URBAN LANDSCAPE SURVEY
IN ITALY AND THE MEDITERRANEAN

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The Integrated Urban Survey at *Sagalassos*

F. Martens, B. Mušič, J. Poblome and M. Waelkens

Introduction

Sagalassos is located *c.* 110km north of Antalya. Since 1990 the town and its territory (*c.* 1200km²) have been investigated as part of an interdisciplinary research project of the Katholieke Universiteit Leuven (Belgium) directed by M. Waelkens (Waelkens 2004; 2006). After a first decade of large-scale excavations mainly within the monumental centre, an integrated research strategy was devised and applied to obtain a better insight into the development of the town plan (Figure 9.1) and the chronological evolution and functional organization of the urban area. This research comprised a programme of test soundings on the network of streets (1998–2008: Martens 2007; 2008) and an architectural and intensive surface survey covering over two-thirds (23.43ha) (Figure 9.2) of the inhabited urban area (*c.* 31.5ha) within the sepulchral zones (1999–2005: Martens 2005; Martens *et al.* 2008). The results of this work could be combined with the evidence generated by other non-invasive techniques including geophysical survey (since 2002), supervised by Branko Mušič (2008; Mušič *et al.* 2009).

State of the art

For a long time archaeological survey in Turkey was largely confined to single-period or architectural-epigraphic survey projects (Alcock 1994: 181). This situation has been changing fast during the last decade (Yıldırım and Gates 2007: 277), as is also testified by the growing number of survey projects represented in the yearly conference proceedings of non-invasive archaeological research in Turkey (*Araştırma Sonuçları Toplantısı*). Although the number of multi-method urban surveys still remains limited, ongoing projects on major sites (Ephesos: Groh *et al.* 2006: 48, n. 10; Troia: Jablonka 2006: 6–7) are conducting intensive surface collections, combined with geophysical survey. In addition, site based topographical/architectural surveys are increasingly incorporating these survey techniques as well, as in the case of the 'Pisidia Project' (e.g. Vandeput and Köse 2004; Vandeput *et al.* 2005). Modern research at *Sagalassos* was initiated within the framework of the 'Pisidia Project' (1985–1989: Mitchell 1998, with references; Waelkens 2006: 325–326). Meanwhile, large-scale excavations and the interdisciplinary investigation of town and territory (Waelkens 2008) have made *Sagalassos* one of the better documented sites of Pisidia. The urban research allowed reconstructing the building history of *Sagalassos* from the Hellenistic period[1] into the seventh century AD, whereby a devastating earthquake, occurring between 600 and 620AD (De Cupere *et al.* 2009), further enhanced the decline, which had already set in during the second half of the sixth century AD.

As opposed to earlier assumptions, however, the site continued to be inhabited by small-scale communities at least into the thirteenth century AD (Vionis *et al.* 2009: 193). For the town's *chora* the occupation pattern was first explored with a reconnaissance survey (1993–1998) (Vanhaverbeke and Waelkens 2003), forming the basis for an intensive survey (1999–2006) by H. Vanhaverbeke applying a stratified sampling strategy in the primary catchment area of the settlement within a *c.* 5km radius (one hour walking from the town across flat terrain) (Vanhaverbeke in Martens *et al.* 2008). Simultaneously with the hinterland survey, in 1999 also the urban survey was initiated. As there was no comparable work in Turkey at this time, the initial research design followed the example of the Boeotia survey (Bintliff and Snodgrass 1985). However, the unploughed character of *Sagalassos*, the low finds density and the steeply sloping terrain conditions presented major methodological challenges.

