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Combined Caesium Magnetometry and Resistivity Survey in Palmyra (Syria) 1997 and 1998

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"In Hellenistic times, the caravan city of Palmyra, situated in the Syrian desert, had almost no direct contact with the great centres in the west such as Pergamon in Asia Minor or Rome. During this early period, the politics, economy and culture of Palmyra were all oriented towards the east, to the recently founded cities on the Euphrates and Tigris, such as Seleucia or Dura-Europos, and later to Parthian cities such as Hatra. It was only later, after the peace treaty between Rome and the Partians (20 B. C.), that Palmyra developed closer relations to western centres – to Emesa and Antioch, to the cities in Asia Minor and to Rome – in a periode when, especially through the unifying power of normative Augustan politics, a Hellenistic-Roman 'koine', a common language also in the arts were established. At that pe-

riod, the first monumental buildings were also built in Palmyra, including sanctuaries, such as the temple of Bel dedicated in A.D. 32, and funerary monuments, such as the tower of Atenatan built in 9 B.C." (Schmidt-Colinet, 1997). This rather clear view of the political and cultural situation of Palmyra stands in contrast to the actual knowledge of the city of Palmyra in Hellenistic times, which is completely unknown except of the above mentioned temple of Bel.

Following the ideas of Schmidt-Colinet the Hellenistic city of Palmyra may be situated in the south of the Roman city wall of Diocletianus which is still an upstanding monument like many other buildings in the Roman city. Nowadays this area is a vast field of ruins but without any architectural structures to be seen above ground. Only after careful fieldwalking some buildings eroded to the foundations appear, but their dating is almost uncertain. In spring 1997 after a long period of heavy rainfalls some building near the surface showed up as vegetation marks, but they vanished within several hours and could not be mapped before.

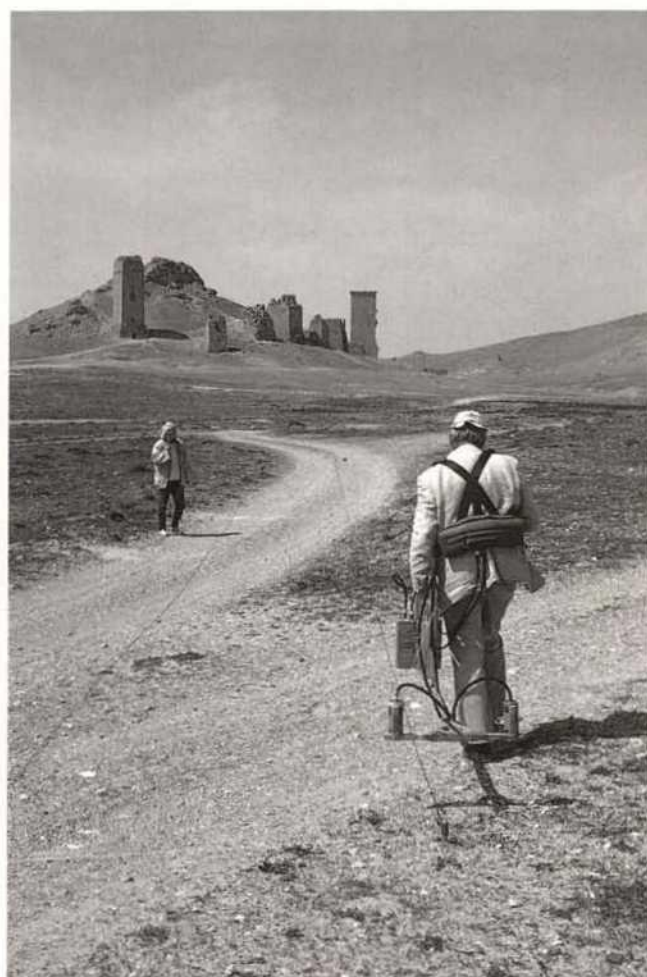
In March 1997 and 1998 nondestructive geophysical methods were tested in the "Hellenistic city" of Palmyra for archaeological prospecting. A 700 m long main line (azimuth = 100/280°) was fixed by stable architectural elements in the field and a 40 m grid was marked by wooden stacks. Two geophysical techniques were applied for this project:



Fig. 1. Palmyra 1997. Western corner of the Hellenistic city situated between the wadi, Roman city wall and the oasis to the south, the huge building complex in the upper part in the middle is the temple of Bel. Extrem oblique view from a hydraulic crane from 8 m high; marked control points on the ground (white)

1. Caesium magnetometry with Scintrex SMARTMAG SM4G-Special with a sensitivity of 0.01 Nanotesla (10 pT) at 0.1 sec cycle. This instrument was applied with duo-sensor configuration at 0.5 m traverse interval and 0.1 sec cycle which corresponds to about 10 cm sample distance (Fig. 2a). Time mode sampling allowed the coverage of 1 hectare per day (400.000 measurements). Data processing was made using GEOPLOT V2.2 software with graphic facilities for visualization the measurement as grey-shading plots. Caesium Magnetometry covered a total area of about 18 hectares. The archaeological structures showing up by this method as negative alignments (stone walls) and also as positive anomalies for mudbricks and burnt areas (see Fig. 3a, b).

Fig. 2a, b. Palmyra 1997. Caesium magnetometer Scintrex Smartmag SM4G-Special with duo-sensor configuration for prospecting the Hellenistic city south of the wadi



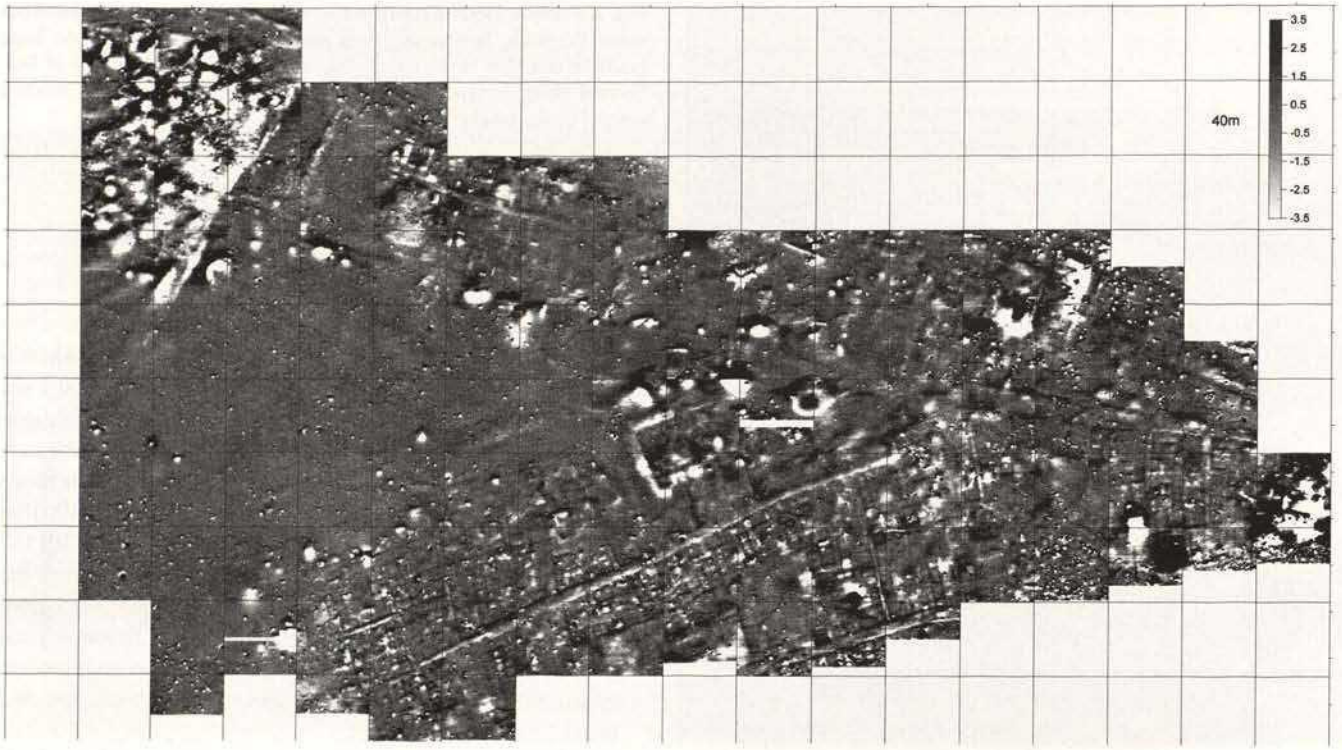
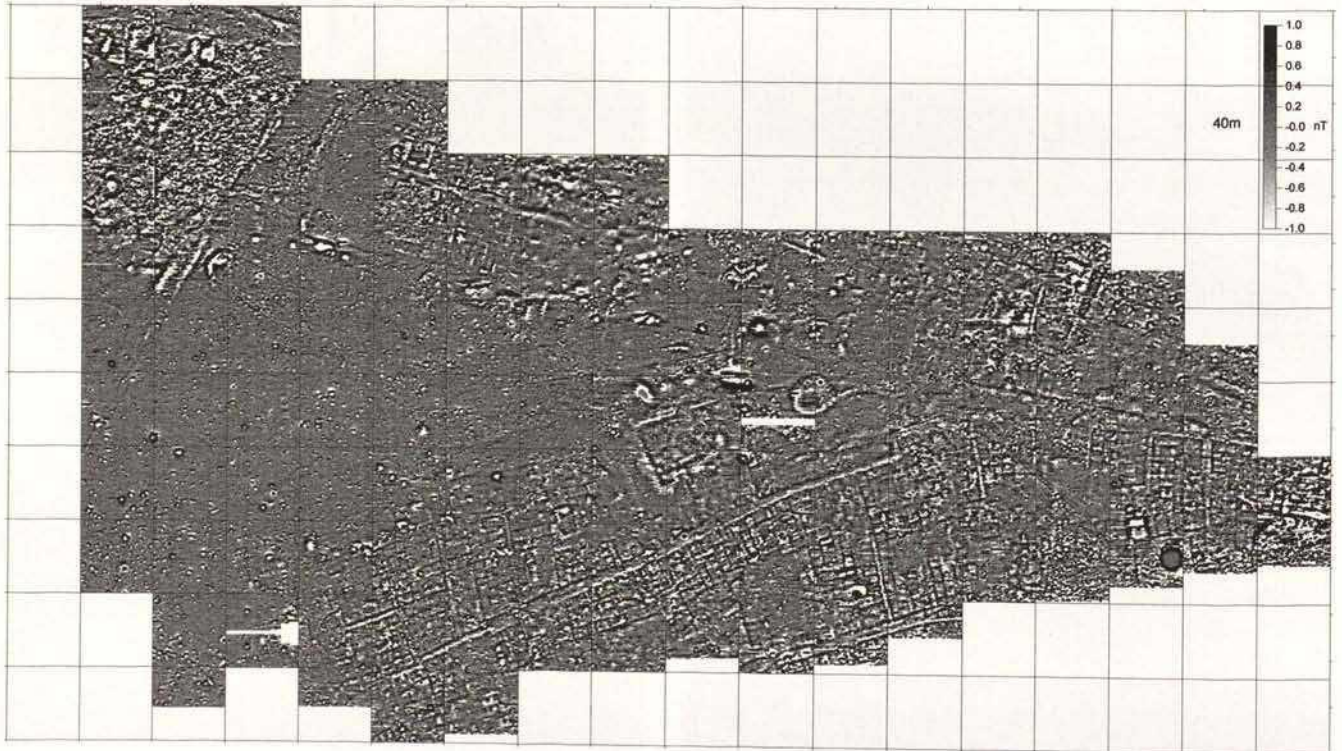


Fig. 3a. Palmyra 1997–1998. Magnetogram of the whole area of the Hellenistic city. Caesium magnetometry SM4G-Special in quadro-sensor configuration, sensitivity 10 pT (=0.01 nT Nanotesla), Dynamics -3.5/+3.5 nT in 256 grayscales (black/white), raster after resampling 0.25/0.5 m, 1 Hz bandpass filter, reduction of the diurnal geomagnetic variation by line-mean value, 40 m grid, north upwards

Fig. 3b. Palmyra 1997–1998. Magnetogram of the same data set after highpass filtering 10 x 5 pixel. Same technical data as Fig. 3a except dynamics -2.0/+ 2.0 nT



