



Information Technology and a New Theory for the Verification of the Location of the Ancient City of Helike in Achaia, Greece

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Abstract. According to the historical literature, the ancient Helike was a city-state in Achaia, North Peloponnese, Greece, which disappeared completely after a strong earthquake in 373 BC. The verification of the exact location of ancient Helike remains one of the greatest mysteries of the science of Archeology, worldwide. Although the efforts to verify the location of the ancient city have increased during the last decades, the discoveries that have been identified to date are rather limited (both offshore and onshore), and nobody can claim that has verified the exact location of this ancient city.

Since the area of North Peloponnese is characterized by an irregular terrain, active seismic faults, and high seismicity, the present study aims to establish a new theory according to which the ancient city of Helike has been completely covered by the ground mass of a deep-seated earthquake-triggered landslide that took place during the strong earthquake of 373 BC. In order to establish this theory, apart from the historical data, all the available geodata (topographical, seismotectonic, geological, and geotechnical) for the specific area have been collected and evaluated on a Geographical Information System (GIS), while a preliminary geotechnical earthquake engineering study has been carried out which mainly includes numerical simulations of seismic slope instability.

Keywords: Ancient city Helike · Historical seismicity · Earthquake · Earthquake-triggered landslide · Active seismic fault · Geographical Information System

1 Introduction

The ancient Greek polis (i.e. city-state) Helike was located in Achaia, North Peloponnese, Greece, very close to the modern town of Aigion or Egion (see Fig. 1(a) and (b)). Since the area of North Peloponnese is characterized by high seismicity, the Helike was destroyed completely after a strong earthquake in 373 BC.

Nevertheless, a fact that is extremely remarkable is that, according to the historical literature [1, 2], the Helike was completely disappeared and all the inhabitants perished without a trace. Due to this “mysterious” complete disappearance of the city, the verification of the exact location of ancient Helike remains one of the greatest mysteries of the science of Archeology, worldwide.

After various simplistic theories in the 19th century and the 20th century, few decades ago researchers claimed that Helike had probably submerged into the sea, and therefore they tried to discover the ruins of the Helike on the seabed of the Gulf of Corinth. Judging from all the findings of their research, the effort was rather unsuccessful.

More recently, another group of archeologists and associate geoscientists [3, 4] developed a new theory according to which the location of Helike was not near the shore, but on a very flat area between the shore and the nearby hills. That group attributed the complete disappearance of the city to a hypothetical huge tsunami which destroyed and submerged the city. Based on this theory, various geophysical surveys and excavations have taken place. However, the discoveries that have been identified to date are rather limited, and nobody can claim that has verified the exact location of the ancient city.

The current study, based on some facts and evidences, is trying to establish a new more realistic and reasonable theory. Since the area of North Peloponnese is characterized by an irregular terrain (i.e. hills, mountains, rivers), active seismic faults, and high seismicity, the authors of the present study claim that the main part of the ancient city of Helike (including its fortification wall and the palace) was located on the slope of a hill, while only few structures/buildings of Helike were located on the seaport and/or the flat fertile area. Therefore, the city of Helike disappeared without any trace (i.e. ruins and victims) due to the fact that it has completely been covered by the ground mass of a deep-seated earthquake-triggered landslide that took place during (or just after) the strong earthquake of 373 BC. Additionally, it has to be emphasized that the ancient colony of Helike in south-east Spain (the town of Elche, close to Alicante) had been established around 600 BC (almost two centuries before the earthquake) and had a similar setting (i.e. located on a hill, close to a river, and a flat fertile area downstream).

In order to establish this theory, apart from the historical data, all the available geodata (topographical, seismotectonic, geological, and geotechnical) for the specific area have been collected and evaluated on a GIS platform, while a preliminary geotechnical earthquake engineering study has been carried out which mainly includes numerical simulations of seismic slope instability.



Fig. 1. Satellite views showing (in yellow circles): (a) Achaia, North Peloponnese, Greece, and (b) the area under investigation which is close to the town of Aegion and the village of Rodia.

