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Zofia Sulgostowska and Andrzej Jacek Tomaszewski

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TOMASZ HERBICH AND ALEKSANDER JAGODZIŃSKI

GEOPHYSICAL INVESTIGATION OF THE DRY MOAT OF THE NETJERYKHET COMPLEX IN SAQQARA

The current geophysical investigation of the Dry Moat in Saqqara benefited considerably from the work done in the 1980s, at the insistence and with the generous support of Prof. Romuald Schild, by the Department of Applied Sciences of the Institute of Archaeology and Ethnology of the Polish Academy of Sciences in the Neolithic flint mines situated on the northeastern footslopes of the Świętokrzyskie (Holy Cross) Mountains. One of the objectives of that research, carried out with the aid of geophysical methods, was to develop ways of determining the extent of areas exploited to obtain raw flint (Herbich 1997 : 81). This required limestone bedrock structure to be traced to a depth much greater than is usually the case on archaeological sites, that is, 10–15 m. The method used for the purpose was vertical electrical soundings (VES), a resistance method commonly employed by geophysicists working for geologists but virtually unknown at the time among archaeologists using geophysical methods. It became more commonly used in archaeological geophysics in the 1990s, when automation of measurements became possible (Szymanski and Tsourlos 1993; Gaffney and Gater 2003 : 34–35).

Experience obtained in the Świetokrzyskie Mountains, coupled with growing appreciation of the usefulness of the VES method in archaeology, came in handy on sites with uncomplicated geology (*e.g.* Schwarzach, see: Herbich, Misiewicz and Teschauer 1997), as well as on sites where understanding their function demanded analyses from the border of archaeology and geology. A good example of the latter kind of research is the survey conducted in 2004 on the south side of the Old Kingdom complex of Netjerykhet in Saqqara.[1]

THE SITE AND THE DRY MOAT PROBLEM

The imposing funeral complex of Netjerykhet (ruler of the Third Dynasty, known as Djeser from the Middle Kingdom) in Saqqara has been the location of intensive exploration ever since 1924 (Lauer 1976 : 90–136). Excavators were concentrated, however, on the complex itself, taking interest in the neighboring areas solely in context of structures raised there from the time of Userkaf (Fifth Dynasty). It was Nabil Swelim who first made the observations that led him to conceive of a great trench once surrounding the funerary enclosure, a trench which he called a dry moat owing to the fact that it had never been filled with water (Swelim 1988). The theory was based on old maps by Lepsius (Lepsius 1972: bl. 33, Fig. 1) and de Morgan (Fig. 1) and aerial photographs (especially from the first half of the 20th century, when the original lay of the ground had not yet been blurred by excavation dumps, Fig. 2). The dry moat was alleged to be a trench *c.* 40 m wide, running around an area measuring roughly 750 × 600 m. On the south side, this moat would have been formed of two unconnected sections (called below the inner and outer south channel, *cf.* Fig. 3).

A reconstruction of the western and northern channels left little doubt as the depression filled with windblown sand is perfectly clear on 19th century sketch maps and modern contour maps (eg. map of the Ministère de l'Habitat et de la Reconstruction, 1978, 1 : 5000, sheet H-22), as well as on contemporary aerial and satellite photographs (eg., www.google.earth, 29°52'16" N 31°12'59" E). The course of particular sections of the eastern channel, which are less well visible in ground relief, was marked out on the grounds of a combined study of maps and photos, confirmed by observations of various trench walls (Swelim 1988 : 17–18).

The southern section of the dry moat remains the most difficult to reconstruct. It is completely invisible on early photographs (Fig. 2A). A key factor was an analysis of excavation results from the middle of the 20th century (Swelim 2006). Digging the necropolis to the south of the Netjerykhet complex, archaeologists kept uncovering evidence of a deep ditch of obscure function. In keeping with Swelim's reconstruction, the

[1] The survey was done for the Louvre Museum expedition excavating the mastaba of Akhehetep, directed by C. Ziegler. The survey results were presented as a poster at the VI Conference on Archaeological Prospection in Rome in September 2005, abstact see Herbich and Jagodziński 2005.