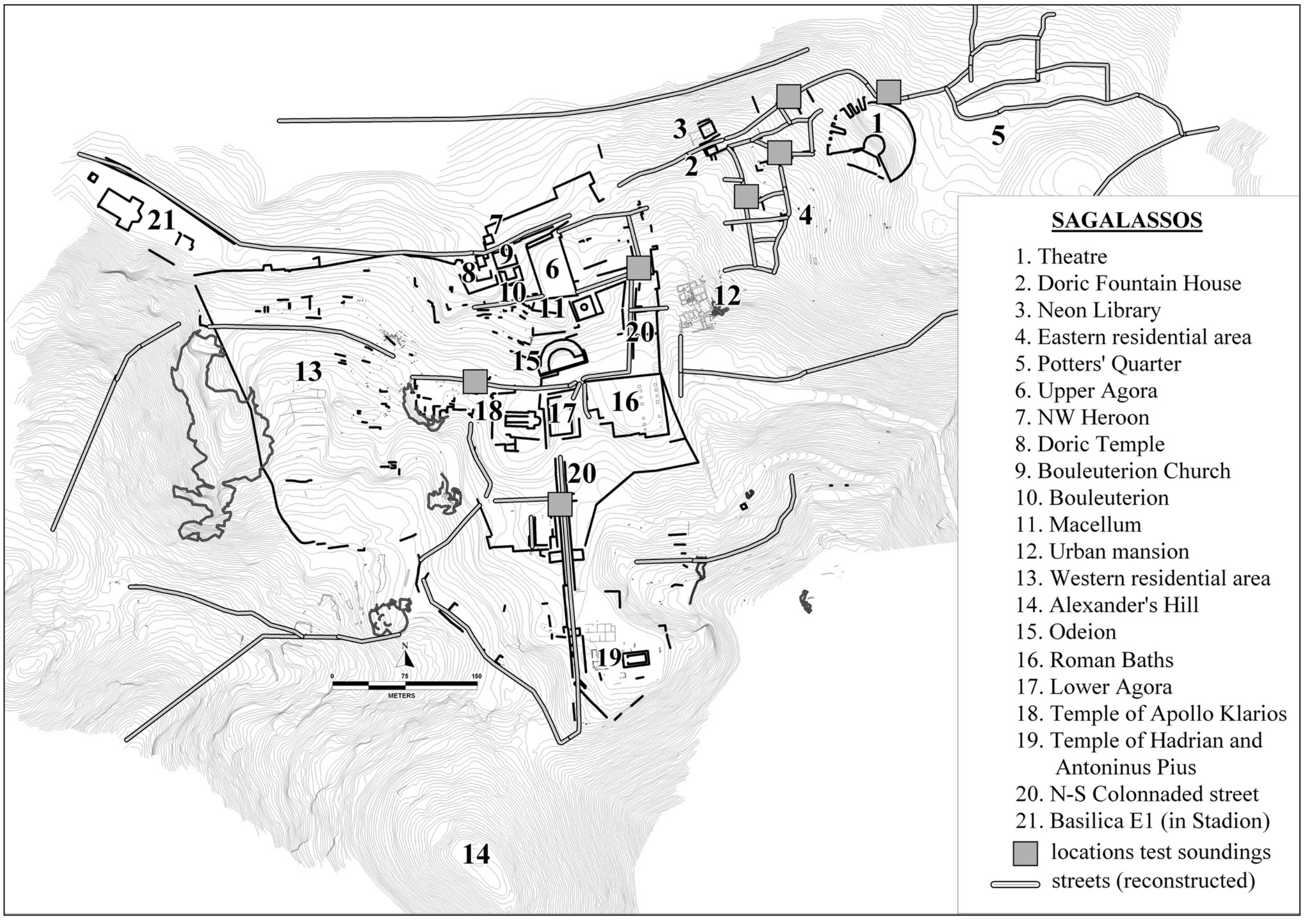

Figure 9.1 The urban plan of Sagalassos *with the street system as reconstructed on the basis of excavations and geophysical survey (F. Martens; B. Mušič).*

For the application at *Sagalassos* of high resolution shallow geophysics, the challenges were posed by the diverse archaeological contexts of different origin and preservation, the alternating geomorphological units with natural or man-made obstacles at the surface and the diverse top soil compositions of varying depths and lithologically variable underlying bedrock. As it was difficult to classify the *signal to noise ratio* for each geophysical technique for such diverse or unpredictable subsurface conditions, a multi-method approach was designed using various complementary geophysical methods, as tested at *Tanagra* (Boeotia) (Bintliff *et al.* 2000; 2001; Mušič *et al.* 2004; 2005) or *Trea* (Potenza Valley) (Vermeulen *et al.* 2009: 85–110). In addition, the approach of other surveys in comparable conditions was consulted to resolve specific tasks and special attention was paid to certain algorithms used in the processing flow for enhancing the *signal to noise ratio*.

Methodology

The intensive archaeological survey

Field conditions at *Sagalassos* differed from many other archaeologically surveyed Mediterranean sites in the sense that the town was laid out on sloping terrain, which had not been intensively cultivated after the end of the large-scale occupation. This had consequences for the distribution of the surface material. The absence of a regular turnover of artefacts in the soil implied that a chronological superposition of archaeological evidence was to be expected, whereby the last phase of the large-scale occupation prevailed in the surface record (Figure 9.2), unless when disturbed by post-depositional processes. This situation, together with the fact that the average pottery densities proved to be rather low (0.2 sherds per m²) with a small amount of diagnostic sherds (0.03 per m²)[2] especially in comparison to the rates seen in many Mediterranean surveys, urged us to try and control or assess as much as possible the impact of biases

