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► To cite this version:

Lionel Darras, Corinne Castel, Olivier Barge. A new approach to the acquisition of microtopography associated with geophysical survey (Bat/Al-Arid, Sultanate of Oman). 15th International Conference on Archaeological Prospection ICAP2023, Mar 2023, Kiel, Germany. pp.341-344, 10.38072/978-3-928794-83-1/p68 . hal-04315100

HAL Id: hal-04315100

<https://hal.science/hal-04315100>

Submitted on 30 Nov 2023

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A new approach to the acquisition of microtopography associated with geophysical survey (Bat/Al-Arid, Sultanate of Oman)

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Abstract

We present a new approach to acquire microtopography without a GPS System with decimeter precision. This can be used for acquiring microtopography on all environments (forest, urban, underground). It enables an easy interpretation of geophysical maps with microtopography easily acquired.

Keywords

altimeter; easier interpretation; magnetic prospection; microtopography without GPS system

Introduction

Geophysical surveys on archaeological sites provide a useful complementary information for the archaeological study of a site. Once the geophysical survey has been carried out, the geophysicist wishes to quickly interpret the geophysical map on the field. The knowledge of the local topography allows correlation and discrimination between geophysical anomalies and topographic features to have a quick and better interpretation. To have a topographic map of the prospected area, there are two main solutions:

The first solution is to use a centimetric GPS-RTK synchronized with the geophysical device. The second solution is to have a topographic map acquired by conventional methods, by LiDAR, or by aerial photogrammetry (UAV, kite).

The first solution requires the use of positioning equipment of a certain weight and a volume that it is sometimes more complicated to transport by air and to have importation authorizations in addition to geophysical material. On archaeological sites, it is frequent to have only one GPS system available for the entire team. When the positioning equipment has to be used during all geophysical prospection it might prevent other essential studies, depending on this system, to be occurred at the same time. In addition, if the geophysical prospecting is in an environment with the

more or less dense presence of trees or walls, the precise positioning may be interrupted, which may prevent the continuity of the topography measurements taken by the GPS-RTK system.

The second solution obviously requires the work of a topographer, whereas in the context of certain campaigns, the presence of such a specialist is not always honored.

From this inventory, a reflection was initiated to properly interpret a geophysical map: is the positioning (x, y, z) of each measurement so essential? Geophysical prospecting can be carried out using a grid marked on the ground providing a local reference (x, y) and a profile tracking in this same landmark. The georeferencing of the map can be done by noting the precise position of the angles of these prospected areas using a GPS or a total station.

With this method, the positioning in (x, y) of the measurements can be carried out in post-processing. However, the z coordinate at each measurement point is still unknown. It is for all these reasons that our new approach has been focused solely on measuring the z-coordinate of the position of each measurement in the simplest possible way with a good precision of the decimeter order. This project was developed under the name of ZheoPS (Z Positioning System).



Fig. 1: Bat/At-Arid site general view, © archaeological Mission Bat/al-Arid. C. Castel.

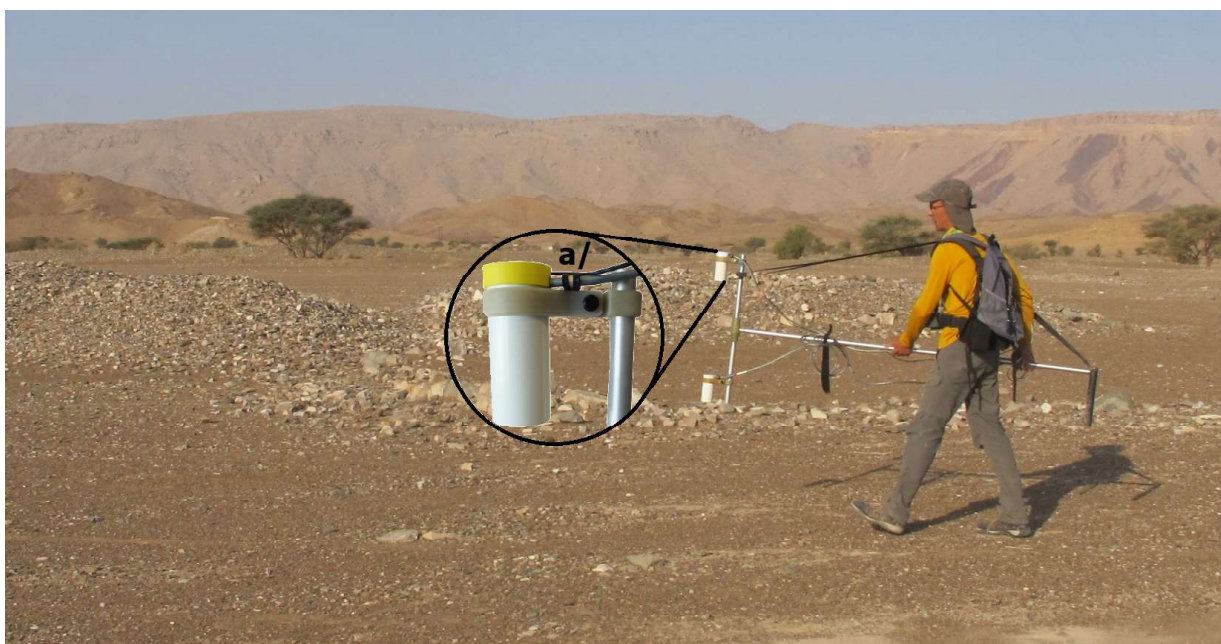


Fig. 2: Magnetic prospection coupled with ZheoPS system, © archaeological Mission Bat/al-Arid. C. Castel.

