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Resafa and its Surroundings – Resafa-Sergiupolis / Rusafat Hisham The Employment and Evaluation of Diverse Methods

Abstract: The subject of the current investigation is the remains of the residence of the Caliph Hisham b. Abd al-Malik (724–742 AD) in the environs of the now ruined but still impressive city Resafa, situated between the Palmyrene desert and the river Euphrates in Northern Syria. The project "Resafa and its Surroundings" is notable for the wide range of techniques used. Over the course of several campaigns, geodetic measurements of large buildings have been taken, archaeological surveys and geophysical prospections have been carried out, the data for Digital Terrain Models has been recorded and aerial photographs have been rectified. In addition, archaeological excavations at selected sites were begun in autumn 2006. The current paper presents the application, interaction and results of the aforementioned methods, followed by an evaluation of the possibilities and limits of the techniques employed, illustrated by examples from the investigation of the residence.

Resafa, City of Pilgrimage and Caliph Residence

Resafa, situated between the Palmyrene desert and the river Euphrates in Northern Syria, served as a Limes Castrum in the Roman Empire, defending the border with Persia. After the Martyrdom of Saint Sergios around 300 AD, Resafa flourished for centuries as a significant pilgrimage destination. The importance of the early city is documented by the monumental churches as well as by large water cisterns, and an impressive city wall built up during the 6th century. The worship of St. Sergios continued through the Islamic period into the Middle Ages when the city was finally abandoned following the invasion of the Mongols around 1250 AD.

The subject of the current investigations is the remains of the residence of Caliph Hisham b. Abd al-Malik (724–742 AD) in the southern environs of Resafa. After his appointment as Caliph, Hisham built a large mosque adjacent to the main Christian church, today known as Basilica A. Hisham, being a man of the desert, erected his private residence outside the city of Resafa *(Fig. 1)*.

Early Archaeological Investigations

In 1907 F. Sarre and E. Herzfeld rediscovered Resafa and published the first descriptions of the architectural remains (Sarre / Herzfeld 1909). More extensive archaeological investigations, supported by the German Research Foundation (DFG), began in 1952 under the direction of J. Kollwitz. J. Kollwitz carried out a survey of the great Byzantine monuments inside the city walls and W. Karnapp investigated the city wall itself (Karnapp 1976). An Islamic palace outside the city walls was excavated by K. Otto-Dorn (Otto-Dorn 1957). The German Archaeological Institute (DAI) has funded the investigation of Resafa since 1976. T. Ulbert directed various investigations within the city until spring 2006. These activities comprised not only the excavation, recording and publication of investigations of Basilica A (Ulbert 1986), but also a topographical record of the whole archaeological zone in 1976 by H. Tremel and, most importantly for our investigations, an extended archaeological survey by M. Mackensen (Mackensen 1984). This detailed survey located and mapped several objects of archaeological significance around and especially to the south of the city, and assigned to them short labels, for example PK for a palace complex (Palast-Komplex) or FP for a findspot (Fundplatz). D. Sack studied, recorded and published the investigation of Hisham's mosque (Sack 1996) near Basilica A, and began as early as 1983 with a more detailed descriptive record of areas of most probably Islamic settlements based on the archaeological findings of M. Mackensen.

Recent Activities in Resafa

A more intensive study of the Islamic architecture and the remains to the south of the city was carried

Fig. 1. Aerial view from the south (M. Stephani, 1999).

out by D. Sack (Sack / Becker 1999), who suggested the probable uses of various places of interest, providing insights into the location of buildings and their possible functions. Since 1997, a step-by-step documentation of the Islamic remains has been carried out, beginning with geophysical recordings (Becker et al. 2001). Two main geophysical recording methods have been applied so far. The magnetic anomalies of selected areas have been recorded and chronicled by H. Becker, whilst F. Shouker has supplied electrical resistivity data for selected areas. Digital Terrain Models of local areas of interest have been constructed by M. Stephani, and aerial photographs were taken with a professional Rollei SLX 6 cm × 6 cm camera system in a helicopter flight over Resafa and its surroundings in 1999.