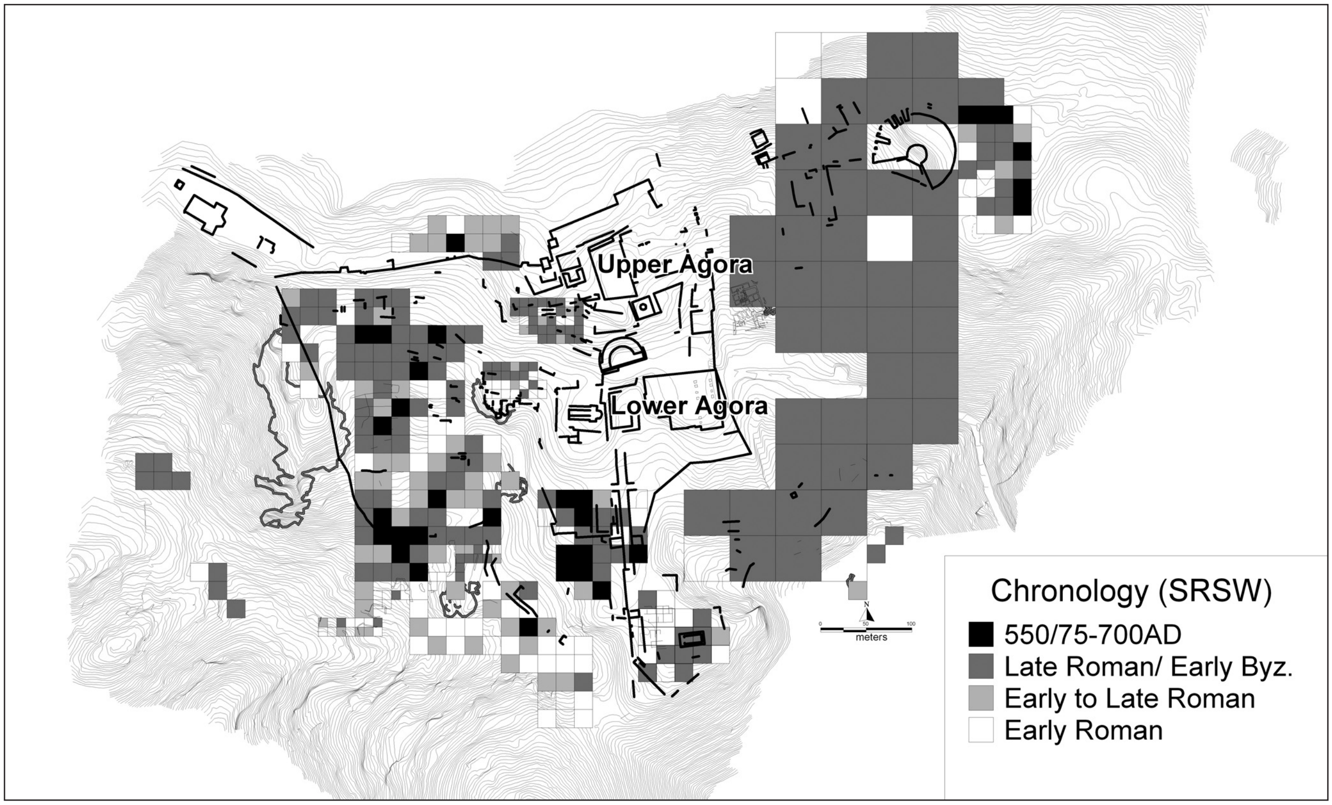

Figure 9.2 The chronological distribution of the surface finds, showing the youngest prevalent period per surveyed square (F. Martens).

either related to the survey procedure or caused by the field conditions (Martens *et al.* 2008).

Firstly, with regard to the field strategy, the intensity of the coverage, the size of the grids and the choice of the collected material were important. The field strategy evolved from a sampling strategy (1999) based on 50 × 50m squares, providing a reliable yet insufficiently differentiated research result, over a too intensive and thus slowly progressing full coverage strategy in grids of 10 × 10m (2000), to result in an intensive coverage of squares of 20 × 20m with a walker distance of 2m, which ultimately proved to be both time-efficient and most likely to produce a representative data-set (Martens 2005: 235–240: figs 3, 5).

To calibrate the density counts and to compensate for the level of ground cover the degree of surface visibility was assessed using five classes with increasing visibility. Objections have been formulated against using visibility rates to produce visibility corrected pottery distribution maps (Lock *et al.* 1999: 59–60; Meyer and Schon 2003: 52–57; Thompson 2004). One of the arguments is that the empirical data of the density count are multiplied with a factor generated on the basis of a subjective visibility allocation (Mattingly 2000: 12). Yet, provided that the raw data are presented as well and that 'corrected figures' are marked as such, visibility correction can be justified. By using five instead of ten classes (as in the Boeotia survey), the visibility categories could be linked to clearly described field conditions (involving specific constellations and vegetation species) which were thus more likely to be assessed in the same manner by all field walkers. To increase the reliability of the surface collection all material – diagnostic as well as non-diagnostic – was counted and collected, except for building ceramics which were counted in the field. Surface architecture was measured and mapped on a scale 1:200. Two teams of five persons surveyed simultaneously and to improve the consistency of the procedure meters were laid out along each grid. As such the person registering the density counts and visibility assessments could ensure that equal ranges were covered per step. Prior to the survey, team members were introduced to the material at the project's find depots and in the field it was checked regularly whether they used the same standards for density counts and visibility assessments.