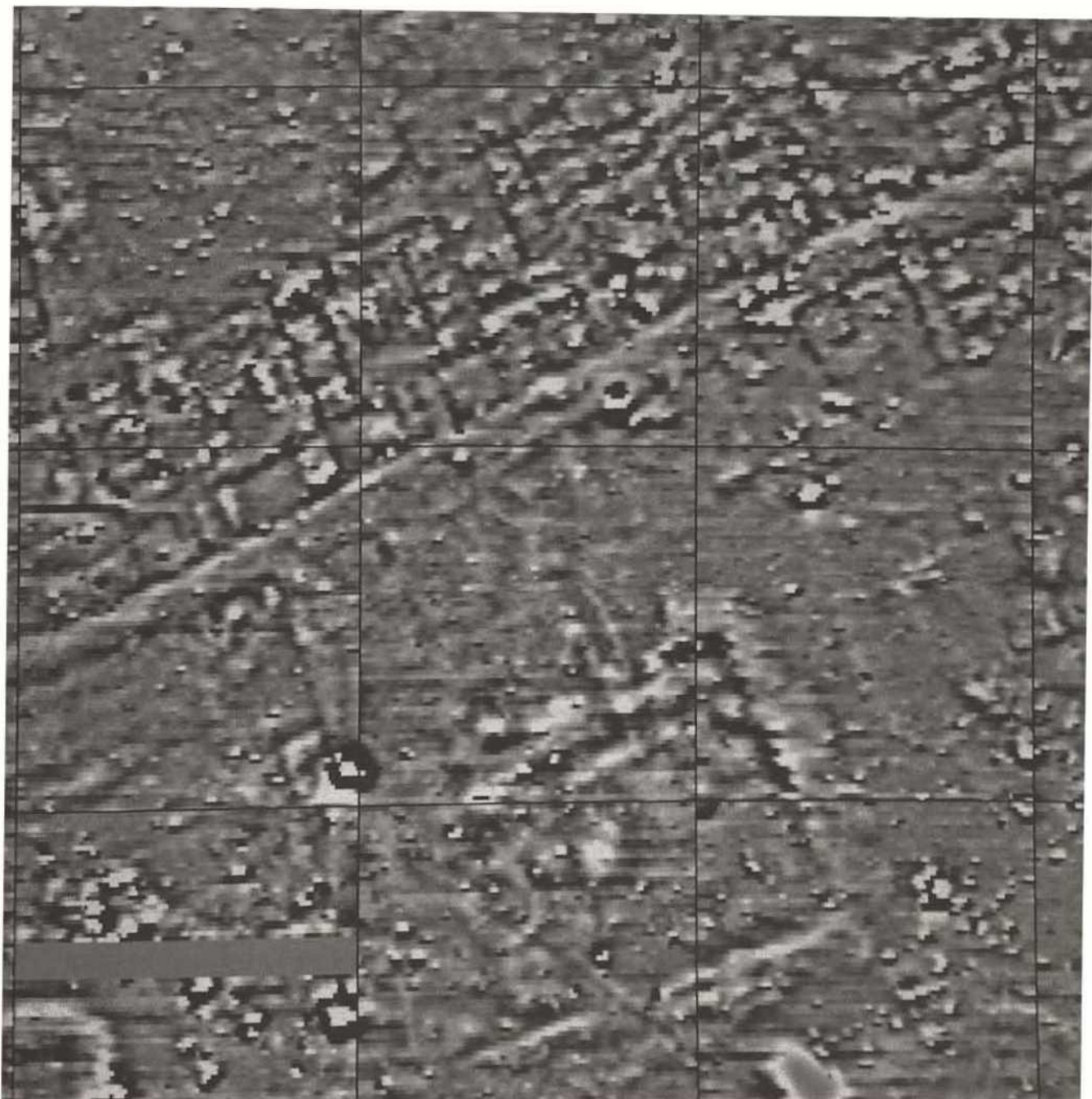


Fig. 4. Palmyra 1997–1998. Magnetogram of a part of the centre of the Hellenistic city, showing a major street, some narrow lanes with adjacent houses, which may be a bazaar or working quarter and the huge hypogaeum (36 to 52 m) in the middle. Caesium magnetometry SM4G-Special in duo-sensor configuration, sensitivity 10 pT (=0.01 nT Nanotesla), dynamics -1.2/+1.2 nT in 256 greyscales (black/white), raster after resampling 0.25/0.5 m, highpass filtering 10 x 5 pixel, 1 Hz bandpass filter, reduction of the diurnal geomagnetic variation by line-mean value, 40 m grid, north upwards