In order to undertake a deformation study of Basilica A and to determine any necessary restoration work, a larger GPS-based geodetic high precision network was established by H. Heister in 2002 (Kowoll / Sternberg / Heister 2007). High precision digital levelling was applied to determine the height of some seventy points inside and outside the Basilica A structures. The amount of deformation was ascertained by repeating the measurements in 2006, in conjunction with a terrestrial laser recording of the structures of Basilica A. Since 2006, the investigations in and around Resafa have been carried out under the direction of D. Sack and a further project phase with five subprojects has begun.

There are still plans for an archaeological map with chronological layers for the whole site, a more detailed survey of the city walls, strategies to develop preparations for restoration schemes, concepts for site management, and last but not least, the archaeological excavation of selected areas of the Islamic remains *(Fig. 2)*. The investigations within the city, including the city walls, are supported by the German Archaeological Institute (DAI). The investigations of the residence of the Caliph Hisham b. Abd al-Malik in the environs of Resafa are funded by the Fritz Thyssen Foundation. In the remainder of this paper, the methods and results of the subproject "Rusafat Hisham – The residence of the Caliph Hisham b. Abd al-Malik" are presented in more detail.

Archaeological Survey of the Islamic Remains

The Early Islamic buildings, situated mainly to the south of the city of Resafa, date back to the time of Hisham and were built mostly using mud brick. For this reason these settlements are only noticeable as small undulations on the desert surface. The outline of the walls are best seen when the sun is low, either in the morning or the afternoon. Digital Terrain Models (DTMs) are best suited to model such small undulations. Input data for the DTMs was the 3D coordinates of arbitrarily distributed points and so-called break lines, with which discontinuities of the surface curvature could be described. In the case of small undulations, a dense set of precise points was required to obtain suitable results. Using the data from the site, 3D points and break lines, a triangle or "raster" based DTM was calculated and stored by suitable software. The DTM data was then used to derive contour lines, cross sections, volumes, shaded reliefs, perspective views and other visual data.

Archaeological Surveys: Levelling and Hand Measurements

During the short spring period, humidity traces of the walls can sometimes be observed directly with the naked eye. By observing and interpreting the on-site undulations, it was possible to sketch a plan based on the archaeological survey with non-equidistant contour intervals, showing the outlines of buildings and even settlements. This preliminary method of direct observation, here called "archaeological levelling," was used in combination with a DTM to interpret building structures.

The archaeological levelling sketches were enhanced by precise hand measurements. Outlines of buildings, visible due to humidity traces and remains of plaster from the mud brick walls, were marked out with pegs and cords. These "floor plans" were then measured with geodetic support (a total station and a GPS). The reconstruction of the floor plans on-site by marking out the remains at the surface was essential to this process. The mere geodetic

