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Reevaluating a seismic traveltime tomography survey at Kastas tumulus (Amphipolis, Greece)

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ABSTRACT

Recent archeological excavations at Kastas tumulus (Amphipolis, Northern Greece) have revealed structures within the tumulus that have provided an excellent opportunity to reassess a seismic tomography survey of the tumulus, improving the geophysical imaging and the archeological understanding of the tumulus structure. We reevaluated and reprocessed the original dataset, considering the findings of the on-going excavation. We studied in detail the velocity distribution of expected burial structures and tested the detection ability of tomography using various target object positions, shape and dimensions. An updated inversion of the traveltime data verifies and improves the original result. The stone-lined dromos leading to the interior of the monument is imaged as a low-velocity area, as are other low-velocity areas possibly related to additional access walkways and funeral chambers. The circular stone wall surrounding the tumulus, not a target of the survey, was not imaged due to target and site peculiarities and the method's detection ability. However, part of a low-velocity anomaly that runs along the original foot of the hill successfully images the deep soil-filled trench in which the wall is buried, providing indirect evidence for the existence of a significant structure related to the tumulus. The results of the present study strongly support the use of seismic traveltime tomography as a robust tool for investigating burial mounds, particularly beneficial for locating funeral chambers and other structures at the deepest levels of a tumulus, which are usually beyond the imaging ability of other methods commonly applied in archeological prospecting.

1. Introduction

Kastas tumulus is located off the side of the village of Mesolakkia (to the south of the city of Serres, Northern Greece) and near the Amphipolis archeological site (Fig. 1a). It is an artificial hill of near circular shape, with a circumference of about 360 m, average diameter of 160 m and height of 21 m with steep sides. It is made of alternating layers of sand, red soil and gravel, and is suspected to contain important funeral chambers (Lazaridis, 1993).

A seismic traveltime tomography survey was made in 1998 (Polymenakos et al., 2004) at Kastas tumulus (Fig. 1b) in an attempt to image the interior to detect possible funeral chambers. The survey was designed to provide an improved and complete subsurface imaging, overcoming the limitations posed by the restricted access at the top and sides of the hill. Furthermore, the considerable height of the artificial hill and hence thickness of deposits seriously affect the vertical and horizontal information that can be captured by geophysical methods commonly applied in the investigation of tumuli-shaped structures (such as resistivity, electromagnetic induction, ground penetrating radar, magnetic, and seismic refraction; see e.g. Tsokas et al., 1995, Froehlich Gugler and Gex, 1996, Von Der Osten-Woldenburg et al., 2002; Persson and Olofsson, 2004, Yiğit and Bilge, 2010; Papadopoulos et al., 2010).

Excavations at the tumulus that commenced in 2012 have revealed an impressive nearly circular stone wall, around 3-m-high and 1.6-m-wide encircling the tumulus (Peristeri, 2014), as well as a stone-lined and soil-filled tunnel vault extending about 25 m to the interior (hereafter referred to as the tunnel). The tunnel is located near the southern tip of the tumulus (Fig. 1c) and has internal dimensions 6 m high by 4.5 m wide (YPPO, 2014a) and overall dimensions of 8 × 6 m considering a wall thickness of 1–1.5 m. The excavation has also partly revealed the earth materials that make up the hill. On the eastern side (Fig. 1d), an artificial embankment of mixed earth materials overlies a marl substrate (hereafter referred to as bedrock) that underlies the hill and also forms part of the hill structure (it extends above the top of the wall and the surrounding ground surface on which the tomography survey was undertaken). The circular wall is located in a trench within the bedrock. On the southwestern side (Fig. 1e), the embankment extends over the entire height of the hill, whereas the bedrock does not appear on the excavated hillside. The base of the circular wall appears to be at the level of the local ground surface. A simplified conceptual cross-

