Geophysical Prospection in Roman Rottweil – Arae Flaviae

A Resistivity Survey and its Results

Mit einer deutschen Kurzfassung

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Introduction

Rottweil is situated on both sides of the upper Neckar in a natural gap between the Black Forest and the Swabian Alb. Whereas the medieval and modern Rottweil are located on the left side of the Neckar in a loop of the river, the earlier medieval Rottweil ("Königshof") lay in a bend of the river further to the southeast. The centre of the Roman town was situated even more to the east at the right of the Neckar between this river and a little river called the Prim (fig. 1). Earlier Roman forts were erected at the site of the town as well as to the left of the Neckar in the area where the Königshof was later built.

The earliest Roman structures are connected with the military occupation of southwest Germany under the Emperor Vespasian in the years following the Four-Emperors-Year (69 A.D.). Extensive settlements of camp-followers, so called military vici, then emerged around several consecutive forts. The last fort to the right of the Neckar was probably dissolved under Domitian and the settlement there was transformed into a Municipium (a town with an explicit charter). It served as economic and administrative centre of the region between the Black Forest and the Swabian Alb until the end of the Roman occupation in the second half of the 3rd century A.D.

After the first recorded discovery of Roman ruins in Rottweil in 1784, excavations have been undertaken in many parts of the forts and the town[1]. Since 1967 excavations have run almost continuously, although their main purpose has changed. While the goal in earlier years was purely to discover the remains of buildings and presentable finds, today's excavations seek to record features and archaeological contexts prior to their destruction through construction. The modern excavations are directed primarily by time constraints and the location of building projects.

The results of more than 200 years of excavation are shown on the "Gesamtplan des römischen Rottweil"[2] in a scale of 1:2500. Unfortunately, however, not all of the features indicated there are precisely located. This is the case not only with those labelled "nicht eingemessen" (not measured), but also with some of those labelled "gesichert" (proven). The reason for this is that

1 For a detailed history of the archaeological research see D. Planck, Arae Flaviae I. Neue Untersuchungen zur Geschichte des römischen Rottweil. Forsch. u. Ber. Vor- u. Frühgesch. Bad.-Württ. 6 (Stuttgart 1975) 13ff.

2 Landesdenkmalamt Baden-Württemberg (Hrsg.), Mvnicipivm Arae Flaviae, Gesamtplan des römischen Rottweil (Stuttgart 1980). In parts shown with some later additions in Abb. 1.

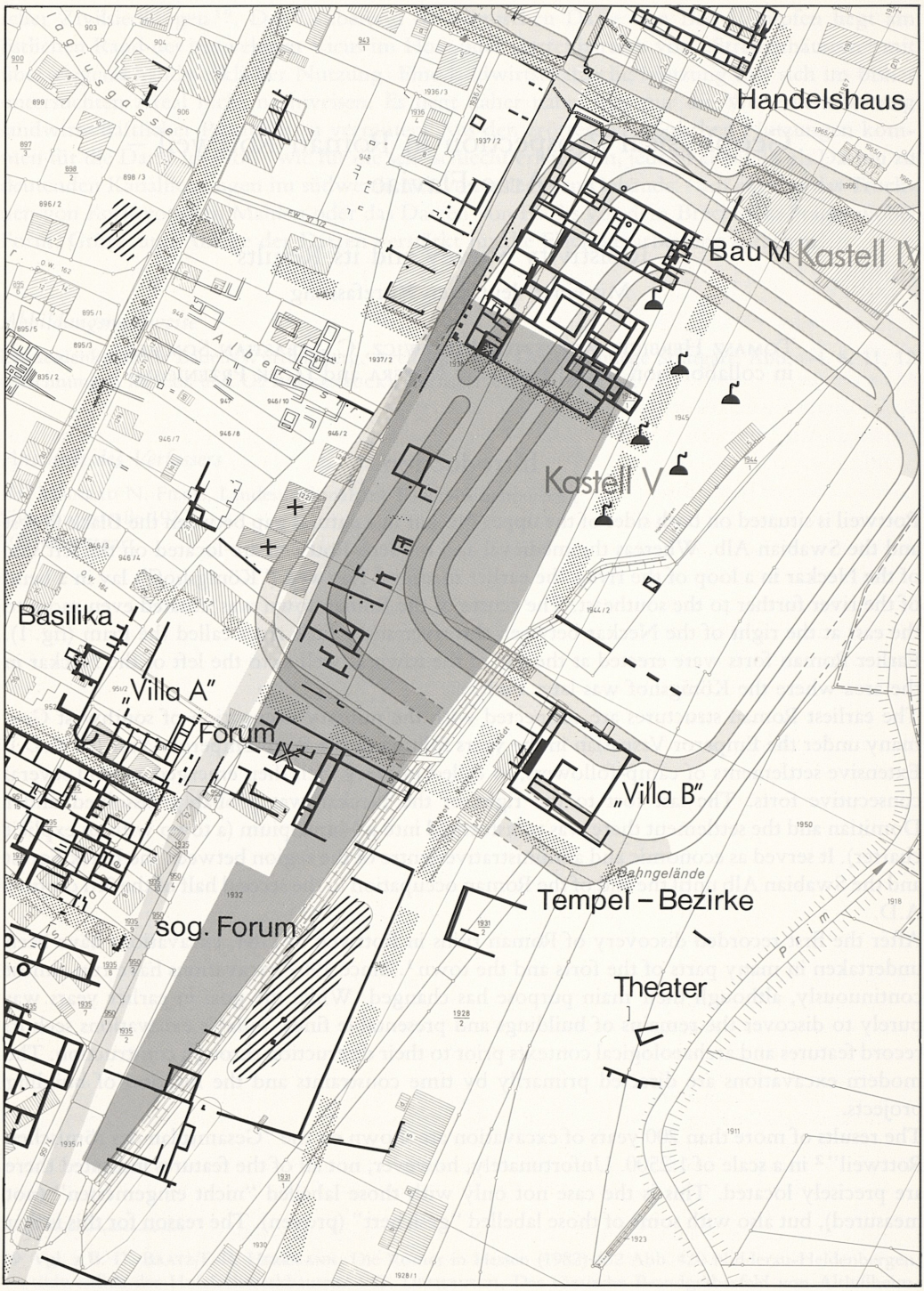

Fig. 1 Central part of the Municipium Arae Flaviae. After "Gesamtplan des römischen Rottweil", with additions. Marked in grey is the area which was surveyed. 1:2500.

discoveries of the 19th century in particular were not always plotted accurately or were often related to features such as houses, trees etc. which can be traced only vaguely today – or which no longer exist.

The permanent expansion of the modern town presents a growing threat to undisturbed sites. The only way to assure longer or even permanent protection seems to be to schedule monuments ("Eingetragenes Kulturdenkmal") or to establish "Grabungsschutzgebiete" (areas where all digging is forbidden) [3]. Areas like this have been set up in the central part of the Roman town of Rottweil.

Both the necessity to present evidence of archaeological features in areas considered for protection as well as scientific interest in areas which are already protected or are otherwise inaccessible to excavation call for non-destructive methods of exploration. The simplest, and most likely cheapest approach – aerial photography – is not applicable everywhere and has not achieved satisfactory results in Rottweil to date. Thus, it was felt that the application of geophysical methods might provide valuable information. An inofficial cooperation between the Landesdenkmalamt Baden-Württemberg and the Institute of Archaeology and Ethnology (formerly Institute of the History of Material Culture) of the Polish Academy of Sciences in Warsaw provided the opportunity to apply and test geophysical methods at Rottweil, in particular the measurement of ground resistivity [4]. Between the 1st of September and 10th of October 1988 T. Herbich, K. Misiewicz, M. Mizera, J. Przeniosło and M. Skrzydelski surveyed an area of approximately 1.5 ha in the centre of Roman Rottweil. The archaeological context was provided by C. S. Sommer [5].

The area surveyed consisted of the last undisturbed area of significant size within the Municipium Arae Flaviae in the centre of the area now called "Hochmauren" (fig. 1). Most of it is under special protection [6]. Only the northernmost part of the area surveyed is under direct threat. The Landesdenkmalamt Baden-Württemberg has been conducting excavations here since the middle of the 1970's because the town of Rottweil plans the construction of a sports field in this area. Immediately after the geophysical survey a strip between $y = 900$ and $y = 910$ was excavated in 1988 and 1989 [7].

Excavations had already been undertaken in several parts of the surveyed area in earlier times. The first one began in 1784 under J. B. Hofer. During this time the famous Sol-mosaic was

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3 § 12 and § 22 Denkmalschutzgesetz of Baden-Württemberg (law of the protection of ancient monuments).

4 At this time the Landesdenkmalamt Baden-Württemberg did not have an own unit for geophysical prospection. See H. v. der Osten-Woldenburg, Naturwissenschaften und Archäologische Denkmalpflege (4). Die Geophysik am Landesdenkmalamt im Aufbau. Denkmalpfl. Bad.-Württ. 21, 1992, 25–33.

5 Valuable technical help on the site was given by Grabungstechniker Th. Schlipf. As the common language of the participants is English, this article is written in English. We are grateful to M. Wong-Sommer for her corrections and useful comments on the text. A preliminary report was given by C. S. Sommer/T. Herbich/K. Misiewicz/M. Mizera/J. Przeniosło/M. Skrzysdelski, Geophysikalische Prospektion in Rottweil. Arch. Ausgr. Bad.-Württ. 1988, 96–98. Aspects of this survey were presented as a lecture by T. Herbich under the title: Multilevel Profiling – are the longer and costlier investigations worthwhile? at the 14th General Meeting of the European Geophysical Society in Wiesbaden April 1991 (abstract in Annales Geophysicae 9 suppl., 1991, 612–613). The reason for the fairly long duration of the survey will become clear in this article. In addition to the area which is presented here, an area of about 800 m^2 was surveyed in Hoferstraße Flst.-Nr. 551/1 at the same time. Due to the poor state of preservation there the results of this survey were rather vague. They will be published together with the results of the subsequent excavation (for a preliminary report see C. S. Sommer, Ausgrabungen im römischen und mittelalterlichen Rottweil 1990. Arch. Ausgr. Bad.-Württ. 1990, 121–123).

6 It consisted of the plots 1932 (excluding its western part), 1933 (scheduled monument according to § 12 Denkmalschutzgesetz); 1938 south and 1942 south up to approximately $y = 910$ („Grabungsschutzgebiet" according to § 22 Denkmalschutzgesetz up to $y = 890$).

7 See C. S. Sommer/J. Lauber, Ausgrabungen im Municipium Arae Flaviae – Rottweil. Arch. Ausgr. Bad.-Württ. 1988, 91–93; C. S. Sommer, Ausgrabungen im Municipium Arae Flaviae – Rottweil 1989. Arch. Ausgr. Bad.-Württ. 1989, 127–131.

uncovered but later forgotten. Although O. HÖLDER also conducted an excavation here in 1894, the mosaic was not rediscovered until 1915/16 by Baurat MAEHRLEN[8]. The complex which surrounds the mosaic lies opposite the so-called Villa A (Basilika) and is marked in fig. 1 with Forum[9]. The southwestern part of this complex was excavated by D. PLANCK in 1968 prior to the construction of the house Flavierstraße 14[10]. To the south, some walls were discovered in 1926 by O. PARET when the local railway to Balingen was built[11]. The central part of this area ("sog. Forum" in fig. 1) was later interpreted either as forum[12] or as a sacred district where it was suspected that the Flavian altars stood which gave the town its name (based on its similarity to a large open complex at Kempten)[13]. However, recent excavations[14] as well as the geophysical survey have shed serious doubts on both these interpretations (see below).

Several excavations must have been performed to the north of the area where the mosaic was found. One may have occured in 1895 and seems to have been confined to the plot 1938[15]. Traces of many more or less parallel stone buildings have been found here facing the major north-south road. Additions to a 1910 plan[16] show that further work must also have taken place to the east. This is also indicated by a 1928 plan in which not only the continuation of some of the stone buildings are shown, but also the existence of timber buildings through a signature "Holzbauten"[17]. The same features are included in a previously unpublished plan drawn in 1914 by MAEHRLEN (fig. 18)[18]. Unfortunately, the results of these excavations have not been incorporated into the "Gesamtplan des römischen Rottweil" (see fig. 1). As the full extent of these excavations were never recorded, it is unclear whether all existing walls have been found or not. In these excavations, and also in the more recent ones until 1989, large parts of a complex which later was called "Handwerkerbau", or more neutrally, "Bau M" were uncovered (fig. 1, beyond $y = 890$)[19]. In the more recent excavations it was found that the old excavations were almost exclusively concerned with the detection of the walls. Often the old excavation trenches ran just along one side of a wall, cutting through sidewalls and/or following them. As a result, most areas between the walls were left undisturbed. Unfortunately, after the excavations many of the exposed faces of the walls were robbed, most likely by the farmers involved in the excavations, in order to use the stones for new buildings (fig. 2).