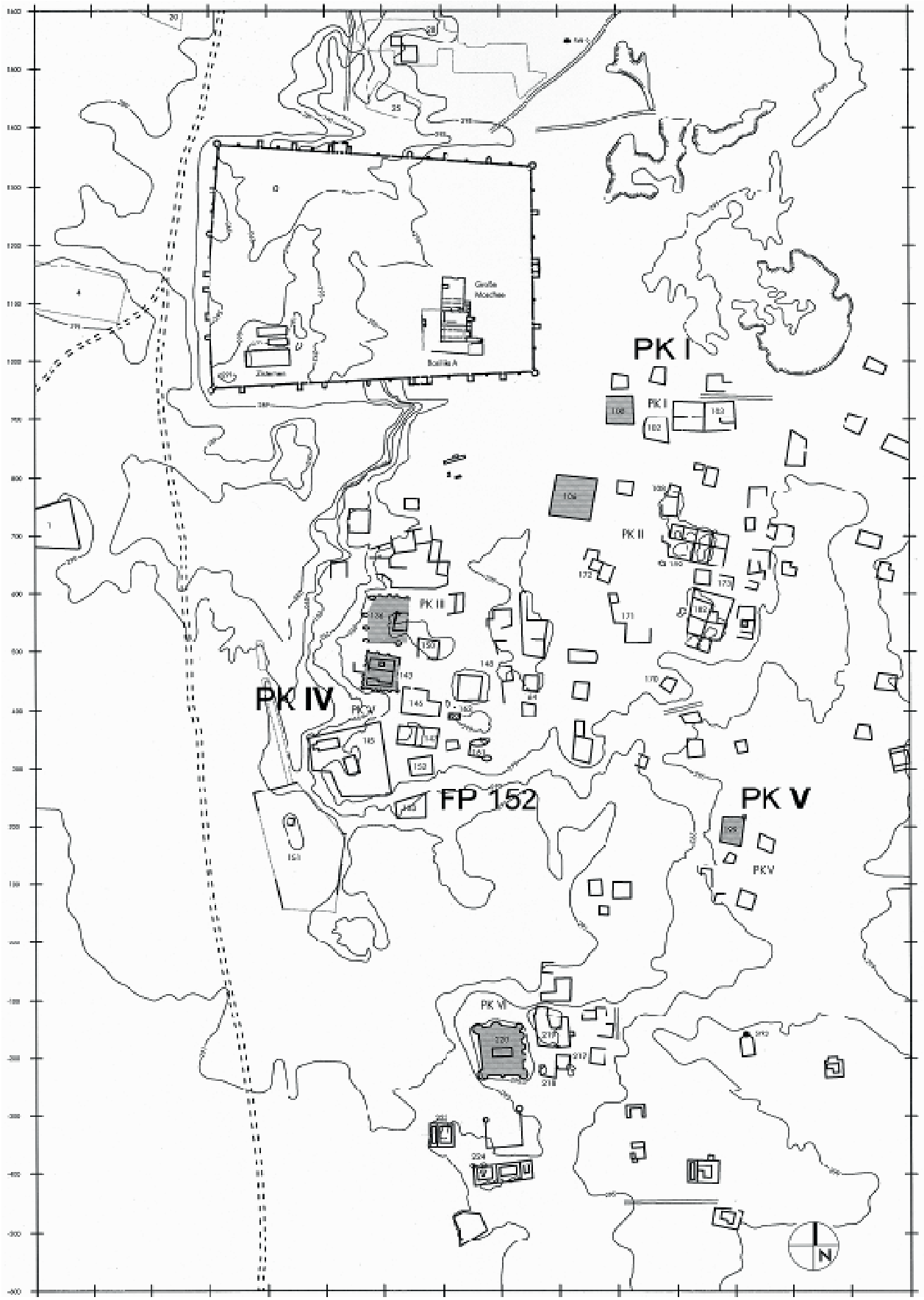


Fig. 2. Site map with palace complexes (PK), findspots (FP) and designation of areas of current investigations, 2001/2006 (D. Sack, M. Gussone, 2001).

