



Satellite imaging in the pyramid fields

In recent years Egyptologists have made increasing use of remote-sensing techniques and satellite imaging to survey and map ancient sites. **Miroslav Bárta** and **Vladimír Brůna** report on current Czech work at sites in the area of the pyramids.

The Satellite Imaging Project of the Czech Institute of Egyptology began in 2002 to improve understanding of the topography and development of the site of Abu Sir and a set of high resolution aerial views was ordered from the QuickBird system of the GIS imaging company DigitalGlobe (www.digitalglobe.com). The satellite's orbit had first to be pre-set on the basis of detailed parameters supplied by the Institute to record precisely the area of our interest. This included the pyramid fields of Abu Sir, Saqqara and Dahshur. The data received was then analysed and compared with the results of other techniques, including a detailed surface survey of the site, 3D modelling and geophysical surveying. The starting position was extremely advantageous: the resolution of the images is 0.65m in the panchromatic and 2.56m in the multi-spectral zone. For an archaeologist the 0.65m precision per pixel means that virtually all significant structures forming architectural elements of the cemeteries may be reliably identified. The images cover an area of 65 sq. km.

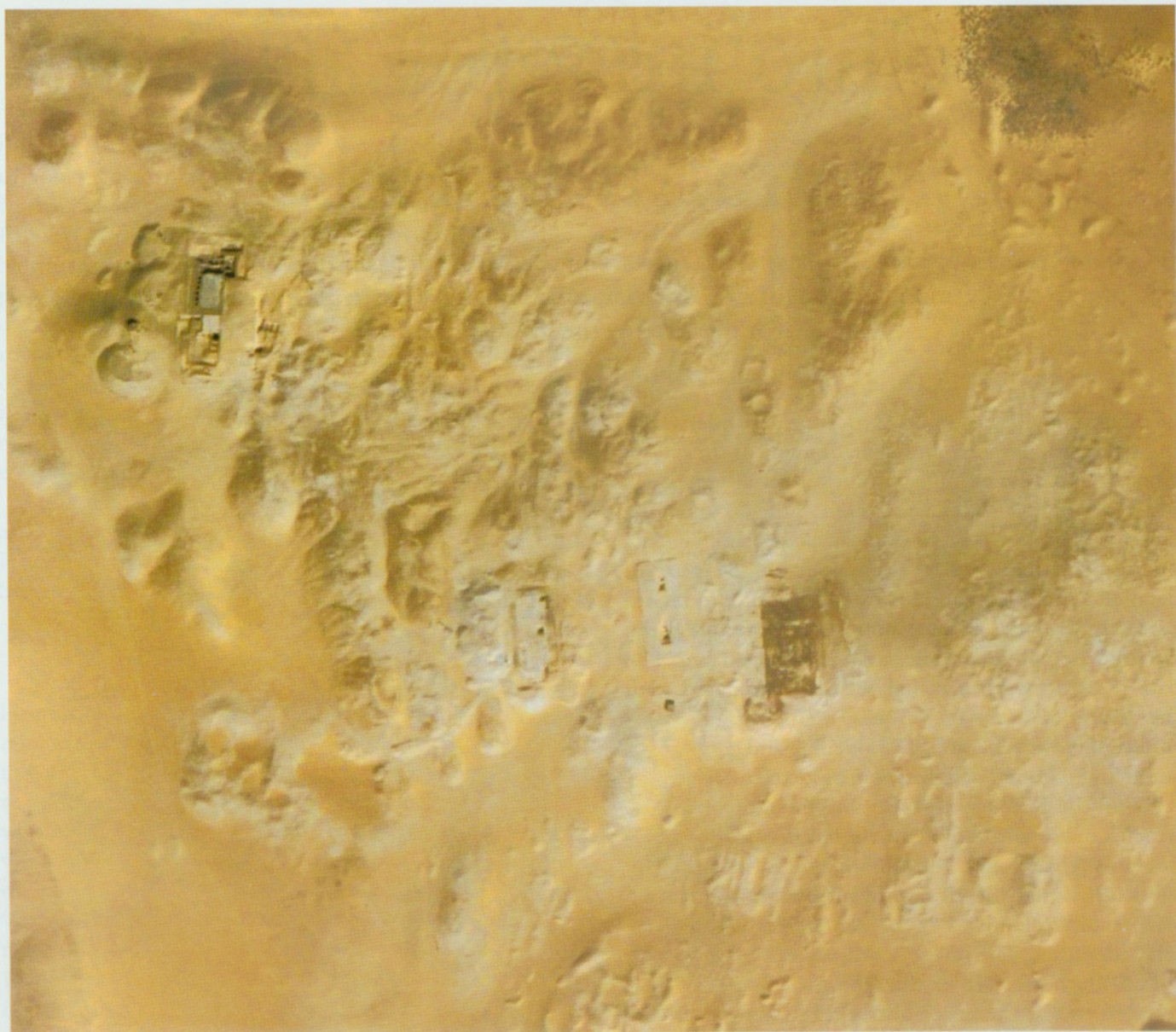
The southern part of the Abu Sir concession was selected to test the contribution and potential of the satellite image in the field as this area is currently one of the principal centres of activity for the Czech Institute. The geomorphology of this particular corner of the pyramid field of Abu Sir and Saqqara seems to have been untouched over the last few cen-



