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GEOPHYSICAL SURVEY ON ARCHAEOLOGICAL SITES ON SIR BANI YAS ISLAND, ABU DHABI (UAE)

GEOFYZIKÁLNÍ PRŮZKUM NA ARCHEOLOGICKÝCH LOKALITÁCH NA OSTROVĚ SIR BANI YAS, ABU DHABI (SPOJENÉ ARABSKÉ EMIRÁTY)

Roman Křivánek

To apply geophysical survey on very remodeled desert landcsape, it seems to be very difficult from many points of view. The results of it must be everytime limited by conditions and possibilities of measuring. Experimental application of magnetometric survey during archaeological excavations gave an idea about more and less destroyed parts of observed sites. The results showed that in case of better preserved subsurface layers and archaeological features it is possible to identify "non-magnetic" claystone or coral walls in monotonous non-magnetic sandy background. Success of identification of their low positive magnetic anomalies is dependent only on non-presence of another higher anomalies caused by recent changes and activities.

1. INTRODUCTION

Between beginning of March and first half of April 1995 I took a part in forth season of Abu Dhabi Archaeological Survey Project. The Abu Dhabi Islands Archaeological Survey Project (A.D.I.A.S.P.) was established in 1991 and is charged with research into the archaeology of the coast and offshore islands in the Western Region of Emirate of Abu Dhabi. Project is undertaken undrer the patronage of UAE Chief of Staff Lieutenent General Sheikh Mohammed bin Zayed al Nahyan and is sponsored by a number of major local and british companies. During the 1992 to 1994 season archaeological survey and excavations were carried out on the island of Dalma, Merawah and on a number of smaller islands in this region. One from the most interesting excavations started on the big island of Sir Bani Yas (see *Fig. 1*).

Sir Bani Yas island is situated 170 km west of the capitol Abu Dhabi only 9 km offshore. The whole island 17 x 9 km is a private residence of Sheikh Zayed without any present structure of settlement (except one camp of workers in Khor Da sah Bay). The preliminary archaeological survey of the island of Sir Bani Yas began in 1992. During the first season a total of 34 archaeological sites were identified. Most of them were situated in open coastal areas which have rapidly altered by bulldozing and plantation activities which have lead to the creation of an artificially flat landscape. The first rescue archaeological excavations of these sites began during the 1993 season. After three seasons of the project it became clear that the development of further plantations and the loss of archaeological localities was increasing dramatically. For this reason it was decided that the application of a geophysical survey could enable a more efficient strategy to be pursued in relation to future excavation/survey work. It seemed that problems would be encountered applying a resistivity survey. The information resulting from such a resistivity survey would probably in these dry desert conditions (together with irrigation system and water terminals for plants) not facilitate the simple discernment of anomalies and allow the possibility of identifying archaeological features. An experimental magnetometric survey was therefore carried out.

2. CONDITIONS OF MEASURING

Magnetometric survey in archaeology is an applied geophysical method which observes changes in the magnetic field within the first few metres beneath the soil surface. It allows the discernment of sources of magnetic anomalies of different materials, and thus could allow the separation of different archaeological features from their natural background. Optimal conditions for magnetometric survey are:

1) ability to distinguish magnetic anomalies of archaeological features and material differences from their background,

2) a quiet magnetic field without magnetic disturbances and irregular variations,

3) homogeneous and low magnetic material forming the soil and bedrock,

4) flat or low lying slope areas without deep terrain-steps and blocks of stone on the surface

5) a minimal amount of recent anthropogenic activities within the survey area.

For the magnetometric survey at Sir Bani Yas island, conditions no. 3) and 4) were acceptable. From the physical point of view all of the coastal sediments (corals, limestones, sandstones) have low magnetic properties. The material used for constructing buildings is often actually the same as the bedrock and therefore the clear identification of structures is only possible in the case of well preserved remains. Another problematic point for magnetometry was the variation in the magnetic field during the day, which was dependent mainly on the degree of sun activity. The best geophysical results obtained within archaeology are generally those carried out on open preserved original landscapes without substantial changes present to their ground-relief, and thus without damaged archaeological layers and structures. Unfortunately, Sir Bani Yas island is largely an example of an artificially flattened landscape. Changes of origin desert to organised unnatural garden are really suprisingly unsensitive, dramatic and very fast. Recent plantations and the bulldozing of the surface, as well as the cutting of a system of trenches for water pipe-lines, will all influence the results of geophysical measuring and sampling. With regards to this reality there was not easy to find optimal methodology of measuring.

3. METHOD OF MEASURING

For observing the magnetic field in absolute readings **T [nT] a single** magnetometer was normally used. Changes in the level of the magnetic field at Sir Bani Yas island was the principle reason why it was important to measure the vertical gradient of intensity of the magnetic field δT [nT] with two parallel magnetometers. This gradient system, in contrast to measuring with a single instrument, allows magnetometric survey to be carried out also in areas with changeable levels of magnetic field (see *Fig. 2*). It was possible to realise at least in two ways:

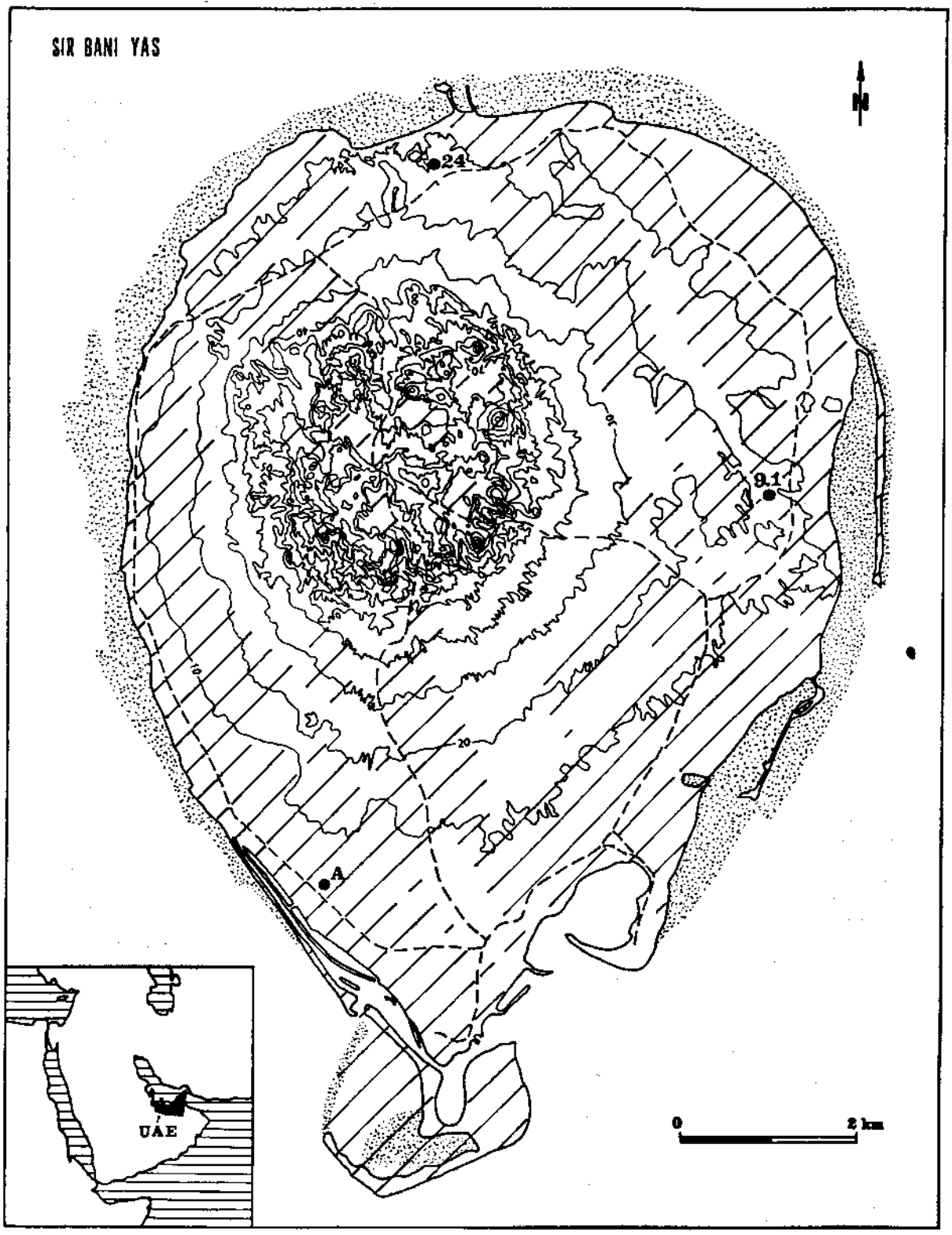


Fig.1. Sir Bani Yas island map with the position of the archaeological sites where has been applied geopfysical prospection. The areas signed /// demonstrate deep changes of the origin landscape by buldozing and plantation activities.

