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Optimized electrical resistivity tomography investigation established in identifying pit tombs of Mogareb, a cemetery area in a Pre-Aksumite archaeological site of Seglamen, northern Ethiopia

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ABSTRACT

The larger area of Aksum is known as the most important archaeological areas in northern Ethiopia. It is included in the UNESCO World Heritage List as from about the IV century BC, it developed as one of several polities on the Tigrean plateau and emerged as the capital city of a powerful kingdom roughly between the II and the VIII centuries AD. The Mogareb is a cemetery in a Pre-Aksumite archaeological site of Seglamen located about 12 km South-West of Aksum.

The geophysical survey was deployed to investigate the cemetery with the objective of finding and locating unmarked tombs. This work was also intended to test potential of the technique for the wider archaeological area of Aksum, in similar context to Mogareb, where application of geophysical techniques in multidisciplinary archaeological researches, in general, is not common.

The approach in this work established an optimized use of the electrical resistivity tomography technique in understanding the archaeological context of the Pre-Aksumite site of Seglamen. The electrical resistivity tomography investigation of large cemetery sites as Mogareb requires a methodological approach designed to define areas of maximum interest where data collection should be planned. Thus, the ERT method suited the Mogareb cemetery area due to the large amount of apriory information from previous archaeological expeditions involving surface collections and excavations that identified and limit extent of the cemetery and were used in the calibration of geophysical survey results.

The electrical resistivity tomography survey was conducted on a rectangular grid of 19.5 m by 44.25 m with 0.75 m unit electrode spacing and line spacing in a Dipole-Dipole configuration resulting in high resolvable 2D and 3D electrical resistivity model sections. The models were successful to show interpreted pit tombs anomalies some of which were verified in an excavation of a 10 m by 10 m grid that had an overlap of 6 m by 10 m area to the Northern edge of the electrical resistivity tomography grid.

1. Introduction

The larger area of Aksum is known as the most important archaeological areas in northern Ethiopia included in the UNESCO "World Heritage List". It was one of several polities on the Tigrean plateau and emerged as the capital city of a powerful kingdom from about the IV century BC to VIII centuries AD [19,20,40–41].

Several hundreds of sites have been recognized to implement the archaeological map of Aksum and its general territory in 2006 as part of the Ethiopian Cultural Heritage Project, Aksum Branch [18,17,24,42–43]. The sites are set on the hilltops, along the slopes and in the plain field where the majority are very badly preserved as they are highly disturbed by soil erosion, modern settlements, cultivation, stone quarrying and illegal excavations [48]. The archaeological investigation of Aksum and its environs is thence primarily relevant in terms of preservation of the cultural heritage.

The Seglamen archaeological site, one of the several hundred sites in the area of Aksum, is located about 12 km to the south-west of Aksum's city-center in the modern village of Seglamen. It extends over an area of about 70,000 square meters on a remarkably flat cultivated terrace at the edge of the western cliff of the Negus river gorge and encompasses the localities of Amda Tsion and Mogareb [21] (Fig. 1).

The Seglamen site has been excavated since 2010 by the Italian Archaeological Expedition of the University of Naples "L'Orientale", in collaboration with Aksum University [21,48,51,50,49]. This allowed to identify two different sectors within the site: the settlements at