A second and even more important bias for the surface survey comprised site formation processes and post-depositional disturbance. The monumental centre of *Sagalassos* was laid out on a complex of extended limestone platforms, whereby the homogeneous debris slope with grasses and low shrubs of the Eastern Residential Area contrasted strongly with the terraced western domestic (Martens 2005: 234, fig. 4), artisanal and sepulchral zones with more rugged vegetation. Geomorphological research suggested that these sloping terrain features combined with other physical agents (local absence of vegetation, heavy rainfall causing surface run off, animal trampling) exposed the archaeological record to significant post-depositional disturbance (Paulissen *et al.* 1993; Martens *et al.* 2008: 131, with further references). This was exemplified by a comparison of the surface-subsurface conditions. In the Eastern Residential Area, surveyed with the 1999 sampling strategy, test soundings 'TSW1' and 'TSW2' were excavated (Figure 9.1: 4; Martens 2007: 324, fig. 2: 7). In these trenches either through man-induced or natural erosive processes – possibly after the decay of certain retaining structures – exclusively early Imperial contexts were excavated, which were not represented in the surface record here, where as an overall result the late antique period prevailed (Martens *et al.* 2008: 132). At the western edge of the same residential zone also trench 'TSW5' testified severe (local?) surface erosion (Martens 2007: 324, fig. 2: 11; 352–353). Elsewhere in the Eastern Residential Area the chronology of the excavated levels did reappear in the surface material, but not necessarily in a quantitatively proportional relationship.[3] The 1999 sampling strategy, in general, proved to be less well suited to record ill-represented periods or non-ceramic material categories. As opposed to the eastern part of the site, early to middle Imperial sherds did appear in high densities ('chronological windows') in the western part of the site, especially at those locations where severe erosive processes affected sparsely vegetated slopes (Martens 2005: 246–248; Martens *et al.* 2008: 136–137).

The geophysical survey

(B. Mušič)

As for surface collection, also for geophysics there is no 'cook-book strategy'. In compliance with the field conditions of each zone, various geophysical techniques were applied at *Sagalassos*, building upon preceding results and with feedback offered by evidence from the excavations. Initially a testing polygon (*c*. 1ha) was selected within the Eastern Residential Area, whereby the reliability of the results could be verified using the data from the test soundings (Martens 2007). In the period 2002–2010, an area of over 12ha was surveyed at the eastern half of the site using the magnetic method, of which 37 regions (*c*. 3.6ha) were re-surveyed by closely spaced parallel GPR profiles (Figure 9.3). The

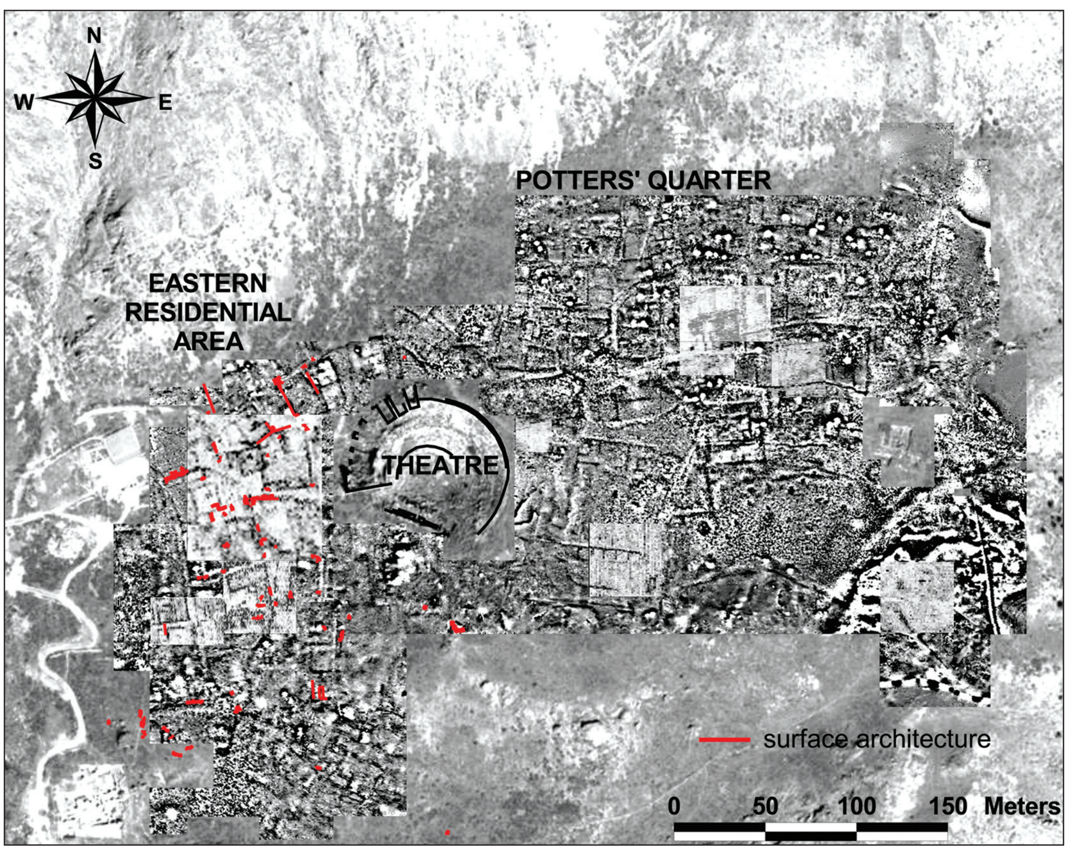

Figure 9.3 Selected GPR time slices and mapped surface architecture on the magnetometry map of the Eastern Residential Area and Potters' Quarter (B. Mušič; F. Martens) (Satellite image: © 2003: Digital Globe. All rights reserved. 19.09.2003 at 8.30 AM).

resistivity and conductivity methods were applied to a lesser extent at the Eastern Residential Area and Potters' Quarter. These procedures will be outlined below.

