

Effectiveness of DC Resistivity Imaging and Shallow Seismic Refraction Techniques Around El Giza-Pyramid Plateau, Egypt

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Abstract

The Giza plateau is considered the most characteristic examples of the ancient Egyptian civilization. It still attracts archeologists just like any other historical sites. Therefore it is important to carry out a geophysical survey representing seismic refraction and direct current resistivity imaging methods for mapping the different rock units around the pyramids and studying any groundwater infiltration that might have a bad impact on the archeological remains. The results have shown the presence of geoseismic layer of high velocity value corresponding to the dolomitized limestone, the main lithologic unit of the pyramid plateau. It is covered at some localities by moderate and/or low velocity geoseismic layers. The low velocity layer is interpreted as friable sand and fragments of limestone. The moderate velocity layer is interpreted as fractured-marly limestone that might be caused by the percolation of groundwater resulting from rainfall and drainage systems indicating relatively low resistivities as illustrated in 2D resistivity imaging results. The possibilities of the presence of archeologically small anomalies representing caves, mysterious tombs and/or secret rooms are indicated by localized anomalous resistivities.

Keywords

Geoseismic layer • Resistivity imaging • Giza plateau • Percolation of groundwater

1 Introduction

Egypt has a deeply rooted civilization that extends over thousands of years. This civilization has left a huge amount of traces and antiquities. The study area (Giza Pyramids Plateau) is one of the most important areas among those interesting archeological locations in Egypt. It is located at the northern extension of the necropolis of Memphis, situated on the west bank of the River Nile and today part of the suburb of modern Cairo (Fig. 1). The three great Pyramids are the most famous and prominent monuments at Giza plateau. They are still the interest for tourists and for every scientific works because of its historical background.

