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Magnetic Modelling for the 3D Reconstruction of the Neolithic Circular Ditch System of Steinabrunn/Austria

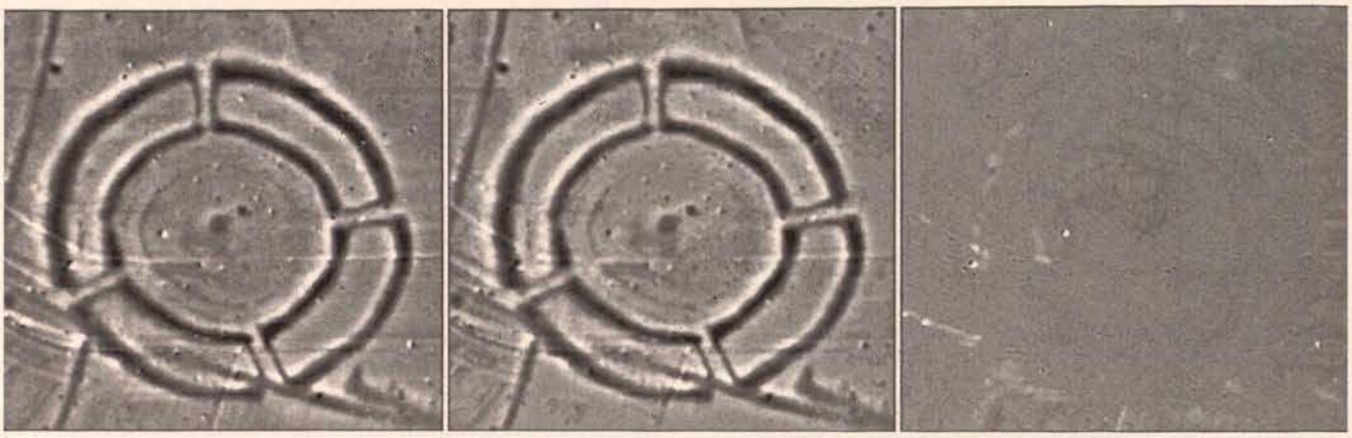
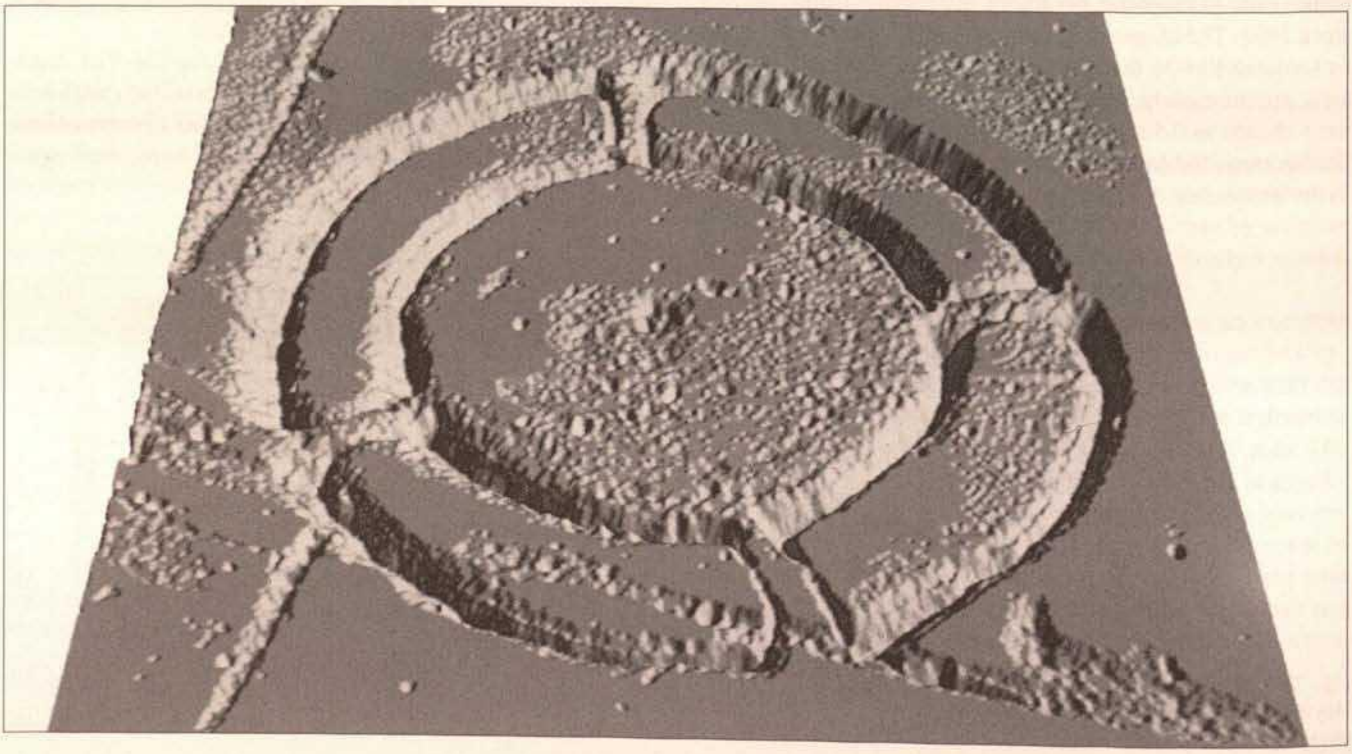