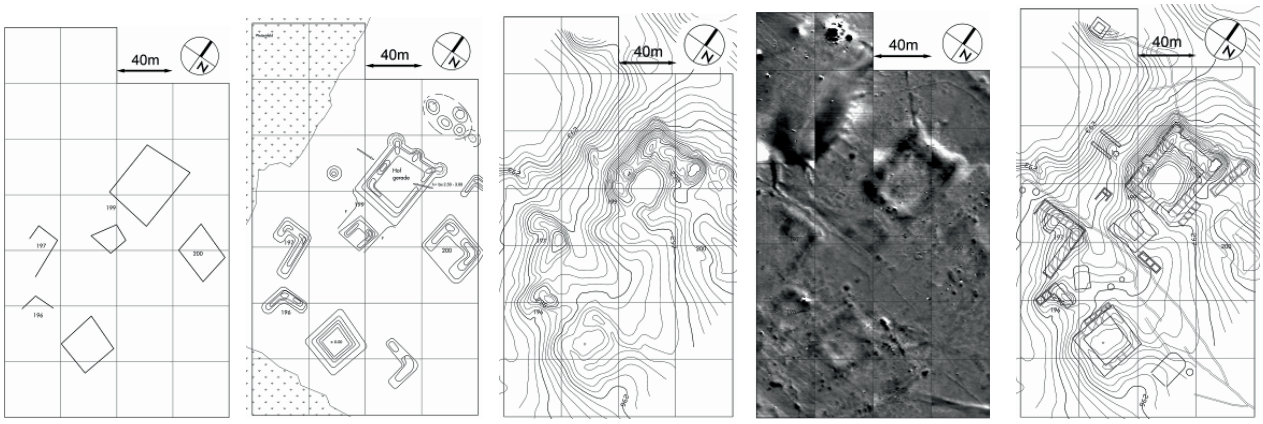


Fig. 3. PK V, combination of methods. 3a. Topographical survey, 1977: Outline of structures (Tremel, 1977). 3b. Archaeological survey, 1983: interpreted sketch (D. Sack, 1983, CAD M. Gussone, 2001). 3c. Digital Terrain Model, 2001: Objective contour lines (M. Stephani, 2001). 3d. Magnetogram, 1999: Subterranean condition (H. Becker, 1999). 3e. Combined interpretation, 2004: Interaction of methods (M. Gussone, 2004).

measurement of the traces was not sufficient for a later off-site reconstruction due to a lack of traces or poor visibility in some areas; a precise interpretation of the remaining traces and their relation was enabled by reconstruction on-site.

Geophysical Prospections

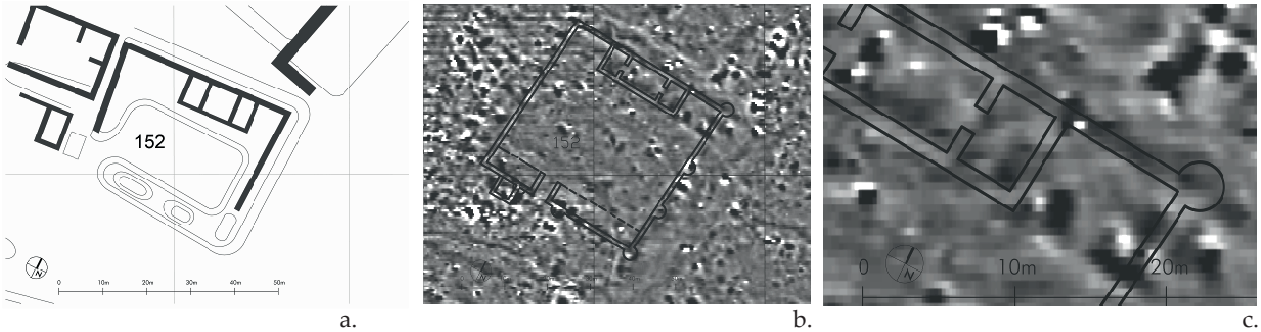
In 1997 a first geophysical prospection was conducted in order to verify whether these methods would be suitable for the non-destructive recording of mud brick remains in Resafa. Both the geophysical methods applied produced unexpected and remarkable results. The distinct contrast of the mud brick walls compared to the surrounding terrain was probably due to the fact that most of the walls were built on a foundation of stones (Becker et al. 2001). While geomagnetic measurements could be taken all throughout the year, only early spring was suitable for resistivity measurements due to the lack of humidity during the rest of the year. The recording procedure for both methods followed the same scheme. First a set of squares was marked on the ground, typically of 20 × 20 m for resistivity and 40 × 40 m for magnetic prospecting. Very dense profile data was then ascertained by measuring along the plastic cords marking the profile on the ground. Later the profile data was interpolated to an eight-bit image offsite. The resolution of this image was derived from the interpolated distance between adjacent profiles, typically 0.5 m or 0.25 m. To attain the best results, the dynamics of the data was scaled according to subterranean anomalies, and image processing algorithms were applied. Geomagnetic recording gave a less detailed representation of the archaeological structures than resistivity measurements, but required far less time. Ground penetrating radar has not been used at this stage (Sack et al. 2004).

