The Roman town Teurnia is located in the area of the "Holzerberg" in todays St. Peter im Holz (Carinthia), covering approximately 17 hectares. Since 1845, excavations have been going on, which revealed parts of the towns wall, the forum, residential terraces and several early christian churches. Among them also the episcopal church dating from the 5th and 6th century A.D on top of the Holzerberg. A part of the town at the eastern bottom of the Holzerberg was photographed several times from the air by S. Tichy, a member of Carinthia´s building surveyor´s office between 1978 and 1992. These oblique photographs show the crop-marked town map of an area of 23,000 sqm To be able to integrate the information of these photographs into a complete town map, the aerial archive at the institut for Prehistory in Vienna was consulted.

The area of interest expands over several narrow fields with different crops, each responding differently to the underlying archaeology. This results in a patchwork, where photographs show cropmarks only in single fields. Fortunately, since the photographs were taken over several years, cropmarks could be recorded on each field. Therefore, all of the photographs had to be used for interpretation. Additionally a vertical stereopair (1:10,000) was available, produced by the Austrian air force during summer 1980. It covers the whole area of Teurnia. The oblique photographs were taken using a non-calibrated small format camera with unknown focal length. Unfortunately, some photographs showed a bad distribution of possible control points.

To be able to deal with these problems, we decided to use a bundle adjustment, where control points (= points with ground control) and tie points (= points visible in two or more photographs, but without ground control) are measured on all photographs and all measurements are adjusted to the ground control values in a single solution. The whole procedure was done digitally using the software Softplotter™ on a Silicon Graphics O2 workstation with 256MB RAM. The vertical photographs and the slides were scanned with 2,000 DPI. Ground control was measured using a total station. After the orientation, topographical data (3D-points and breaklines) were measured and a digital terrain model calculated. Consequently, this was used to rectify all of the photographs which were oriented by the bundle adjustment. The resulting orthophotographs have a pixelsize of 0.2 m. The accuracy depends on the quality of the distribution of the control points and lies between 0.5 m in the central part (which contains most of the archaeology) and up to 3 m in the more distant parts.

The interpretation was done using the geographic information system ERDAS Imagine®. Using the provided image enhancment techniques, the orthophotographs were treated with contrast stretch, Wallis filter or crispening. All of the georeferenced orthophotographs and their filtered variations were interpreted on screen. The interpretation drawing was combined with digitized results from the previous excavations which had been done between 1971 and 1978. The combined analysis of the results from the excavation and from aerial interpretation provided archaeologists with new clues to the extent of the settlement area during the 1st to 3rd century A.D. It will also function as basis for future archaeological activities as geophysical prospection.

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3D Reconstruction of Archaeological Sites Based on Prospection Data

The Middle Neolithic circular ditch at Schletz is located in the hilly landscape of northeastern part of Lower Austria and was detected by aerial archaeology in 1981. The interpretation of the aerial photographs was done using analytical photogrammetry. For the whole procedure, an analytical plotter device with a PC 386 was used. This device has a high precision in measuring picture coordinates (at about two mycrons) and therefore produces highly accurate 3D maps of the relevant archaeological information. In that way, the outline of the circular ditch could be drawn which was used later on for setting out the grid used by the geophysical prospection. Additionally, a raster of 3D-points and 3D-breaklines were measured and consequently, the digital terrain model of this site was calculated.

In 1995, a magnetic survey of the site using a high resolution caesium gradiometer was carried out. An area of two hectares was measured in a raster of 0.5 x 0.25 m. The data were visualised as digital images and georeferenced for interpretation. The archaeological interpretation shows a highly eroded single circular ditch with two interruptions, which were used as entrances. Each entrance feature is flanked by two short ditches, which meet the main ditch at a right angle. Using GIS, all the different prospection data were digitally combined to create additional images for subsequent archaeological interpretation.