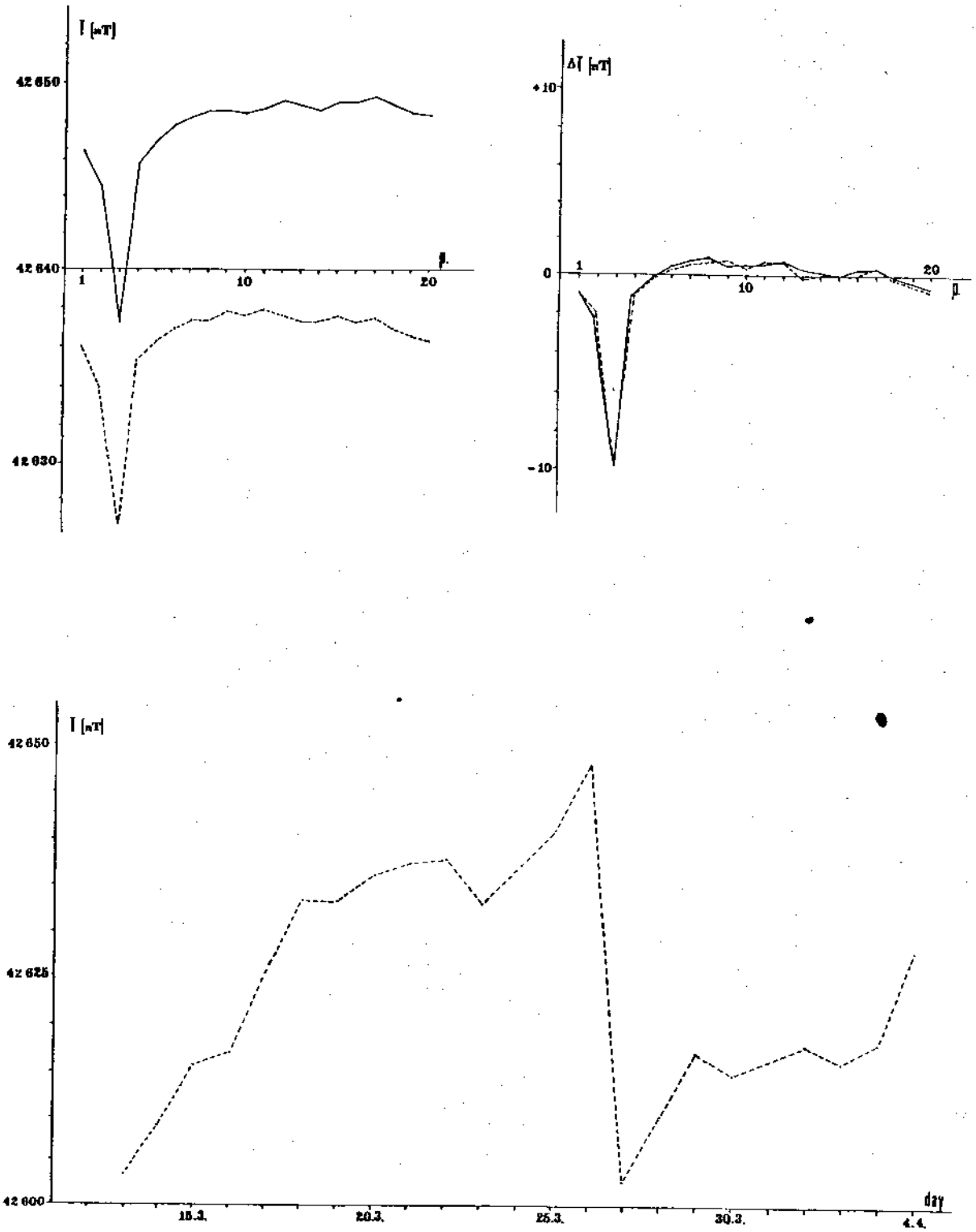


Fig.2. Diagram illustrating the measured absolute intensity of the magnetic field T [nT] and its gradient δT [nT] at the same time on 22 March 1995 (- - - - morning, ___ - noon, p. - control profile).

Fig.3. Diagram of the sinusoidal type of variation exhibited by the magnetic field T [nT] during measuring carried out between 12 March to 4 April 1995.

1) by parallel measuring with one portable magnetometer moving along the profile and the second observing changes of magnetic field on variation station

2) by parallel measuring with two portable magnetometers moving along the profile without any other later corrections being required.

By my previous experience the idea no. 1) with using of results of variation station for calculation of the vertical gradient is not always (in case of varying magnetic field) without mistakes. The real vertical gradient can be guarantee only by measuring with two parallel magnetometers (coils) at the same time. For the field survey two portable PM-2 proton magnetometers, kindly loaned by the Institute of Archaeology, Prague, were utilized. Prior to undertaking the magnetometric survey it was important to prepare the surface, removing all visible metal/iron objects and to establish a uniform grid system across the entire survey area using wooden pegs.

Due to the fact that there was no one information about experience within magnetometric survey in similar conditions in Arabian Gulf Region there was necessary to test the area at first. The most optimal configuration for measuring was selected after testing of the instruments (with various distance and height of coils above the surface and various density of measured points) on part of the area excavated during the 1994 season on site 9.1. The best results were with the uniform vertical distance between the upper and lower coil being 1.5 m, with a uniform height for the lower coil of 0.3 m and for upper 1.8 m above the surface of the terrain, both coils having a uniform orientation towards north. The orientation of measured profiles in a grid was selected after seeing the terrain surface and traces of the previous seasons's excavations, which assisted in the prediction of the probable orientation of future potential archaeological features. The magnetofnetric survey was carried out in a uniform rectangular grid-system selected with regards to archaeological interest as well as the amount of available time. As the intensity of the magnetic field was changeable during the day, it was very important to observe these changes on a control-profile at the beginning and end of the measuring procedure each day. From these results was constructed a diagram which showed a sinusoidal change in the intensity of magnetic field T [nT] over a time period of a month that measuring was carried out (see *Fig. 3*).

