5 Graphic representation methods in archaeological prospection in Czechoslovakia

Vladimír Hašek, Hana Petrová & Karel Segeth

5.1 INTRODUCTION

For processing of archaeo–geophysical data, many different programs have been applied, written for primary evaluation of the data, and for their qualitative and quantitative interpretation. Different types of personal computers are used for this purpose, mainly the IBM PC. This topic has previously been treated (Hašek 1990; Hašek *et al.* 1988; Hašek & Měřínský 1989; Hašek *et al.* 1990; Hašek & Vencálek 1989; Hašek *et al.* 1991).

In the present paper, attention is drawn to some new ways of graphic data representation. The results are used by archaeologists in reconnaissance prospection as well as in detailed prospection of individual sites.

Application of these methods is demonstrated on a site in the vicinity of Brno (ČSFR) showing up on a satellite image as a double circular object.

5.2 THE PROCESSING METHODS APPLIED

Archaeological tasks such as location of sites and drawing of the ground–plans of fortified settlements, etc. are treated using the two principal geophysical methods — magnetometry and the DEMP geoelectric method (Hašek 1990, Hašek & Záhora 1991). Field data can be plotted on computers either in the classical form of isolines (ΔT, ϱDEMP) — Figure 5.1, i.e. derived maps, or in the form of shadow maps, and in axonometric form. It has been found that the latter is more useful for archaeologists than the derived maps.

That is why a package of programs was created for the IBM PC, DEC VAX and other computers for solving these problems of graphic representation of measured field anomalies.

5.3 THE GENERAL PROCEDURE

Let us look at the construction by means of different methods of shadow maps and pictures based on perspective representation of the anomalies of the total vector of the geomagnetic field.

The data obtained at individual points on profiles was:

1) processed into ΔT anomalies;
2) recorded on a diskette in the form of X, Y, ΔT;
3) transformed to the binary file .SIT;
4) smoothed by means of linear interpolation and filtering using the routine ZJEMNI.

Then the graphic representation of the data was performed in the following steps:

1) On an IBM PC the program SURFER ACCESS SYSTEM, Version 4.15 was applied, using GRID for computing the network and SURF for 3D representation. A picture was printed on a STAR printer and plotted on DIGIGRAF (Figure 5.2).
2) A Picture was generated on a DEC VAX computer using the routine PLOTSIS and recorded on magnetic tape. Subsequently, a colour map was plotted on a RDS–500 VERSATEC plotter using the routine VERSD. Each value was assigned a colour shade from a scale set in advance (Figure 5.3).
3) The basic data was processed by means of Fourier transformation and frequency filtering (Figure 5.4 and 5.5) according to the procedure described in the next section.

5.3.1 Fourier transformation and frequency filtering

The procedure used for the processing of the data is based on the discrete frequency filtering. The

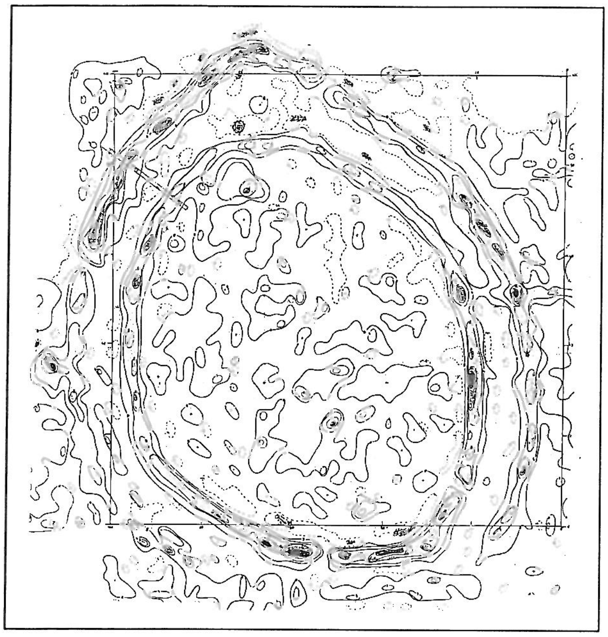

Figure 5.1: Šumice, district Znojmo: Map of ΔT isoanomalies.

discrete Fourier transform (spectrum) of the data is computed by means of the fast Fourier transform and FFT. Then it is multiplied by the sampled filter frequency characteristic, and the inverse transform is computed (again by means of the FFT). The processing is fast due to the properties of the FFT algorithm.

