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From data to structures
Multistage geomagnetic data interpretation within the Mautern Hinterland Survey

Volker Lindinger *, Stefan Groh * and Joris Coolen *

Key words: Interpretation, GIS analysis, Geomagnetics.

While archaeological prospection techniques are constantly being developed and improved, relatively little attention has been paid to the interpretation process. This tendency is illustrated by introductions (Gaffney & Gater, 2003; Aspinall *et al.*, 2008) and papers on geophysical prospection, which usually concentrate on the physical and technical aspects of the matter before (in the latter case) 'jumping to conclusions'. The lack of attention to the interpretation process can be attributed to another trend, where the geophysical data are only considered to represent the subsoil features archaeologists are interested in, instead of being treated as a dataset on its own, linked to the archaeological features, but with entirely different characteristics and thus requesting a different interpretation approach (Benech, 2007).

While GIS now seem indispensable in the presentation and interpretation of geophysical data, their use often seems to be restricted to creating overlays of different maps and drawing anomalies on a digital map (e. g. Neubauer, 2004). For this purpose, the geophysical data are often exported as a greyscale image, in which the original data have been replaced by abstract values.

In this paper, we will discuss the different stages leading from data to interpretation as used in the Mautern Hinterland Project,[1] a large survey project, which studies Roman rural settlement and land use in the hinterland of the Danubian Limes in Lower Austria (Groh *et al.*, 2007) (Fig. 1). The main prospection method used for the project is magnetometry. The geomagnetic surveys are carried out with two Geoscan FM 256 Fluxgate gradiometers, with traverse intervals of 0.5 or 1 m and the sample interval set at 0.125 m.

After the data have been downloaded to a computer, the software used for data restoration, processing and enhancement (Geoplot 3.0) usually displays the data as a raster image. To this purpose, each value or value class is assigned a specific colour, defined by its 8-bit RGB or greyscale value. When the image is stored as such to be used, for example, in a GIS, the original data are discarded and only the coded colour values remain. This presents no problem as long as the image is only used for display, and some calculation can even be carried out, as the colour levels still represent the original values. However, it is anything but obvious just how they represent these values, which poses a serious disadvan-

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1. The Mautern Hinterland Project is carried out at the Austrian Archaeological Institute with funding from the Austrian Science Board FWF (Project Nr. P19227). Project homepage: [*http://www.oeai.at/limeshinterland*].