In the earliest stages, the field work comprised a *magnetic survey* measuring the vertical gradient of the earth's magnetic field by means of a Fluxgate gradiometer Geoscan FM36 in addition to resistivity mapping with a resistance meter Geoscan RM15 in a twin probes configuration. Considering the rough terrain conditions, the choice of a light-weight easily portable magnetometer was self-evident. The measurements in grids of 0.5 × 0.5m, however, were not entirely satisfactory due to the lower resolution of the fluxgate sensors in comparison to the optically pumped caesium sensors. Moreover, for the resistivity mapping the high-resistivity contact was hindered by the surface debris and the dryness of the topsoil. 2D resistivity sections across the Eastern Residential Area (Similox-Tohon *et al*. 2004: 1–18), however, suggested the presence of well-preserved archaeological structures (*c*. 2.5 × 5m) (see also Mušič *et al.* 2009).

Consequently, a total field magnetometer Geometrics G-858 in gradient mode was introduced, which generally amplifies the weak magnetic anomalies of small structures at shallow depths in favour of long-wave anomalies caused by the geological background. This magnetometer also allowed observing magnetic field readings separately on the top and the bottom sensors, so that a single sensor resolution approach, a more refined method for specific archaeological contexts (e.g. potters' workshops), could be tested (Tabbagh 2003: 75–81; Mušič 2008: 60: fig. 13). The Geometrics G-858 attained a resolution of 0.1–0.2 nT/m in measuring the total magnetic field density with an acquisition at a rate of 5Hz along the 0.5m spaced transects. The readings were interpolated to a sample interval of 0.25m using the cubic 'spline approximation to the sinc function'.

The magnetic method especially produced excellent results for the northeastern part of the town. Measurements of the apparent magnetic susceptibility of samples of top soil, excavated levels or drillings revealed extremely high susceptibility values at the Eastern Residential Area and Potters' Quarter (see Mušič 2008, 54: fig. 3). Aside of the thermoremanent magnetization, also the significant differences between the susceptibility of the (limestone) building materials and the surrounding soil,[4] induced a clear representation of the archaeological remains (Figure 9.3). Besides of the anthropogenic agents, the observed differences in magnetic susceptibility of the topsoil were also determined by the complex geology of the site (see Similox-Tohon *et al.* 2004: 1–18). The magnetic method picked up the induced magnetization typical for stone built walls (in the Eastern Residential Area) and the strong thermoremanent magnetization of clay-built structures (e.g. kilns in the Potters' Quarter). In the data processing some less common approaches were used to amplify the *signal-to-noise* ratio. Due to the bipolar nature of the geomagnetic field, magnetic anomalies located elsewhere than at the magnetic poles are asymmetric even when the magnetic source distribution is symmetrical. In general, the RTP transformation (see Telford *et al.* 1990) significantly reduces the complexity of the distinctive bipolarity of induced and thermoremanent magnetic anomalies, which is characteristic for the latitude of *Sagalassos*. As such, e.g. walls detected close to each other could still be accurately discerned (Mušič 2008: 55, fig. 4; 57, fig. 8). The *Sagalassos* results demonstrated that this transformation was also useful for objects with thermoremanent magnetization (kilns; furnaces; forges) (Mušič in Uytterhoeven *et al.* 2010: 303, fig. 3).

For interpreting the results all-encompassing 2D archaeo-physical magnetic models were convenient (e.g.: Mušič and Orengo 1998: 157–186, Mušič and Horvat 2007: 219–283, Mušič 2008: 58, fig. 10), which were generated by comparing on-site measured values of the total magnetic field density with the calculated magnetic anomalies for the presumed archaeo-physical model. Such model's variables comprise the shape, dimensions and depth of the presumed remains and the magnetic susceptibility values of the building material.

Finally, a better recognition of anomalies was obtained by determining the deeper magnetic sources with a significant background noise reduction using the upward continuation (Mušič 2008: 57, fig. 7). The values of the potential earth's magnetic *field* can be calculated using measurements of the magnetic *field* at a certain level above the modern surface. Residual magnetic anomalies are obtained by subtracting the upward continuation field from the initial on-field observation. The residual magnetic field is opposed to the upward continuation, which is normally used for the recognition of high frequency magnetic disturbances from sources close to the surface (Yaoguo and Oldenburg 1998: 431–439). At *Sagalassos* higher residuals corresponded to areas diffusely polluted by strongly magnetic iron minerals (blacksmiths' and/or potters' activities?) (Mušič 2008: 58, fig. 9).