Fig. 1. The comparison of the measured and reconstructed anomalies shows the equally good reconstruction of all parts of the monument; caesium gradiometer 0.5 m – 2.0 m; raster 0.5 m x 0.25 m; area 110 x 105 m; visualised anomalous range [-6,15] nT

The most efficient method for investigating circular ditch systems from the Middle Neolithic (Lengyel culture) situated in homogenous loess is high resolution magnetic prospection. Their shape, the number of ditches and entrances and the state of preservation become obvious. By using caesiumgradiometers in a raster of 0.5 x 0.25 m even the remains of inner wooden palisades become visible in the magnetogram. This high resolution and high precision data forms an excellent input for 3D magnetic modelling to reconstruct the depth, width and shape of the ditches.

The reconstruction of the ditches of such a large monument is achieved by simulating the measured data using a simplified magnetic subsurface model of the filled ditches. The subsurface model is realised by single dipole sources with specific magnetisation arranged in a 3D array. The distribution of the dipole

Fig. 2. Three-dimensional visualisation of the reconstructed ditch of the rondel at Steinabrunn; the ditches have diameters of 81 m to 87 m and 52 to 57 m and a reconstructed depth up to 3.2 m



sources is determined by an iterative optimisation algorithm similar to simulated annealing. This iterative algorithm has to minimise two measures: the absolute difference between the measured data and the modelled magnetic anomalies and a regularisation term to produce a smooth ditch interface, which may include pre-information about the ditch section. The specially developed optimisation algorithm is called leaped annealing and is able to optimise various magnetic models. The reconstruction problem is therefore converted into an optimisation problem with plenty of parameters. For the monument Steinabrunn 184,800 parameters have to be determined.

The particular magnetic model was developed based on archaeological-geophysical excavation results and uses two independent magnetic horizons to represent the complicate stratification of the fill of the ditch. The first horizon models the upper parts of the filled ditch, which show high magnetic susceptibility contrast. The other models the lower parts of the ditch with lower magnetic susceptibility contrast. The application of the developed model is able to successfully reconstruct all parts of the monument due to its ability to adapt to different fill and varying state of preservation. The magnetic modeling of Steinabrunn uses an array of dipole sources with 0.25 x 0.25 m spatial and 0.1 m depth resolution.

The fully automatic reconstruction takes a few hours on an up to date computer and is divided into the following steps. In a preprocessing step the corrected data are classified to eliminate strong anomalies of modern source from the reconstruction. Then a first reconstruction is computed using an regularisation term which smoothes the ditch interface. The result of that first reconstruction is used to detect the shape of the ditches. This information is necessary to be able to integrate the known shape of the ditch section into the regularisation term within the final reconstruction step. The mean difference between the measured and the modelled magnetic anomalies of the rondel Steinabrunn is 0.085 nT $\pm$ 0.53 nT, the ditches have a reconstructed depth up to 3.2 m.