2 Description of the Wider Area

As aforementioned, the area under examination is a hilly area between the villages of Rodia, Nikolaiika and Kato Pteri (see Figs. 2 and 3). Judging from the topography and the prevailing geological/geotechnical conditions, it is evident that a deep-seated landslide has taken place in the past. The whole area is near Kerinitis river, the peculiar shape of which indicates also the occurrence of an old landslide.

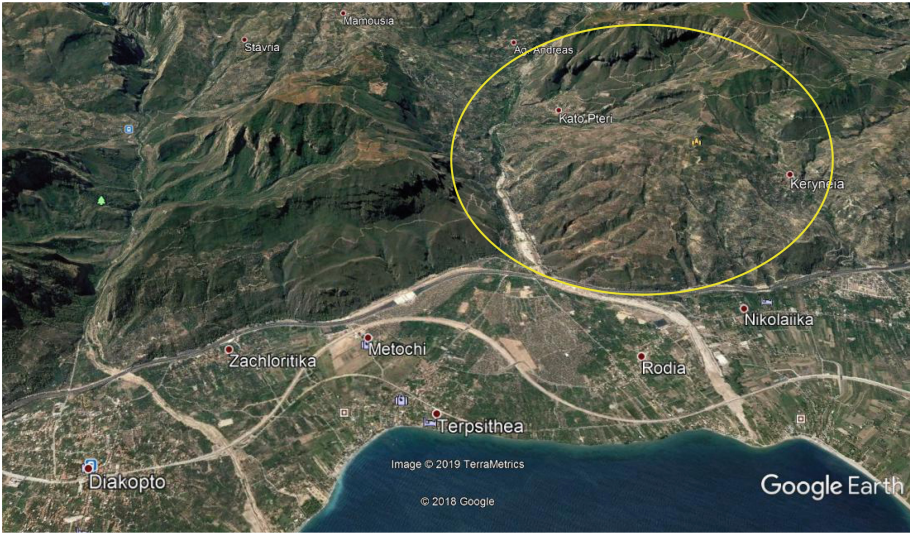


Fig. 2. A satellite view showing the area under investigation (in yellow circle).



Fig. 3. A view of the area under examination (in yellow circle).

3 Seismicity, Tectonics, and Slope Instabilities

As shown in Fig. 4, Greece is characterized by high seismicity. The Gulf of Corinth in Central Greece is actually a rift that has been studied extensively during the past decades, as it is one of the most seismically active regions in Europe. As it is shown in Fig. 5, it is characterized by normal faulting in an approximate WSW-ENE direction with an extension rate increasing from east (~ 6 mm/yr) to west (~ 14 mm/yr) [6]. The western part of the Gulf of Corinth has been the site of significant earthquakes in the past, the most recent being the M_s 6.2 earthquake which struck the town of Aigion in 1995. Figure 6 shows a schematic cross section through the Gulf of Corinth, where the Helike fault is also shown in the southern (left) part of the Gulf.

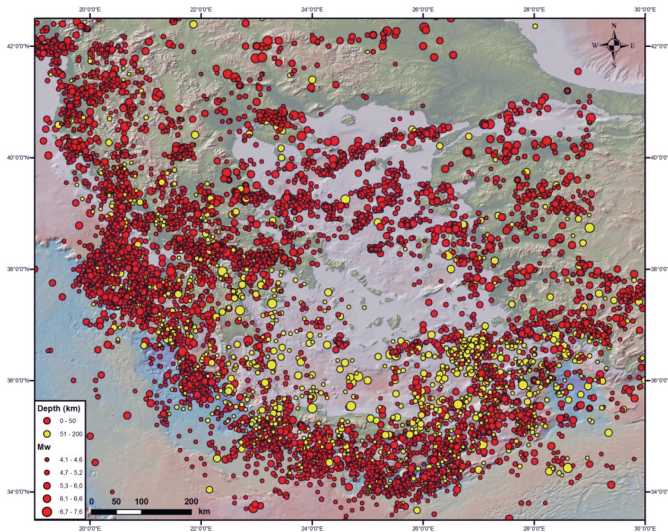


Fig. 4. Seismicity in Greece and adjacent areas between 1900 and 2009 (after [5]).