Photogrammetric Recording

The Islamic remains are spread out over a large area, mainly to the south and southeast of the city of Resafa. As larger building structures and distinct single settlements are distinguished, their previous functions can, to some extent, be inferred from their topographical positions. In order to create a general picture of the remains, an overview was necessary, either in the form of a special map or aerial photographs. Aerial photographs were taken at 160 m and 80 m above ground on a helicopter flight in 1999. The images were taken as diapositives with a hand held Rollei SLX 6 cm × 6 cm camera with 52 mm focal length as single oblique views. The area of interest was photographed late in the afternoon, from the relatively low flying height of approximately 80 m above the ground. After digitizing all the images, some were rectified using ground control points. Hence uniformly scaled orthogonal representations of selected areas became available.

Archaeological Excavations

As the archaeological excavations began in 2006 and are to be continued over the next years, only limited



a. b. c.

Fig. 4. FP 152, complementary interpretations. 4a. Archaeological levelling, 1983 (D. Sack, 1983, CAD: M. Gussone, 2001). 4b and 4c. Magnetogram with geodetic integrated hand measured traces of mud brick walls, 2001 (D. Sack, U. Siegel, CAD: M. Gussone, 2001).

verification of the results from the other methods is possible at this stage. The main goal of the excavations is to obtain an overview of selected objects, rather than to carry out an exact investigation of all individual objects. Further goals include the verification and if necessary correction of the interpretation of the geomagnetic results, as well as the dating of the buildings.

Evaluation of Results

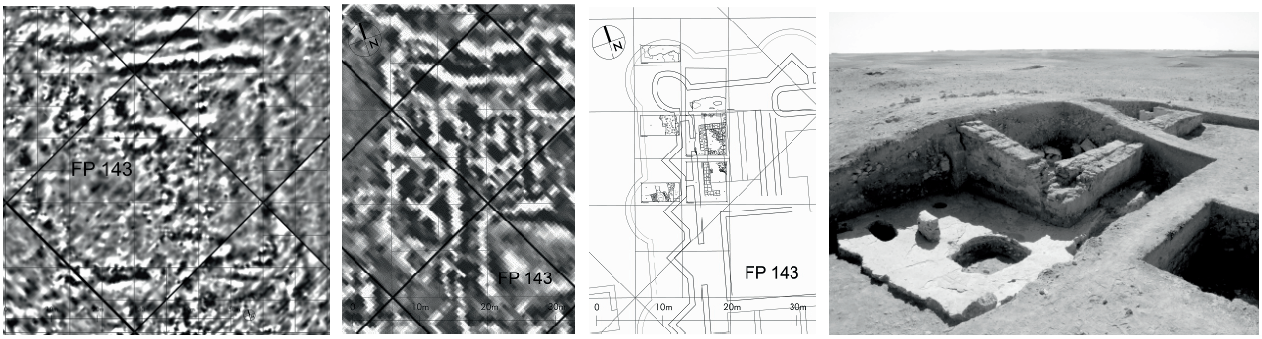
The project "Resafa and its Surroundings" has evolved over a long period of time. The use and the combination of different methods in these investigations has resulted in detailed knowledge of the archaeological site on different scales. In the following, examples of the interaction between the methods used in Resafa and some unexpected preliminary results of the different methods are discussed. The focus is on the verification of geophysical prospection (1997–2001) by the results of archaeological surveys and excavations. The detailed survey of archaeological structures using hand measurements began in spring 2001 and the excavations started in autumn 2006 are to be continued in the following years (Sack et al. 2007).

