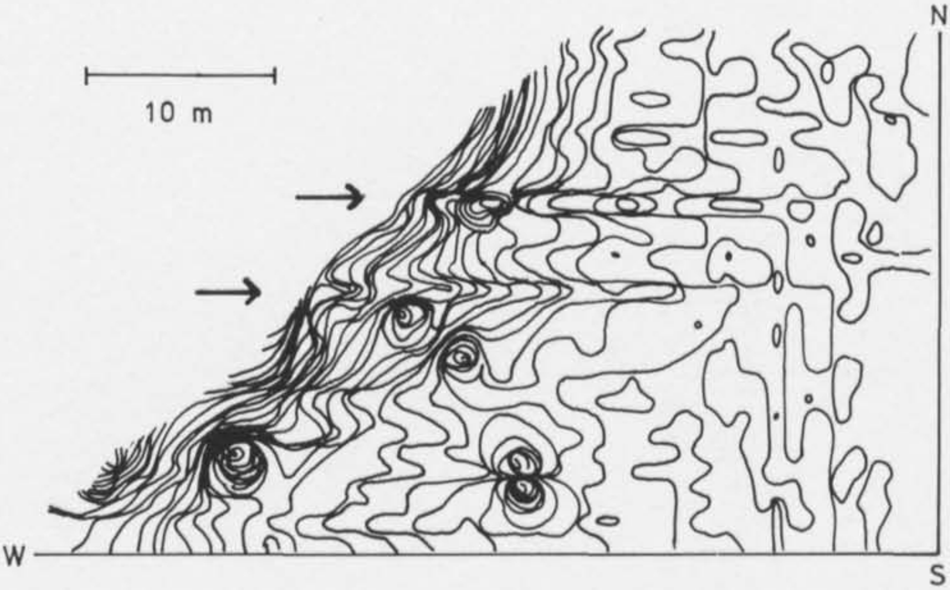

Fig. 3. Map of anomalies revealed by the magnetic method. Arrows indicate distorted profiles. – Karta över anomalier med magnetisk metod. Pilar markerar störda profiler.

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 grid. The results are shown in Fig. 3. Unfortunately, two profiles were distorted by the arrival of cars. These profiles are indicated by arrows in Fig. 3.

Comparison of the magnetic survey (Fig. 3) with the excavation results (Fig. 4) shows that the magnetic measurements could not to detect any remains. A later geological and magnetic investigation of the local stones and rocks indicated that most of the stones in the hearths consisted of nonmagnetic gneisses. This low magnetic rock type is however 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.

Conclusion

The results of the resistivity survey show that this method is capable of detecting areas of archaeological interest, and large stones. This method does not allow differentiation of natural stone clusters and hearths. However, all hearths within the detailed investigation area were detected. This promising result should encourage archaeologists to perform more experiments with resistivity measurements of other archaeological sites with different geological conditions, and to refine resistivity instruments and methods.

The magnetic survey of this site was not adequate to detect archaeological remains. Further tests must be carried out at other sites with different geological conditions, before the suitability of the method for detecting Stone Age remains is fully evaluated.

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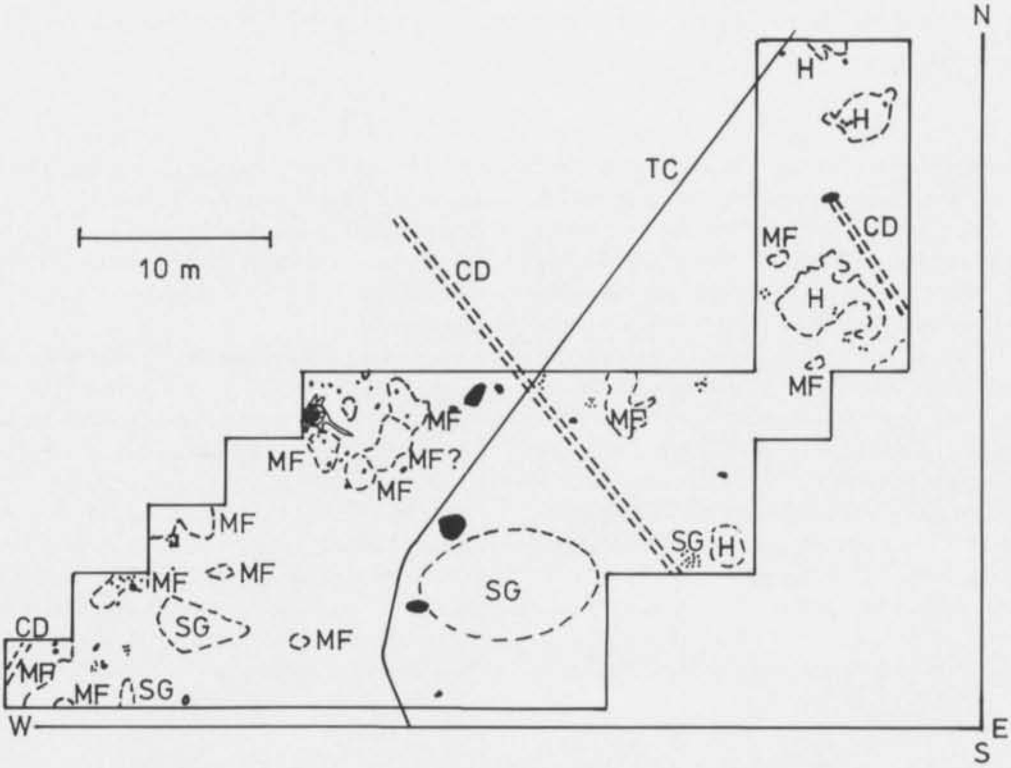

Fig. 4. Excavation map. H = hearths, SG = Stone group, MF = dark shaded constructions, CD = covered drains, TC = telephone cable. – Karta över utgrävningsområdet. H = härdar, SG = stensamling, MF = mörkfärgning, CD = täckdike, TC = telefonkabel.

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Arkeologisk inventering med geofysiska metoder i Svanesund på Orust

På en stenåldersboplats i Svanesund på östra Orust har försök gjorts med olika geofysiska metoder för att spåra ovan jord ej synliga fornlämningar. Två olika metoder användes, resistivitetskartering och magnetisk (magnetometer-)kartering. Resistivitetskartering innebär att man mäter variationer i det elektriska motståndet i marken, medan magnetometerkartering innebär att man registrerar variationer i jordmagnetismens styrka. Från arkeologisk synpunkt är detta intressant, därför att människan genom olika ingrepp i marken, exempelvis genom anläggande av härdar, stolphål och hyddbottnar m. m. förändrar både det elektriska motståndet i marken och jordmagnetismens styrka.

Genom resistivitetskarteringen var det möjligt att lokalisera härdar och även recenta stenkonstruktioner under markytan. En vidareutveckling av metoden behövs dock för att säkrare kunna skilja naturliga stenkoncentrationer från av människor utförda anläggningar.

Den magnetiska metoden visade sig inte fungera tillfredsställande. Framför allt berodde detta på ogynnsamma geologiska förhållanden och på störningar, bland annat av en telekabel som övertvärade området.

Vidare försök med dessa och andra geofysiska metoder pågår inom ramen för ett samarbete mellan Riksantikvarieämbetet och Chalmers. Ändamålet är att förbättra och effektivisera inventerings- och utgrävningsmetodiken på olika typer av fornlämningar.