4. MEASURED SITES

4.1. Site 9.1

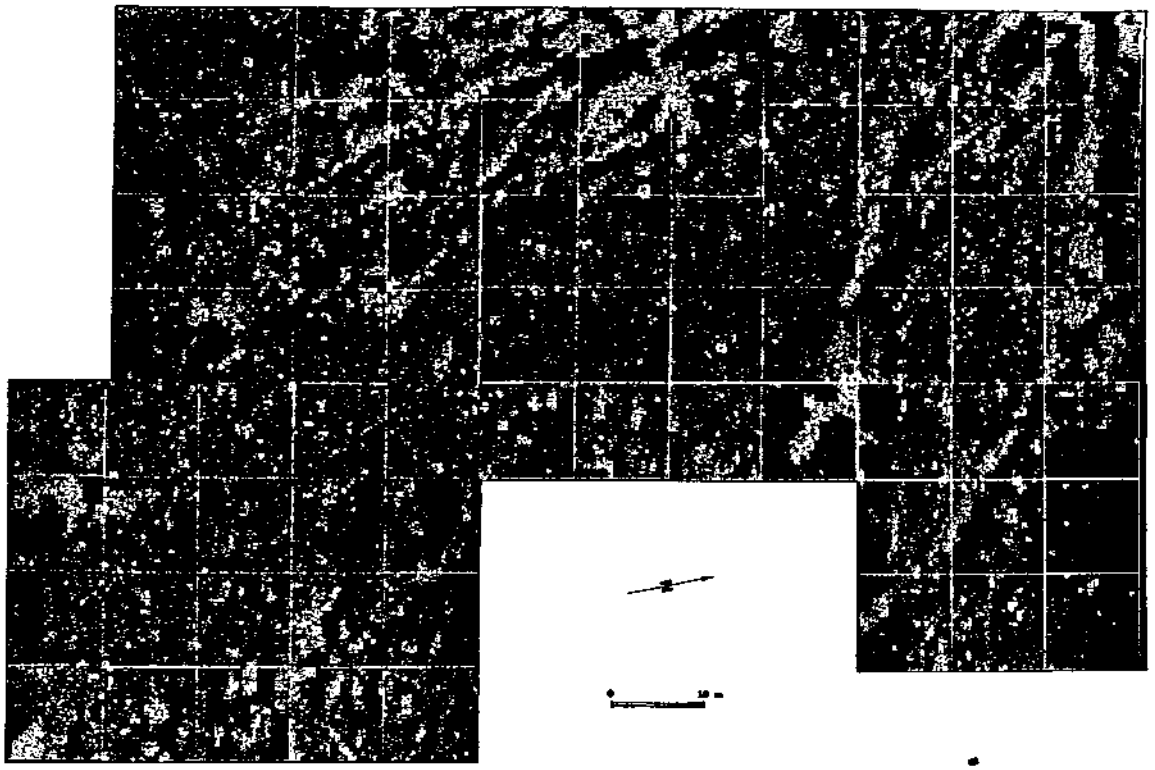
The largest archaeological site is situated on a wide plateau on the eastern coast of the island (Al Khor). The whole area is fenced and reused for a plantation with irrigation system (lines and probably trenches). In 1993 trial trenches were made at the site to examine the general size of the locality as well as to investigate how well it was preserved. A full archaeological excavation began at the site in 1994 which uncovered part of a settlement complex dating to the pre-Islamic period (between 5th and 8th century AD). Part of this settlement complex (which had been backfilled at the end of the 1994 season) was chosen for preliminary experimental measuring to establish the best configuration and possibilities for undertaking magnetometric survey. An area of 10 x 10 m was measured with differing densities of measured points, and with different distances and heights between the coils. The best configuration proved to be that with a vertical distance between the coils of 1.5 m, the height of the lower coil being 0.3 m above the terrain. The density of measured points is the most crucial point which depends largely on the size, thickness and depth of the surveyed structures. For example, a survey density of 0.25 x 0.25 m is 8 times more accurate than that with a density of 1 x 1 m, but you will spend 16 times as long measuring the same area. This means that you cannot generally efficiently measure large areas using a high density approach. It is therefore very important to combine global geophysical measuring of the whole area with more detailed measuring of some selected areas of interest. A total of 77 grid squares, each measuring 10 x 10 m, were measured in a uniform grid-system of 0.5 x 0.5 m on site 9.1.

A systematic survey on the plateau was oriented to the north, west and south of the identified settlement and 1995 excavation area. It was clear after observing the surface that various recent activities might have influenced the magnetometric survey. From the overall map of processed magnetometric results it is clear that most of the area has been modified in recent times (see *Fig. 4*). In recently reused areas it is very difficult to identify and separate archaeological structures with low levels of magnetic anomalies from broad and high anomalies above more solid recent features. Stone structures are very often scattered as separate blocks of stone. The best results for archaeology achieved by the magnetometric survey are in the western and southern surroundings of the excavated area in 1995, where there appeared to be fewer modern water trenches. In this area it was possible to identify several parts of potential archaeological features.

The best results were obtained within the area of grids Z10, Z11, Z12, Z26, Z27, Z28, Z30, Z31, Z32, Z34, Z35 and Z36 where potential walls and the corner of large building were by very low positive magnetic anomalies (+1 to +3 nT) identified (see Fig.5a). On the detailed picture of grid Z10 are visible linear anomalies of best preserved remains of walls of large building (see *Fig. 5b*). Subsequent archaeological excavation, after geophysical measuring in choosen parts of grids Z10 and Z11, uncovered part of a pre-Islamic church - ?the central building within the settlement. It is expected that further remains of structures will also be found in the non-excavated area situated to the W of this building and to the S and SW of the 1995 excavations. For example a detailed picture of grid Z59 showed another potential remains of walls (see *Fig. 5d*) and detailed picture of grid Z51 identified a probably well preserved remains of rectangular feature (see *Fig. 5c*). In all of the aforementioned locations a mixture of archaeological material was identified on the surface (incl. ceramics, flints, and coral), which had probably been scattered by bulldozing and modern trenching. The results of this geophysical survey can be used in future for the selection of better preserved areas with potential archaeological structures, as well as to eliminate those areas badly damaged by plantation, trenching and other military activities (see *Fig. 6*).