Most of the knowledge concerning this complex and the underlying structures which extend to the south comes from the modern excavations. It has been discovered that in the later 2nd and 3rd centuries A.D. the area was built over with a large civil complex of connected stone

8 PLANCK (Anm. 1) 14; 17; 21; P. GOESSLER, Ein römischer Mosaikfund aus Rottweil im Jahr 1916. Fundber. Schwaben 22–24, 1914–16, 43–60.

9 A. RÜSCH, Das römische Rottweil. Führer arch. Denkmäler Bad.-Württ. 7 (Stuttgart 1981) 48–51 suggests this indirectly through the choice of the presented comparisons. This opinion is supported by C. S. SOMMER, MVNICIPIVM ARAE FLAVIAE – Militärisches und ziviles Zentrum im rechtsrheinischen Germanien. Ber. RGK 73, 1992 (forthcoming).

10 PLANCK (Anm. 1) 119–121; then Flst.-Nr. 954/5. This excavation is being prepared for publication by M. KLEE, Saalburg-Museum.

11 PLANCK (Anm. 1) 21; Fundber. Schwaben N. F. 4, 1928, 82–85.

12 A. RÜSCH, Arae Flaviae. Die Militärlager und die Zivilsiedlung in Rottweil am Neckar. ANRW II 5.1 (Berlin/New York 1976) 583.

13 RÜSCH (Anm. 9) 53.

14 C. S. SOMMER, Neue Grabungen in Rottweil. Arch. Ausgr. Bad.-Württ. 1986, 111.

15 PLANCK (Anm. 1) 18.

16 Stadtarchiv Rottweil.

17 P. GOESSLER, Arae Flaviae. Führer durch die Altertumshalle der Stadt Rottweil (Rottweil 1928) Beil.

18 Stadtarchiv Rottweil. We are grateful to W. HECHT for his permission to publish the relevant parts of this plan here.

19 RÜSCH (Anm. 12) 593ff.; SOMMER/LAUBER (Anm. 7) 91–93 with further literature; SOMMER (Anm. 7) 127–131. These excavations were interpreted in a dissertation at Freiburg by J. LAUBER (Forsch. u. Ber. Vor- u. Frühgesch. Bad.-Württ. forthcoming).

Fig. 2 Part of Bau M under excavation (walls 37, 100, 30, 47, and 33). Clearly visible is the varying state of preservation of the walls and in particular the robbed faces.

buildings covering about 65 × 95 m and facing the north-south road with its western front. Below this, traces of timber buildings (post-pits, trenches of sleeper-beams, pits etc.) of the late 1st and early 2nd centuries have been found. Originally they formed part of the military vicus of the latest fort in this area ("Kastell III"), but they continued to be used in the early times of the Municipium as well. They overlaid the double ditches of two consecutive older forts ("Kastell IV" and "Kastell V"), which have been filled in. These are marked in fig. 1 as a reconstruction (the ditches were excavated only underneath Bau M and were sectioned at their southeastern part beyond the area surveyed). Subsequently, later levels and stone walls occasionally sank into the filled-in ditches.

The Resistivity Survey

Background

Since the 1940's, when geophysical methods were applied to archaeology for the first time[20], significant progress has been made in this field and many geophysical methods have been adapted to the specific needs of archaeology. The most popular among them are resistivity and

20 M. Aitken, Physics and Archaeology (New York/London 1961) 3f.; A. Clark, Resistivitiy Surveying. In: D. Brothwell/E. S. Higgs (Hrsg.), Science and Archaeology (London 1975) 695; I. Scollar/A. Tabbagh/A. Hesse/I. Herzog, Archaeological Prospecting and Remote Sensing (Cambridge 1990) 371.

magnetic methods. Seismic, electromagnetic (e.g. sub-surface-interface radar = SIR), and occasionally gravimetric and thermic methods are also used[21]. Furthermore, there has been great progress in the evaluation of the data through new computer technology[22]. Some of these methods are somewhat simple, such as those concerning the measurement and evaluation of data (resistivity and magnetic); others are still too complicated to be commonly used by archaeologists themselves (seismic, SIR).

One should keep in mind that the choice of the proper method to be applied depends mainly on the character of the site, the kind of features expected and the problems to be solved.

In Rottweil, our decision to use the resistivity method was based on the following factors:

1. The geology of the site was favourable for detecting disturbances caused by human building activity (relatively lower values of soil resistivity in relation to the higher values of building remains).
2. Limestone and sandstone used for construction are more likely to be detected by resistivity measurements than by magnetic measurements (these kinds of stone have very low magnetic susceptibility and do not cause traceable, direct changes in the earth's magnetic field).
3. The time needed for the survey and especially for the evaluation of the data was estimated to be shorter than that of other methods (apart from the magnetic method).
4. The costs of the survey (considering the surface surveyed) were less than those of other possible methods (apart from the magnetic method).

A resistivity survey can achieve positive results when a relatively homogeneous background is disturbed by the presence of features characterised by a different conductivity than that of the surroundings. In this case, two principally different measurement techniques can be used – sounding and profiling[23].

Sounding (expanding probe system – when the distance between current probes increases with every next measurement) collects the information from different levels and allows one to observe the stratigraphy of a site. Profiling (the array is moved point by point along profile lines with constant distance between current and potential probes) provides the chance to trace changes in the layers up to the depth resulting from the distance between the current probes. For Rottweil we used primarily the method of profiling. As we had exact data concerning the geology, the stratigraphy and the depth of the features, soundings were only applied in choosing the most appropriate distance between the probes in the array for the profiling. An array chosen in such a way gave us the chance to define exactly the position of the objects causing deviating values of resistivity.

Conditions of the Survey

The surveyed area is generally flat and is part of the plateau between the rivers Prim and Neckar. In its northern border it slopes slightly towards the northwest. Its altitude is about 575 m NN. Excavations have shown that the archaeological layers lie directly under a plough-horizon of

21 H. Becker, Geophysikalische Prospektionsmethoden in der Archäologie. In: B. Hrouda (Hrsg.) Methoden der Archäologie (München 1978) 48–62; J. W. Weymouth, Geophysical Methods of Archaeological Site Surveying. In: M. B. Schiffer (Hrsg.), Advances in Archaeological Method and Theory 9, 1986, 311–395; Scollar et al. (Anm. 20) 307–632; H. v. der Osten-Woldenburg, Geophysik am Landesdenkmalamt: erste Ergebnisse. Arch. Ausgr. Bad.-Württ. 1991, 360–365; ders. (Anm. 4) 26.

22 J. B. Arnold III, Archaeological Application of Computer Graphics. In: M. B. Schiffer, Advances in Archaeological Method and Theory 5, 1982, 186–201; Weymouth (Anm. 21) 328.

23 Scollar et al. (Anm. 20) 327–334; 339–341; M. Hvotdara/J. Tirpak, Modelling of electric fields in the presence of twodimensional non-conductors for the purposes of resistivity profiling in archaeology. Slovenská Arch. 35, 1987, 165–188.

Fig. 3 Wall 37 of Bau M with several phases overlying the filling of the outer ditch of Kastell V. To reduce possible sinking of the wall, a slightly stronger foundation was built here. The ditch was cut into the natural clay.

about 0.2 m thickness. They are up to approximately 1 m thick. The top layers often consist of the stones of collapsed walls. The archaeological layers overlie sandy, glacial clay of varying thickness (up to 1.5 m; fig. 3) and a layer of glacial gravel in some areas. A bedrock of "Muschelkalk" lies below this. The top layers are well ventilated and, except in deep layers of the Muschelkalk, no wet parts exist.

Most of the earlier archaeological features are cut into the clay and occasionally into the gravel (later features were often inserted into earlier cultural deposits). Only very deep features like wells and sometimes fort ditches penetrate the bedrock. In general, the Roman walls in Rottweil consist of a lower part of rubble-foundation on which some layers of mortared foundation follow (fig. 3). The main parts of the walls are often a little narrower than their foundations (fig. 4, background). They are generally two-faced and consist of neat layers of "hand-stones" (Handquader) at the outside with a fair amount of mortar and broken stone in-between. The stones used for the walls are limestone and various kinds of sandstone.

The 15 530 m^2 of the area surveyed (fig. 1) were limited in the north by the zones already excavated[24], in the northeast by a little track and in the southeast by a ridge along the field, followed by a sewage ditch and a road. Under the track and along the ditch runs a 20 KV power-line. At the southwest lies a pasture in which we could not get permission to survey. In the west the survey was limited by fences (at two places it was possible to cross them and to survey further towards the west). At the time of the prospection the area was used for different cultivation purposes[25]. The area was crossed by a little dirt road (which did not pose any

24 The southern border of the excavated area is defined by the coordinates x = 508; y = 910; x = 508, y = 870; x = 525; y = 870; x = 525; y = 910; x = 560, y = 910; x = 560, y = 880; x = 575, y = 880; x = 575, y = 910.

25 Plots 1938 and 1932 north were pasture (with some single standing fruit trees in plot 1932). 1942 and 1932 south as well as 1933 were harvested fields. On a 2 m wide strip between plots 1938 and 1942 turnips were ▶

Fig. 4 Area of walls 37, 44, 30, 47 and 33 at the end of the excavation. The different depths of walls 30 (centre) and 44 (left) are clearly visible. In the background the robbing of one face and the step between the mortared foundation and the rising part of 47 can be distinguished. In the background the complete robbing of most of 33 is evident.

problems for the probing) and also – according to old documents – by a low-voltage cable (this did not appear in the data taken).

Since 1967 all excavations at Rottweil have been recorded according to a local grid-system ("Arae-Flaviae-System")[26]. As the long axis of the area to be surveyed was approximately parallel to the y-axis, it was convenient to use this system as a basis for the geophysical survey. This offered the possibility to transfer the results without further calculation into the "Gesamtplan des römischen Rottweil".

Technique of the Survey

For the survey, an alternative-current resistivity meter GEOMES R 1 was used[27]. Based on the results of the preliminary resistivity soundings we found that a Schlumberger array with distances of 4 and 8 m between the current probes AB, 1 m between the potential probes MN, was

growing. However, it was possible to survey this part later. At the edge of 1932 cabbage was growing; here the probes were placed between the plants. Only a small part around x = 535, y = 690 was completely inaccessible as vegetables were planted there.

26 D. MÜLLER, Der archäologische Plan des römischen Rottweil. In: RÜSCH (Anm. 9) 102–110; esp. 108 f.

27 Constructed in Poland. The power for the array was supplied by a block of 4.5 V batteries forming a current of 200 V and 1.5 mA; the frequency of the instrument was 12 Hz.

optimal in the given situation. As the different distances between the current probes equal different depths of prospection (down to approximately 0.8 m or 1.5 m respectively), the array allowed us to distinguish features of different depth. With a team of four people working in the field we were able to take the readings of both levels simultaneously. An alternating grid system was used, i.e. profile lines were marked out 1 m apart, measurements were taken every two metres (odd metres in odd-numbered profiles and even metres in even-numbered profiles). Such a system obtains roughly similar information about the disposition of the resistivity as a 1 m^2-grid. However, the number of measurements is reduced by half.

To present the preliminary results we prepared hand-drawn, coloured maps of isolines (lines of equal resistivity) for the two levels of the prospection[28]. This was done parallel to the data collection. For the final presentation of the results we used the Golden Software computer program SURFER[29]. This made it possible for us to interpolate the measurements onto a more detailed grid. It also enabled us to use several different methods of presentation (contour lines and three-dimensional models) as well as to apply different parameters in the graphs (density of lines, horizontal and vertical scale, angle, direction of observation etc.). Whereas the three-dimensional model shows anomalies in relief (in our way of presentation: inverted, i.e. "walls" etc. appear like small ridges), the contour lines enable one to plot anomalies in a vertical scale. We feel that both ways of presentation have their advantages and therefore we present the results in fig. 5–12 accordingly[30].

Description of the Results

The survey presented us with a picture of changes in the disposition of the ground resistivity resembling two different levels of prospection (fig. 5–12). The readings are between 50 ohm-m and 200 ohm-m for the shallow layer (AB = 4 m) and between 30 ohm-m and 160 ohm-m for the deep layer (AB = 8 m). On both levels, zones of different disposition of resistivity are visible. The majority of the prospected area has a low and homogeneous resistivity in an average range of 30–60 ohm-m for both levels. In other parts there are limited zones where the values of the resistivity rise to 100–150 ohm-m. These zones have sharp borders and include many dynamic changes of resistivity. It is certain that these kinds of changes (anomalies) cannot be of natural origin and therefore must be treated as the results of human activity.

On all maps of the northern region a straight, narrow, north-south line is visible (around x = 533–537). This line is not caused by archaeological structures but corresponds to an area where measurements were taken at a later time than its surroundings due to the presence of a different crop (see footn. 25). The absolute values are different here due to varying ground humidity. In the computer evaluation we tried to eliminate this effect by calculating average values of resistivity and smoothing the contour lines. However, the complete elimination of this disturbance was not possible.