Landsat satellite image of the Old and Middle Kingdom pyramid fields, with (in box) the DigitalGlobe image of Abu Sir/Saqqara/Dahshur



South Abu Sir and the North Saqqara plateau as seen from the pyramid field of Abu Sir, looking south-east. (Photograph: KamilVodera)



Detail of the central mound in South Abu Sir

turies and thus provides a unique opportunity for study.

South Abu Sir contains an extensive necropolis which grew up over a period of several centuries, and in 1991 the Institute started a systematic survey of the site. Since then it has proved possible to document, and in many cases also to restore, the tombs of several high state officials. Prominent amongst these are the tombs of the Commander of the Army Kaaper, the mortuary priest Fetekty, the Overseer of the Granaries of the Residence Ity, the Property Custodian of the King Hetepi, and the Vizier Qar and his sons. Bearing in mind the historic significance of the area during the third millennium BC, situated between the main cemeteries of Abu Sir and Saqqara, and the exposed location of the monuments, a long-term plan was devised to document the main surface features of the site in advance of intrusive archaeological activity.

During the initial surface survey a wide range of archaeological information was gathered and features

were identified and recorded. As a direct result, a 3D map of the site has been compiled, with all the surface traces including tomb ground plans and masonry (consisting of limestone and bricks of both mud and *tafl*), dumps, concentrations of ceramics, human and animal bones, pockets of wind-blown sand and isolated artefacts. The map is linked to a database containing both textual and visual information for every single feature.

The surface survey was then followed by a geophysical and remote-sensing exploration of the site. The immediate results, in combination with the satellite imaging described above, have enabled the expedition, even in this phase of analysis of the cemetery, to resolve many previously unanswered questions about the history of the site.

The cemetery in South Abu Sir developed from the end of the Third Dynasty, when the first tombs of distinguished dignitaries (Hetepi, Ity) were built, extending the burial ground of high state officials from

the northern part of Saqqara to Abu Sir. At the beginning of the Fifth Dynasty, the tomb of Kaaper followed, paralleled by development at Saqqara, especially in the area north of Djoser's tomb complex and very close to South Abu Sir. There is, as yet, no evidence for tombs of the later Fifth Dynasty in South Abu Sir, and it is highly probable that most of the non-royal tombs of the time were constructed in the pyramid field at Abu Sir itself and close by. In the middle of the Sixth Dynasty the tomb complex of the Vizier Qar and the adjacent tombs of his sons (Inti, Qar junior and Senedjemib) were constructed. These tombs gradually occupied dominant topographic locations from the south-east to north-west, which gave them a very impressive appearance. They created a south-east/north-west axis, which respects both the natural topography of the mound and possibly the proximity of the Abu Sir Lake, which formed the main route of access to the area during the Old Kingdom.

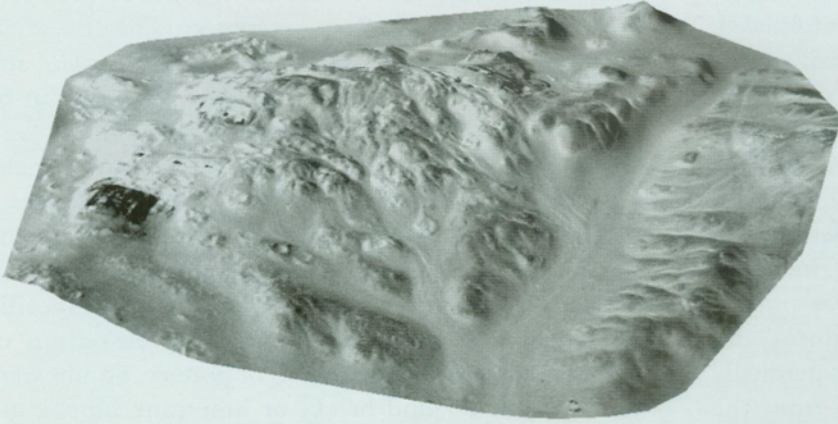
A significant contribution of the various mapping activities is the reconstruction of several ancient access routes which led to the cemetery from the Abu Sir Lake area. These routes led to the main, dominant tombs of the cemetery and are also located so as to

guarantee access both to the main parts of the cemetery and to their less frequented parts. The courses of these routes are quite distinct from natural *wadis*, and features which occur alongside some of them can be associated with cultic cemetery activities.