Improvement of Precision and Knowledge through the Combination of Methods

The first example, "Palace Complex V" (PK V), situated to the southeast of the city, shows the development of methods used in the investigation of Resafa and its surroundings. First, the dam like structures visible at the surface, representing sunken mud brick walls, were recorded in an archaeological survey (Mackensen 1977) as quickly as possible (approx. 4 measuring points were used per structure). The outlines, shape, size and position of of the buildings were described, giving a first impression of the extent and typology of the settlement *(Fig. 3a)*. Then followed a second archaeological survey based on the outlines recorded in the first survey. Here interpretive sketches were drawn and archaeological levelling carried out during field walking. Addition-

a. b. c.

Fig. 5. PK I, FP 102 / 105, archaeological validation. 5a. Magnetogram, 2001 (H. Becker, 2001), 5b. Excavation FP 102, view to the south (M. Gussone, 2006), 5c. Overlay of the magnetogram with the results of the excavation, 2006 (H. Becker, M. Gussone, CAD: J. Ahrens, 2006).



a. b. c. d.

Fig. 6. PK IV, FP 143. 6a. Magnetogram (H. Becker, 1999), 6b. Resistivity, detail northwest corner FP 143, 1999 (H. Becker with N. Djaramani, 2001), 6c. Comparison of geophysical prospection and excavation results (D. Sack, M. Gussone, 2001, Chr. Konrad, 2006, CAD: J. Ahrens, 2006), 6d. Archaeological excavation, northwest corner of FP 143, view from northwest (C. Konrad, 2006).

al, more detailed information about the structures required only a relatively short period of time to be gathered *(Fig. 3b)*. The survey observations, interpretation and dating of findings made it possible to infer the likely function of individual structures and to classify them historically.

In a next step, the data for a Digital Terrain Model (DTM) was geodetically recorded. This required no longer than the archaeological levelling, yet ensured higher accuracy due to the high standard technical equipment used (a total station and computer aided post processing). DTMs provide objective contour lines as well as shaded relief models with precise spatial integration in the geodetic system of the whole site *(Fig. 3c)*. With continuing work, the detail of the descriptions of individual structures is increasing, as well as the technical requirements (Sack et al. 2004).

While the above mentioned methods explored the surface characteristics of the investigated sites, a further step was undertaken in the geophysical prospections to ascertain the subterranean conditions. The magnetogram of PK V showed a clear distinction between the man-made structures and the soil, and it was possible to identify the type, and in some areas the interior structure, of the sunken buildings *(Fig. 3d)*. In a final step the combination of information from the archaeological survey and the Digital Terrain Model enabled the differentiation between primary functions, infrastructural elements (e.g. water pipes), and secondary structures *(Fig. 3e)*. The time needed for magnetic prospecting based on geodetic grids in an open area without interfering with vegetation is equivalent to the time required to gather data for a DTM or to carry out an archaeological survey. However, the technical requirements are higher than with standard devices and expenses for specialised equipment have to be taken into account.

Complementary Interpretations, Limitations of Methods

The second example, FP 152, shows the results of archaeological levelling, magnetic prospecting and geodetic supported hand measurements. The archaeological levelling sketch shows the northern part more or less accurately, but the position and shape of the building is twisted, and the southern part is missing *(Fig. 4a)*. In the magnetogram the building can be identified but not traced precisely. The hand measurements of the mud brick walls, which are visible by traces of plaster and in the spring as damp marks at the surface, show the whole structure of the buried building in detail *(Fig. 4b)*. The integration of the whole project into a geodetic system provided precise positioning and orientation of individual archaeological structures *(Fig. 4c)*.

It is unfortunate that the mud brick walls were not represented in the magnetic prospection, as they could be clearly seen on the surface. This was due to the similar magnetic characteristics of the soil and building materials in this area. Magneting prospection in these conditions is thus more suitable for the fast recording of large areas with a low level of detail of the archaeological structure represented, whereas hand measurements are better suited for attaining more precise detailed information. The dependency on climatic conditions for the visibility of archaeological structures on the surface needs to be considered. The various methods applied thus complement each other and their appropriateness depends on the scale and the properties of soil, as