A comparison of the maps shows that the anomalies do not have the same shape and character on the two different levels of prospection, although they have a fairly similar general appearance. This strongly suggests that the features causing the anomalies have different shapes and

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28 Unfortunately at that time neither the Institute of Archaeology and Ethnology nor the Landesdenkmalamt Baden-Württemberg was in possession of computers which would have been able to process the data. For that reason the time-consuming method of hand-processing had to be used.

29 We are grateful to J. TARNOWSKI, Institute of Archaeology and Ethnology, for the input of the data as well as to W. M. WERNER, Landesdenkmalamt Baden-Württemberg, for his advice and help with the hardware.

30 In the three-dimensional models the viewing direction is towards the south under an angle of 30° in a 1/2 m^2-grid with a vertical scale-factor of 0.03: For other methods of presentation see v. DER OSTEN-WOLDENBURG (Anm. 4) 30 f.

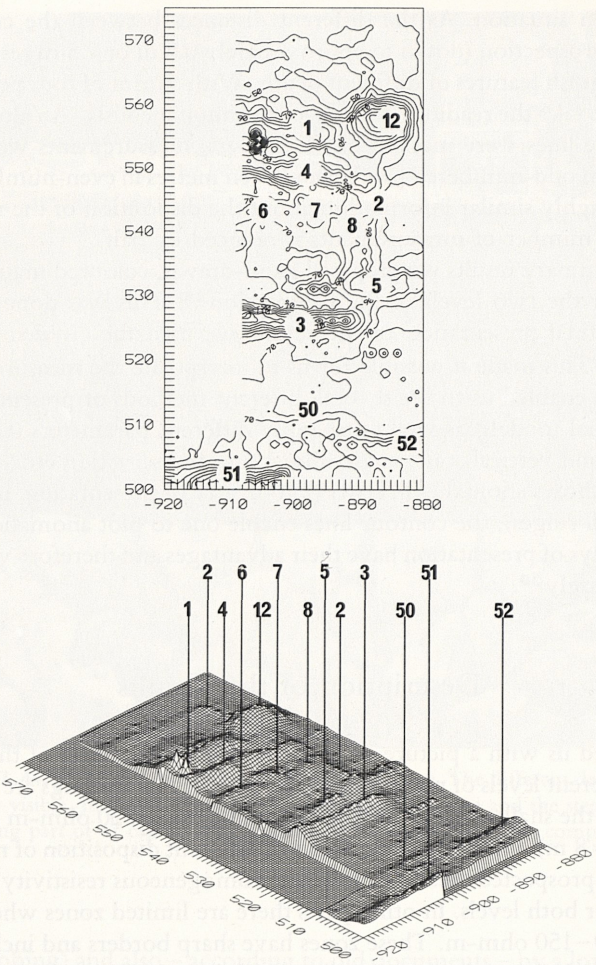

Fig. 5 Zone I, three-dimensional model and contourmap of the shallow layer.

dimensions in different depths. As the zones of denser anomalies are separated by areas of homogeneous resistivity, we have divided the area into four separate zones labelled I–IV (the cut between zone II and III could also be made further to the south). The maps in fig. 5–12 show the separate zones. The anomalies in these zones are numbered continuously starting from the north (single-dot anomalies equalling individual peaks in the three-dimensional models and very faint anomalies are omitted as they might represent misreadings).

Zone I (x = 520–560, y = 885 – beyond the survey; fig. 5; 6)

This zone of approximately 40 by 25 m[31] is defined by a complex of anomalies with values of 90–150 ohm-m for the shallow layer and 80–120 ohm-m for the deep layer. All anomalies form

31 All measurements will be given first in east-west then in north-south direction (the maps in Abb. 5–12 are oriented east-west to be compared easier with the three-dimensional models).

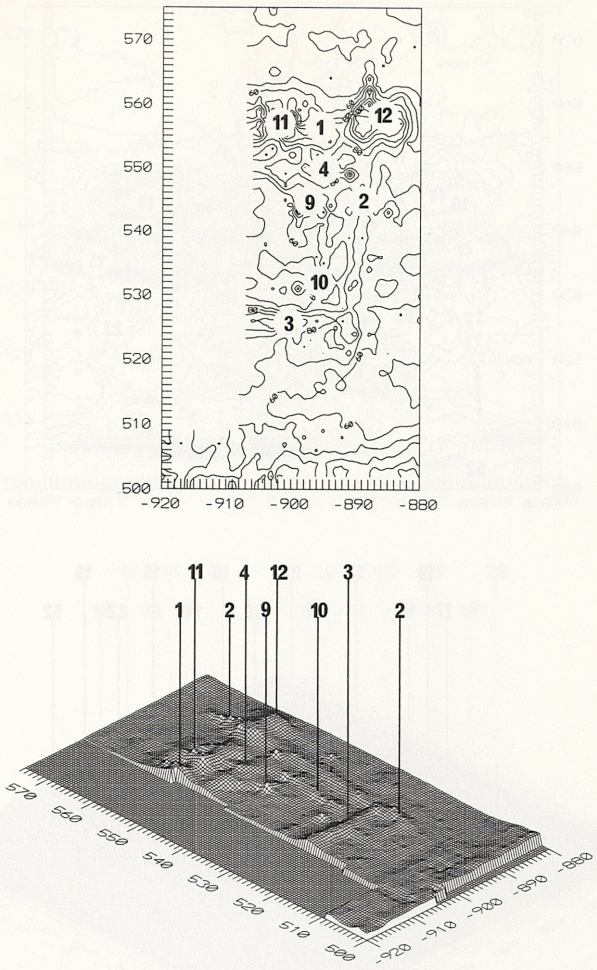

Fig. 6 Zone I, three-dimensional model and contourmap of the deep layer.

straight lines parallel to or crossing each other in right angles. Anomaly 1 represents the eastern border of the zone, 2 the southern and 3 the western border. They appear in both levels although anomaly 2 is not as clear in the shallow layer. The northern border of this zone lies outside of the prospected area. Within the zone we have several local increases of resistivity values, of which anomalies 4 and 12 are present on both levels, whereas the weak anomalies 5–8 are visible only on the shallow layer. It is possible that 5 is a result of the line which was discussed above. Anomalies 9–11 appear only in the deep layer.

Most anomalies lie in a north-south direction parallel to the profile lines. In the deep layer the perpendicular component becomes stronger.

Zone II ($x = 505-550$, $y = 800-870$; fig. 7; 8)

This zone is formed by a large complex of high resistivity anomalies with values comparable to those in zone I. It is dominated by several wide anomalies running vaguely in a north-south direction in both levels. Clearly distinctive are also several anomalies which run in straight parallel lines in an east-west direction and which partially overlie the other anomalies.

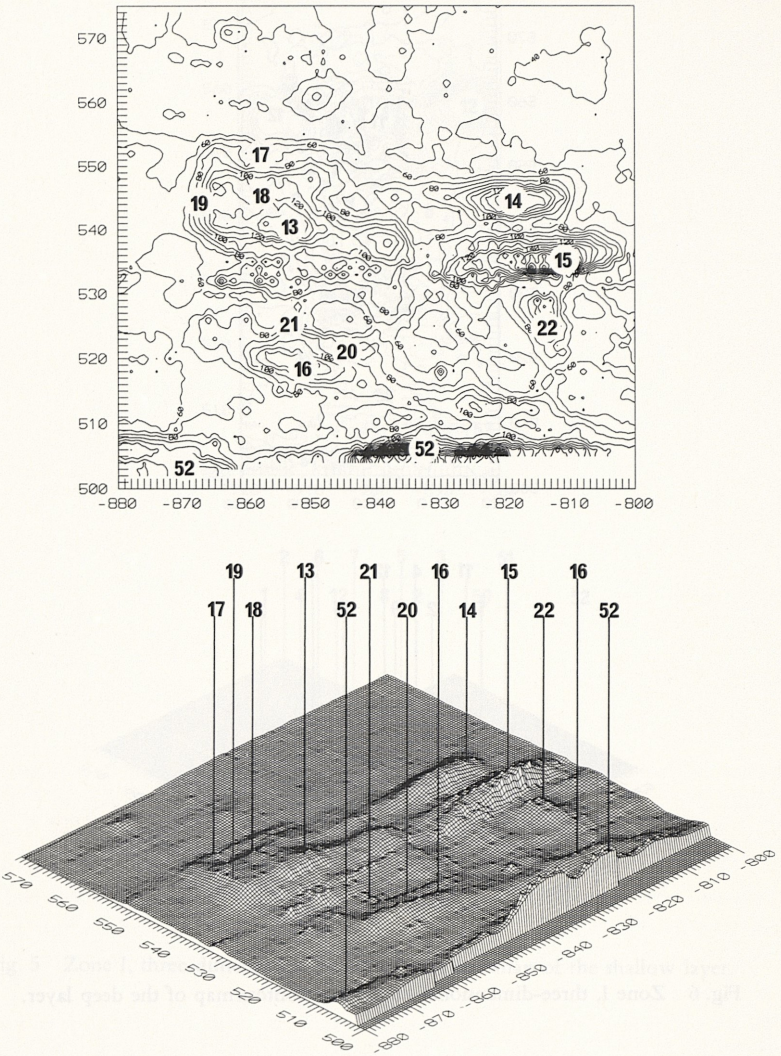

Fig. 7 Zone II, three-dimensional model and contourmap of the shallow layer.

In the shallow layer the four most prominent anomalies (13–16) are rather wide. Whereas 14 and 15 are parallel to the profiles, 13 and 16 run at in a slight angle (15 continues into zone III). All four are also visible in the deep layer, although it has to be pointed out that 14 becomes narrower there. In the shallow layer the somewhat thinner anomalies 17, 18 and 20 are also running in a north-south direction. They are parallel to each other and more or less parallel to 13. In the deep layer only 18 is faintly visible. The weak anomalies 19, 21 and 22 run in an east-west direction. They are also visible in the deep layer; 22 becomes much clearer and longer there. Additionally, in the deep layer the long east-west running anomalies 25 and 26 as well as the more vague ones 23 and 24 appear.

Zone III ($x = 505-560$, $y = 695-795$; fig. 9; 10)

The anomalies of this zone lie within the range of 90–225 ohm-m in the shallow layer and 80–150 ohm-m in the deep one. The general disposition of the anomalies in both layers is linear

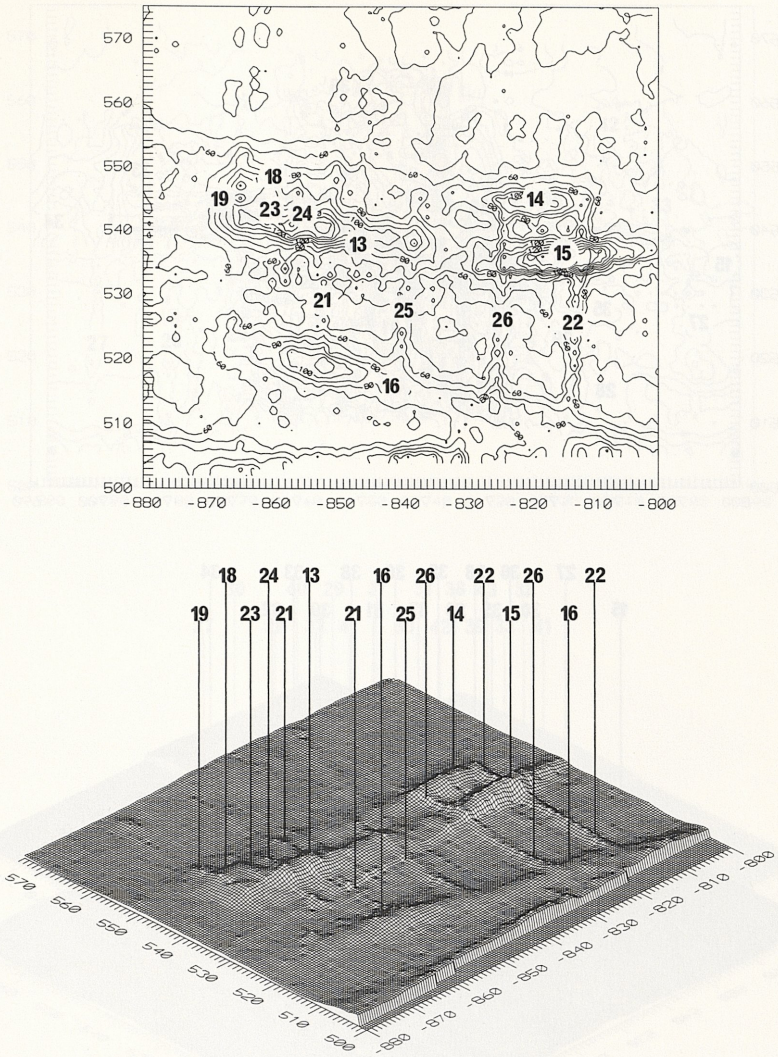

Fig. 8 Zone II, three-dimensional model and contourmap of the deep layer.

with the majority of them running east-west. In the southwestern part of the zone we have a large area of high-resistivity values which lies in the shallow layer between x = 510–545, y = 705–740, and in the deep layer between x = 528–545, y = 705–730. It is difficult to distinguish individual anomalies here.