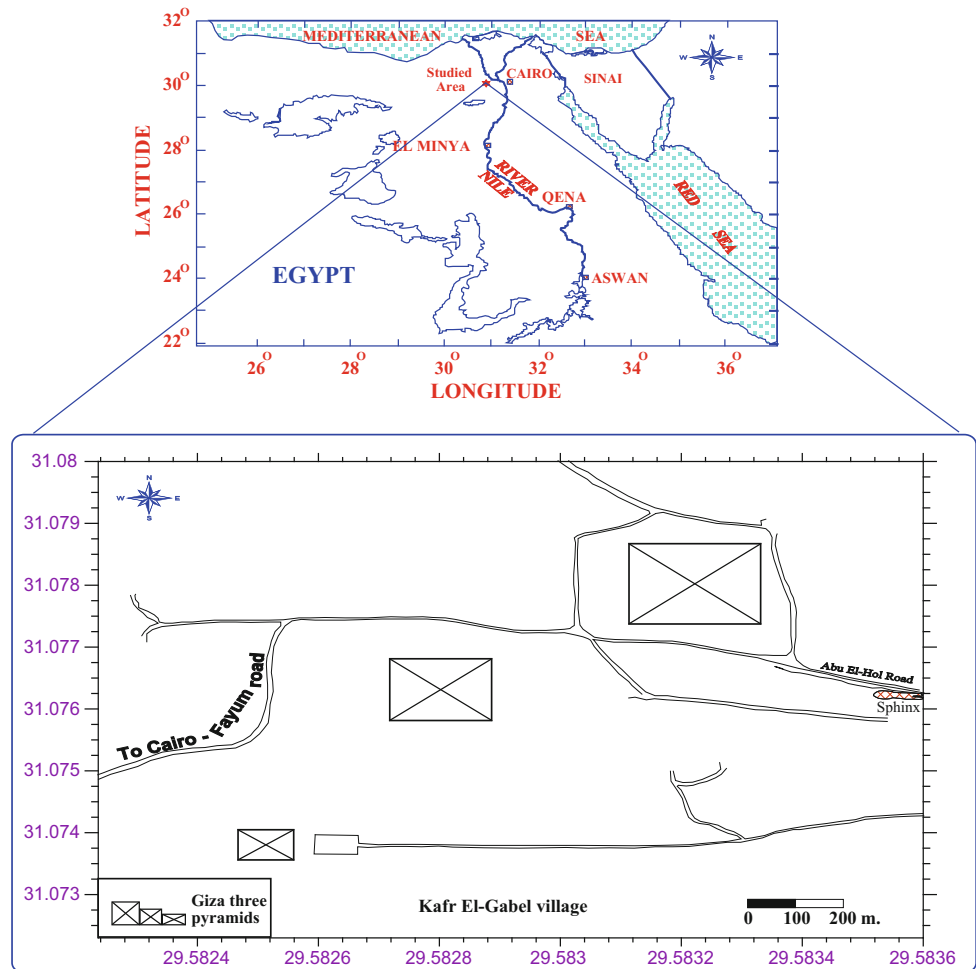
2 Materials and Methods

Two geophysical techniques were applied around the Giza Pyramids Plateau; shallow seismic refraction and geoelectrical resistivity techniques using Wenner-Schlumberger array. The shallow seismic refraction method was carried out in the form of profiles, 38 for the longitudinal P-wave and the same number of profiles for the shear S-wave at the same locations. The P-wave profiles were acquired using the seismographs StrataView (Geometrics, USA) 24 channels while the S-wave profiles were conducted using DOLANG (Dolang, ITALY) with 12 channels. Forward, reverse and central shooting surveys were conducted for most of the profiles. A sledge hammer of 15 kg weight was used for both seismographs. The length of the profiles was controlled by the validity and access of the area. It ranges between 50 and 75 m while the geophones interval was spaced 1 and 3 m and the shot point was 3 m from the nearest geophone. On the other hand, thirty four-geoelectric resistivity profiles have been carried out at the pyramids area using a multi-electrode system consisting of the equipment Syscal/R2 resistivity meter, remote control multiplexer (RCM), multi-electrode cable, 12 V battery and 3 Node Boxes, each Box contains 16 nodes (c.f. [1–3]).

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Fig. 1 Base map of the study area



3 Results and Discussion

The results of seismic data were presented vertically in the form of velocity–depth profiles (Fig. 2). Generally, there are three geoseismic layers in the area, the high velocity one representing the bedrocks are covered at some localities by moderate and/or low velocity layers. The first and top geoseismic layer is characterized by low seismic velocity values ranging from 900 to 1300 m/s for the P-wave while its S-wave velocity ranges from 450 to 710 m/s. It has a variable thickness ranging from 0.5 to 13.5 m. This layer is corresponding to the accumulation of loose sand and some fragments of limestone rock as indicated from given lithology. It generally appeared at the seismic profiles far from the pyramids themselves and passes through constructed roads for pedestrians. The second geoseismic layer that was remarked along most of the seismic profiles is characterized by a moderate seismic velocity values ranging from 1400 to 2000 m/s for the P-wave while its S-wave ranges from 840 to 1220 m/s. It has a variable thickness with minimum and maximum values of 1 and 20 m, respectively. This moderate

seismic velocity layer is related to fractured marly limestone. The third geoseismic layer, on which the three pyramids were constructed, is characterized by high seismic velocity values of ≥ 2010 m/s for the P-wave and reaches up to ≥ 1230 m/s for S-wave. This seismic velocity layer is correlated to dolomitized limestone as illustrated in the given lithology [4]. Besides, some of the time-distance curves reveal shallow and small local high velocity zones. These zones might be corresponding to the presence of archaeological remains that cannot be quantitatively represented by the software used in this study.

On the other hand, 2-D resistivity imaging profiles were produced (Fig. 2b). They also portray three geoelectric layers. The first one is indicated by high resistivity values from 550 to 3000 Ω m. This resistive zone might reflect the effect of the aridity. The second geoelectric layer is characterized by relatively low resistivity values ranging from 15 to 150 Ω m. This layer corresponds to the marly limestone layer that might be wetted as a consequence of percolation of rainfall, particularly this DC resistivity survey was carried out in the rainy season, and/or the seepage of unmanaged domestic waste causing the low resistivity zones. The third