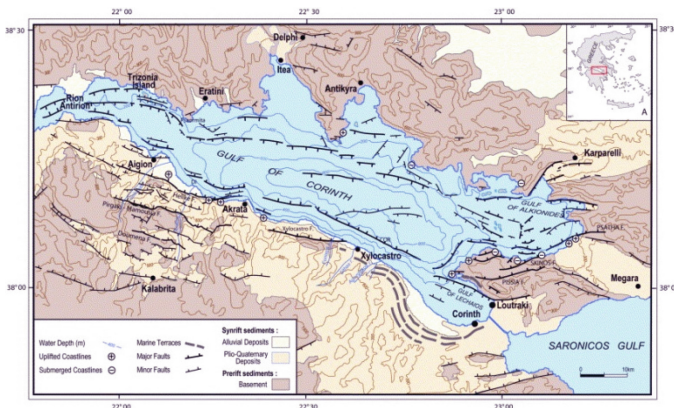


Fig. 5. Structural map of the Gulf of Corinth showing the active seismic faults (after [7]).

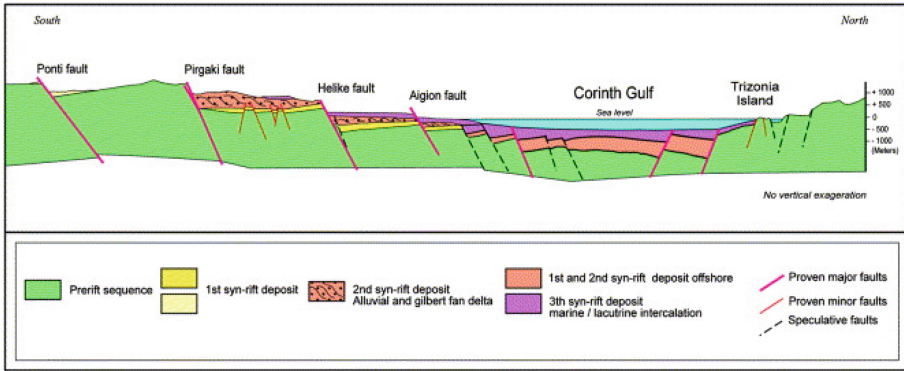


Fig. 6. Schematic cross section through the Gulf of Corinth (after [7]). The various faults of North Peloponnese (including the Helike fault) are evident.

The Gulf of Corinth is also characterized by slope instabilities and landslides, both onshore and offshore. As it is expected, many of them are triggered by earthquakes. Figure 7 shows a map with the landslide frequency at the Gulf of Corinth, referring exclusively to the onshore landslides. It becomes evident that the areas with the highest incidence of landslides are close to large and active fault zones and that the area under examination is a landslide-prone area with a moderate landslide frequency index and various slope instability phenomena. The direct relationship between slope instability and earthquakes can be found in [8], while more details regarding the slope instability of the area under examination can be found in [9].

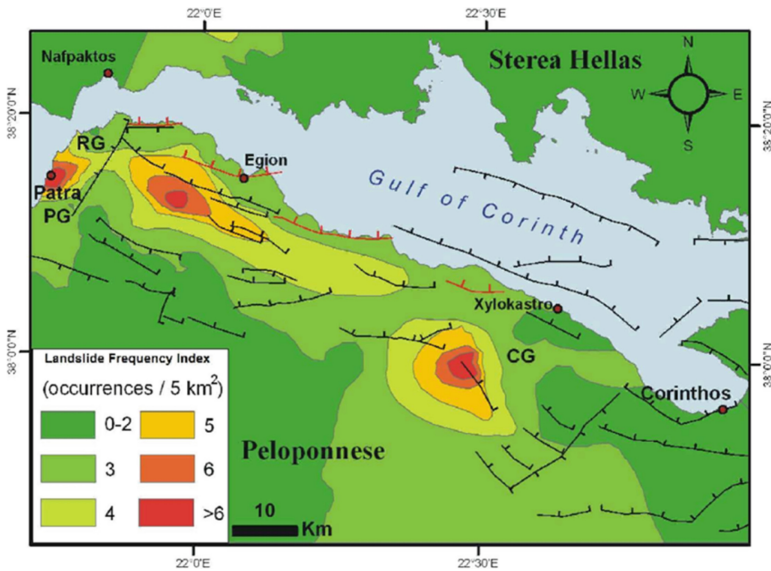
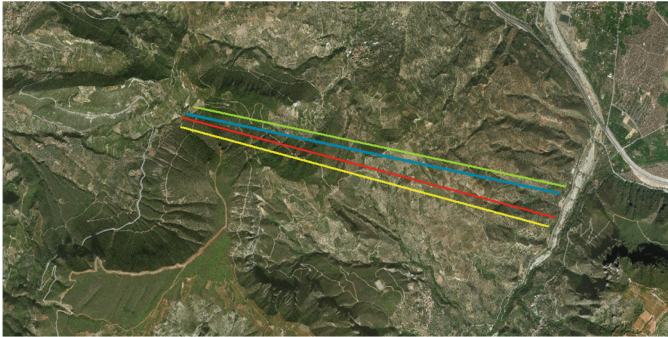