In the shallow layer a bundle of east-west anomalies consists of 27–34 (the double line of 30 is most likely caused by only one feature. The doubling of the line is a result of the so-called side-effect which occassionally appears with the Schlumberger array [32]). All but 34 are traceable in the deeper layer, too and even appear to be clearer there in most cases. Running in the north-south direction are the anomalies 35–39, of which only 37–39 are visible in the deep layer too. In the area of high resistivity to the west of 39 no linear anomalies can be defined.

32 A. Clark, Archaeological Prospecting: A Progress Report. Journ. Arch. Science 2, 1975, 297–299.

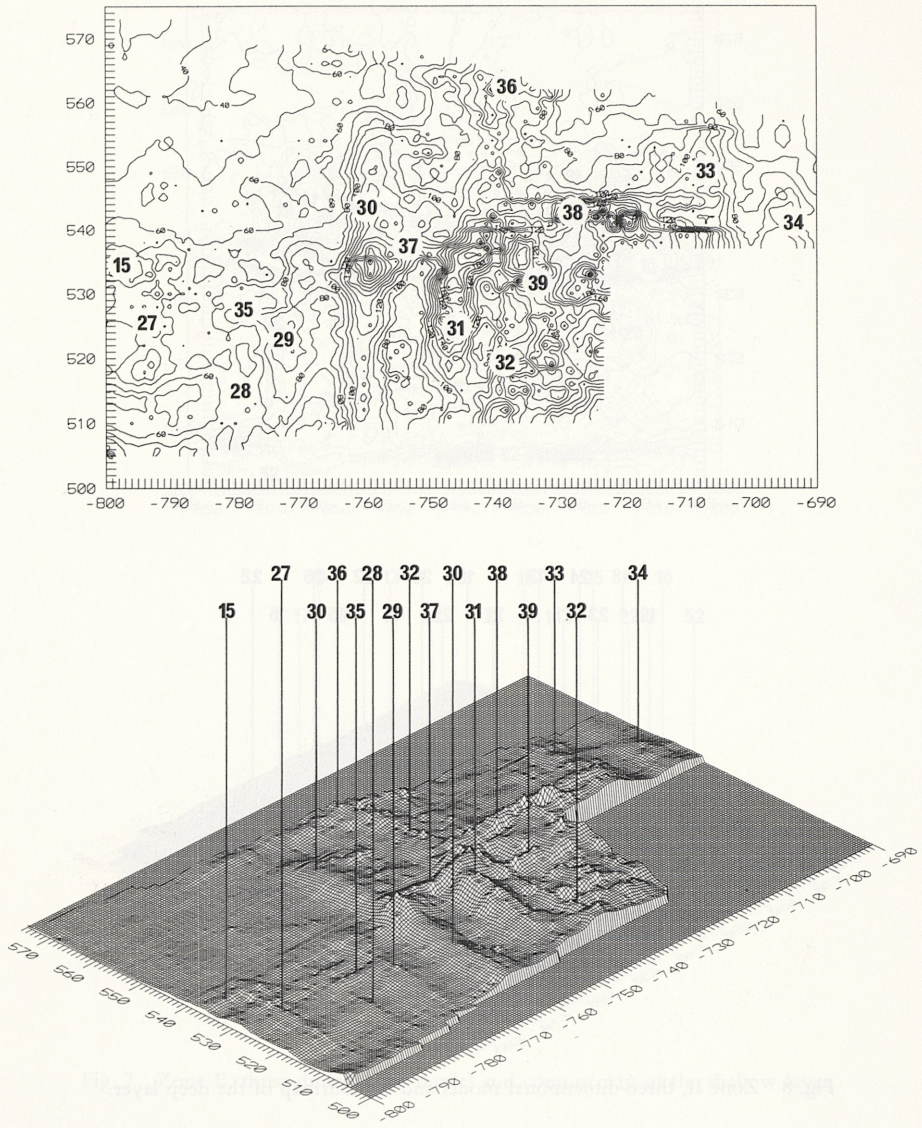

Fig. 9 Zone III, three-dimensional model and contourmap of the shallow layer.

Linear anomalies which are only visible in the deep layer are 40–42 in an east-west direction and 43 in a north-south direction. It is unclear whether a slight change of resistivity between 42 and 33 can be interpreted as linear.

Zone IV (x = 525–545, y = 560–640; fig. 11; 12)

The values of the anomalies forming this zone range between 80–130 ohm-m in the shallow layer and 70–100 ohm-m in the deep one. All of them have a linear character. 44–47 run parallel east-west. They are visible in both layers. Two anomalies 48 and 49 lie perpendicular to them. They are clearly visible only in the shallow layer.

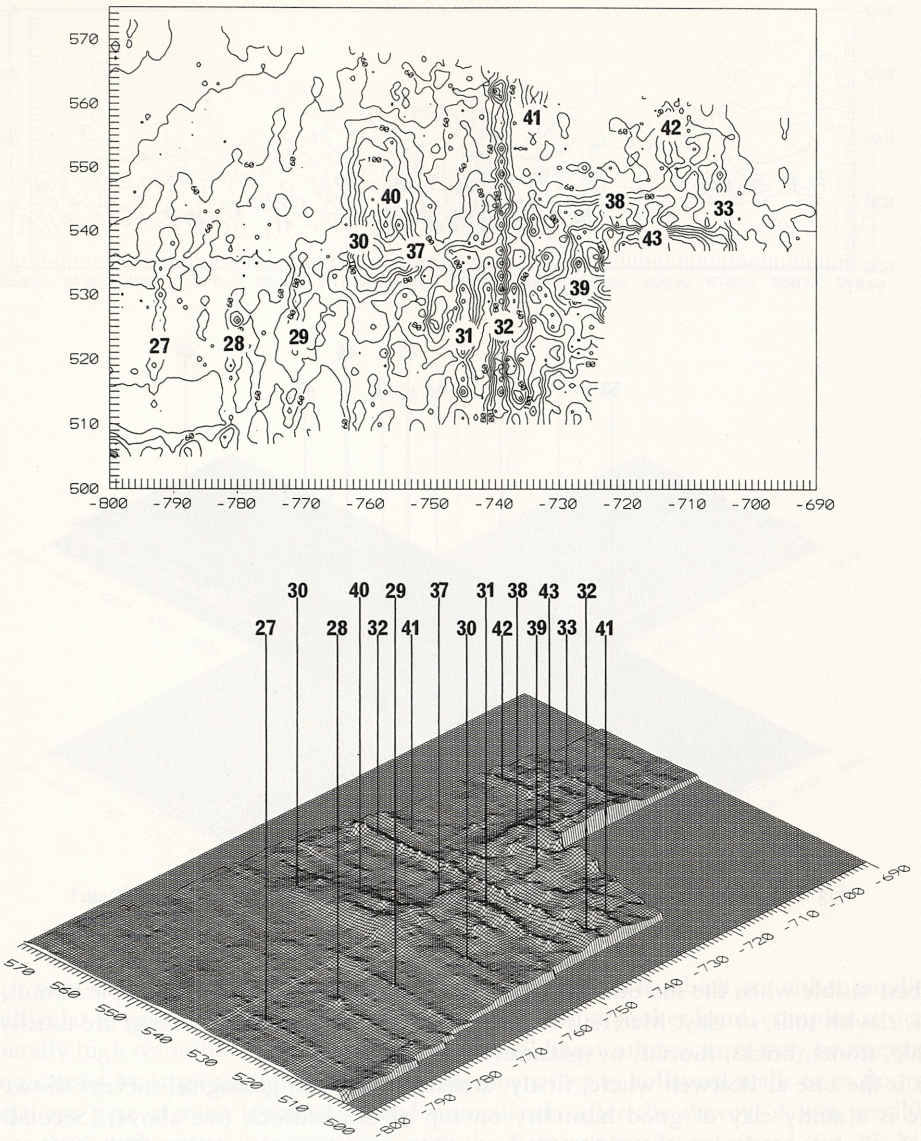

Fig. 10 Zone III, three-dimensional model and contourmap of the deep layer.

At the northwestern edge of the surveyed area as well as between zones III and IV are several additional features: 50–53 (fig. 5; 7; 11). They are slightly obscure as their limits lie partially outside the surveyed area. This is especially the case for 51 and the southern part of 52. All these anomalies are only visible in the shallow layer. 51 and 52 run parallel to the profiles, 53 slightly oblique. The appearance of the latter is somehow similar to 16 in zone II. It is also parallel to it.

Interpretation

General experience shows that high differences of resistivity usually equal concentrations of material of one kind surrounded by homogeneous material of another kind. Such differences

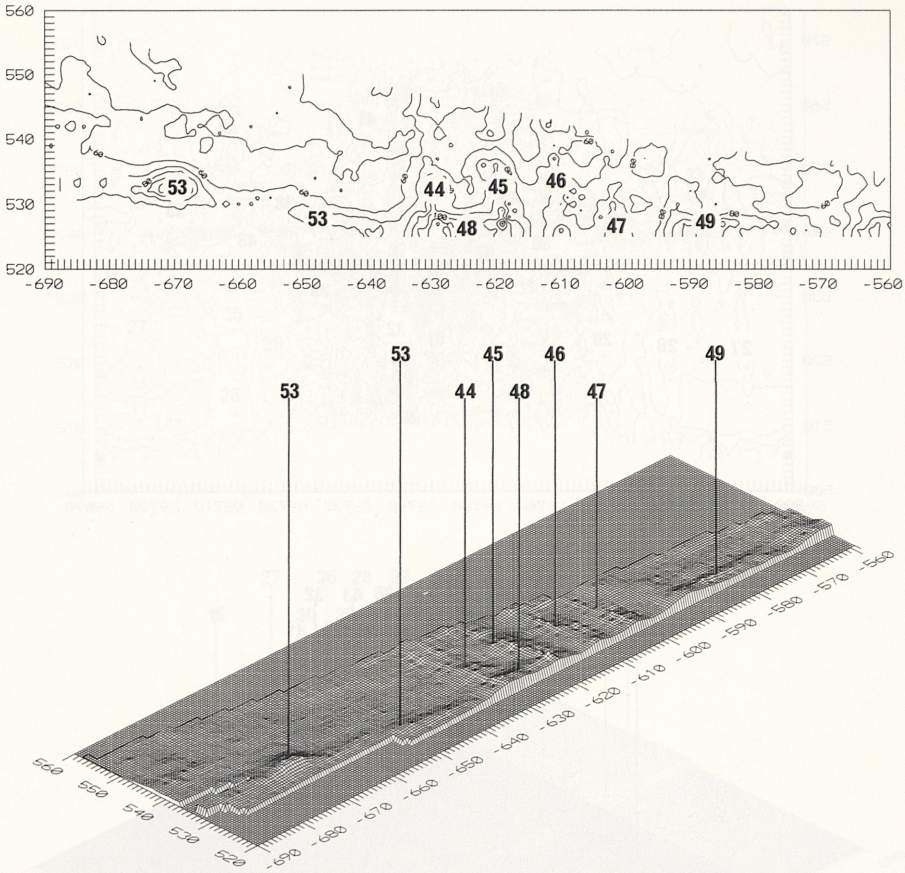

Fig. 11 Zone IV, three-dimensional model and contourmap of the shallow layer.

are best visible when the surrounding material is of low resistivity, for example humus, mud, loess, clayish soils, or clay. Materials causing anomalies in these surroundings are usually sand, rubble, stones, bricks, mortar, or mixtures of those, such as walls[33].

This is the case at Rottweil where, firstly, archaeological and geological surveys showed that there is a sandy clay of good humidity on top of the bedrock (see above). Secondly, the geophysical survey had results of 20–60 ohm-m in areas with no anomalies. This points towards a clayish soil. Thirdly, we know from previous excavations that there are walls of lime- and sandstone in the area surveyed.

However, from the recent excavations in Bau M it is obvious that these features differ in type, kind and preservation (fig. 2–4): the walls found there varied in width, depth where they began and where they ended, thickness of the mortared parts, foundation width etc. Occassionally only robber-trenches existed, filled with rubble and mortar-pieces. Additionally, it should be noted that collapsed walls and roofs were sometimes preserved as were areas of strong rubble serving as foundations of floors, for example in connection with hypocausts.

Based on this knowledge we can suggest that many of the anomalies in the geophysical picture of the surveyed area, obtained as the result of the measurements taken in the field, are caused

33 A. Hesse, Manuel de prospection géophysique appliquéee à la reconnaissance archéologique. Publ. Centre recherches sur les techniques gréco-romaines 8, 1978, 15.

