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

GEOFYZIKÁLÍNÍ PRŮZKUM NA ARCHAEOLOGICKÝCH LOKALITÁCH NA OSTROVĚ SIR BANI YAS, ABU DHABI (SPOJENÉ ARABSKÉ EMIRÁTY)

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To apply geophysical survey on very remodeled desert landscape, it seems to be very difficult from many points of view. The results of it must be everyday limited by conditions and possibilities of measuring. Experimental application of magneto metric 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" claystones or coral reefs 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 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 under the patronage of UAE Chief of Staff Lieutenant 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, Misrah 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 capital Abu Dhabi only 18 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 Khorr Dabah 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 building up and plantation activities which have lead to the creation of an artificially flat landscape. The first rescue archaeological excavations on these also 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) facilitate the simple discernment of anomalies and allow the possibility of identifying archaeological features. An experimental magneto metric survey was therefore carried out.

2. CONDITIONS OF MEASURING

Magnetic 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 magnetic anomalies of different materials, and thus could allow the separation of different archaeological features from their natural background. Optimal conditions for magnetic survey are:
1) ability to distinguish magnetic anomalies of archaeological features and material different 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 few lying slope areas without deep terrain-steps and blocks of stones on the surface,
5) a minimal amount of recent anthropogenic activities within the survey area.

For the magneto metric survey at Sir Bani Yas island, conditions no. 3, 4) and 5) were acceptable. From the physical point of view all of the coastal sediments (clays, 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 magneto metric 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 natural garden are really suprisingly insensitive, 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 B [nT] with two parallel magnetometers. This gradient system, in contrast to measuring with a single instrument, allows magneto metric 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 geophysical prospection. The areas signed /// demonstrate deep changes of the origin landscape by bulldozing and plantation activities.
Fig. 2. Diagram illustrating the measured absolute intensity of the magnetic field $H$ [nT] and its gradient $\delta H$ [nT] at the same time on 22 March 1995 (--- morning, --- noon, p. - control profile).

Fig. 3. Diagram of the semidurnal type of variation exhibited by the magnetic field $H$ [nT] during measuring carried out between 12 March to 4 April 1995.
4. MEASURED SITES

4.1. Site 91

The largest archaeological site is situated on a wide plateau on the eastern coast of the island (Al Khan). The whole area is fenced and rented for a plantation with irrigation systems (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 1995 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 buried under the sand 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 angles between the coils. The best configuration proved to be that with a vertical distance between the coils of 3.5 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 site, richness 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 91.

A systematic survey on the plateau was oriented towards 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 treated areas it is very difficult to identify and separate archaeological structures, with low levels of magnetic anomalies from high and high anomalies above more solid recent features. Stone structures are often scattered as separate blocks of stone. The best results for archaeology are 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 areas of grids 210, 211, 212, 226, 227, 228, 230, 231, 232, 234, 235 and 236 where potential walls and the corner of large building were by very low positive magnetic anomalies (±1 or ±2x1) identified (see Fig. 5a). On the detailed picture of grid 210 were visible linear anomalies of best preserved remains of walls of large building (see Fig. 5b). Subsequent archaeological excavation, after geophysical measuring in chosen parts of grids 210 and 211, uncovered part of a pre-Islamic church - the vertical 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 230 showed another potential remains of walls (see Fig. 5c) and detailed picture of grid 231 identified a probably well preserved remains of rectangular feature (see Fig. 5d). 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 plantations, 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 (Hatbat al Mask). A complex of Islamic burial graves was identified on a flat area with rocky desert plateau between two eastern ridges of the wadi. In 1996, Magnetometric survey was carried out on an area of 23 m on the 22nd March 1996. Experimental measuring was carried out of one of the best preserved grave (c. 3 x 8 m in size, using a grid system of measurements for each 0.25 x 0.25 m). For such small features with thin surface accumulations of stones it is reasonable not to expect excellent shaped anomalies. That 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 91. (1 grid = 10 x 10 m).