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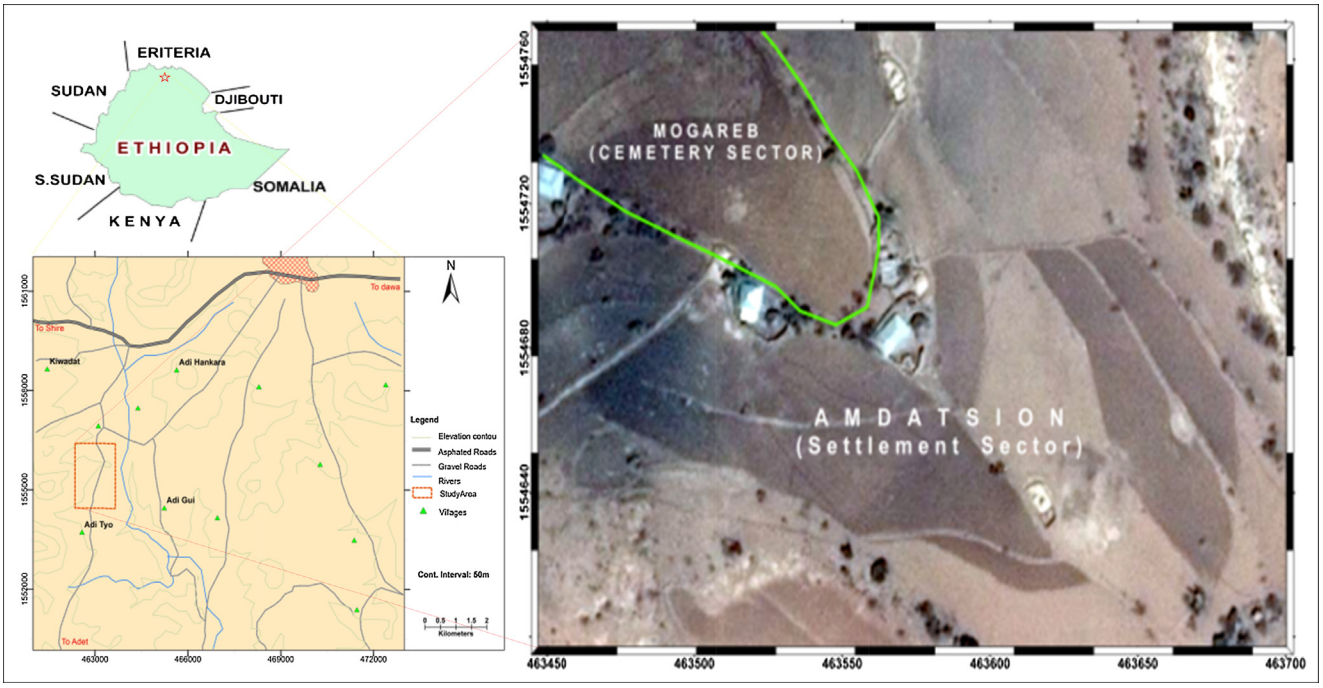

Fig. 1. Location map showing the Mogareb Cemetery; Inset Aksum area, Northern Ethiopia.

Fig. 2. Panoramic view of the Mogareb cemetery, Seglamen archaeological site in Aksum, North Ethiopia.

Amdetsion area and the cemetery at Mogareb area. Fig. 2 shows panoramic view of Mogareb cemetery.

Geophysical methods have been used with increasing frequency in archaeological site investigation since 1946 [4]. However, it is quite common to see several multidisciplinary archaeological research projects operating in this broad and archaeologically relevant area are not using them. Only few unpublished studies are from Ethiopia, including reconnaissance magnetic surveys by few these archaeological expedition projects.

Commonly applied integrated with other methods such as magnetics, the electrical resistivity surveys have been a strong candidate in archaeological prospection [1,2,10,14,22,25,28,34,39]. Today, the application of electrical resistivity tomography (ERT) in archaeological investigations has become an important tool, as several sophisticated systems that permit the achievement of very large data sets over a relatively larger area at a very high data density in a limited time have become available (example, [1,2,3,5,6,39,38,47]). Interpretation computer programs also allow obtaining true models of the subsurface in two and/or three dimensions.

Geophysical investigation of cemeteries started since 1980s [23,37] and has always been challenging in terms of locating and recognizing unmarked graves and tombs. Every cemetery, with different types of graves of diverse conservation status, has its own specific characteristics. The small size of the graves and buried features in addition to slight physical contrast between the refilled material and the surrounding soil renders the location of such structures a real challenge to archaeological geophysics.

One of the first systematic tests on the potential of geophysical methods in outlining marked and unmarked graves was presented by Bevan [7]. Their non-invasive nature made them appropriate for the mapping of graves in cemeteries through the employment of various techniques like ground penetrating radar, electrical resistance, electromagnetic and magnetic methods (e.g. [12,26,27,29,35]), albeit dominated by the Ground Penetrating Radar (GPR) method (e.g. [11,15,44,46,52]).

GPR investigations, however, may not be suitable in certain sites, for example in large survey areas and/or where soils have very high clay contents, like the area under consideration, that rapidly attenuates radar signal that results in poor penetration depths being attained [45].

The application of magnetometers to map burials at cemeteries is occasionally reported [7,8,16]. Studies at Californian cemeteries by Brock and Schwartz [8] successfully used a proton magnetometer to