To derive 3D reconstructions of the archaeological features a magnetic model was constructed. This was done by 3D modelling of the subsurface using dipole spheres of equal size and ho-

Fig. 1. Magnetogram of the circular ditch at Schletz, Lower Austria; caesium gradiometer 0.5 – 2.0 m, raster 0.5 x 0.25 m, area 19,200 sqm, dynamic range [-5,7] nT

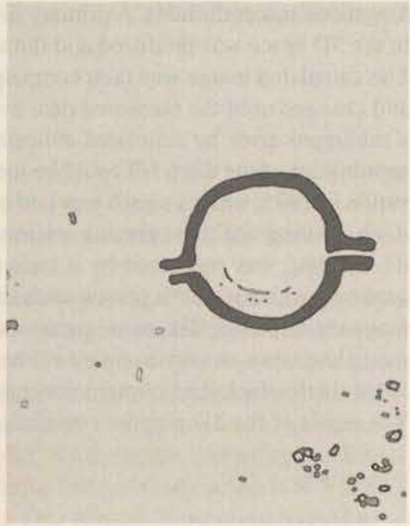
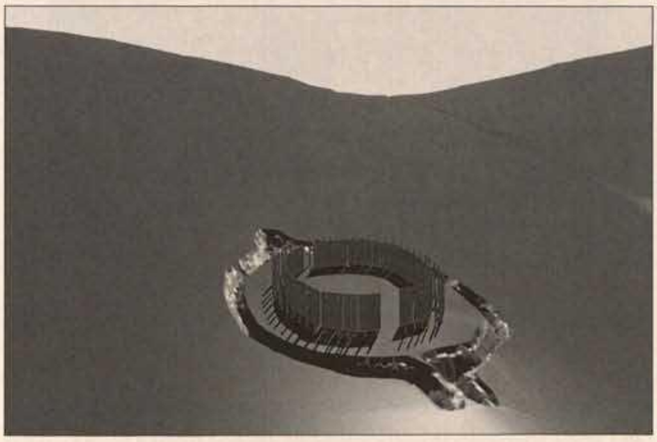


