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 ± 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-

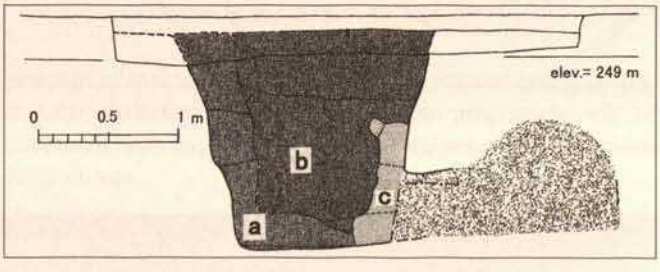

Fig. 1. Cross-section of Feature 3, showing relation of vertical shaft, passageway, and chamber; a: fill from the initial construction of the grave; b: fill from a subsequent burial; c: shadow of thick wooden boards used to seal entrance

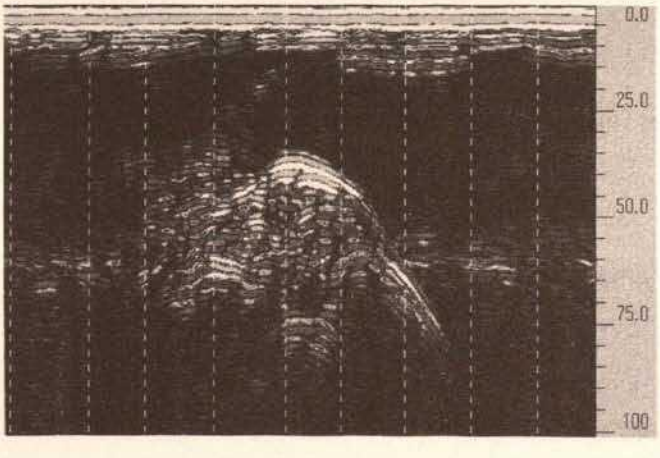

Fig. 2. GPR profile of Feature 3, showing parabolic anomaly indicating the chamber; disturbance to the left is the shaft

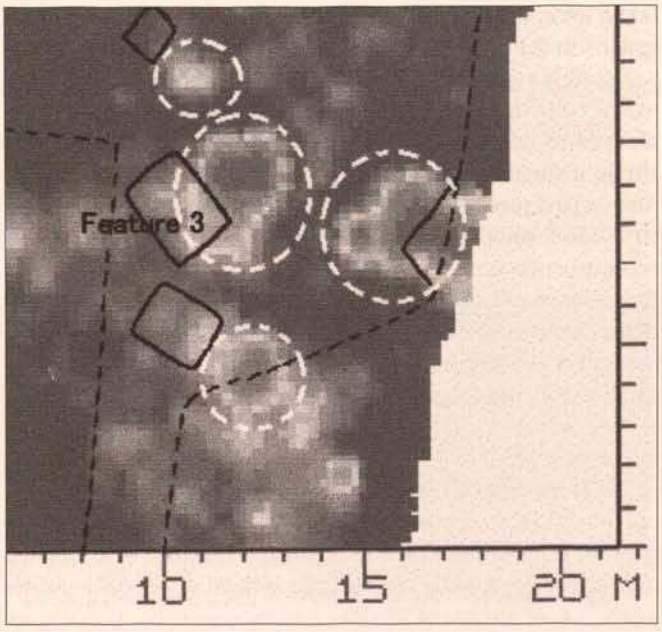

Fig. 3. Portion of time-slice image, showing strong anomalies (circled) indicating locations of chambers in relation to the corresponding shafts (rectangles)

file (Fig. 2), and horizontal time-slice analysis (developed by D. Goodman) showed these correlated closely with the shafts previously located by the Prefecture, presumably indicating the directions in which the chambers lie (Fig. 3). As no such anomaly was seen in association with Feature 8, however, it was provisionally concluded from the GPR results that the identification of this feature through conventional excavation as a grave shaft was mistaken.

The conclusions derived from the GPR survey were subsequently tested through limited excavation in December 1998. Feature 8 was sectioned east-west, with the southern half excavated, showing it to be a shallow pit ending shortly below the modern surface, and not leading to a chamber. Similar sectioning of Feature 3 (Fig. 1, 4) confirmed the existence of a passageway entrance on the northeast side of the shaft, as suggested by the time-slice images. Careful examination of the section showed that the chamber had been reopened after its initial construction, presumably for the purpose of a subsequent burial, and that the entrance had been sealed with a thick wooden board, rather than stone slabs (Fig. 1). Observations such as the latter are beyond the current capabilities of research by prospection alone.

Finally, a hole was opened through the dirt filling the entrance to the chamber of Feature 3, and first a miniature video camera, then a digital still camera were inserted, both attached to the ends of long poles, to obtain visual images of the chamber's interior. The digital camera in particular provided useful images showing the skeletal remains of two or more individuals, at least one of whom was an adult female, which had been arranged after decomposition of the flesh along the back wall of the chamber.

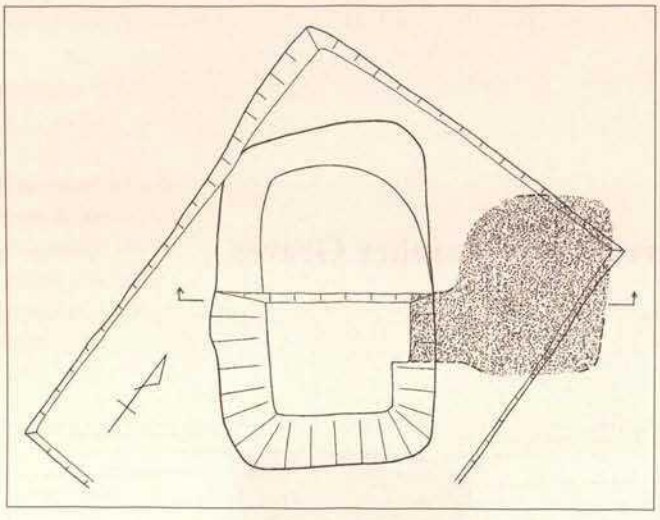

Fig. 4. Plan of Feature 3, sectioned, with outline of associated chamber (shaded, drawing based upon visual inspection)

G. Fuchs, I. Kainz

Archaeological Prospection for the Koralmbahn in Austria

A new high capacity railway line, the socalled Koralmbahn, is planned to connect the cities of Graz and Klagenfurt in Southeastern Austria. In the East of the Koralm range, which will be passed by a long tunnel, it runs through the Laßnitz Valley, where numerous archaeological sites from the Neolithic to the Roman periods were expected, but only a part was known.

For the evaluation of possible impacts to the archaeological heritage existing data were not suitable, so a systematic archaeological survey was carried out to cover the whole valley floor completely for a length of ca. 20 km. Different methods were applied in combination to check reliability of observations and to facilitate interpretation. In addition to the ground survey, aerial prospection was carried out. The detailed mapping of morphology made it possible to detect some regularities in site distribution and to define important parameters for the positioning of settlements. As the valley is still flooded today, the deposition of