Some false high frequencies can be introduced into the data if its values near the borders are substantially different. To prevent this unfavourable edge effect, the data is smoothed across the borders (Bezvoda *et al.* 1990).

Note that the frequency domain filtering is based on the discrete convolution theorem (Bezvoda & Segeth 1981) expressing the relationship between the discrete data, the discrete filter and their discrete convolution. No discretization (and therefore no aliasing) is involved in the processing.

The most important feature of the frequency domain filtering is the possibility of implementing the discrete and the inverse discrete Fourier transform efficiently by means of the FFT algorithm (Cooley & Tukey 1963). The only conditions when transforming the $M \times N$ data are that $M = 2\mu$ and $N = 2\nu$, where μ and ν are integers. If M and N are not integral powers of 2, these numbers can be increased by adding the necessary number of zero rows and zero columns to the data. At the same time, the smoothing of the data near the borders is supported by this enlargement.

The data presented was processed using the FREDPACK package. The package was run on an IBM–compatible personal computer and is reasonably fast even for the 128 × 128 data items. It reads the data from diskette and can present them on a monochrome or colour display. A half–toned picture (Ulichney 1987) or a pseudo graphic (overprinted) picture (Scollar *et al.* 1986) can be printed as well. FREDPACK consists of independent subroutines performing the indi-

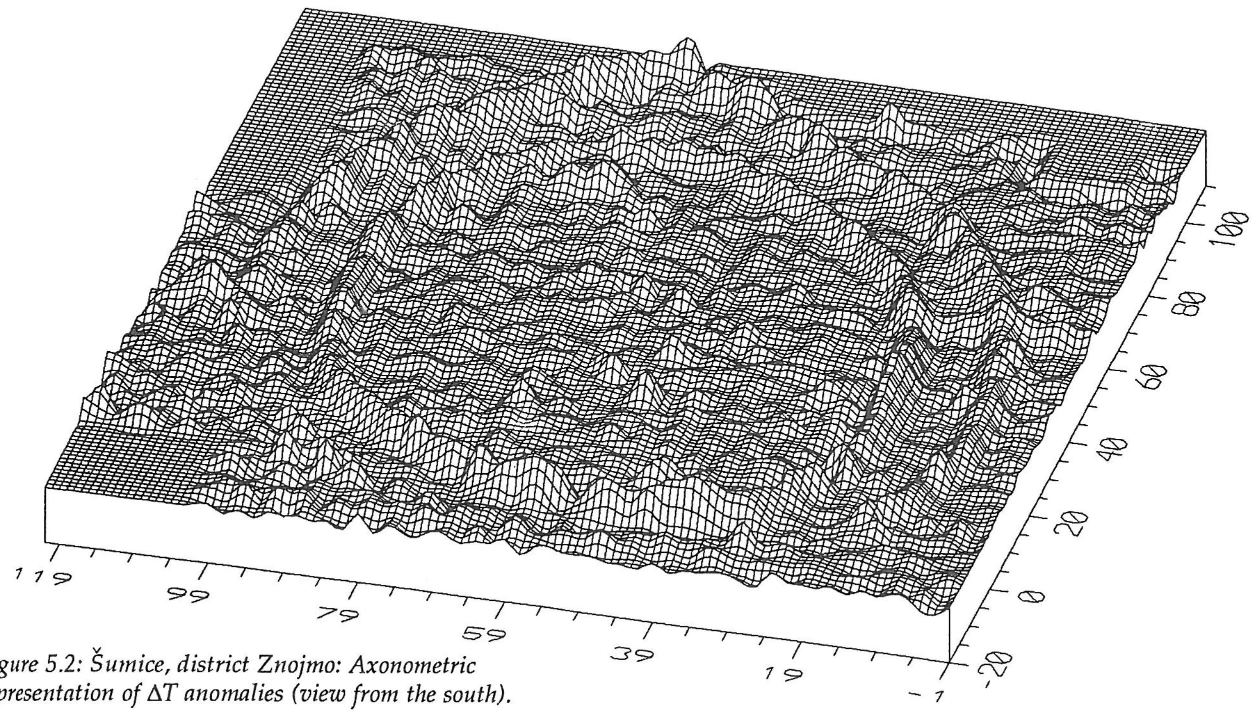

Figure 5.2: Šumice, district Znojmo: Axonometric representation of ΔT anomalies (view from the south).