The reconstructed ditch can be intersected with the digital terrain model and mapped with additional information and reconstructed features from excavation results, like the palisade. New sights of such a Middle Neolithic monument can be achieved by animation of the scene to help understanding the purpose of these oldest Middle European monuments.

W. Edwards, M. Okita

Application of GPR to the Study of Subterranean Chamber Graves in Kyushu, Japan

The utility of GPR in the study of subterranean chamber graves was tested in an experimental program combining prospection and other forms of non-destructive investigation with limited excavation at a sixth-century cemetery site in southern Kyushu.

The existence of subterranean chamber graves at the Himori Site in Takaharu Village, Miyazaki Prefecture, was first revealed when part of a natural knoll was leveled for agricultural purposes in 1969. Investigations of the tombs, conducted from that time on by the Board of Education of Miyazaki Prefecture, show the basic shape of these features to consist of a vertical shaft no more than 2 m deep, from which a narrow horizontal passageway and burial chamber 2 m x 2 m or smaller are tunneled in one direction only (Fig. 1). The entrance to the passageway was typically sealed with a pile of stone slabs, preserving the chamber as a hollow cavity, while the shafts had been filled in completely. The Prefecture also conducted a shallow excavation over a 440 sqm area at the top of the knoll in 1981, locating ten pits, rectangular in horizontal plan, believed to represent the upper portions of vertical shafts corresponding to an identical number of chambers.

In September 1997, GPR was conducted over the area of the Prefecture's investigation at the knoll's crest. Anomalies suggesting the presence of chambers were readily detected in pro-

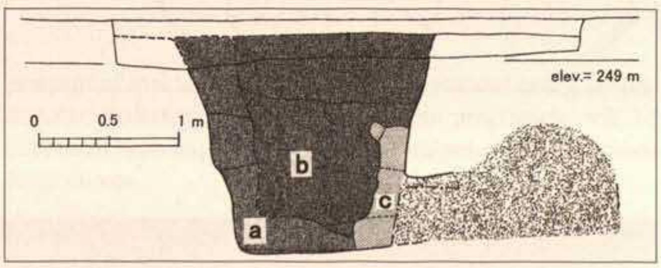


Fig. 1. Cross-section of Feature 3, showing relation of vertical shaft, passageway, and chamber; a: fill from the initial construction of the grave; b: fill from a subsequent burial; c: shadow of thick wooden boards used to seal entrance

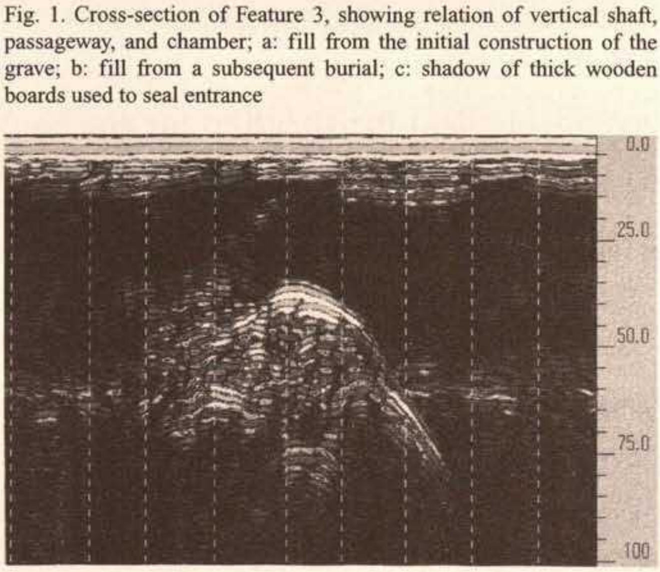


Fig. 2. GPR profile of Feature 3, showing parabolic anomaly indicating the chamber; disturbance to the left is the shaft