In a later stage of the geophysical survey at *Sagalassos Ground Penetrating Radar* (GPR) sounding was introduced. This technique, using 200, 400 and 500 MHz antennas (*GSSI SIR3000*), was applied on the instigation of the magnetometry results to resolve research questions concerning the reconstruction of the water network (preservation issues) and the street system (presence or absence of pavement) or the analysis of complex building remains. The quantitative data required for a 3D display of the architectural remains was obtained through an analysis of individual GPR echoes. While the width of the walls was deduced by applying migrations and Hilbert's transformations, the preserved depths were determined using the 'hyperbola adaptation method' (Conyers and Lucius 1996: 25–38). However, the propagation velocity of the electromagnetic waves altered throughout the site due to the subsurface composition and soil moisture.

The GPR results confirmed the suitability of the more robust 200 MHz antenna, rather than the 400 MHz antenna, which was better-suited for surveying shallow archaeological targets. The upper and lower limits of a horizontal reflector (e.g. a paved street surface), was visible on the radargram if its width exceeded one quarter of the wavelength. At the estimated dielectric permittivity (10–12) of the soil of the northeastern part of the town the wavelength of the 200 MHz antenna measured *c.* 0.5m, implying that horizontal layers (paved areas) thicker than 0.1m were reliably discerned on the radargrams. For representing the GPR results the 'time slices method' was used showing a series of parallel, usually equally spaced profiles (Figure 9.3) (e.g. Goodman *et al.* 1995, Mušič in Uytterhoeven *et al.* 2010: 304, fig. 4), in addition to 3D visualizations (Mušič 2008: 61, fig. 15; Mušič in Uytterhoeven *et al.* 2010: 304, fig. 5).

Based on the results of the magnetic prospection at *Sagalassos*, as a last technique, the *electric conductivity* method using electromagnetic induction (Geonics EM38) was tested. Measurements were carried out in 'step mode' with a 0.5m interval using the instrument's highest sensitivity (depth: 1m). As anticipated in these extremely dry soil conditions the results were somewhat better in areas with quick lateral changes in the top soil susceptibility, but generally this method was less suited for *Sagalassos*.

Results

The integrated research strategy applied at *Sagalassos* contributed to various research questions concerning the organization and chronological development of the urban area (for a detailed overview see Martens 2005: 242–249, figs. 7, 11, 12; Martens *et al.* 2008: 135–139; Martens in prep.). As a general chronological result, the large-scale occupation of the urban area, which based on the excavated evidence seems to have experienced a swift expansion beyond the Hellenistic wall circuit from early Imperial times onwards, proved to have continued into the sixth century AD (Figure 9.2), with a less extensive (and less dense?) occupation during the later sixth and into the seventh century AD.

A re-study (2007–2009) of all of the collected pottery including also the non-diagnostic sherds[5], allowed identifying scatters of formerly ill-known Classical/Hellenistic and early medieval to mid Byzantine sherds throughout the urban area, thus filling in gaps in the settlement history of *Sagalassos* and offering better grounds to study the significance of the town within the region during these periods. Remarkably high densities of Classical/Hellenistic pottery on the erosive slopes in the artisanal-sepulchral zone southwest of the walled circuit refer to an active exploration of this area during this period, the nature of which remains to be further investigated.

At the other end of the chronological balance, surface pottery from the promontory of the former sanctuary of Hadrian and Antoninus Pius (Figure 9.1: 19) proved to correspond with the occupation of this fortified refuge from the later seventh–eighth century onwards and in middle Byzantine times, as was revealed by excavations here (Vionis *et al.* 2009: 192, 200).

With regard to the spatial organization of the town the analyses of find categories other than pottery (including surface architecture), combined with the results of geophysics and test soundings, allowed determining a basic functional zoning, whereby the monumental centre proved to be flanked to the east and west by residential zones including a variety of urban functions (see Martens 2005: 242–245; Martens in Uytterhoeven *et al.* 2010). Artisanal zones were excluded from these domestic areas and concentrated in the southwestern and eastern periphery of the site, close to or intermingled with the sepulchral zones surrounding the town. Whereas in the area of the Potters' Quarter, which was not covered by the archaeological survey, kilns and workshop infrastructure could be identified through geophysics (Figure 9.4; Mušič *et al.* 2009: fig. 9, 10, 13) and excavations (Murphy and Poblome 2011), in the southwestern artisanal zone metal working was identified through geochemical analyses (Kellens *et al.* 2003: 551–552).[6]

As for the urban planning of *Sagalassos*, on these steep terrain conditions a technologically sound principle of practical planning proved to be applied. In the Eastern Residential Area e.g., groups of *insulae* – which from early Imperial times onward were supplied with running water – were divided by 2–3.50m wide streets (Figures 9.4, 9.5), which were only partly accessible to wheeled traffic. These *insulae* showed different orientations, either following the cardinal directions or determined by the direction of the slope. After a major phase of urban layout during the first half of the first century AD at least one major building phase followed during the second–third century AD, whereas certain plots were no longer in use in late antique times (Martens 2008; for a detailed description, see Martens in Uytterhoeven *et al*. 2010, 289–307). Particular methodological challenges for geophysics concerning the possibility to distinguish paved street surfaces from dismantled streets or to identify and trace well-preserved stone or brick-built water channels, remained problematic unless reference could be made to nearby excavations.