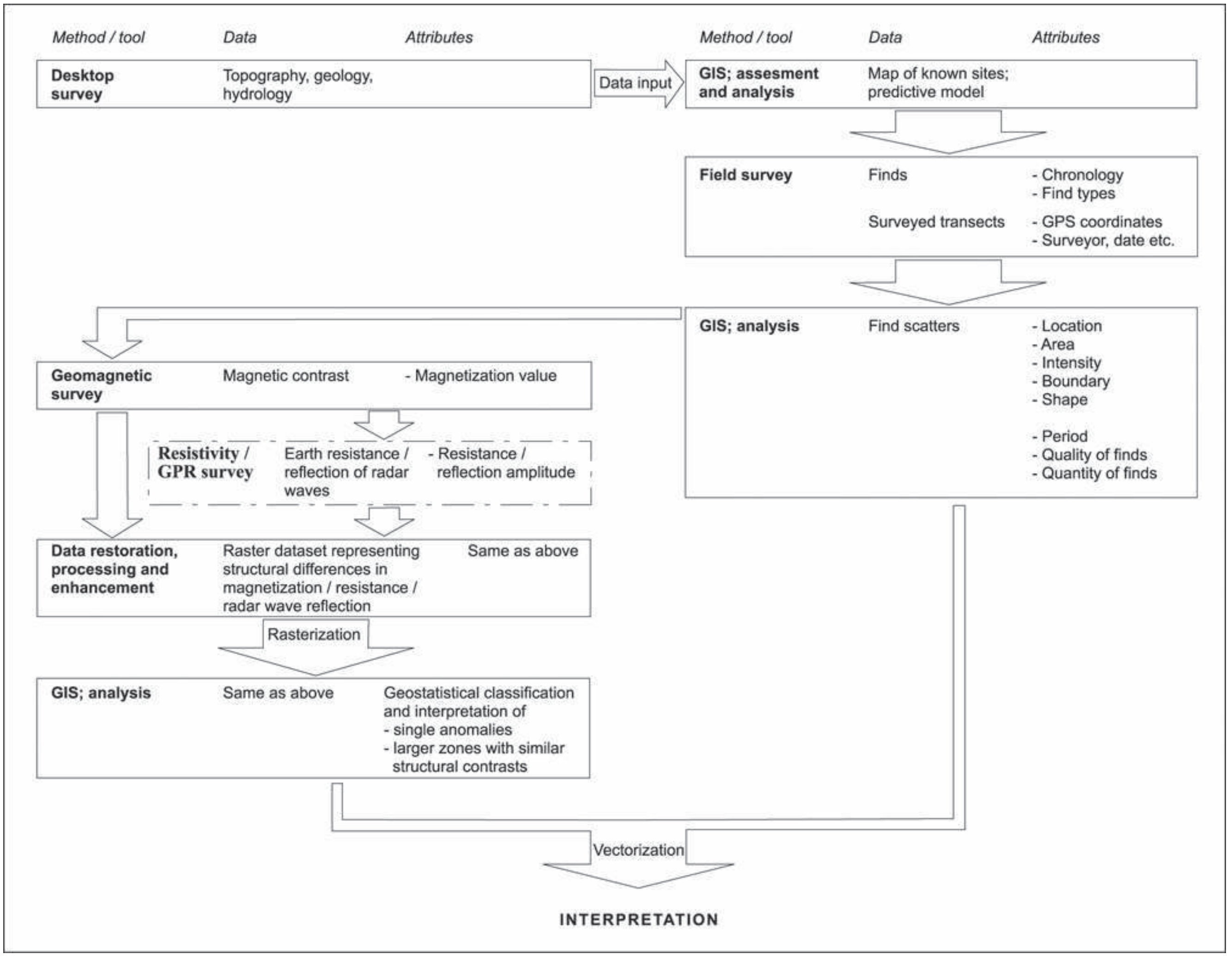

Figure 1: Workflow of the Mautern Hinterland Survey.

tage for interpretation. Therefore, the data themselves need to be imported into the GIS.

Instead of the entirely subjective and laborious manual vectorisation of single anomalies, these can be discriminated on different scales with various statistical analyses implemented in the neighbourhood statistics tool in ArcGIS' spatial analyst as well as in various extensions. A large analysis mask (5 m or more) is chosen to analyse whether the surveyed area can be divided into different zones based on the degree of magnetisation and spatial distribution of magnetic anomalies. In one case, several zones can be discerned based on the relative richness – a diversity index mainly used in ecological studies (Fig. 2). Although this division may seem obvious from the magnetogram, it needs to be quantified to become convincing. Moreover, we can now identify several areas with increased magnetisation, which can hardly be made out, let alone circumscribed, if single anomalies form the starting point of our interpretation.

A small analysis mask applied in the statistical analysis allows us to discriminate single anomalies. For Statzendorf, this was done by calculating the median within 0.5 m around each cell, thus reducing the influence of small spikes in the data (Fig. 3). The resulting grid was reclassified, using five classes divided by natural breaks, and subsequently converted to a polygon shapefile. Through the application of zonal statistics, the minimum, maximum and mean values of the survey data within each polygon were established and joined to the attribute table of the polygon shapefile. Various metrical attributes were added using the Vector-based Landscape Analysis Tools Extension (V-LATE) for ArcGIS (LARG 2005).

Taking the next step towards a conclusive interpretation, the anomalies can be classified on the basis of several criteria:

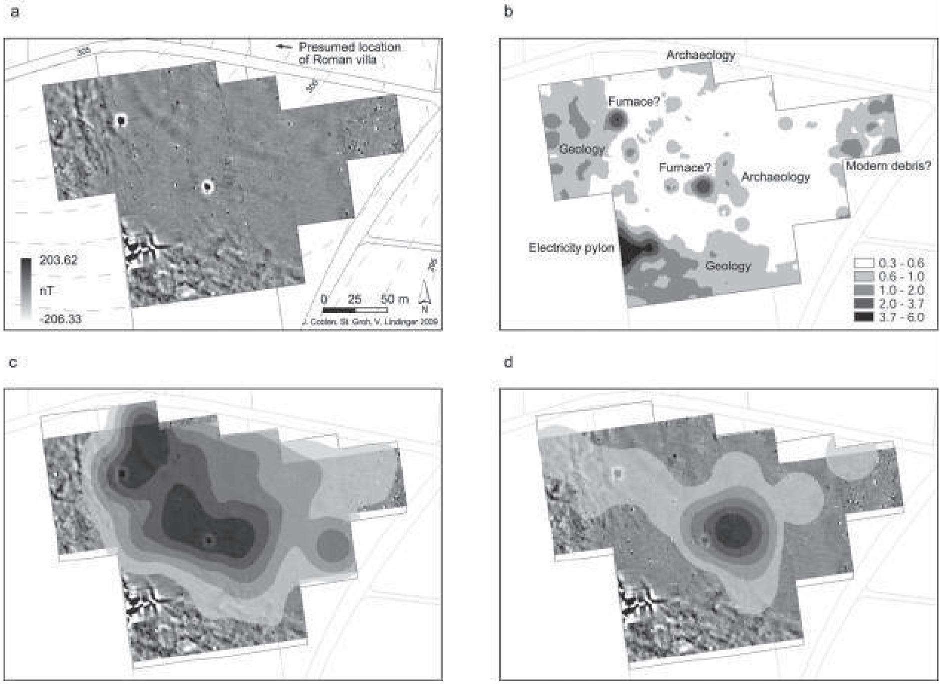

Figure 2: Watzelsdorf. a: Magnetogram, data stretched by 1 std. dev.; b: focal mean (r = 5 m) of relative richness of magnetisation values, classified by natural breaks; c: kernel density of brick and tile fragments (search radius 30 m), classified by natural breaks; d: kernel density of slags (search radius 30 m), classified by natural breaks.

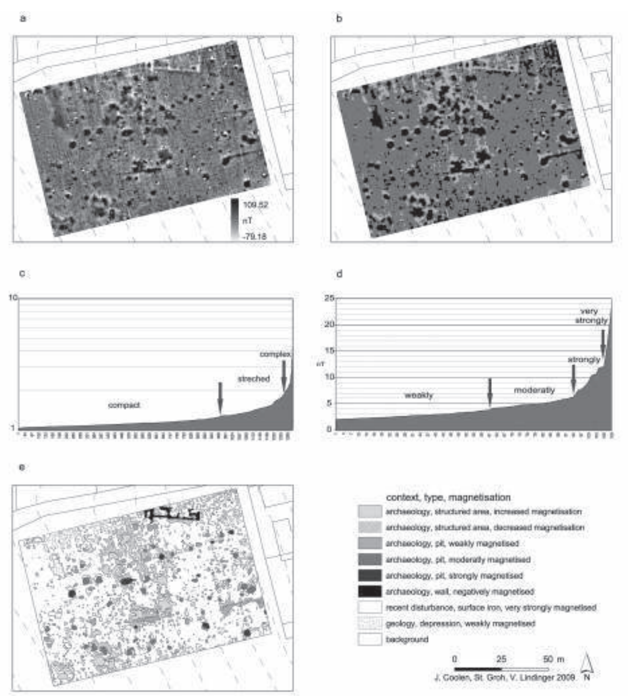

Fig. 3. Statzendorf. a: Magnetogram, data stretched by 2 std. dev.; b: focal median (r = 0.5 m) of magnetisation values, classified by std. dev.; c: distribution of the area-perimeter indices of all anomalies. d: distribution of the maximum magnetisation values of all anomalies that were classified as pits. Strongly magnetised anomalies can be ascribed to surface iron; e: archaeological interpretation of single anomalies.

area and shape (*i. e.* area-perimeter index), maximum magnetisation, context (archaeology/geology/interference by recent features/measurement artefacts) and feature class (pit/ditch/wall/kiln etc.). While the first three criteria simply summarize the variables that were determined before, the latter three are already interpretative. However, to get to a final interpretation, we need to combine all of these classes as well as the available information gained through other methods.

The main difference between the method described above and the conventional process may not be so much the final interpretation as the way we get to it. Apart from speeding up the interpretation process, it provides an interpretation with a more objective and comprehensible basis. Instead of reducing our data to a number of alleged features, we can now use the whole data set to deduce areas of archaeological interest.

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