2. A smaller area was measured with the resistivity-meter Geoscan RM15 with double twin electrodes at 0.5/0.5 m intervals (about 1.5 hectare in thirtytwo 20 m grids, about 50,000 measurements). This work was done by our geophysicist colleagues from Damascus University, who were trained on both instruments during this Syro-German joint mission. Resistivity shows stone walls much clearer than caesium magnetometry, but is about 5 to 10 times slower in the field measurement dependent on the spacial resolution. Therefore resistivity surveying should be used only for detailed prospecting work of specific building-structures.

3. On March 25, 1997a pseudo-photogrammetric investigation was undertaken with rather extreme oblique photos (colour and black and white) from a hydraulic crane, which provided a platform about 8 m above ground. The 40 m grid of the prospecting work was used as ground control. It is planned to convert this oblique views by digital image processing techniques in the computer laboratory of the Bavarian State Conservation Office Munich. By this method archaeological structures visible above surface should be added to the geophysical maps.

Results: It became evident by this test, that the combination of magnetometry, resistivity surveying and oblique photogrammetry will result in a rather detailed plan of the archaeological structures above and under the surface. With the second campaign in spring 1998 one could establish a complete city map of the Hellenistic Palmyra as the base for further archaeological activities.

In the 1998 campaign caesium magnetometry could be applied with two complete duo-sensor systems which were operated by the author and J. Fassbinder. Almost the whole rest of the Hellenistic city area was prospected from the wadi to the modern street to the south. There is only a rather small strip left south of the modern street to the oasis, which should be measured when the very busy street can be closed for traffic completely. Another problem for magnetic prospection are myriads of rubbish cans left by the nomads on both sides of the modern road. Nevertheless it became almost clear, that caesium magnetometry is the best method for making the city map of Hellenistic Palmyra. This city is organized by three main streets forming a big > pointing to the east (Fig. 3). The main axis may be the street parallel and very close to the modern asphalt road. The next parallel street to this main axis comes to an dead end on the western side. There are many narrow lanes between these two streets showing an almost radial orientation. This secondary street must have been very active because of numerous houses on both sides. It looks like a bazaar or working quarter. The houses are clearly detectable with all rooms, sometimes even with the foundations of columns with an negative magnetization contrast of the limestone foundation to the cultural debris. Many ovens can be detected. The other axis to the west shows a different pattern of buildings which are much bigger in this area. This street parallel to the wadi leads to the main necropolis to the west following almost the same track which is still used today. In the very west of the surveyed area the trace of a city wall can be identi-

fied, which is no longer visible on the surface. Outside this city wall a very dense clustering of burial monuments is located which continues to the huge west necropolis, but there are also some burial monuments inside the city. The most exciting finding may be a huge limestone building in the underground near to the point of the triangle conjunction of the two main streets, possibly a hypogaeum some 36 to 52 m in dimension. There is absolutely no trace of this building at the surface, but especially its western half is clearly to be seen in the magnetogram possibly due to a rather strong magnetized filling of the excavation for the subsurface building. This structure was also tested by resistivity surveying which gave almost the same signature of the huge stone building in the underground. Only 40 m to the east another underground burial monument was found, but this only measures 8 to 10 m. Surprisingly the major part of the >-shaped area between these two streets is completely free of any building structures except some ovens and some small graves (Fig. 3). This might have been the caravan site for keeping the cattle or for living in tents like the nomads or even the people of the city today.

In late spring 1999 a first archaeological test excavation had taken place in order to prove the structures in the magnetogram and their interpretation. As the same grid was used for the excavation the direct comparison between prospection and excavation became possible.

References

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- Schmidt-Colinet, A., 1997. "Aspects of 'Romanization': The Tomb Architecture at Palmyra and its Decoration", in: S. E. Alcock (ed.) *The Early Roman Empire in the East*, 157-177