Fig. 2. Archaeological interpretation of the combined prospction data



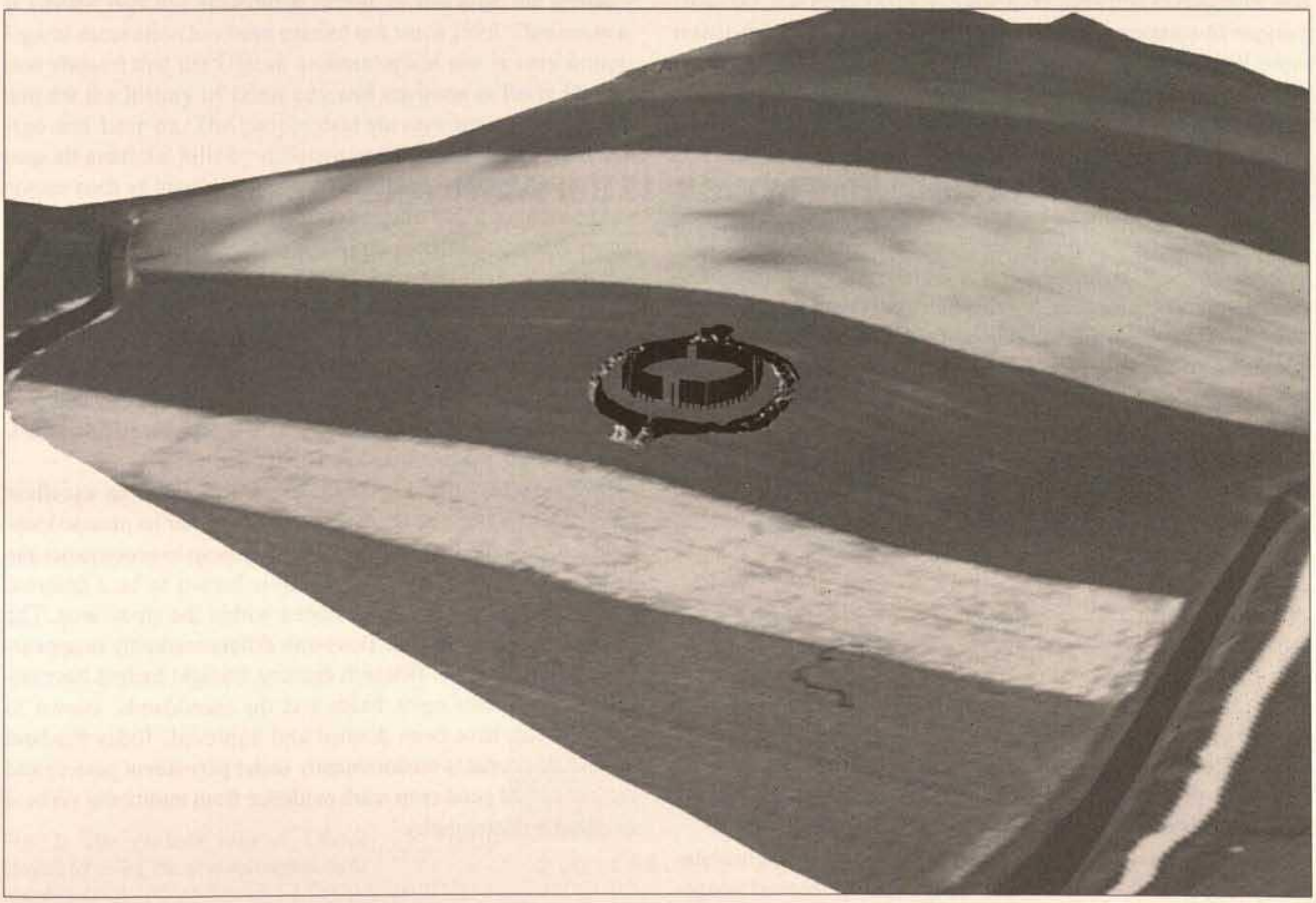


Fig 3 and 4. 3D view of the reconstructed monument Schletz mogenous susceptibilities. A primary distribution of the spheres in the 3D space was produced and the anomaly was calculated. The calculated image was then compared to the measured data and changed until the measured data were accounted for within a minimum error by simulated annealing. In Schletz, the susceptibilities of the ditch fill could be measured during the excavation in 1995, when a trench was laid out through the V-shaped ditch. During the stratigraphic excavation, each layer of the ditch-filling was registered by a tachymeter and magnetically analysed, which lead to a precise understanding of their size and magnetic influence. The consequence of these results for the 3D modelling were an improvement of the magnetic model of the filled ditch which lead to more accurate reconstruction results. The result of the 3D magnetic modelling was intersected with the digital terrain model and in that way visualized within its landscape. Aerial photographs were then mapped on the terrain, which can then be looked at from any direction and animated to produce virtual flights. Other details, as the single posts of the palisade could be taken from the 2-year's excavation. The postholes were digitised and thus, the whole palisade could be reconstructed.

Images as magnetograms, digital aerial photographs, reconstructions of the ancient environments or photographs from excavated parts of the monuments can hierarchically be mapped on the digital terrain model. Integration of reconstructed archaeological features based on additional excavation data produces a virtual model of monuments that had been covered by soil over thousands of years, bringing them back to (virtual) life.

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Airborne Thermal Prospection in the 8–12 μm Wavelength Range

The use of thermal infrared imaging for archaeological prospection has received relatively little attention compared with other geophysical techniques. However, it appears to have potential for identifying archaeology under permanent pasture which is a land use that covers an extensive part of the UK rural landscape and which rarely yields crop marks in conventional vertical or oblique photography. An experiment was carried out to test the ability of airborne thermal imagery to detect shallow ground disturbance at the site of the Battle of Bosworth (1484) in Leicestershire, UK. The relatively uniform temperature of the ground surface normally hides information contained in daytime thermal imagery. Instead, we invert the heat flow equation using pre-dawn and mid-day image pairs acquired from an airborne thermal line-scanner to compute a measure of diurnal heat capacity (apparent thermal inertia). In theory, we would expect structures that lie buried beneath the ground to have a diurnal heat capacity distinctive from the surrounding soil.

First, we present a methodology for deriving diurnal heat capacity (apparent thermal inertia) from airborne thermal imagery. Secondly, we interpret the raw and processed imagery for the presence of buried structures and shallow ground disturbance. Finally, we assess some of the interpreted structures by comparing their location and morphology with independently acquired, ground based, magnetic and resistivity surveys.

Bosworth battlefield in Leicestershire provides an excellent test site partly because there is controversy over its precise location and disturbed ground features may help to reconstruct the geography of the battle. Also, there is known to be a deserted medieval village lying unexcavated within the study area. The modern landscape around Bosworth differs markedly in appearance from that of the fifteenth century. Straight hedges have enclosed the former open fields and the marshlands, known to have existed, have been drained and improved. Today the land around Bosworth is predominantly under permanent pasture and does not yield good crop mark evidence from traditional vertical or oblique photography.