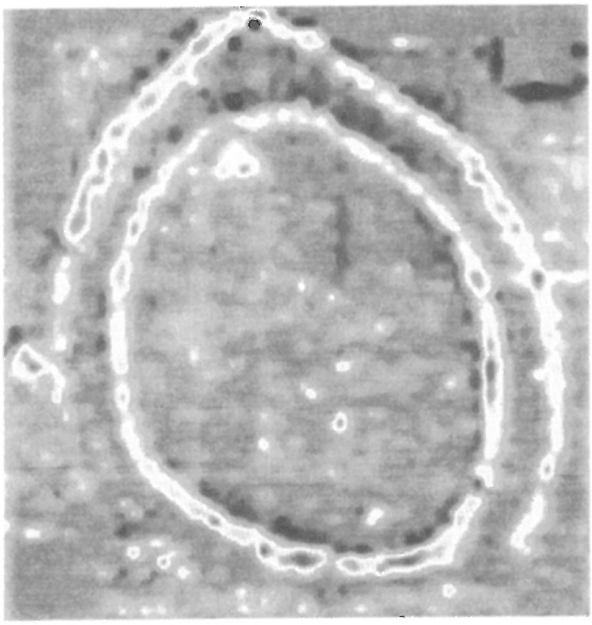

Figure 5.3: Šumice, district Znojmo: Colour shadow map of ΔT anomalies (Losos 1991).

Figure 5.4: Šumice, district Znojmo: Shadow map constructed using the obtained data.

vidual steps of the processing. The detailed user–oriented description of the package as well as its source listing is dealt with in (Bezvoda *et al.* 1990).

In the processing, a weak low–pass filter (suppressing noise at high frequencies) was combined with a weak high–pass filter (suppressing the trend of low frequencies). No directional filter was applied since the data has a circular character, and no noise prevailing in any direction is apparent.

5.4 DISCUSSION

For comparison, magnetic data from the locality Šumice in the surroundings of Brno, an area of 110 × 120 m, recorded on a 2 × 2 m grid, was represented in the form of ΔT iso–anomalies (Figure 5.1), in perspective (Figure 5.2), in the form of a colour shadow map (Figure 5.3) and in different tones of grey by Fourier transformation and frequency filtering (Figure 5.4 and 5.5).

Evaluating the maps from the viewpoint of archaeological interpretation of ΔT anomalies, we can conclude that almost identical results were obtained from both the colour shadow map and its black–and–white version. The latter is actually more detailed in our case (e.g. the inner structure). The perspective 3D representation together with the map of ΔT iso–anomalies can be of good practical use though the intensity and size of the anomaly as well as the angle under which the data is observed are of critical importance.

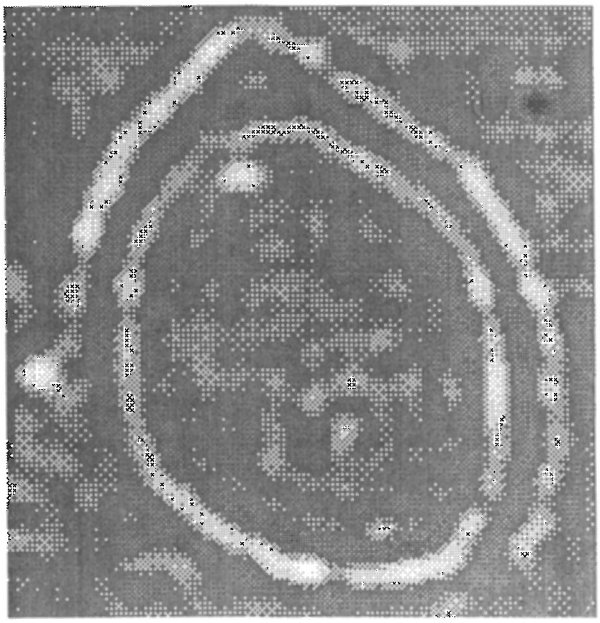

Figure 5.5: Šumice, district Znojmo: Shadow map, low frequencies partially smoothed, high frequencies smoothed (approx. 1/2).

5.4.1 Geophysical interpretation of maps

Using all the maps to diagnose the archaeological object, we found that there are two oval inner moats with 90 and 75 m long semi–axes, and two outer moats with semi–axes approx. 120 m and 100 m long. All have an orientation north–north–west to south–south–east. While the approx. 5 m wide inner moat is distinct in the geophysical picture (14 nT), the outer one, of the same width, (16 nT) is almost illegible on the southern and south–western side. It cannot be excluded that it was nearly filled up during a phase of restructuring, or that it had never been finished.