Combining the evidence of the surface survey, geophysical measurement and satellite imaging gives a much better understanding of the topography of the site. The surface survey helped with the interpretation of larger features such as tombs, and identified specific structures, major burial shafts or concentrations of material such as bone fragments or pottery. Tombs were usually built of mud bricks or limestone blocks and their eroded tops leave clearly coloured traces on the surface of the desert but it is harder to identify structures built from *tafl* bricks, which are not markedly apparent on the surface. One other weakness of the surface survey became evident on the slopes, where features are less apparent because of geomorphological and post-depositional processes, especially washing and erosion. The survey is also subjectively affected by the optical properties of light, the season and the time of day. The same factors significantly hinder geophysical measurement and satellite monitoring, too.

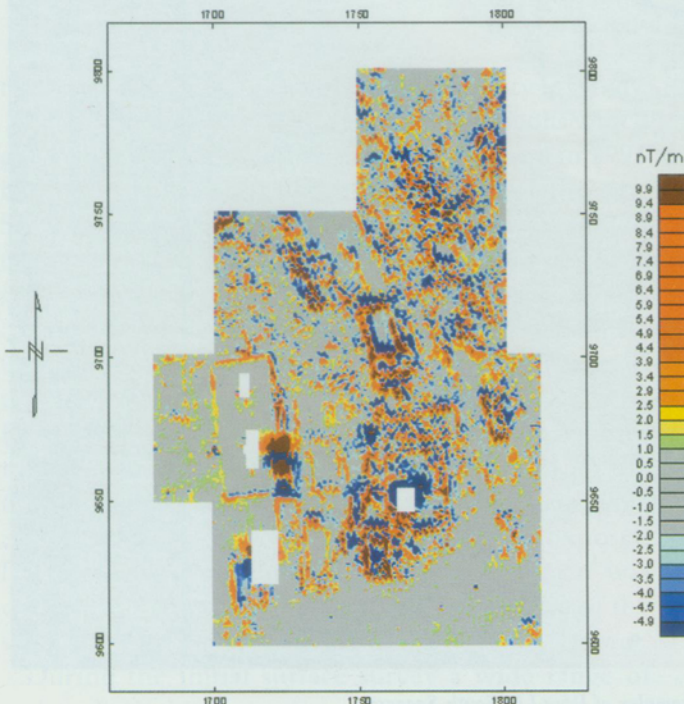


High-resolution image of the pyramid complex of Pepy I in South Saqqara



3D model of South Abu Sir with the satellite image texture

The geophysical survey facilitated the verification of the results of the surface survey and also detected an array of smaller elements and internal structures of the individual larger features. The only weakness of magnetometric measurement is in the mapping of the *tafl*-brick structures which are physically almost identical with the properties of the *tafl* subsoil of South Abu Sir. Geophysics was unexpectedly very successful even on the slopes, and so it has contributed significantly to the completion of the archaeological plan of the site. A smaller-scale comparison of the results achieved immediately to the south-east and east of Hetepi's tomb also provided interesting results. Whereas in the south-east, two smaller, tightly fitting tombs (with a brick coat and internal sand and limestone waste fill) were detected through geophysical survey, they were not detected at all during the surface survey, probably because of the very undulating terrain at this part of the site.



Two ways of showing the same information.
Above: a 3D model of South Abu Sir with individual groups of the mapped surface features (viewed from the north).
Left: the eastern part of South Abu Sir represented as a geophysical map

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The satellite images have several comparative advantages: the whole of the site explored is recorded at one moment in time, the images are not conditional on any subjective human factor, and they capture the entire area. Through this it is possible to identify and verify the existence not just of the bigger, more obvious structures but of smaller structures as well. However, the greatest significance of the technology is for analysis of the overall properties of the site under investigation, such as its basic components and their spatial distribution, the geomorphology of the terrain and the impact on it of human

activity, and, last but not least, analysis of the communication system. Nevertheless, the satellite picture does not detect all components and sometimes not even some which are detected through geophysical and/or surface survey. It is certainly true to say that the full potential is realised only when all three methods are linked and interrelated.

The collection of data which has taken place over the past two–three years will require just as much time for full evaluation and interpretation. However, it is already evident that with the aid of these methods it will be possible to improve significantly the quality and effectiveness of further archaeological activities so that work can be targeted to provide answers to outstanding questions about the lesser-known aspects of Egyptian archaeology in this area. The Czech Institute has made the satellite image of the pyramid fields available to all expeditions working in the area, and to our partners in the Supreme Council for Antiquities.