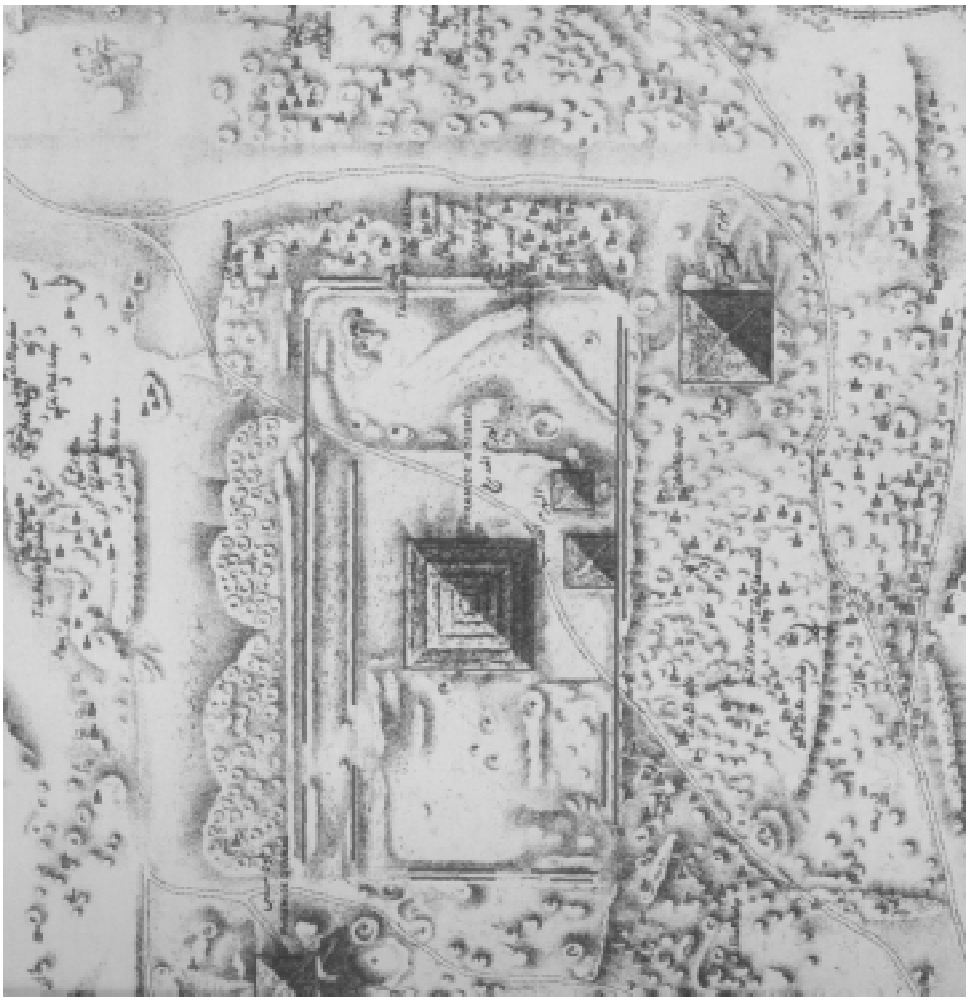

Fig. 1. Complex of Netjerykhet, map by J. de Morgan (de Morgan 1897: Pl. 10)
(Maps in Figs 1–3 are oriented according to cardinal directions).