Fig. 6. Schematic interpretation of magnetometric survey in grid-system around site 91 (--- 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, Z34, Z36, Z39, 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 (AWAP). On a flat partly eroded and weathered surface there lies a collapsed stone prehistoric structure dating by piece of pottery to the 7th millennium 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 5th March and the 4th April, 1995, a total area of 7950 m² was surveyed, 7700 m² at site 9.1, 225 m² at site 24. Unfortunately, it was not possible to use magnetometers on the other excavated sites, as at these 2 locations accumulations of iron shard 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 m² (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 afternoon and evenings were used for data processing and re-charging of batteries.

The overall results of the magnetometric 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 its 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 preserved and the depth of archaeological features ranges from 10 cm down to a few meters, it is possible that after global geophysical survey greater success may be achieved by utilizing more expensive geophysical methods of measuring - such as electromagnetic resistivity, seismic or by more detailed magnetic susceptibility survey, Radiometry, gravimetry, thermometry or classic resistivity 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 re-modelled 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 realized 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 Hellier (Co-ordinator of A.D.I.A.S.P.).

SOÚHRN

Oblastem výše uvedeného čísla je předem a diskuse výsledků geofyzikálních měření uskutečněných v rámci čtvrté sezóny archeologických výzkumů projektu A.D.I.A.S.P. na ostrově Sir Bani Yas v arabském emirátu Abu Dhabi, které jsou mohou uskutečnit díky sociální spolupráci ARU Praga s School of Oriental and African Studies a University of London. Ačkoliv se jedná o geofyziky a ideologicky o krajině velmi zváženého hlavního způsobu využívání a jedlá v zemích evropských, nezbytnost ochrany archeologických památek je zde jak děložní čtení a vedení zachovalých archeologických výzkumů nikoliv zažádané, ale spíše zcela opačného účelu, který se smaží něsto uchovat z nekontrolovaného měniče krajiny.


Z objektivních příčin byla experimentálně aplikována magnetometrie. Bez možnosti využití i jízdních podmínek podobných předcházejících aplikací geofyziky v oblasti bylo těžko nejprve vytvořit a otestovat nejprv nejčistší metodu měření. Na počátku nejlepšší n.vážnosti lokalit 9.1. dokázala magnetometrie čeméně čtyři mezičasové výběrky výsledků na zachování části krajiny přímo pro vědy buď pravěkého života, nebo pro nejlepší přírodní krajiny. Mezi hlavní otázky je možné zaučit z vědeckého povědomého pořádku a šiření dobrého krajiny v souvislosti s tohoto dobytí a dalších společných projektů, které jsou mohou uskutečnit díky sociální spolupráci ARU Praga s School of Oriental and African Studies a University of London. Ačkoliv se jedná o geofyziky a ideologicky o krajině velmi zváženého způsobu využívání a jedlá v zemích evropských, nezbytnost ochrany archeologických památek je zde jak děložní čtení a vedení zachovalých archeologických výzkumů nikoliv zažádané, ale spíše zcela opačného účelu, který se smaží něsto uchovat z nekontrolovaného měniče krajiny.
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).
činou podob ještě dramatickějších. Na rozdíl od naší společnosti, při absolutní absenci informovanosti o možných dopadech, nesou přes některých změn, při absenci zodpovědného a zasevěnczo-mu rozhodování, nesouvěrně ochraně a zájmu legislativy je šance pro východoási k zájemu stave v zemích Perského zálivu i do nejblíže budoucnosti minimálně.

Předložený článk je nemožné ani nezaleh klást za cíl odsvět širokou tezmu projektu veřejnosti. Jeho předmětem je zájmu srovnánové evropské archeologie při vědě. Autorka z hlediska sociální ochraně kultura ddílivila a zejména z hlediska povědomí o něco rychlejší aplikaci geofyziky v archeologii víceho potřeba prezentace výsledků svého posledního. Taktéž proto byl zvolen časopis přírodovědců archeologické s podrobným komentářem v jazyce anglického. Za tuto možnost prezentace bych rád redakci poděkoval.

REFERENCES


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