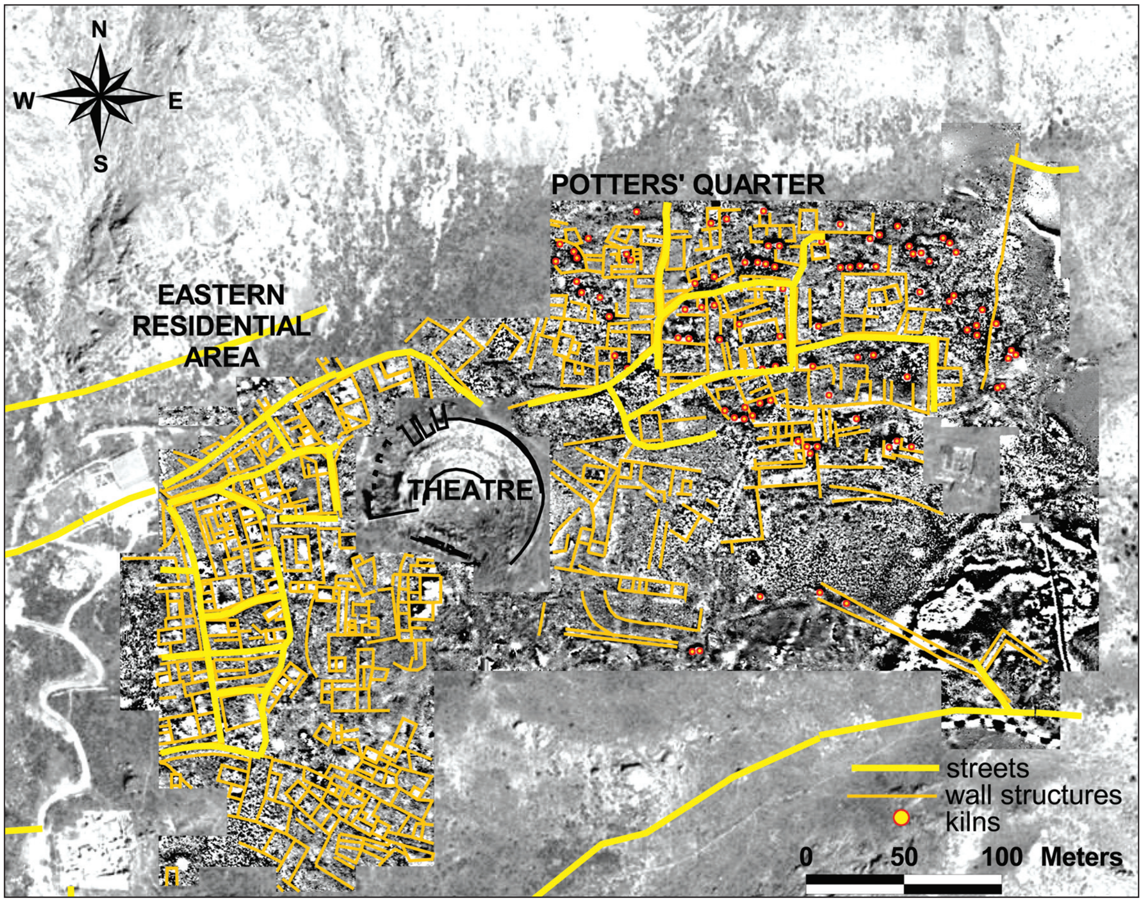

Figure 9.4 Interpretation of the results of geophysics at the Eastern Residential Area and Potters' Quarter (B. Mušič) (Satellite image: © 2003: Digital Globe. All rights reserved. 19.09.2003 at 8.30 AM).