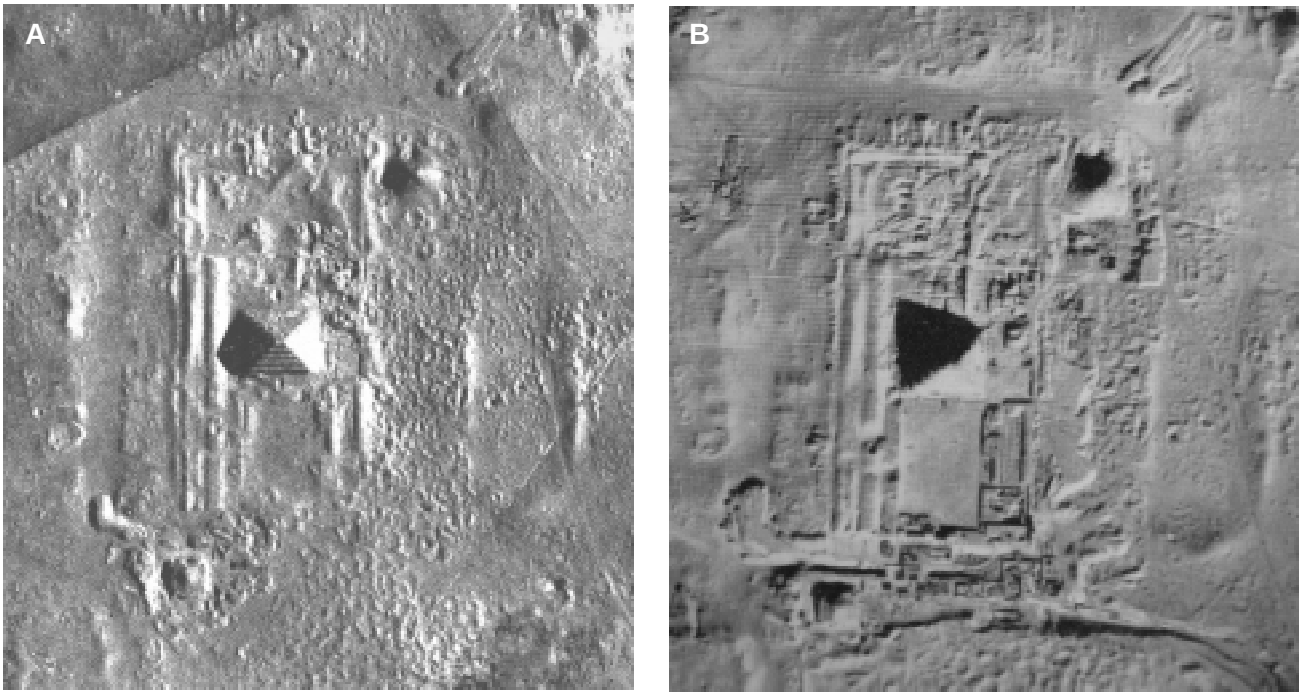

Fig. 2. Aerial pictures of the Netjerykhet complex. A – picture taken in 1926 (after: Capart 1930: Pl. XIV);
B – picture undated, probably taken in the fifties (after: Emery 1965: Pl. 2).

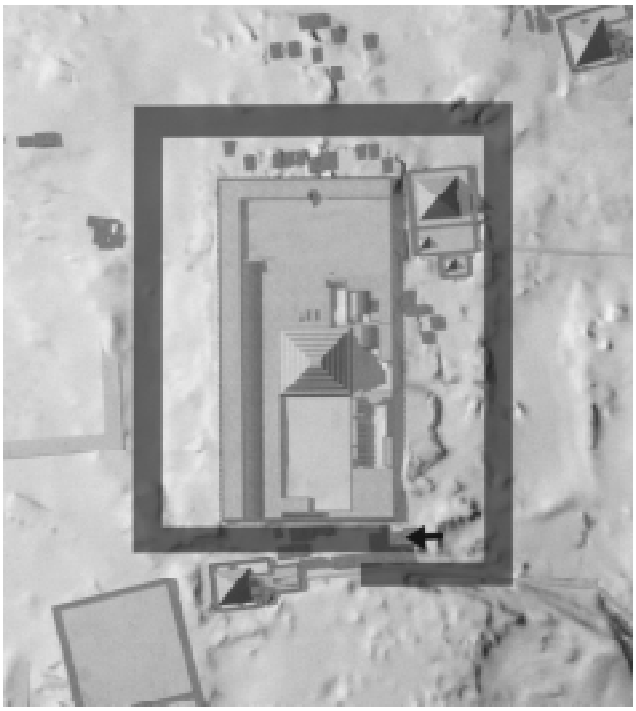

Fig. 3. Location of the dry moat (location based on Swelim 1988: Fig. 3). 3D model of the Netjerykhet complex and its surroundings after Bresciani 2003 : 64. Arrow marks the inner south channel.