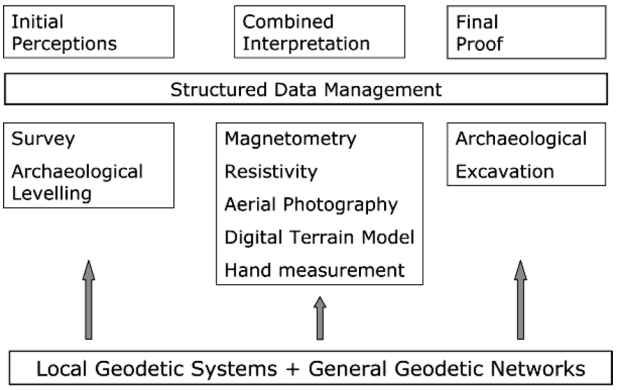


Fig. 7. The interaction of different methods (M. Gussone, M. Stephani).

well as the building materials of the investigated structures.

Archaeological Validation

The third example compares the results of magnetic prospection at Palace Complex I (PK I) with the excavation of the building FP 102 in autumn 2006. The archaeological structure is clearly visible in the magnetogram *(Fig. 5a)*, and the interpretation suggested details of the building such as a gate as well as interior structures with partitions and doorways. At the gate and at one corner of the building, trenches of about 3 m by 6 m were excavated to verify the magnetic prospecting and to attain information about the function and date of its construction and use *(Fig. 5b)*.

Magnetic prospection was a particularly efficient preparation for the archaeological excavation in this case. The first important finding was that the use of a layer of anhydrite concrete-like gypsum for the foundation of the building clearly distinguished the building's structures from the surrounding soil. The second finding was that the magnetogram image shifted with respect to the position of the building to the south, even though the same grid was used during prospection and excavation. For the preparation of an excavation this shift of the magnetogram has to be considered.

In the fourth example, the results of the excavation at findspot (FP) 143 were compared to the magnetic prospecting, resistivity survey and their interpretation. FP 143 was the main object of investigation between 1997 and 2001. The visible remains of a rectangular structure with regular slight hills at the outer limits resemble the Early Islamic palace buildings, which were typically fortress-like with regular towers. Magnetometry and resistivity seemed to result in a clear image of the archaeological structure. In magnetometry the contrast between mud bricks, foundations and debris seemed appropriate, and the results of the resistivity were even clearer, showing a floor plan like image of the building (Sack et al. 2004). The building structures seemed to be represented more precise in the resistivity survey than in the magnetic prospecting. However, magnetic prospecting is five times as fast to carry out and resistivity surveys are heavily depending on humid conditions of the soil (Becker et al. 2001).

The results of the excavation differed considerably from the results of the prospection methods. The building which seemed to be clearly represented in the resistivity survey could however not be found in the excavation. The parts of the ruined building found in the excavation, for example the anhydrite floor finish and debris of vaults, appeared to be those interpreted in the images of the geophysical prospection as building structures. These images were caused by debris rather than actual building structures. It was only possible to differentiate between actual building structures and debris in the excavation. The results are still to be analysed in more detail, but it has to be accepted that the result of geophysical prospecting is not always as clear as assumed. The interpretation of "dense" archaeological areas can be made difficult by multiple building phases and debris. The architectonic interpretation of geophysical prospecting can be prejudiced by architectonic expectations.

Conclusions

The importance of structured data management and the combined interpretation of different ways to perceive an archaeological site is continuously increasing. It is necessary to integrate the results of different methods with a strong geodetic support in structured CAD-systems or even in Geographical Information Systems (GIS) to enable direct comparisons and overlays of different layers of perception.

Due to the fact that the cost of excavations with regard to time and manpower greatly exceed the cost of all other methods, these other methods are to be considered first in modern archaeology.

Thus, non invasive techniques should be preferred as much as possible, though in cases of doubt targeted excavations may remain the best solution

to attain reliable results. However, it is clear that it is not a single method that leads to the best results and makes possible prospective statements in archaeological investigations, rather it is the interaction of a diverse range of methods and thus of various layers of perception.

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