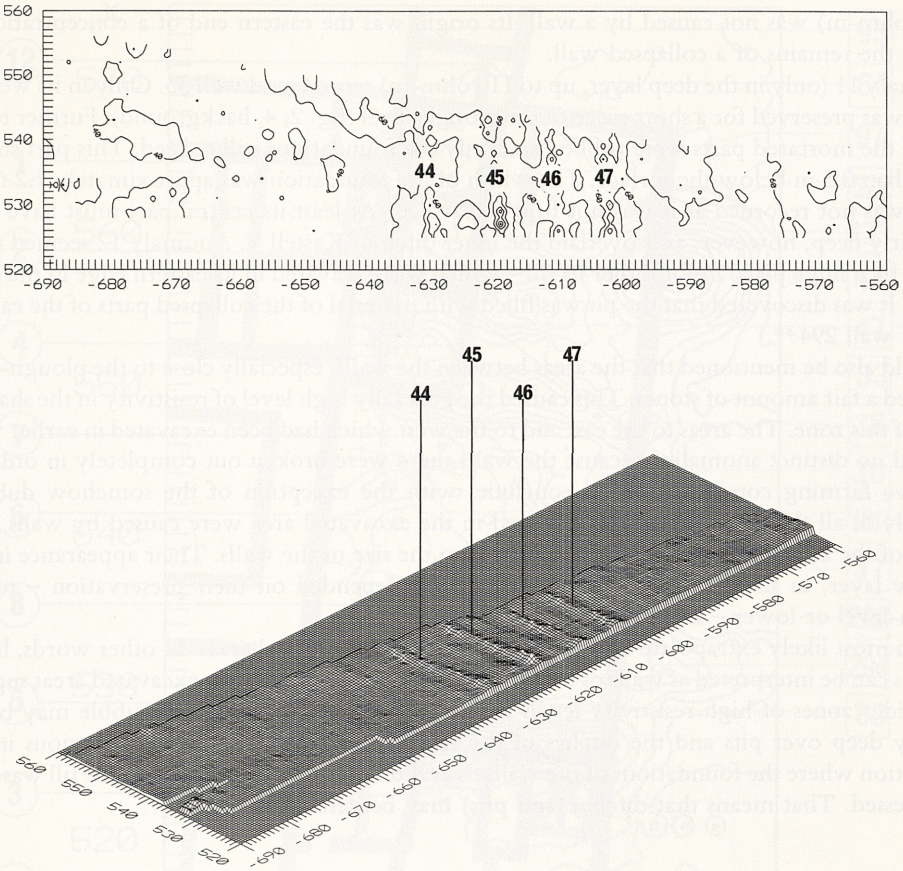

Fig. 12 Zone IV, three-dimensional model and contourmap of the deep layer.

by such man-made features. Therefore, narrow linear structures which are either parallel or perpendicular to each other seem to be caused by walls. On the other hand, complex structures of generally high resistivity with or without additional linear substructures may be interpreted as being caused by large agglomerations of stone due either to collapsed walls or to floors. As the northern part of zone I was excavated immediately after the survey, it was possible to correlate these preliminary interpretations with the features actually excavated (fig. 13; 14, see also fig. 2; 16; 17). Anomaly 1 (up to 125 ohm-m) was caused in its northern part by wall 47 which had a width of 0.9 m and was ca. 3 m deep (including its foundation; parts of its western face were robbed) and possibly by the very weak wall 100 which was only 0.35 m deep[34]. 47 had such a deep foundation because it was built into the fill of the inner ditch of Kastell V. Anomaly 2 (up to 90 ohm-m) corresponded in its eastern and western end with the excavated parts of wall 294 with a width in the west of about 1 m, in the east of about 1.1 m, and varying depth. Anomaly 3 (up to 120 ohm-m) corresponded exactly with wall 88 (fig. 15) which was very well preserved and had a width of 1.2 m. It was excavated to a depth of 2.1 m and extended still further. Its foundations, more than 1.5 m deep, were sunk into the fill of the underlying inner ditch of Kastell IV. Anomaly 4 (up to 100 ohm-m) resulted from wall 38 with a width of 1.1 m and a depth of more than 1.4 m. The week anomaly 6 (only in the shallow layer, up

34 We are grateful to J. LAUBER for providing us with the necessary archaeological information.

to 80 ohm-m) was not caused by a wall. Its origin was the eastern end of a concentration of stones, the remains of a collapsed wall.

Anomaly 11 (only in the deep layer, up to 110 ohm-m) represented wall 33. Only in its western part it was preserved for a short piece to the plough-level (fig. 2; 4, background). Further to the east all the mortared parts were robbed and only the foundations still existed. This part started more than 0.5 m below the surface. The width of the foundation was approximately 1.2 m; its depth was not recorded as it was not fully excavated. At least its central part must have been also fairly deep, however, as it overlaid the inner ditch of Kastell V. Anomaly 12 seemed to be caused by a huge pit 572 – or rather its fill – which was excavated in its eastern edge in the early 1980's. It was discovered that the pit was filled with material of the collapsed parts of the eastern part of wall 294[35].

It should also be mentioned that the areas between the walls, especially close to the plough-level included a fair amount of stones. This caused the generally high level of resistivity in the shallow layer of this zone. The areas to the east and to the west which had been excavated in earlier years showed no distinct anomalies because the walls there were broken out completely in order to improve farming conditions[36]. To conclude, with the exception of the somehow dubious anomaly 6, all the linear anomalies detected in the excavated area were caused by walls. The values of the anomalies are very closely related to the size of the walls. Their appearance in the shallow layer, in the deep layer, or in both layers depended on their preservation – to the plough-level or lower – and to their depth.

We can most likely extrapolate this correlation to the unexcavated areas. In other words, linear features can be interpreted as walls of different quality. Additionally, the excavated areas suggest that wider zones of high resistivity levels are caused by rubble. Walls and rubble may be especially deep over pits and the ditches of the underlying forts. This became obvious in the excavation where the foundations of the walls over ditches extended deeper and the fill was later compressed. That means that ditches (and pits) may be detected indirectly.

Zone I (fig. 5; 6; 13; 14; 16)

The anomalies outside the excavated area are caused by the remains of the southern part of Bau M, too. The continuation of anomaly 1 to the south suggests a wall in the direction of wall 47[37]. However, based on the identified part of Bau M it is suggested that this wall is not in direct contact with the east-west wall 33 but joins wall 97 (this wall may have caused a weak anomaly parallel and to the south of 11 on the deep layer [fig. 6; 14]. Because of its weakness it was not mentioned in the geophysical interpretation). It also seems that the wall causing the anomaly runs a little to the east of 47. We believe that its apparent continuation to the south beyond anomaly 2 (see below) is not a prolongation of this wall but the bottom of the big pit 572 causing anomaly 12.

Anomaly 2 proves the continuation of the identified wall 294. This wall forms the southern limit of Bau M. The resistivity level here suggests that the wall does not reach very deep west of pit 572. This corresponds to the fact that in this area no more ditches are expected[38]. The southern

35 A. Rüsch, Ausgrabungen im römischen Rottweil. Arch. Ausgr. Bad.-Württ. 1982, 88; C. S. Sommer, Ausgrabungen im römischen Rottweil. Arch. Ausgr. Bad.-Württ. 1992 (forthcoming). It was not possible to include the other results from this excavation into the plans Abb. 13, 14, 16, and 17.

36 For additional plans of those areas see Rüsch (Anm. 35) Abb. 60; 61 and M. Kokabi, Arae Flaviae II. Viehhaltung und Jagd im römischen Rottweil. Forsch. u. Ber. Vor- u. Frühgesch. Bad.-Württ. 13 (Stuttgart 1982) Abb. 2; 3.

37 The southern end of this wall was found in the 1992 excavation (see Anm. 35).

38 Sommer (Anm. 7) 127.

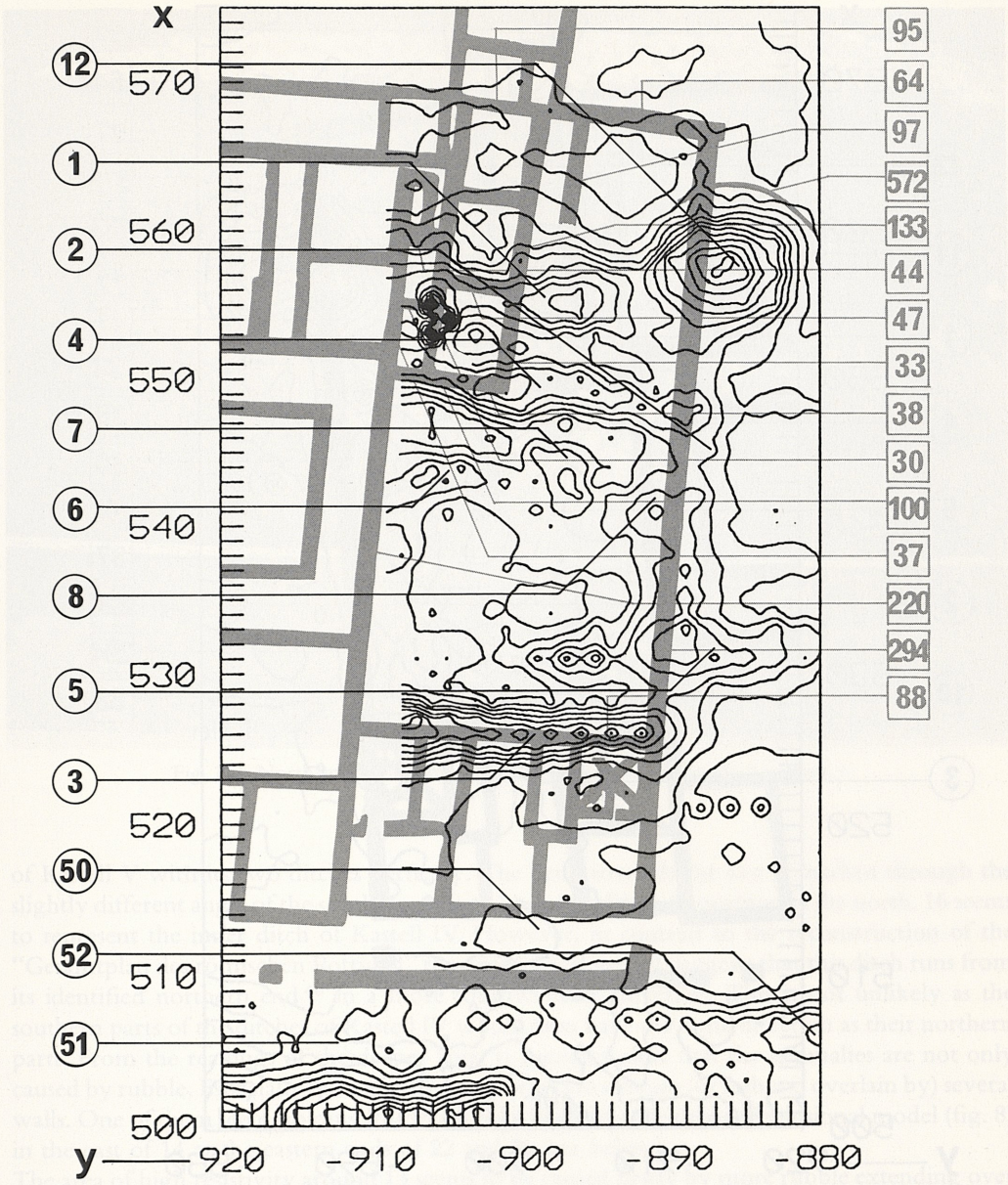

Fig. 13 Plan of the excavation of the southern part of Bau M (grey, numbers of the walls at the right) with the contourmap of the shallow layer with numbers of the anomalies (zone I). 1:500.

part of anomaly 3 is clearly caused by the continuation of wall 88. Anomaly 4 is due to a continuation of wall 38[39]. Anomaly 5 we interpret as a wall which is not deep (due to the fact that it is only visible in the shallow layer). This interpretation causes a problem as this "wall" would lack a continuation in the area already excavated. Whether the "wall" continues beyond wall 294 to the south is not clear; the anomaly there could be caused by the fill of a pit similar to 572. From the geophysical picture it appears that anomalies 9 and 10 represent weak walls