dry moat in this part would have consisted of two channels from 45 to 50 m wide. The inner south channel would have consisted of two parts of different depth: 5 to 7 m in the northern, wider part and up to 26 m in the southern part (which was 3–5 m wide). The layout of the deeper part is unclear – in part, it looks like a ditch with vertical walls cut into virgin rock (Fig. 4) and in part like a system of rock-cut compartments (Fig. 5). Examination of previous archaeological work in the area combined with an analysis of present-day topography led Swelim to consider a wide section of the inner south channel of the dry moat running all the way to the mastaba of Kairer (Fig. 6). The course taken by the moat further to the east was unclear: the mastaba of Kairer and the mastabas lying west of it stood either on the fill of the ditch, which had existed here earlier, or on virgin rock. Bebi's mastaba is evidently founded on virgin rock, at least at its southern edge. The layout of compartments at the south edge of the inner dry moat was clear (fragments can still be seen south of Bebi's mastaba (Fig. 5). East of the line established by the eastern facade of Bebi's mastaba there is no surface evidence of any deep compartments nor of a shallower part of the dry moat (Figs 6 and 7).

Fig. 4. Compartment excavated by Zaaki Saad in 1939–1940 (after Swelim 2006: Fig. 10).

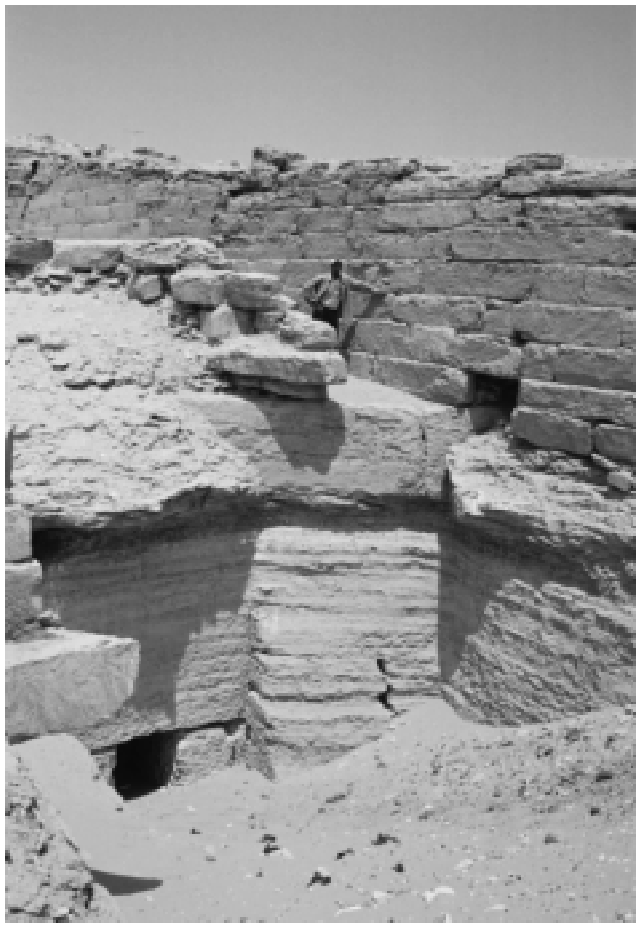

Fig. 5. Eastern edge of the compartment excavated by Selim Hassan in 1937–1938 (view from south-east, the mastaba of Bebi in the background).