Materials and methods

We got inspired by the barometric altimeters used by paragliders to know their altitude variation in real time. Their displayed differential precision is 10cm. The advantage of this sensor is a reduced size with a very low magnetic impact: it can be placed in close range to a geophysical sensor without disturbing its measurement. It can be connected to a compact acquisition board which performs the measurements and which transmits the altitude measurement information in a NMEA frame format. This frame

can be transmitted to the geophysical instrument, to synchronize the altitude and the geophysical measurements. In this first version, the raw altitude is used. Each altitude measurement is subtracted from the average of the measurements along the profile to remove the influence of the variation in meteorological conditions. Two transverse profiles are carried out to calibrate the profiles with each other. This calibration method allows the construction of a microtopographic map of the area.

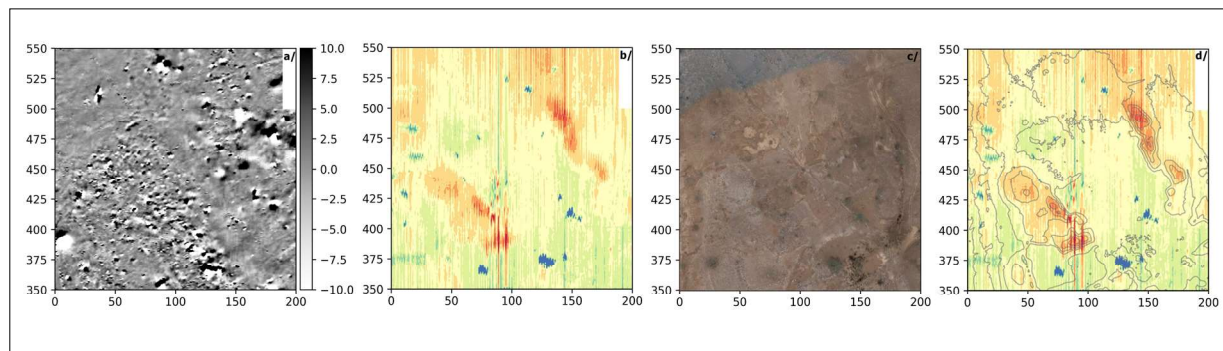


Fig. 3: a) Magnetic map, b) microtopographic map (ZheoPS), c) Aerial view, d) microtopographic map combined with topographic map (isolines every 50cm).

Results

As part of an archaeological mission in Bat/Al-arid (Sultanate of Oman), a second magnetic prospecting campaign was scheduled for January 2020 (Castel et al. 2020). Al-Arid is an Early Bronze Age settlement site in the interior of the Oman peninsula. The purpose of this geophysical campaign was to continue the overall study of the site initiated a year earlier. The environment was of relatively low topography with, however, the presence of towers, canals, small mounds and some trees (Fig. 1).

We placed the altimeter sensor of ZheoPS project on the magnetic sensor (Fig. 2a). We placed the altimeter datalogger in a bag behind the operator and we connected it to the geophysical datalogger to synchronize measurements during magnetic prospecting (Fig. 2).

In the same local landmark, a magnetic map could be constructed (Fig. 3a) synchronized with altitude measurements made by ZheoPS system. These measurements make it possible to construct a microtopographic map (Fig. 3b), without scale due to the use of this first prototype and its relative measurements (a future version (ZheoPS-RTK) will allow the acquisition of real altitude measurements and the construction of a map with a precise scale).

A digital elevation model (DEM) was produced independently thanks to the photogrammetric processing of aerial photographs (Fig. 3c) taken at low altitude (Barge and Régagnon 2017). This DEM, with a resolution of 25 cm and an accuracy of about 3 cm (Fig. 3d), allowed the comparison of our experimental data.

Discussion

The simultaneous construction of magnetic (Fig. 3a) and microtopographic maps carried out with ZheoPS measurement (Fig. 3b) thus makes it possible to establish the correlation between these different measurements. Thanks to the Figure 3d, the topographic map can be compared to the microtopographic map and it is interesting to observe that in the two maps, earth embankments (Fig. 3d, in red) are well detected. With this first version of ZheoPS, we built a microtopographic map corresponding to the variations of the topography of the prospected zone. It facilitates the interpretation of geophysical measurements in its microtopographic environment but it does not yet allow the construction of a precise topographic map. A new ZheoPS-RTK version taking into account weather-dependent measurement errors has been developed (Darras 2022) and already tested to get the elevation of measurement points along an electrical tomography and we will test this system later during a complete geophysical survey to build a real topographic map.

Conclusion

This paper presented an approach on how to measure the microtopography of the area prospected with a decimeter precision. With these results, it is easy to understand the advantages of this new approach and it is still more interesting knowing that this system can be used in forest, urban and underground environments. █

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