4.2. Site 24

The site is situated on a plateau on the northern coast of the island (Halat al Maskr). A complex of islamic period graves was identified on a flat open flint-rocky desert plateau between two cuted relicts of the origin wadi in 1993. Magnetometric survey was tryed out on area of 25 m on the 22nd March 1995. Experimental measuring was carried out of one of the best preserved graves over a 5 x 5 m area, using a grid-system of measurements for each 0.25 x 0.25 m. For such small features with only surface accumulations of stones it is reasonable not to expect excellent shaped anomalies. This magnetometric survey identified an accumulation of stones which were easily distinguishable anomalies formed by accumulations of stones from the central volcanic hills of Sir Bani Yas island. By these anomalies it is possible to identify the outer corner of a grave (see *Fig. 7*).



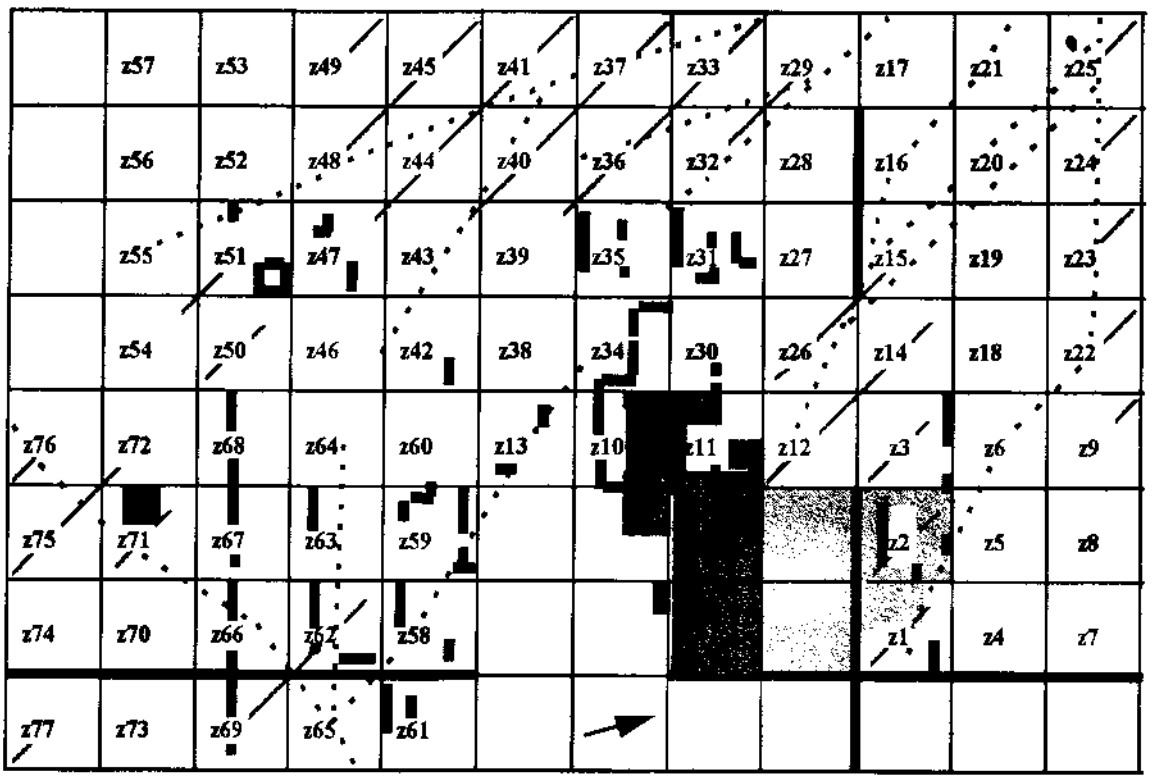


Fig. 4. Map of processed magnetometric results for the whole area around site 9.1. (1 grid = 10 x 10 m).

Fig. 6. Schematic interpretation of magnetometric survey in grid-system around site 9.1 (___ - potential archaeol.structures, ... - water pipe-line trenches, /// - areas with recent landscape changes). Archaeological trenches from 1993 and excavations from 1994, 1995 are shadowed (1 grid = 10 x 10 m).