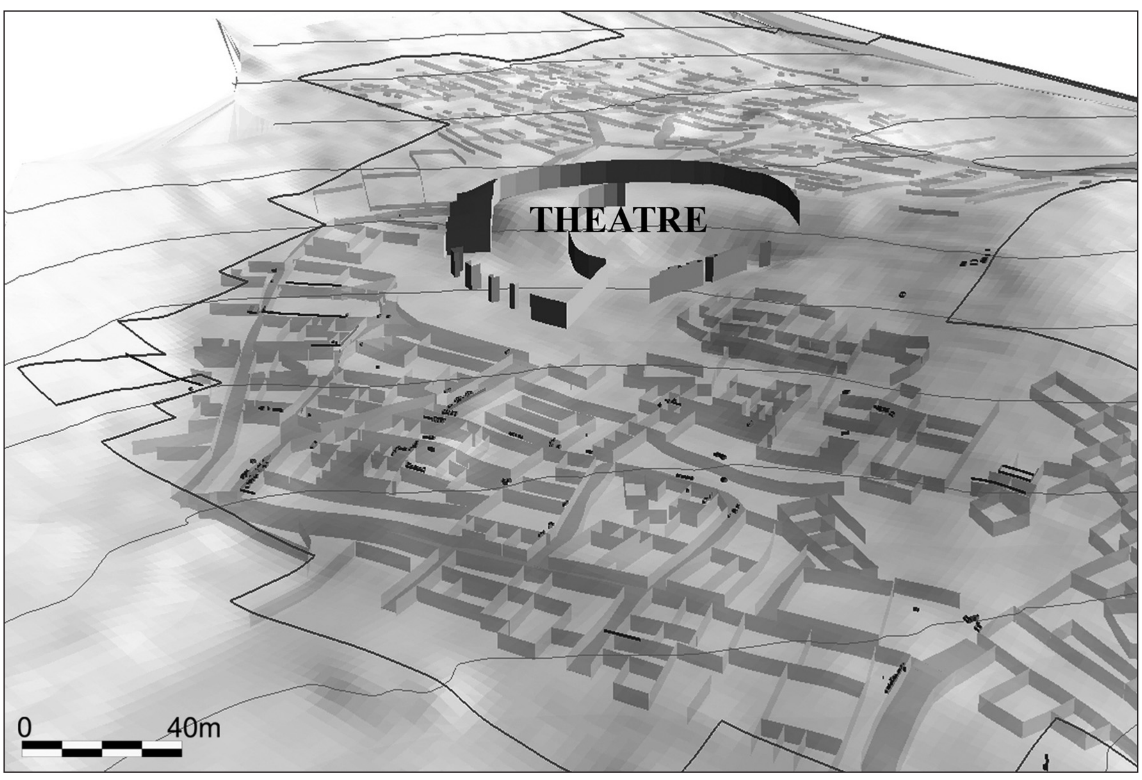

Figure 9.5 3D view of the north-eastern part of Sagalassos *from the southwest, demonstrating the integral interpretation of the results of the multi-method geophysical approach (B. Mušič).*

Conclusions

This paper illustrated how, both for the archaeological as well as for the geophysical survey, devising an appropriate site-specific strategy was a process of trial-and-error. A number of issues could be remedied by an improved research design or had to be born in mind as a restriction for the interpretation of the research results. For the archaeological survey the diversified terrain conditions with a differential impact of post-depositional processes implied that a more intensive survey strategy had to be applied to increase the reliability of the results. The fact that all surface finds were collected allowed a re-study of the sherds, as pottery research evolved. For the investigation of the historical evolution of the urban area the chronological superposition of pottery on the uncultivated terrain nevertheless implied that the absolute number of sherds could not be used to simply measure changes in site size or occupation intensity.

In addition to a clear insight into the functional zoning of the urban area, the archaeological survey thus offered a spatial view on general chronological trends for which the outlines had been offered by the results of epigraphical research, architectural studies and excavations in the monumental centre. For the particular situation of *Sagalassos*, the collected surface evidence on its own would not have been unequivocal enough to offer these insights independently. By combining the survey results with other research data (surface architecture, results from geophysical survey, test-soundings, large-scale excavations) the quality and restrictions of the surface evidence could be better assessed, while obviously the reliability of the obtained overall picture increased significantly by this integrated approach targeting the entire urban area.

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Notes

1 The relationship between *Sagalassos* and the in 2005 discovered Classical/Hellenistic site at 'Düzen Tepe' 1.8km southwest of *Sagalassos,* occupied from the *c*. fifth until the second century BC, is still under investigation (Vanhaverbeke *et al.* 2010, Waelkens *et al.* submitted).

2 These averages are calculated on the basis of the pottery evidence from 238 grids of 20m² (2001–2005).

3 The relationship between evidence from survey and excavations is further discussed in Martens in prep.

4 For instance, the mean top soil susceptibility values for the Eastern Residential Area (4.53×10^{-3}SI) and northern and western parts of the Potters' Quarter (5.48×10^{-3}SI) are comparable. Extremely high top soil susceptibility results mainly from the large quantities of pottery dust mixed in the top soil. The mean susceptibility value of kilns excavated at the Potters' Quarter in 2004 is 19.86×10^{-3}SI. The lower average susceptibility at the eastern part of Potters' Quarter (2.75×10^{-3}SI) refers to the lower top soil susceptibilities upon the ophiolitic melange.

5 Whereas the initial analyses were based solely on diagnostic table wares (*Sagalassos* Red Slip Ware), the new approach developed by J. Poblome and applied by the pottery team (N. Fırat and others) included all sherds, taking into account various functional categories and full typological date ranges (for a first approach, see Poblome *et al.* in Bintliff *et al*. 2004: 561–569). Upon this new dataset various data distribution techniques were applied by R. Willet. The results offer a better view on the representation of various chronological periods, but the functional analysis of the pottery now also allows an assessement of the composition or quality of the 'assemblages'. Hereby, a general preponderance of pottery types used for consumption and serving as opposed to a minority of cooking and other wares (transport, storage, preparation) was noticed for the early and middle Imperial periods, whereas only the late antique material seemed to comprise viable functional (domestic) 'surface assemblages'. These issues, whether influenced by terrain conditions, the impact of the local potters' industry (SRSW) or other contributing factors, are now further investigated in collaboration with J. Poblome and R. Willet (Martens in prep.).

6 Waste products of local metal working or pottery production were commonly used respectively for road metalling or construction activities (levelling, terracing). Geochemical analyses of soil samples from areas with concentrations of metal slag allow a more secure functional interpretation. For references on the research on pottery production, metal working and secondary glass working at *Sagalassos*, see Waelkens 2008: 10–11.

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