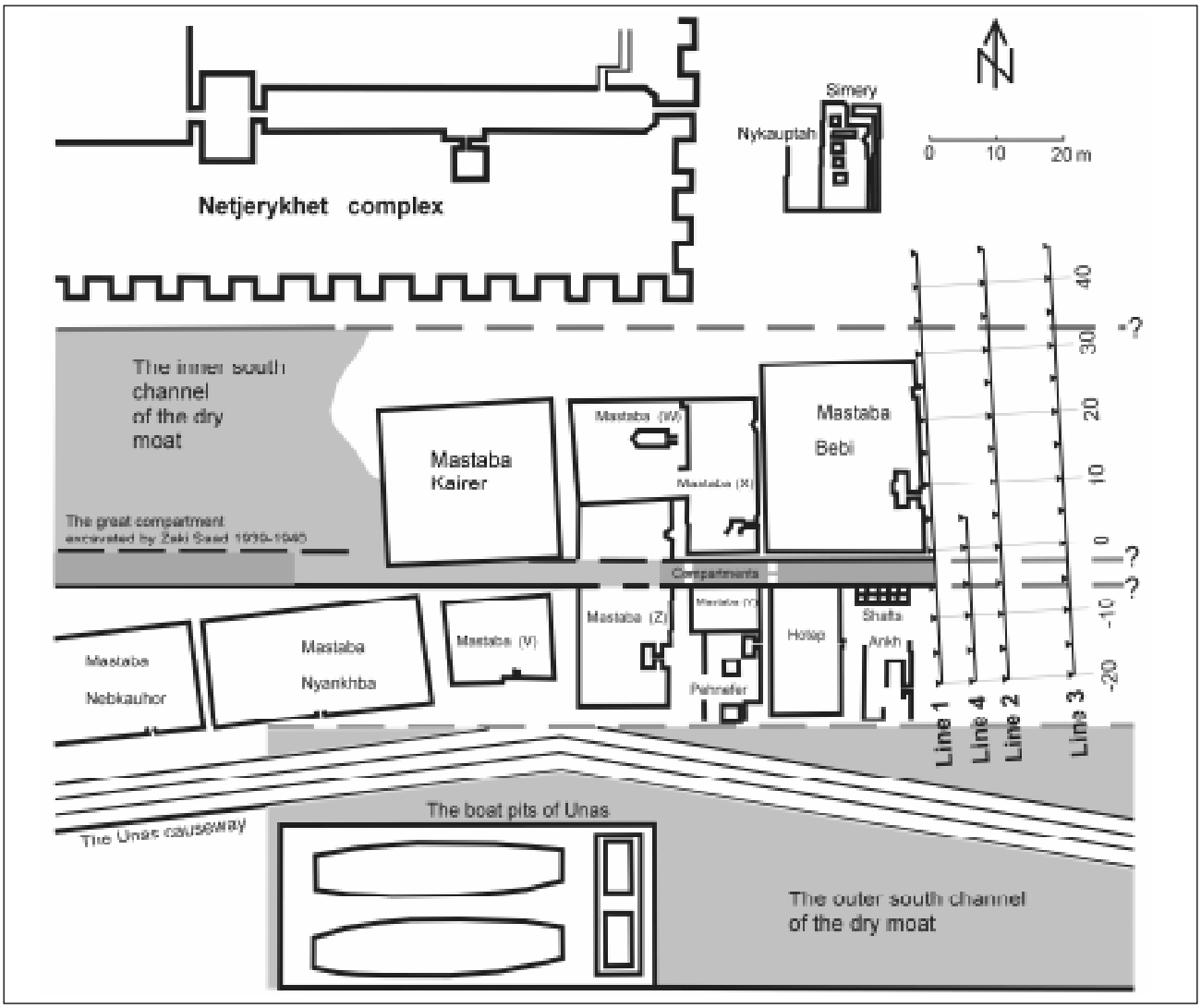

Fig. 6. Eastern section of the inner south channel (based on Swelim 2006: Fig. 1) and location of tha resistivity measurements.

The objective of the geophysical survey was to determine the eastern edge of the inner south channel of the dry moat in a section of the area limited on the west by the mastaba of Bebi, on the south by the Unas causeway, and on the east by the excavation trenches of the Louvre Museum expedition.

THE SURVEY

The Saqqara necropolis is situated on a plateau rising up to 17 m above the alluvial plain of the Nile Valley. The plateau is formed mostly of limestone and marls of the Late Eocene Maadi Formation; the alternating sequence of these rocks, degraded differentially into horizontal bands, is exposed along the steep eastern face of the plateau and can be observed in dozens of shafts (Papa 2003 : 192–194). Thus, the anticipated depth of the feature required observation of changes in ground structure up to a depth of at least 15–20 m. The soundings were carried out with a Polish-made DC resistivity meter equipped with automatic compensation of spontaneous polarization of the probes (Fig. 8). Separate registration of changes in current and voltage, an analog display that went out of common use at least a decade ago, had its strengths in this case, permitting precise monitoring of the measurement process. This in turn assured checks on the reliability of the prospection results, which was of fundamental importance considering the extremely difficult survey conditions (weak contact between ground and electrodes resulting from excessive dryness of surface layers and the presence on the surface of sand and debris characterized by very high resistivity values).