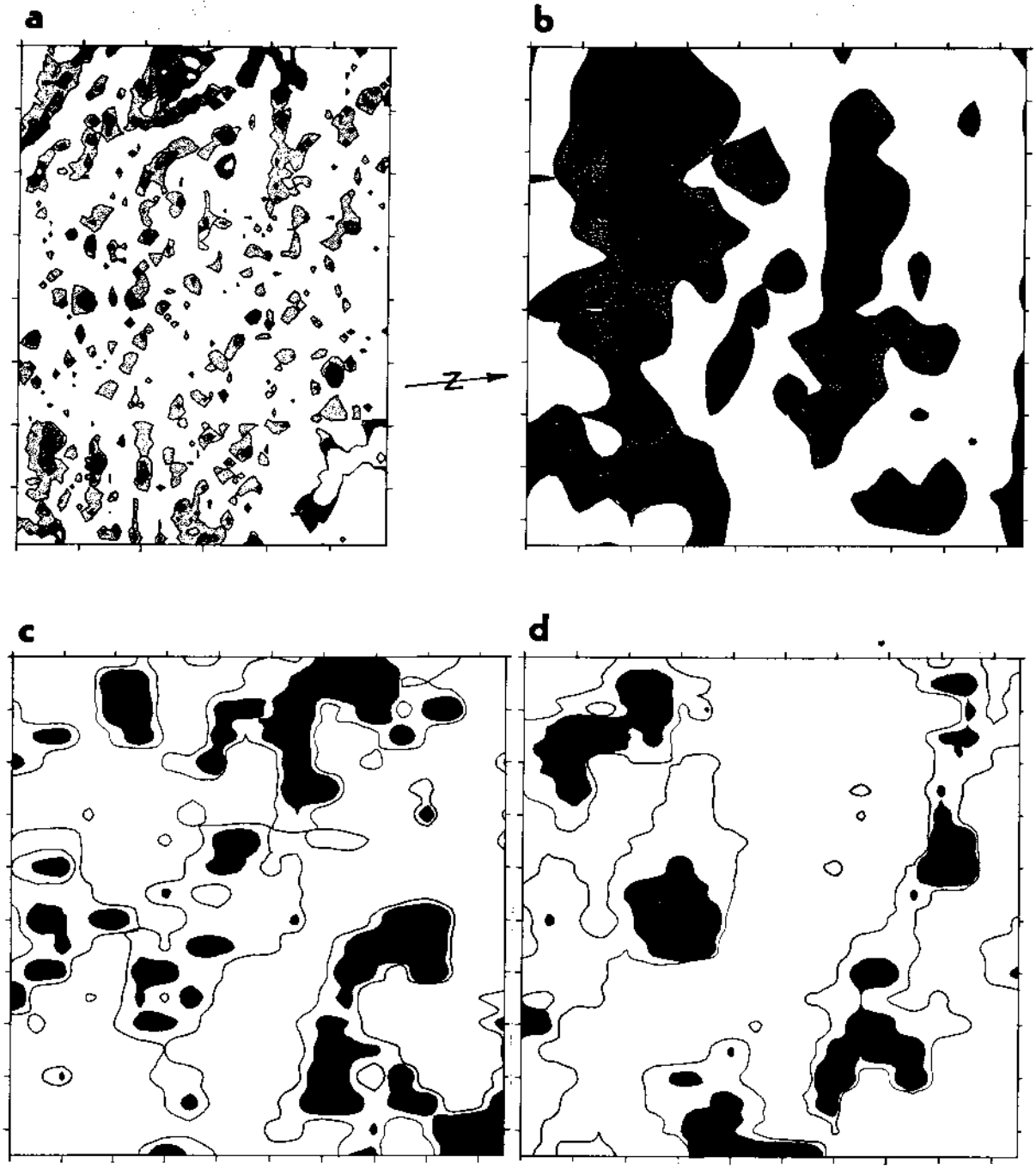


Fig. 5. **Detailed maps of processed results from the magnetometric survey on site 9.1: a - map of grids Z10, Z11, Z12, Z26, Z27, Z28,** Z30, Z31, Z32, Z34, Z35 and Z36 (area 30 x 30 m) identifying the remains of walls and the corner of the W wing of the church; b - map of grid Z10 (area 10 x 10 m) with visible linear anomalies of the best preserved parts of walls of the church; c - map of grid Z51 (area 10 x 10 m) where were identified walls of rectangular feature; d - map of grid Z59 (area 10 x 10 m) illustrating potential remains of walls.

4.3. Site near the airport

The fenced site is situated on the south-western coast of the island near to the airport buildings (AWAFI). On a flat partly eroded and weathered surface there lies a collapsed stoney prehistoric structure dating by piece of pottery to the ?2nd millenium BC. A magnetometric survey was carried out over an area of 15 x 15 m, using a grid-system of measurements of 0.5 x 0.5 m. Unfortunately the primary recorded data were influenced by the surrounding iron fence. After filtering these results, however, within a selected 10 x 10 m area above the structure, it was possible to identify beneath the soil surface the remains of quite well preserved rectangular building, probably without any visible internal divisions (see *Fig. 8*).

5. SUMMARY OF RESULTS

Between the 8th March and the 4th April, 1995, a total area of 7950 m^2 was surveyed, 7700 m^2 at site 9.1, 225 m^2 at site near the airport and 25 m^2 at site 24. Unfortunately, it was not possible to use magnetometers on the other excavated sites, as at site 2 large accumulations of iron shrapnel were recovered during excavations and at site 7 the fenced area was too small and close to the excavations and its surrounding iron fence posts. The total number of measured points during the entire magnetometric survey was 33,500 (including daily control profile measuring and experimental measuring at site 9.1).

The efficiency of the magnetometric results was very much limited by conditions of measuring, and in particular by the rapid artificial changes being made to the landscape. At first there was important to find optimal methodology of magnetometric survey without any previous experience there. This first implementation of magnetometric methods in archaeology within this area of the Gulf with its extreme climatic conditions will assist in the accurate prediction of time estimates for the future survey of potential sites in similar areas and conditions. Our average surveyed area (including data processing) each day was between 300-400 m^2 (using a grid-system of measurements each 0.5 x 0.5 m square). A limiting factor proved to be the life of the batteries within the field. The working capacity of the batteries during temperatures exceeding 30 °C was 2-3 times shorter than during a typical European climate. This was the main reason why a similar work strategy was adopted each day. Field survey was mostly carried out only in the morning, whilst afternoons and evenings were used for data processing and re-charging of batteries.

The overall results of the magnetometry survey show that it is possible to use it for the identification of various types of archaeological structures (including non-magnetic), but its success is largely dependent upon their state of preservation, level of magnetic field of background as well as that of their surrounding original landscape. In desert areas where the landscape is still relatively well preserved and the depth of archaeological features ranges from 10 cm down to a few metres, it is possible that after global geophysical survey greater success may be achieved by utilizing more expensive geophysical methods of measuring - such as electromagnetic resistivimetry, seismic or by more detailed magnetic susceptibility survey. Radiometry, gravimetry, thermometry or classic resistivimetry are not suitable in such dry and monotonous formed desert areas. Unfortunately, in the case of Sir Bani Yas island, which has had its landscape dramatically remodelled by a combination of fencing, plantations, bulldozing and trenching activities, the implementation of geophysical methods over a wider area is probably too late.