39 The southern end was found in the 1992 excavation.

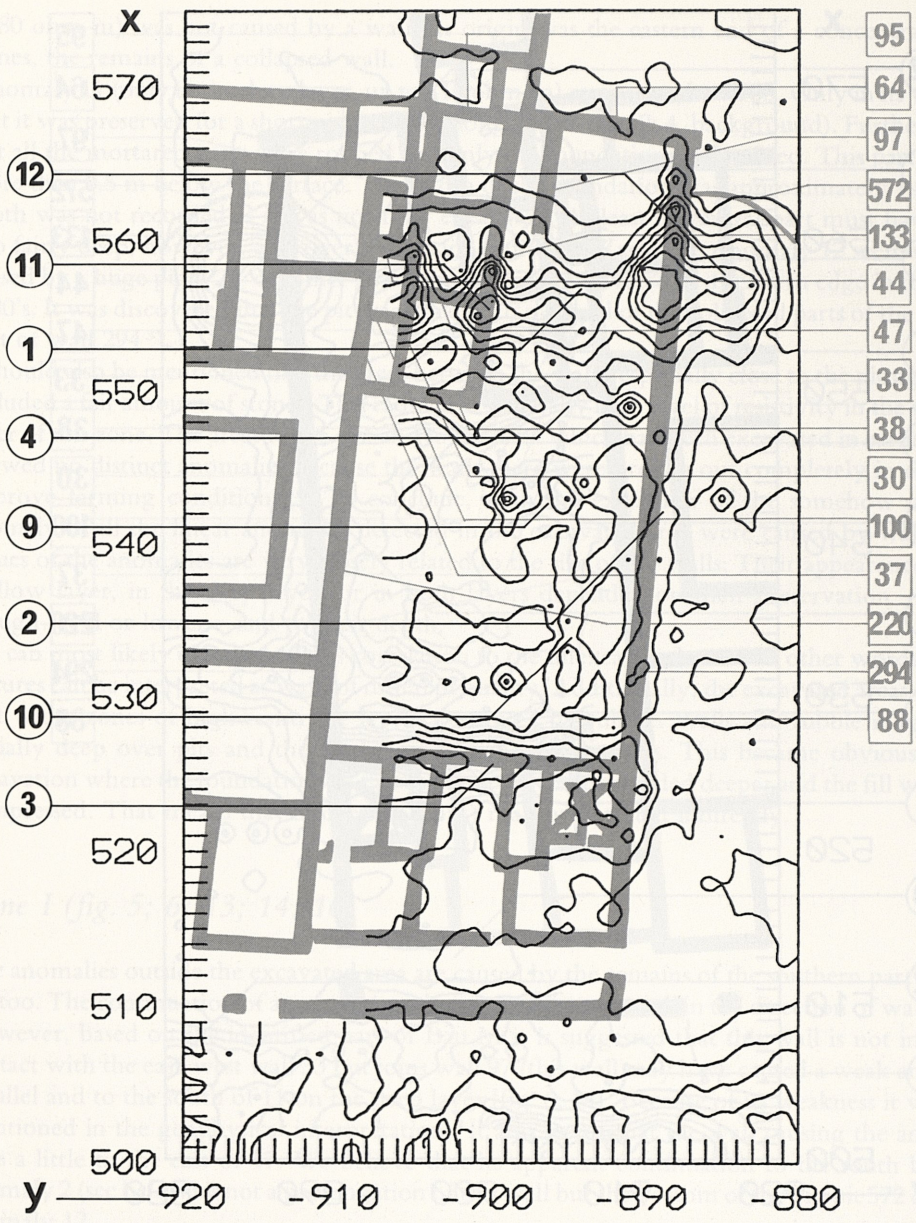

Fig. 14 Plan of the excavation of the southern part of Bau M (grey, numbers of the walls at the right) with the contourmap of the deep layer with numbers of the anomalies (zone I). 1:500.

which start fairly deep below the topsoil, as they are found only in the deep layer. "Wall" 9 poses the same problem as 5.

Zone II (fig. 7; 8; 16; 17)

The wider anomalies 13, 14, 15 and 16 seem to be caused by the filling of elongated pits, most likely fort ditches, which should contain lots of deep rubble. 13–15 match the reconstruction

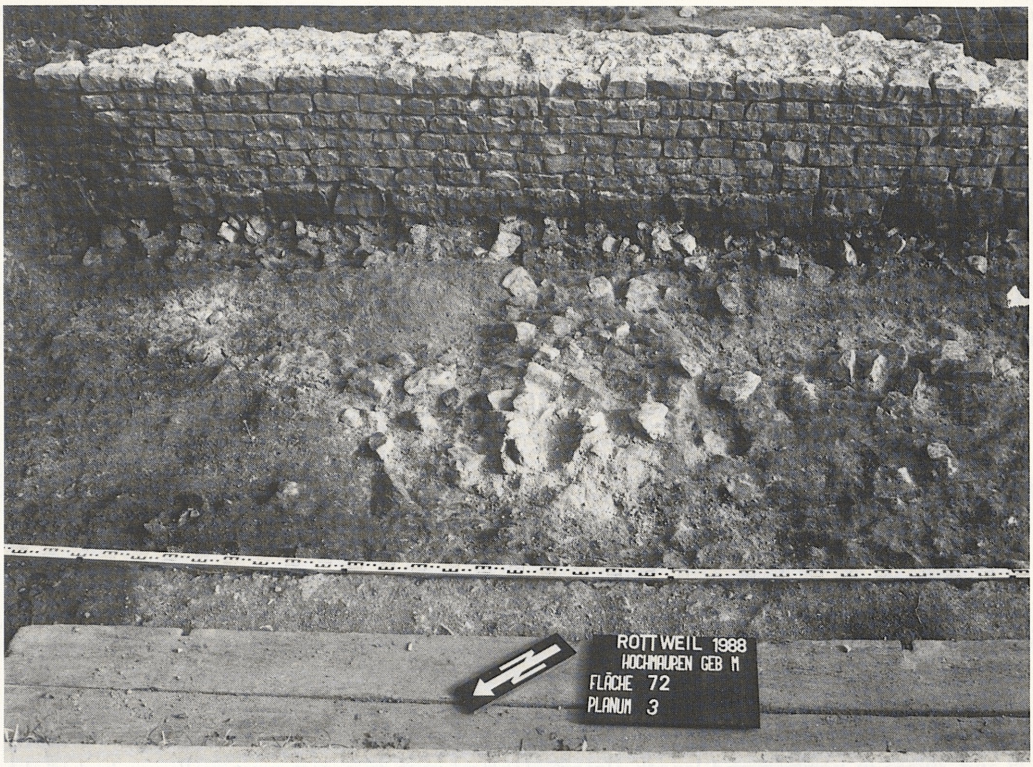

Fig. 15 North-south running wall 88 which caused anomaly 3 in zone I.

of Kastell V with its two ditches perfectly. The bend towards the east is marked through the slightly different angle of the southern ends of 14 and 15. From its position in the north, 16 seems to represent the inner ditch of Kastell IV. However, in contrast to the reconstruction of the "Gesamtplan des römischen Rottweil" the geophysical survey suggests that this ditch runs from its identified northern end[40] in a more southwesterly direction. This is not unlikely as the southern parts of the ditches of Kastell IV would then have the same direction as their northern parts. From the readings of the deeper layer it becomes clear that the anomalies are not only caused by rubble. Especially in 14 and 15 the fill seems to contain (or rather is overlain by) several walls. One of them seems to cause the sharp edge visible on the three-dimensional model (fig. 8) in the east of 14 at the eastern ends of 22 and 26 (see below).

The area of high resistivity around 13 seems to be caused firstly by more rubble extending over the inner ditch of Kastell V and secondly by two north-south running walls 17 and 18 (with a length of approximately 16 m; 17 does not go deep, 18 should be disturbed directly under the surface) and four parallel east-west running walls 19, 23, 24 and 21. The latter have distances of about 4–5 m and with the exception of 21 seem to be confined to the area of the ditches; 23 and 24 should be rather weak or badly preserved, too. 21, on the other hand, extends over a length of 27 m at least into the area of the inner ditch of Kastell IV.

To the south, anomaly 25 runs parallel to this wall with a distance of 13 m. It is most likely caused by a similar wall. Striking is the similarity of these two walls to a building marked on the "Gesamtplan" a little further south at a slight angle. The results of the geophysical survey

40 Kokabi (Anm. 36) fig. 2.

suggest that this building was incorrectly plotted and that it expands further to the east (a comparison with the plan fig. 18 shows that the plotting there is almost identical to the anomalies. This plan also shows the wall which seems to have caused anomaly 17). Part of this building is the week wall 20 which connects the two east-west walls.
Further south, the parallel anomalies 26 and 22 resemble east-west walls. They end in the east at the previously mentioned wall in anomaly 14 (it appears that this wall continues for quite a bit to the north beyond 26). From their weak appearance in the shallow layer (26 would not be noted without knowledge of the deeper layer), it appears that their upper part is poorly preserved. The resistivity level indicates also that, except for the area around the ditches, they do not reach very deep. Together, they seem to form a building of about 35 m in length and 12 m in width. On the "Gesamtplan" a small complex of walls lies in a similar angle within this building. As it did not cause any anomalies, it is most likely that its stones were broken out after the excavation.

Zone III (fig. 9; 10; 16; 17)

The northern part of this zone, with a generally low level of resistivity, appears to be a fairly rubble-free area. Anomalies 27–29 are clearly visible here. Although they are shown on both levels, they seem almost definitely to be caused by walls which are not too strong. They run almost parallel, with distances of 12 and 9 m to each other. Their detected length lies between 20 and 26 m. Anomalies 28 and 29 are connected in the east by the north-south running anomaly 35 which seems to be caused by a wall that is not very deep.
28 and 29 are in position and length almost identical with two east-west walls marked in the "Gesamtplan". 35 corresponds to a wall which lies between these two walls. With this knowledge, it can now be suggested that a very weak – unnumbered – disturbance of the resistivity east of and parallel to anomaly 35 was also caused by a wall. It lies exactly at the position of the eastern north-south wall marked in fig. 18 between the walls which produced anomalies 28 and 29. Another east-west wall marked in the "Gesamtplan" runs in the area of anomaly 27 but at a slightly different angle. Nevertheless, it seems to be the same wall (a similar wall marked in the plan fig. 18 is in the position suggested by the survey).
Anomaly 30 appears 12 m further to the south. From here onwards the area is characterised by a high resistivity caused most likely by greater amounts of rubble in the soil. Additionally, the direction of the east-west walls is slightly different.
In this area, 30–32 are clearly visible. They represent three east-west walls more than 46, 25 and 53 m long with distances of 14 and 7 m between them. 30 and 31 are connected in the middle by anomaly 37 representing a strong wall. 37 seems to join 32, although this is not certain. Approximately 27 m further to the east appears with 36 another distinct north-south running feature which does not seem to be too deep. It may connect 30 and 32. Anomaly 40 is also contained in this complex. As it appears only on the deep layer, its top must have been disturbed. It runs in a distance of 4 m parallel to wall 30 between 37 and 36.
Only the position of 32 is marked on the "Gesamtplan" by a wall, although this seems to run 1-1.5 m further to the south. Nevertheless, we suggest that this is the same wall which is shown in the survey. It belongs to the complex which is described below.
The area south of 32 generally shows an even higher level of resistivity. This seems to be caused by great amounts of rubble. As a result, possible walls cannot be as easily detected, as their stones are part of this "rubble".
However, some walls can be definitely traced: parallel to 32 runs anomaly 41 with a distance of 4–5 m, visible on the deep layer, further south 42 and – visible on both layers – 33. They are connected by 39 and 38, which are rather strong, and 43. These anomalies represent

Fig. 16 Central part of Roman Rottweil with the results of the geophysical survey (possible walls). In light grey are shown the features (walls) as known from previous excavations and marked in the "Gesamtplan" (see also fig. 1), in black the known features from modern excavations as well as the contour lines of the deep layer of the prospection. In light red are shown the "weaker walls" suggested by the survey (visible either on the shallow or on the deep layer) and in dark red the "strong walls" (visible on both layers). 1 : 1000.

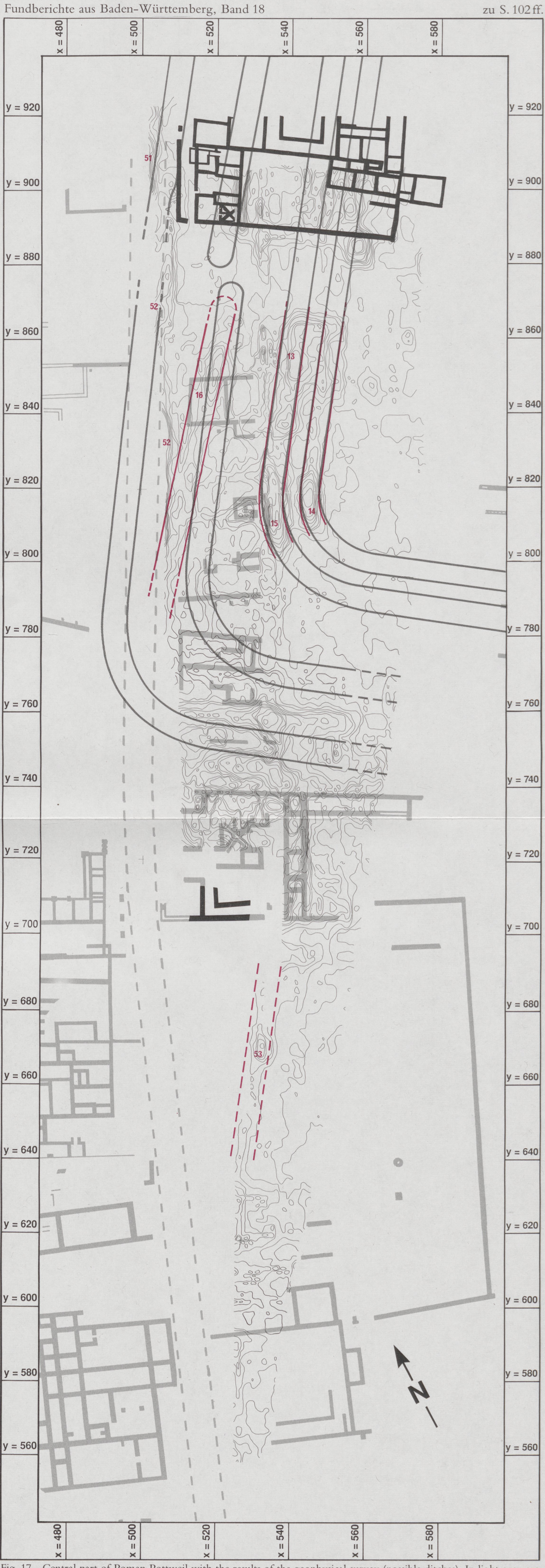

Fig. 17 Central part of Roman Rottweil with the results of the geophysical survey (possible ditches). In light grey are shown the features (walls) as known from previous excavations and marked in the "Gesamtplan" (see also fig. 1), in dark grey the ditches as known from excavations or as reconstructed in the "Gesamtplan", in black the known features from modern excavations as well as the contour lines of the shallow layer of the prospection. In red are shown the lines of ditches as suggested by the survey (visible on the shallow layer). 1:1000.