The Schlumberger array was employed with maximal current electrodes AB spacing equal to 50 m, permitting observation of resistivity changes in the ground down to a depth of *c.* 15–20 m thanks to exceptional resistivity conditions. The spacing between survey points was 5 m along lines 10 m apart, running N-S, transversely to the dry moat, parallel to the eastern façade of the mastaba of Bebi (Figs 6 and 7).

Fig. 7. Location of the resistivity measurements (lines 1–4, view from south-east).

Fig. 8. Resistivity measurements with the use of VES method (phot. N. Swelim).

THE RESULT

The results revealed considerable variability of the rock's resistivity (Fig. 9). A shared feature of all the cross-sections is the high resistivity of the ground surface layer (400–1500 ohm range) and very low resistivity of the layers lying below 10 m (5–20 ohm). This low resistivity of layers is due to processes of water mineralization caused by high evaporation. The original geological setting, before it was disturbed by human

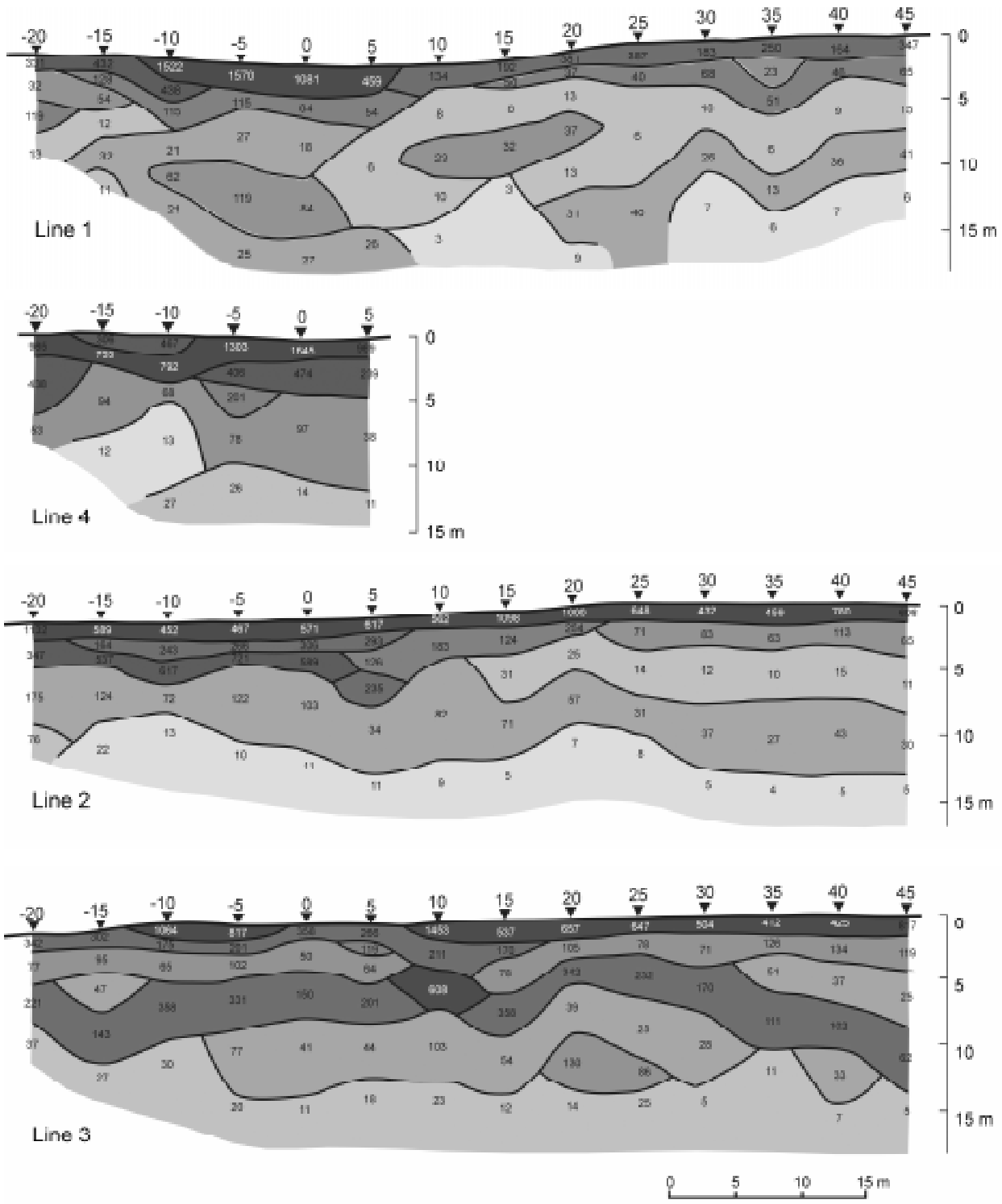

Fig. 9. Resistivity cross-sections.

activity, seems to be reflected in the northern fragment of the cross-section on line 2 (between points 15 and 45). The layers under the high-resistivity ground surface layer (corresponding to sand and sand mixed with debris) demonstrate an evident regularity which reflects the layering of the limestone rock forming the ground here.

The key conclusion from an analysis of the measurements is that the survey provided no clear premises on which to base a belief in the inner south channel of the dry moat continuing on the east side of the mastaba of Bebi. This is particularly evident on line 2, where the section in the presumed location of the north wall of the dry moat (between soundings 30 and 35) reflects the original undisturbed geological setting.

The survey results do not support the idea that the deep compartments found south of the dry moat continue in an easterly direction beyond the east side of

the Bebi mastaba. Traces of a potential compartment have been noted only in the line 1 section (between soundings –10 and 0), which ran in the immediate vicinity of the compartments that can be seen with the naked eye), in the line 2 section the original geological setting is reflected at this point.