The undertaking of geophysical survey was realised only due to good open cooperation between the School of Oriental and African Studies at University of London and the Institute of Archaeology in Prague. I should like to thank to Dr. G. R. D. King (Director of A.D.I.A.S.P.) and Dr. Petr Sommer (Director of Institute of Archaeology in Prague) for giving me possibility to take a part in the fourth season of this project. I am obliged for help to many other people but especially I have to thank to Mark Beech (Archaeozoologist of A.D.I.A.S.P.) and Peter Hellyer (Co-ordinator of A.D.I.A.S.P.).

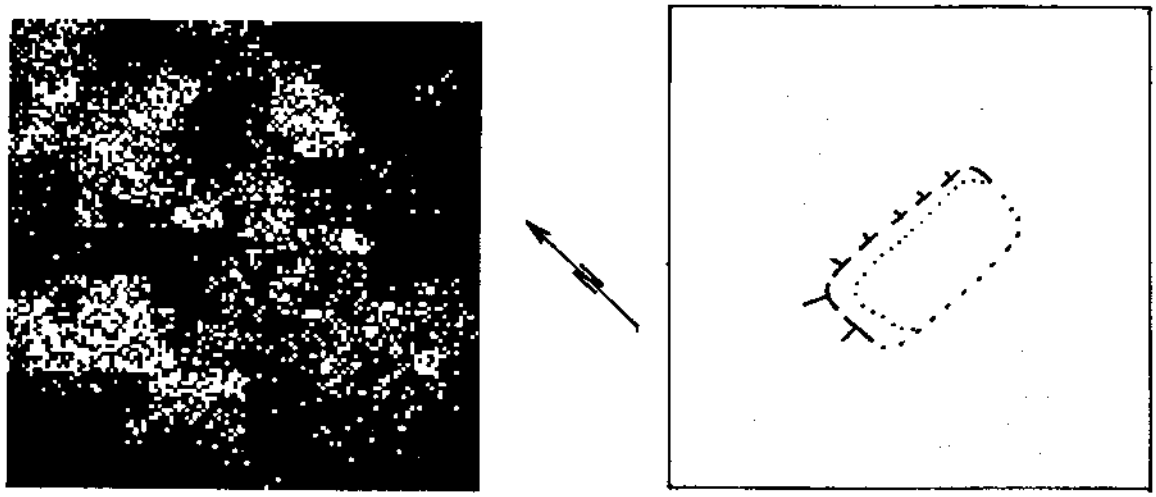
SOUHRN

Obsahem výše uvedeného článku je přehled a diskuse výsledků geofyzikálního měření uskutečněného v rámci čtvrté sezóny archeologických výzkumů projektu A.D.I.A.S.P. na ostrově Sir Bani Yas v arabském emirátu Abu Dhabi, které jsem mohl uskutečnit díky vstřícné spolupráci ARÚ Praha a School of Oriental and African Studies při University of London. Ačkoli se jedná geograficky i ideologicky o kraj velice vzdálený běžnému způsobu uvažování a jednání v zemích evropských, nezbytnost ochrany archeologických památek je i zde stejně akutní a vedení záchranných archeologických výzkumů několika zahraničními expedicemi zůstává tím jediným a často posledním počinem, který se snaží něco uchovat z nekontrolovatelně měněné krajiny.

Britský projekt A.D.I.A.S.P. pod vedením dr. Kinga se dlouhodobě věnuje archeologickému průzkumu, dokumentaci a především vpravdě záchrannému výzkumu na ostrovech ležících v západní části šelfového moře největšího emirátu Abu Dhabi. Cílem geofyzikálního průzkumu bylo přispět na vybraných lokalitách ostrova Sir Bani Yas k ověření možného rozsahu osídlení ponejvíce z 6.-8. století n.l., které by efektivněji usměrnilo postup výzkumů započatých již v roce 1994. Buldozery rekultivovaná pouštní krajina dnes již téměř neobsahuje netknuté povrchové pozůstatky archeologických objektů. Navíc extenzivní přeměna reliéfu ostrova intenzivní výsadbou stromů s rýhami pro meliorace dokázala při pobřeží narušit většinu podpovrchových situací. Přes řadu těchto rušivých vlivů se podařilo úspěšně aplikovat geofyzikální měření na třech zvolených lokalitách.

Z objektivních příčin byla experimentálně aplikována magnetometrie. Bez možnosti vycházet z jakýchkoli podobných předchozích aplikací geofyziky v oblasti bylo třeba nejprve vytvořit a otestovat nejvhodnější metodiku měření. Na plošně nejsledovanější lokalitě 9.1. dokázala magnetometrie kromě četných meliračních linií vysledovat na zachovalejších částech plochy projevy očekávaných podpovrchových reliktů kamenných objektů a zdí. Na základě těchto výsledků bude možné usměrnit vedení plošného výzkumu i do budoucích sezón projektu, stejně jako eliminovat části plochy nejvíce recentně narušené. Ještě téhož roku 1995 byla malá část proměřené plochy odkryta a v místech liniových anomálií byla identifikována část obvodového i interního zdiva a podlah zbořené sakrální stavby - kostela ležícího dle předpokladů v centru dalších skupin objektů odkrývaných od roku 1994. Výsledky experimentálně vedeného magnetometrického průzkumu překvapivě ukázaly i možnost identifikace ‚nemagnetických' mělce podpovrchových struktur. Jejich projev je však možné zaregistrovat pouze za příznivých okolností souvisejících s klidným magnetickým polem a dobrým stavem zachování podpovrchových částí zděných objektů v absolutně homogenním nemagnetickém okolním prostředí. Takové souvislé plochy již na ostrově Sir Bani Yas neexistují.