The orientation and number of entrances into the area are not regular. In the inner oval, three entrances are seen — on the southern, south–eastern, and north–north–western side. In the outer oval, there are four entrances, on the north–north–east, west–north–west, south and south–east side. The main entrance is assumed to be in the southern sector of the area.

Inside the site, magnetic anomalies were found on the southern and south–eastern side (Figure 5.5). These anomalies are presumably associated with the presence of a palisade trench (Bálek & Hašek 1992). It is assumed that the middle part of the site was densely settled.

5.4.2. Archaeological evaluation of geophysical processing

Archaeological prospection carried out in the north–western part of the site revealed two approximately parallel trapezoid moats, 5 m in width and 2,2 m in depth. According to the material found in them the site belongs to the Věteřov group of the later parrt of the Early Bronze Age (Bálek 1991).

5.5 CONCLUSION

Of the described methods of graphic representation of the data on the IBM PC and on the DEC VAX computer the combination of colour shadow maps by means of Fourier transformation and frequency filtering appears to be the most useful for archaeologists. The representation may be enhanced by plotting of results in perspective.

References

Bálek, M.
1991 Dvojitý kruhový příkop věteřovské skupiny u Šumic, okr. Znojmo. *AR* 48:247–252.

Bálek, M. & V. Hašek
1992 *Letecká prospekce a geofyzikální výzkum nových kruhových útvarů na jižní Moravě*. Sbor. prací Filos. fak. brněnské univ. (in print).

Bezvoda, V., K. Ježek & K. Segeth
1990 FREDPACK — a program package for linear filtering in the frequency domain. *Computers and Geosciences* 16:1123–1154.

Bezvoda, V. & K. Segeth
1981 Directional and frequency filtering of geophysical data measured in a rectangular net. *Gerlands Beiträge Geophysik* 90:133–146.

Cooley, J.W. & J.W. Tukey
1965 An algorithm for the machine calculation of complex Fourier series. *Math. Comp.* 19:297–301.

Hašek, V.
1990 *Metodologie geofyzikálního výzkumu v archeologii.* MS PřF UK Praha.

Hašek, V. *et al.*
1988 Geophysical data processing systems in Czechoslovak archaeology". S.P.Q. Rahtz (ed.) *Computer and Quantitative Methods in Archaeology*. BAR, Intern. Ser. 446, pp.195–200

Hašek, V. & Z. Měřínský
1989 Magnetometric modelling in archaeology. *Symp. UISPP, Com.4: Data management and mathematical methods in Archaeology*, Mogillany, pp.45–53.

Hašek, V., Z. Měřínský & K. Segeth
1990 New trends in processing and interpretation of geophysical data in Czechoslovak archaeology. *Science and Archaeology* 32:39–42, Stafford.

Hašek, V. & R. Vencálek
1989 Method for Processing Digital Geophysical Data in Archaeology. J. Richards (ed.) *Computer and Quantitative Methods in Archaeology* BAR, Intern. Ser. 548, pp.179–192.

Hašek, V., R. Vencálek & Z. Měřínský
1991 Anwendung der Korrelations–methode der Anomalientransformation bei der archäogeophysikalischen Prospektion von mittelalterlichen Objekten in Bedingungen der städtischen Agglomerationen. *XII. th. World Archaeol. Congres, Bratislava (in print).*

Hašek, V. & R. Záhora
1991 The Report on archaeogeophysical prospection at Al–Ma–abda (Egypt). *MS Rheinische–Friedrich Wilhelms Universität Bonn.*

Scollar, I., B. Weidner, & K. Segeth
1986 Display of archaeological magnetic data. *Geophysics* 51, pp.623–633.

Ulichney, R.
1987 *Digital Halftoning.* MIT Press. Cambridge, Mass.

Authors' addresses

Vladimír Hašek
Geofyzika Brno a.s.
Ječná 29a
CS–612 46 Brno

Hana Petrová
Fakulty of Natural Sciences
Charles University
Albertov 6
CS–128 43 Praha 2

Karel Segeth
Institute of Mathematics
Czechoslovak Academy of Sciences
Žitná 25
CS–120 00 Praha