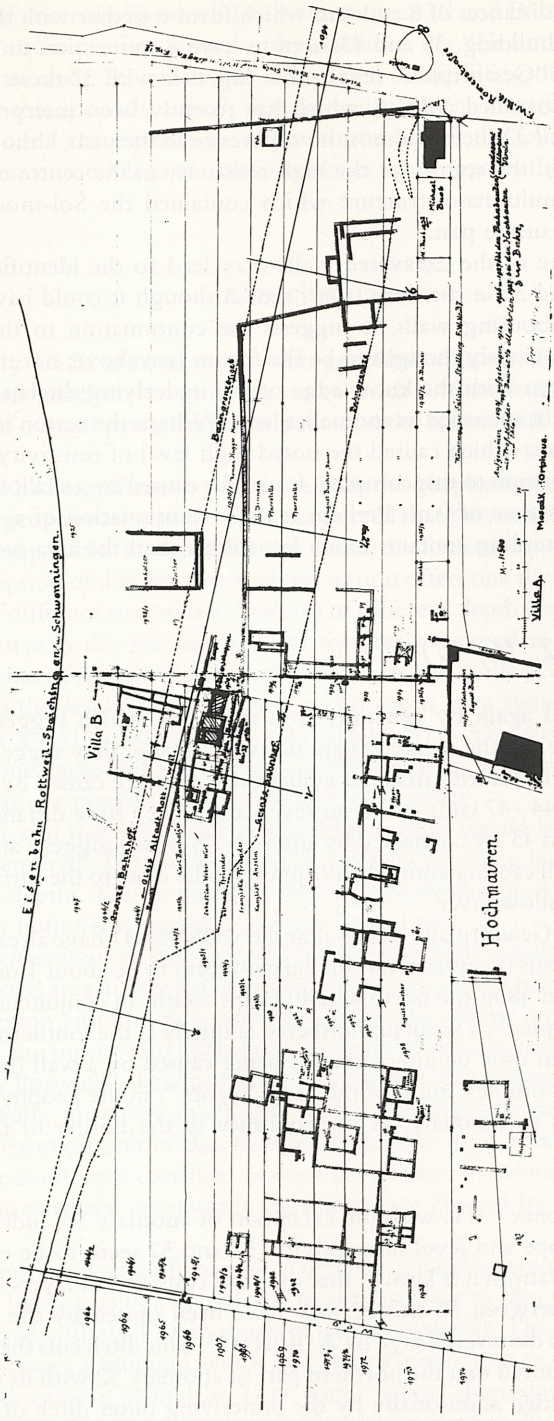

Fig. 18 Plan of MAEHRLEN with later additions. Stadtarchiv Rottweil. Original scale 1:500.

north-south walls with distances of 8 and 4 m which form together with the above mentioned walls a large, complex building. 38 and 43 seem to have a connection to 32.
A comparison with the "Gesamtplan" reveals that together with 32 these walls are part of the building opposite the so-called Villa A which has recently been interpreted as basilica and forum [41]. Except for wall 32 there is almost no difference to the plan, although 42 was hitherto unknown. Based on this, the reason for the high resistivity in the centre of the zone becomes evident: here lies the multiphase structure which contained the Sol-mosaic and which was excavated several times in the past.
The knowledge of some of the excavated walls may lead to the identification of a possible anomaly between 42 and 33 in the deep layer, too. Although it could have been caused by a side-effect of the neighbouring walls, it suggests the continuation to the west of the wall surrounding the area previously thought to be the forum (see above; not marked in fig. 16). It should be noted that even with the knowledge of the underlying ditches of Kastell IV, their course does not seem to be recorded as anomalies here. Perhaps the reason is the generally thick layer of rubble in this area which caused the noted high level of resistivity. Anomaly 34 does not seem to have a connection to this complex. It may be caused by a shallow wall. It is running parallel to 33 with a distance of 9 m. Perhaps it is the continuation of a wall marked in the "Gesamtplan". Its surrounding contains much less rubble than the area to the north.

Zone IV (fig. 11; 12; 16; 17)

The area is characterised again by generally low resistivity which suggests that it does not contain too much rubble. As the anomalies are not very strong, they suggest not very massive structures. However, their linearity makes it evident that they are caused by walls. None of the east-west running walls 44–47 ends in the surveyed area. They have distances of 10.5, 9.5 and 8.5 m respectively. 44 and 45 are connected by anomaly 48 which suggests an even weaker wall. Another north-south wall causing anomaly 49 appears to lie close to the surface, as the anomaly is visible only on the shallow layer.
A comparison with the "Gesamtplan" shows that the walls 45–47 have already been identified, although their real positions (as given from the survey) seem to be about 1 m to the south. New additions are walls 44 and 48 in the north and 49 in the south. In conjunction with a complex structure on the "Gesamtplan", a weak unnumbered anomaly at the southern edge of the survey (south of anomaly 49) can now be interpreted as being caused by a wall (it resembles perhaps the southern wall of the complex south of the "sog. Forum"; in the geophysical interpretation it was not mentioned as an anomaly, as its proximity to the border of the survey made it somehow dubious).

The anomalies outside zones I–IV, with the exception of anomaly 50, indicate wider areas of rubble based on their shape and level of resistivity. 51 and 52 seem to be connected with the Roman road. From excavations it is known that the road consisted of layers of gravel and stone slabs. The interruption between 51 and 52 may have been caused by the southern end of a medieval ditch which was discovered here by A. RÜSCH [42]. This ditch cuts the road in an oblique angle. It should not be ignored that the northern part of anomaly 52 with its apparently slightly oblique angle may be caused additionally by the underlying outer ditch of Kastell IV.

41 SOMMER (Anm. 9).
42 KOKABI (Anm. 36) fig. 3.

The interpretation of anomaly 53 which lies between zone III and IV and also runs in an angle oblique to the lines of the profiles is not so obvious from the "Gesamtplan". It is very similar and also parallel to anomaly 16 which was interpreted as the filling of a ditch. Therefore, we propose as cause for this anomaly a ditch that has not yet been identified. Anomaly 50 which lies to the west of zone I corresponds exactly with the line of the foundations of the porticus of Bau M. In difference to other walls there its stones were apparently not taken out after the excavation.

Conclusion

In the approximately 1.5 ha area surveyed with geophysical methods in the centre of Roman Rottweil a multi-level-geoelectrical profiling system with Schlumberger array was used. Subsequent excavations of a small part of this area provided the framework for the interpretation of the results.

The method applied had significant results from both the geophysical and archaeological points of view. Under the geophysical aspect, it was discovered that the measurements of two different layers resulted in comparable, though different, pictures of resistivity. From the archaeological point of view, the option of differentiated interpretation offers one the possibility to distinguish not only features of different size (width) but also of different depth (or degree of preservation). Particularly impressive is the identification of features preserved in two different layers of occupation: the ditches of Kastell V underlying the layers and walls of later buildings (zone II).

A comparison with the results of the measurements taken by a twin-probe system by H. G. JANSEN in the areas $x=511-551$, $y=880-900$ and $x=511-531$, $y=810-830$ shows that in both surveys the same anomalies were detected. However, an interpretation as detailed as that described above was not possible with the twin-probe survey.

In general, it can be said that the question of which method should be applied depends on the qualitiy of results required. The advantage of multi-level profiling lies in its ability to identify features at different depths. The advantage of the twin-probe system is its speed and the fact that it can be applied in both very limited as well as large areas.

Concerning the archaeology at Rottweil, the survey provided detailed knowledge of a large, permanently protected area in the middle of the Roman town. The information on features now identified in this region amounts to a doubling of the knowledge provided by earlier excavations. Importantly, the survey also indicated that many of the features marked in the "Gesamtplan des römischen Rottweil" were not plotted correctly. The revised positions, together with the newly found walls, provide a much more accurate picture of the layout of the town:

In zone I, the southernmost unit of Bau M seems to contain in its middle an open space perhaps accompanied in the south by a corridor, or sequence of narrow rooms. In the eastern part, two series of rooms (the northern one already excavated) are divided by a corridor leading to the back of the house.

In zone II and the northern part of zone III, a series of parallel east-west walls with distances of 12–15 m are most likely part of a complex somewhat similar to Bau M. Whereas the northern limit seems to be fixed with wall 19, its southern end is disputable. The complex may have ended with 22 (which indicates a building width of 53 m). However, it may also have continued to 27 in zone III (in this case it would be 74 m wide), where three single foundations suggest a porticus – probably to a side street – or even further to the south to 29 (in this case the mentioned foundations would form part of an internal porticus). A continuation of the complex so far south is suggested by the similar direction of the east-west walls in contrast to the walls further to the south. The width of the complex in this case would be identical to that of Bau M (95 m). But, in contrast to it, the units of the complex seem to extend only for about 40–47 m from the street and they do not appear to have such detailed internal divisions made of stone.

The geophysical survey clearly supports the idea of a wider area free of stone buildings south of Bau M. However, the distance between the two complexes is, with approximately 23 m, much less than indicated in the "Gesamtplan" (ca. 40 m).
In the southern part of zone III, there are parts of east-west oriented units. The original plotting of some of the walls had to be corrected in their relation to the street; others were confirmed (although here some walls indicated on the "Gesamtplan" could not be detected, due perhaps to complete stone-robbing following excavations); and others were newly detected. A much clearer picture is obtained for the complex opposite "Villa A". The area with the later Sol-mosaic seems to be surrounded by long rooms on three sides, possibly a porticus (between 32 and the western continuation of 33). Together with "Villa A" it may have formed a double-forum with a basilica at its western end (Basilika and Forum in fig. 1)[43].
Going beyond that which is suggested by the "Gesamtplan", it now appears that to the east of the forum and adjacent to it there is another open space enclosed by long rooms (between 32 and 33, east of 43 or 38). This may be another courtyard with a porticus, possibly related to the temples and the theatre to the east. Unfortunately, its eastern border lies outside the surveyed area.
It is difficult to determine the northern boundaries of this complex and the forum as well as their relation to the other buildings there (up to 30). Several walls here suggest other complex structures which seem to be connected at least through 36 to the northern wall 32 of the forum complex.
In the area to the south (zone IV), which had previously seemed to be almost empty, some corrections can be made. More important, however, is the fact that one east-west wall as well as a north-south wall can be added to the known walls. This indicates a use of this area for either strip-buildings or a complex not dissimilar to the ones discussed in zone II[44]. The results of the survey also propose a slightly different direction of the ditch(es) of Kastell IV. Whether anomaly 53 in the south really is caused by an unknown ditch can only be proven by excavations. However, its position and direction would make the interpretation of an annexe to Kastell IV not unlikely[45].
The geoelectric survey clearly showed the possibility of detecting and interpreting archaeological features, especially walls and similar objects, without excavation. The interpretations proposed here are strongly supported by the clarity of most of the anomalies detected. One should keep in mind, however, that short interruptions of only a few metres in the lines of suggested walls, or features of short length may not have been detected, or may have been incorrectly interpreted. It should also be understood that the absence of anomalies cannot be taken as the absence of features in general (post-pits, pits, etc. without distinct filling cannot be traced with the method used and shallow features consisting of only one or two courses of stone or robber-trenches may not cause anomalies). However, we can now say with almost complete certainty that within the area surveyed there are no substantial walls or major stone agglomerations that have not been detected.

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43 See Anm. 9.

44 For timber buildings to the northeast see C. S. SOMMER, Neue Grabungen in Rottweil. Grabungen im sog. Forum. Arch. Ausgr. Bad.-Württ. 1986, 111.