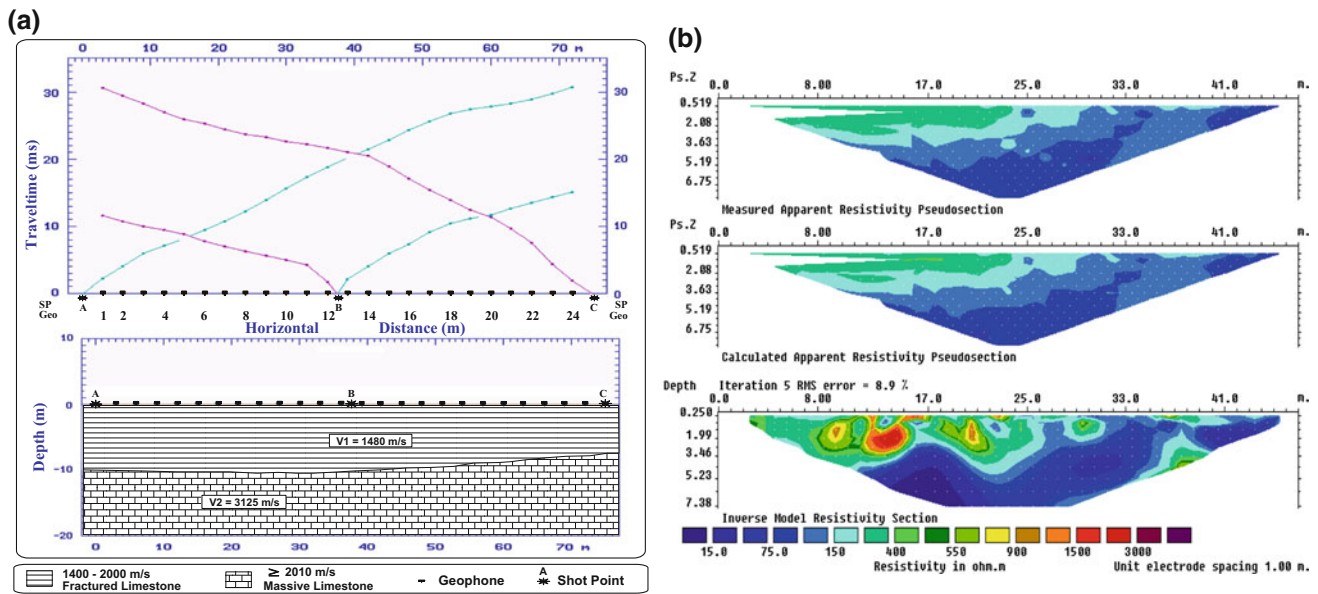


Fig. 2 a, b 2-D electrical resistivity section along profile P-12

layer of dolomitic limestone is detected only along few geoelectric profiles, which go through a greater depth to reach that layer. It is indicated by high resistivity values ranging from 550 to 3000 Ω m. Moreover, small local high resistivity features appear within the first and second geoelectric layers. They could represent the existence of cavities and/or archeological remains as inferred from the above seismic data and have been confirmed by the field observation and archeologists in the area.

4 Conclusion

Two geophysical techniques were applied around the Giza Pyramids Plateau; shallow seismic refraction and geoelectrical resistivity techniques. Seventy-two shallow seismic refraction profiles were carried out, 38 for the longitudinal wave and 38 for the shear wave at the same locations. On the other hand, Thirty-four resistivity imaging profiles have been conducted at the pyramids area using a multi-electrode system with Wenner-Schlumberger array. The output results of the seismic data have shown the presence of three geoseismic layers, the highest velocity one representing the main rock unit appears very shallow or exposed around the pyramids. Moreover, there is an indication of the presence of local and archeological left-overs. The calculated Bearing Capacity and Poisson ratio of the third layer that constitutes the main lithologic units portrayed its high hardness.

On the other hand, most of the 2-D geoelectric resistivity imaging results have portrayed two resistive layers sandwiched by relatively a low resistivity one which might be affected by runoff of rainwater through the fractures and joints and/or the result of leakage of domestic wastes causing the low resistivity zones. However, measurements at different seasons (monitoring) are highly recommended to delimit the origin of wetting agent. The resistivity imaging results indicated the possibility of the presence of cavities and/or archeological residue; however detailed 3-D survey and modeling software should be applied for these prospective localities. The seismic and geoelectric resistivity techniques were generally consistent and have shown their efficiency as costly effective and non-invasive methods for archeological applications in the area of study.

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