The measurements have also revealed a growing thickness of the late deposits overlying the limestone bedrock. The layers appear to increase in thickness in an eastward direction, the limestone cap being recorded in the line 3 section to a depth of 5–10 m.

CONCLUDING REMARKS

Egyptologists have not been quick to accept that one of the icons of ancient Egypt, the complex of Netjerykhet, was surrounded by a structure that required a comparable amount of work as the actual building project. One example of this slowness is a reconstruction of the appearance of the necropolis in the times of the Old Kingdom, presented by Italian archaeologists in 2003 and based on a thorough analysis of all of the archaeological work carried out in Saqqara North. The moat, which must have been a pretty imposing feature of the landscape, was not included in these renderings, not even as a hypothetical idea (Bresciani 2003 : 64, 66). Mark Lenert traces the dry moat around the complex in one of the illustrations in his excellent work on the Egyptian pyramids (Lehner 1997 : 83), but fails to discuss the structure in the text.

The dry moat hypothesis has been bolstered recently by the results of current excavations by the Polish Centre of Mediterranean Archaeology of Warsaw University, carried out on the west side of the Netjerykhet complex. Precipitous drops in the bedrock were discovered in a trench dug across the sand-filled depression, being the western channel according to Swelim's observations. The distance between the two cliff-walls corresponds to Swelim's proposed width of the dry moat (Myśliwiec 2003 : 127; Myśliwiec 2006).

Archaeological verification of the existence of the dry moat on the other sides of the complex is hardly feasible today, mostly because of the high costs of such projects. Geophysical investigation, on the other hand, seems to be the best method for verifying this hypothesis and the work presented in this article should be taken as the first, small step in this direction.

Ackowledgements

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Tomasz Herbich
Institute of Archaeology and Ethnology
Polish Academy of Sciences
al. Solidarności 105
00 140 Warsaw, POLAND
herbich@iaepan.edu.pl

Aleksander Jagodziński
al. Stanów Zjednoczonych 20/34
03 964 Warsaw, POLAND