45 Annexes to contemporary forts are known from Nida-Heddernheim (I. HULD-ZETSCHE, in: D. BAATZ/F.-R. HERRMANN, Die Römer in Hessen[2] [Stuttgart 1989] 276) and possibly Hofheim (vgl. H. U. NUBER, Römisches Steinkastell Hofheim, Main-Taunus-Kreis. Fundber. Hessen 14, 1974, 227f.). Another one has been discovered recently at Zunsweiser (G. FINGERLIN/K. BATSCH, Ausgrabungen im Vicusareal von Zunsweier, Stadt Offenburg, Ortenaukreis. Arch. Ausgr. Bad.-Württ. 1988, 131ff.). For annexes in general see C. S. SOMMER, Kastellvicus und Kastell. Untersuchungen zum Zugmantel im Taunus und zu den Kastellvici in Obergermanien und Rätien. Fundber. Bad.-Württ. 13, 1988, 472ff.

Kurzfassung

Im Zentrum des römischen Rottweil, des Municipiums Arae Flaviae, konnte 1988 ein größeres zusammenhängendes Areal geophysikalisch untersucht werden. Bei der ca. 1,5 ha großen Fläche (Abb. 1) handelt es sich hauptsächlich um Bereiche, die als Eingetragenes Denkmal nach § 12 bzw. als Grabungsschutzgebiet nach § 22 DSchG Baden-Württemberg dauerhaft oder zumindest langfristig vor Bebauung und damit der endgültigen Zerstörung gesichert sind. Lediglich ein kleiner Teil im Norden, im Bereich des sog. Bau M, mußte unmittelbar nach der Prospektion 1988 bzw. 1989 und 1992 archäologisch untersucht werden (Anm. 7 und 35).

Das geschützte Gebiet liegt inmitten der römischen Stadt. Daher besteht hier aus wissenschaftlichen Gründen ein großes Interesse an den Baubefunden. Die Kenntnis dieses Bereichs beruhte bisher ausschließlich auf den aus dem späten 19. und frühen 20. Jahrhundert stammenden Eintragungen im „Gesamtplan des römischen Rottweil" von A. Rüsch und älteren Plänen (Anm. 9). Neue Erkenntnisse lassen ein besseres Verständnis der Topographie und Entwicklung der einzigen römischen Siedlung in Obergermanien rechts des Rheins mit explizitem Stadtrecht erwarten.

Andere zerstörungsfreie Prospektionsmethoden, vor allem die Luftbildprospektion und die Flurbegehung, hatten außer der Feststellung, daß auch hier mit römischen Baubefunden zu rechnen sei, keine weiteren Ergebnisse erbracht. Die Zusammenarbeit mit dem Institute of Archaeology and Ethnology der Polnischen Akademie der Wissenschaften in Warschau bot die willkommene Chance, Möglichkeiten geophysikalischer Prospektion zu erproben (vgl. Anm. 4) und über Rottweil weiterführende Erkenntnisse zu gewinnen. Vom 1. September bis zum 10. Oktober 1988 maßen T. Herbich, K. Misiewicz, M. Mizera, J. Przeniosło und M. Skrzydelski den Erdwiderstand im genannten Areal (Geoelektrik). Diese Meßmethode ließ die besten Ergebnisse erwarten, da durch die vorausgegangenen Ausgrabungen bekannt war, daß in und auf dem geologischen Untergrund (Lehm über eiszeitlichem Kies, darunter Muschelkalk) sowie Lehmfußböden und Planierschichten älterer Phasen Mauern aus Muschelkalk und Sandstein bestanden. Wegen der zu erwartenden niedrigen Widerstände des Untergrundes sollten sich die Mauern mit hohen Widerständen deutlich vom Umfeld abheben.

Nach verschiedenen Vorversuchen wurde eine Schlumberger-Anordnung der Elektroden benutzt (Anm. 20–23; Abstand der Stromelektroden 4 und 8 m, der Spannungselektroden 1 m). Mit dieser Meßanordnung konnte gleichzeitig in zwei Tiefen bis ca. 0,8 m und bis ca. 1,5 m gemessen werden, so daß es möglich war, Befunde in unterschiedlicher Tiefe zu erkennen. Gemessen wurde in einem alternierenden Meter-Meßnetz, d. h. im Meterabstand jeder 2. Meter. Als Basis für die Nord-Süd gerichteten Meßstrecken diente das für Rottweil angelegte und für die Ausgrabungen verbindliche „Arae-Flaviae-System" (Anm. 26). Da zunächst kein Computer zur Verfügung stand, mußten die Daten mit Hand ausgewertet werden (Isoohmen in Abb. 16; 17), in einer späteren Phase konnten Isoohmen und dreidimensionale Modelle auch elektronisch erstellt werden (Abb. 5–14 bzw. 5–12).

Vor dem Hintergrund homogener, sehr niedriger Widerstandswerte, die auf die oben angesprochene Geologie zurückzuführen sind, zeigten sich Anomalien unterschiedlicher Ausdehnung und Stärke. Diese scheinen Gruppen zu bilden. Das untersuchte Areal läßt sich in vier Zonen einteilen (Zonen I–IV), wobei die Grenze zwischen den Zonen II und III auch weiter südlich gezogen werden könnte. Die Abb. 5–12 veranschaulichen die Ergebnisse der Widerstandsmessungen für die hohe und für die tiefe Ebene in den vier Zonen jeweils als Plan mit Isoohmen (Norden ist dabei stets links) und dreidimensionales Modell mit Blick aus Nordnordwest. Dabei wird deutlich, daß viele der Anomalien auf beiden Meßebenen vorhanden sind, andere dagegen nur auf der hohen oder der tiefen Ebene.

Es zeigt sich, daß die genauer ansprechbaren Anomalien mit wenigen Ausnahmen linear angelegt und eng begrenzt sind. Mehrheitlich verlaufen sie entweder Ost-West oder Nord-Süd, einige wenige, eher breite Anomalien (13–16, 53) dagegen etwas schräg dazu. In einigen

Bereichen in Zone I und insbesondere in Zone III heben sich aber die linearen Anomalien nur schwer von einer eher unregelmäßigen Umgebung mit relativ hohen Widerstandswerten ab.
Die archäologische Interpretation der Ergebnisse der geophysikalischen Messungen basiert einerseits auf allgemeiner Erfahrung der Prospektoren, andererseits auf den Ergebnissen verschiedener archäologischer Untersuchungen in Rottweil. Von besonderer Bedeutung waren die der Prospektion unmittelbar nachfolgenden Ausgrabungen im nordöstlichen Bereich des geophysikalisch untersuchten Areals (Abb. 2–4; 15). Sie ermöglichten eine direkte Korrelation der verschiedenartigen Anomalien mit dem archäologischen Befund (Abb. 13; 14) und lieferten die Parameter für die weitere Interpretation der Anomalien in den unausgegrabenen Teilen.
Demnach verweisen schmale, lineare Anomalien auf Mauern oder deren Reste. Die Höhe der gemessenen Widerstände scheint in einem engen Zusammenhang mit der Stärke (dem Querschnitt) der jeweiligen Mauer zu stehen, während die Feststellung der Anomalie in der hohen oder tiefen Ebene abhängig ist von der Fundamenttiefe und den Erhaltungsbedingungen (unter dem Pflughorizont beginnende Mauern mit tiefen Fundamenten zeichneten sich in beiden Ebenen ab, hochliegende flache Mauern nur in der hohen Ebene, weitgehend ausgebrochene oder tief endende Mauern nur in der tiefen Ebene). Ausgedehnte Areale mit hohen Widerstandswerten beruhen anscheinend auf Steinkonzentrationen, wie z.B. Estrichfundamenten, Straßenbelägen, umgestürzten Mauern. Eine nicht auf Mauern zurückzuführende klare Begrenzung dieser Anomalien kann durch Absenkung solcher Befunde in große Gruben oder Gräben verursacht sein. Diese lassen sich somit indirekt nachweisen. Mit feinkörnigem Material verfüllte Gruben und Gräbchen, vermutlich auch Ausbruchgräben, können dagegen mit der Geoelektrik in der Regel nicht festgestellt werden. Nach den Ergebnissen der geophysikalischen Prospektion und der Grabungen umfaßt Zone I den Südteil eines ca. 95 m langen Baukomplexes, des sog. Baus M, der seit vielen Jahren durch das Landesdenkmalamt ergraben wird (Anm. 19, 24 und 35). Diese Zone wird deutlich durch die Südmauer des Komplexes abgeschlossen. Abgesehen von den später auch durch die Ausgrabungen nachgewiesenen Mauern scheint innerhalb Bau M im Süden des bisher als offen angesehenen Innenhofs eine (etwas unklare) Portikus oder Raumflucht zu liegen.
In Zone II und dem nördlichen Teil der Zone III wurden altbekannte Mauern bestätigt und mehrere zusätzliche bisher unbekannte Mauern wahrscheinlich gemacht (Abb. 16; 17). Einige entsprechen in ihrer Anordnung den bereits bekannten Mauern, unterscheiden sich von diesen aber durch Lage und Richtung. Dies macht wahrscheinlich, daß ihre Eintragung in den dem „Gesamtplan" vorausgegangenen Plänen und Skizzen nicht immer korrekt vorgenommen wurde und zu korrigieren ist. Mehrere dieser Mauern sind in einem bisher unpublizierten Plan aus dem Jahr 1914 (Abb. 18; Anm. 18) exakt in der von der Prospektion vorgeschlagenen Position bzw. Ausrichtung eingetragen.
In den Zonen II und III liegt demnach wohl ein großer Baukomplex aus Ost-West gerichteten Einheiten mit einer wahrscheinlichen Ausdehnung von etwa 95 m (Breite wie Bau M). Im Unterschied zu Bau M sind die Einheiten aber weniger lang und weisen eine sehr viel weniger detaillierte Innengliederung (in Stein) auf. Zwischen den beiden Komplexen befindet sich ein von Steingebäuden freier Raum mit etwa 23 m Breite. Weiterhin lassen sich in Zone II die beiden z.T. stark mit Steinmaterial verfüllten Gräben des älteren Kastells V sowie vermutlich der innere Graben des Kastells IV erkennen. Letzterer scheint allerdings etwas mehr in südwestlicher Richtung verlaufen zu sein als dies bisher rekonstruiert wurde. Er hätte somit die gleiche Ausrichtung wie die nördlichen Grabenteile, wenn auch leicht versetzt.
Im südlichen Teil der Zone III verdichtet sich durch wenige Ergänzungen und geringfügige Verschiebung einiger schon bekannter Mauern die Annahme des östlichen Teils eines Doppelforums (zusammen mit „Villa A", in deren westlichem Teil sich wohl eine Basilika befindet). Nach Osten anschließend zeigt sich ein weiterer, von schmalen Raumfluchten, vielleicht einer Portikus, umgebener offener Bereich. Dieser steht vielleicht mit den am Abhang zur Prim liegenden Tempeln und dem Theater in Verbindung. Unklar ist die nördliche Begrenzung

dieser Baukomplexe. Mehrere Nord-Süd ausgerichtete Mauern scheinen eine direkte Verbindung zu dort befindlichen Gebäuden anzudeuten.
In der Zone IV bestätigen und ergänzen sich die bekannten Mauerreste. Damit kann die These, es handele sich bei dem früher mit „Forum (?)" markierten Bereich um einen eingefriedeten unbebauten heiligen Bezirk (Anm. 44), endgültig aufgegeben werden. Völlig unerwartet ist die in Nord-Süd-Richtung verlaufende, wenig ausgeprägte breite Anomalie 53. Nach den bisherigen Ergebnissen müßte es sich dabei um einen Grabenrest handeln, möglicherweise Bestandteil eines Annexes, wohl zu Kastell IV (Anm. 45). Genauer läßt sich dies aber nur durch archäologische Ausgrabungen bestimmen.
Zusammenfassend läßt sich feststellen, daß die Geoelektrik bei geeigneten Bedingungen in der Lage ist, wertvolle Erkenntnisse, insbesondere zur antiken Steinbebauung, zu gewinnen. Über die reine Feststellung von Befunden hinaus bietet die – sicher zeitaufwendige – Messung mit der hier angewendeten Elektrodenanordnung die Möglichkeit einer differenzierten Interpretation der Befunde. Voraussetzung dafür scheint allerdings die Überprüfung und gegebenenfalls Korrektur durch die archäologische Ausgrabung eines Teilbereichs. Die Prospektion in Rottweil vertiefte die Kenntnis über einen zentralen Bereich der römischen Stadt. Ihre Baureste lassen sich nun sehr viel klarer interpretieren und deuten. Insbesondere konnten Widersprüche, verursacht durch unpräzise Eintragung alter Grabungsbefunde, beseitigt werden. Darüber hinaus läßt sich mit einiger Sicherheit sagen, daß in dem untersuchten Bereich kaum mehr mit weiteren, bisher nicht nachgewiesenen Mauern größerer Dimension zu rechnen ist.

Anschriften der Verfasser

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