Mělo-li by být pro nás kupř. Mostecko stále otevřeným mementem technokratického naložení s krajinou, přírodním i kulturním bohatstvím, pak právě ostrov Sir Bani Yas může být jedním z mnoha důkazů, že mocenské zájmy nerovnoměrně bohatého světa žijí také v zemích Perského zálivu a mohou, bohužel, nabývat pod bezproblémovou byť jednostrannou ekonomickou prospe-



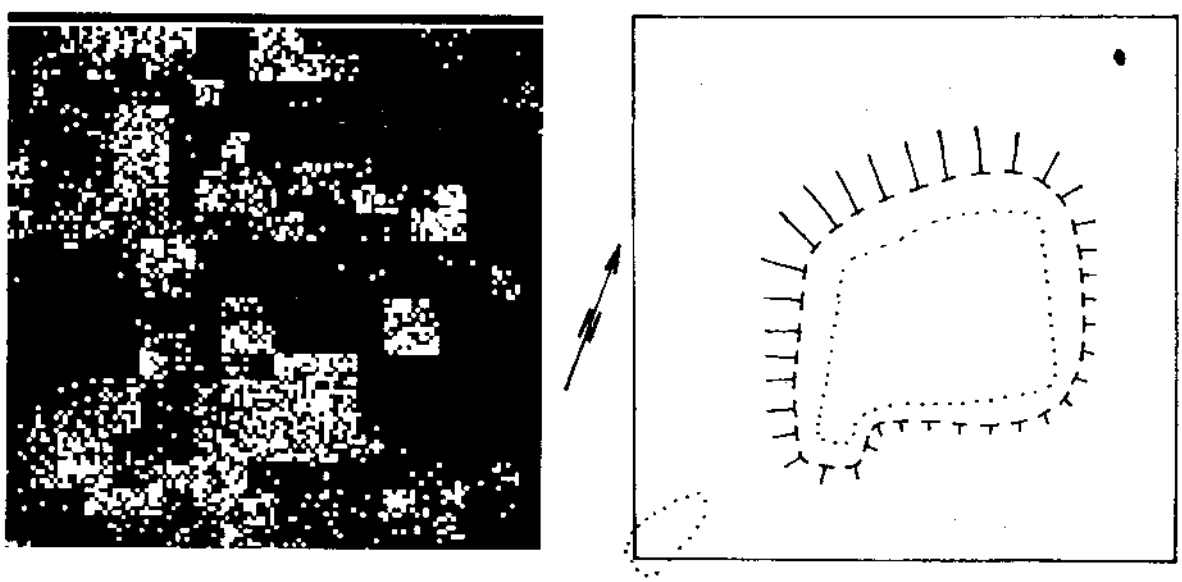


Fig. 7. Comparison of magnetometric survey results with a simple sketch of the selected grave on site 24 (area 5 x 5 m).

Fig. 8. Comparison of magnetometric survey results with a simple sketch of the fenced site near the airport (area 10 x 10 m).

ritou podob ještě dramatičtějších. Na rozdíl od naší společnosti, při absolutní absenci informovanosti o možných dopadech, smyslu některých změn, při absenci zodpovědného a zasvěceného rozhodování, nulové ochraně a zájmu legislativy je šance pro východisko z takového stavu v zemích Perského zálivu i do nejbližší budoucnosti minimální.

Předložený článek si nemohl (a ani nechtěl) klást za cíl oslovit širokou tuzemskou veřejnost. Jeho problematika je zájmu středoevropské archeologie příliš vzdálená. Avšak z hlediska všeobecné ochrany kulturního dědictví a zejména z hlediska prověření dalšího způsobu aplikace geofyziky v archeologii získává potřeba presentace výsledků své opodstatnění. Také proto byl zvolen časopis Památky archeologické s podrobným komentářem v jazyce anglickém. Za tuto možnost presentace bych rád redakci poděkoval.

REFERENCES

King, G. D. R. 1994: A Pre-Islamic Christian site on Sir Bani Yas. In: Tribulus vol. 4.2 - Bulletin of the Emirates Natural History Group, Abu Dhabi, 5-7.

Elders, J. A. 1993: Report on this seasons work on the Pre-Early Islamic (5th-8th centuries) sites on Sir Bani Yas: Season II, April 1993. Unpublished report, Abu Dhabi, 4-12.

Křivánek, R. 1995a: Field report on geophysical survey on archaeological sites on Sir Bani Yas island, Abu Dhabi (UAE), March - April 1995. Unpublished report, Abu Dhabi.

— *1995b:* Report on geophysical survey on archaeological sites on Sir Bani Yas island, Abu Dhabi (UAE), March - April 1995 (2nd version). Unpublished report, Praha.

Address: R. Křivánek, Institute of Archaeology, Czech Academy of Sciences Prague, Letenská 4, 118 01 Praha 1