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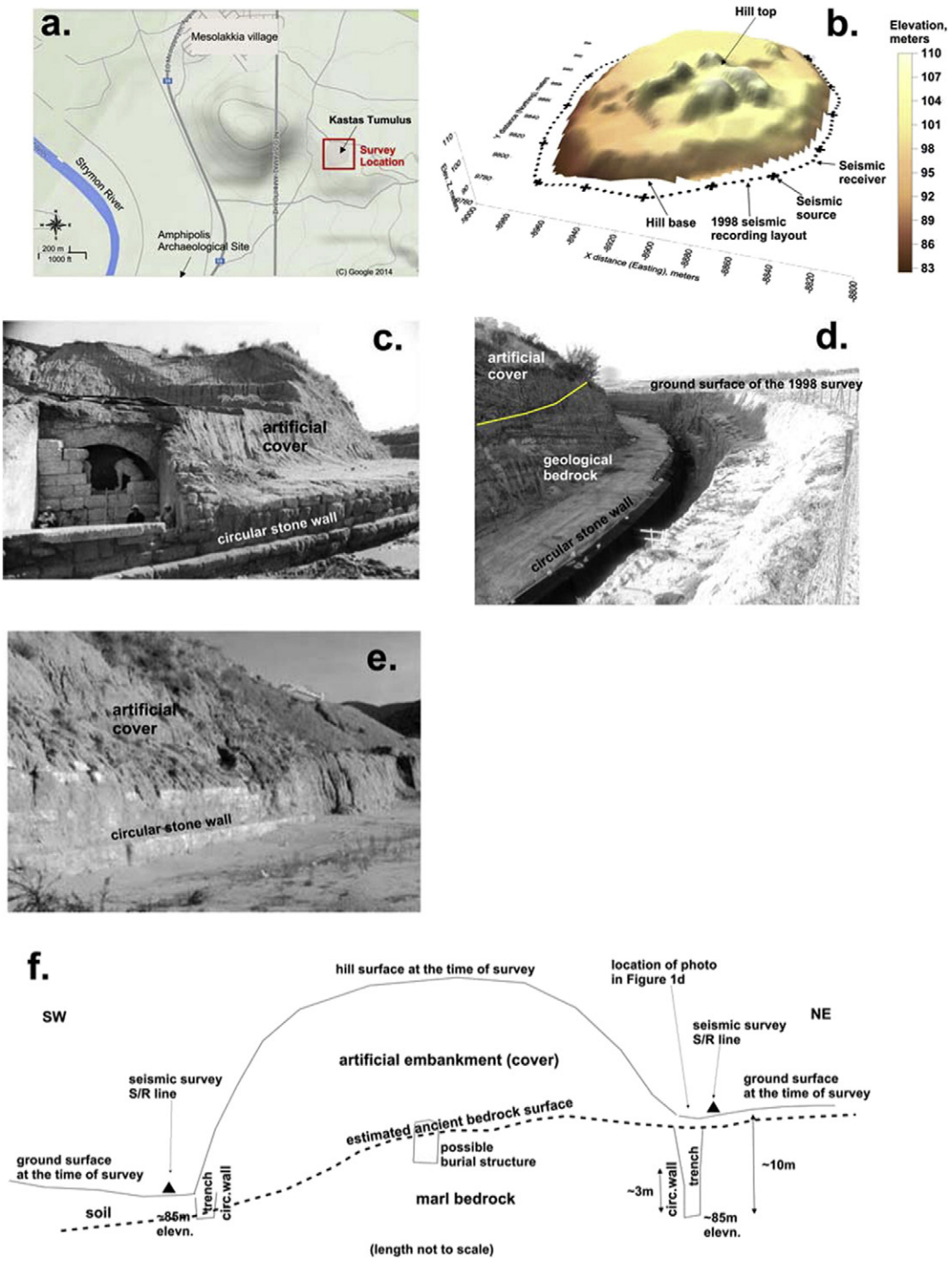

Fig. 1. (a) Map showing the location of Kastas tumulus (image source: maps.google.gr, 2014). (b) Surface map of the hill at the time of the seismic tomography survey (1998). The survey layout is also shown. (c) Photograph of the circular wall and entrance to the stone-lined soil-filled tunnel. View to north-northeast (photo source: Skepetzakis, 2014). (d) Photograph of the hill soil structure, from a cutting on the northeastern sector of the hill, showing the artificial cover material (top left) overlying the natural material (geological background) (center left). Also shown is the position of the circular wall buried under fill material (center-bottom) and the ground surface where the layout of the 1998 tomography survey was positioned (top right). View to northeast (photo taken by the first author, LP, in 2013). (e) Photograph of the hill soil structure, from a cutting on the southern sector of the hill, showing the artificial cover material extending through the height of the hill side. Also shown is the position of the circular wall buried under fill material (bottom left). Part of the ground surface where the layout of the 1998 tomography survey was positioned is shown in bottom left. View to east (photo taken by the first author, LP, in 2013). (f) Simplified cross-section of the tumulus showing an estimated internal morphology and geology. The position of seismic survey is shown. Compiled from site observations and excavation information. For details on the various features presented, see Section 1.

section of the Kastas tumulus, compiled from the above information, emphasizes the general structure of the artificial hill and its base with respect to the tomography survey layout (Fig. 1f).

Tumuli erected in the area of Northern Greece at the time of the Macedonian kingdoms (400–200 BC), known to the archeological community as 'Macedonian tumuli', are artificial burial mounds characterized by an evolution from simple burials covered by earth making up the mound, to more elaborated structures introducing built funeral chambers and walkways connecting the outer part of the mound to the chambers. They were constructed in three stages: (a) construction of the ground surface as a base for accommodating the funeral chambers whose top might be level with the surrounding