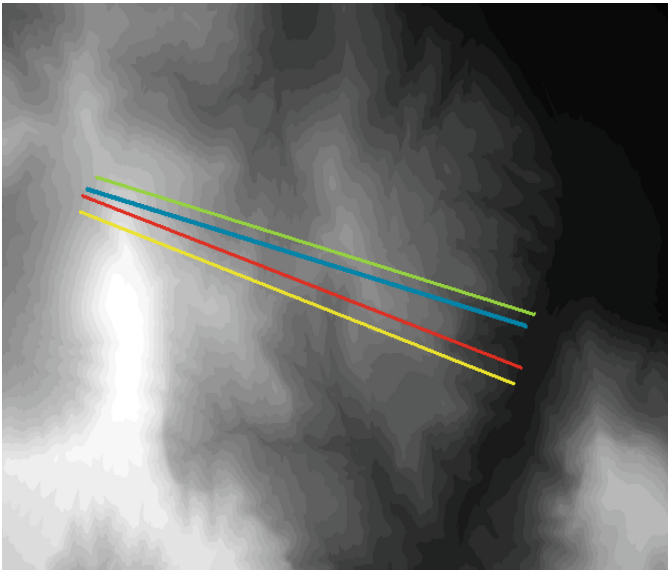
Fig. 7. Landslide frequency map at the Gulf of Corinth (after [9]).

4 Preliminary Analyses

As it was mentioned, in the current study a set of preliminary slope stability analyses have been performed in order to estimate (at least in a qualitative way) the landslide phenomena that have possibly taken place in the area under examination. Making assumptions regarding the initial topography of the slope, all analyses were actually



(a)



(b)

Fig. 8. (a) Satellite (plan) view of the area under examination. The colored lines show some of the examined cross sections. (b) Digital elevation model of the area under examination. The colored lines show some of the examined cross sections.

“back analyses” and they were based on the available seismological data and the (rather limited) geological/geotechnical data. More details can be found in [10]. Figure 8(a) and (b) show respectively the plan view and the digital elevation model of the area under examination on a GIS, while an indicative cross section is given in Fig. 9.

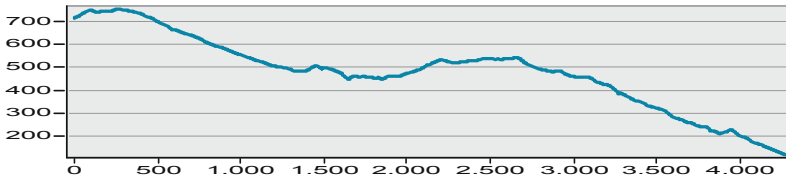


Fig. 9. An indicative cross section of the area under examination (at its current state).

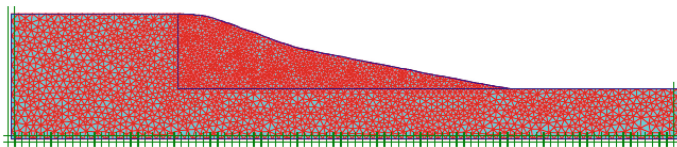


Fig. 10. The two-dimensional finite-element model for the numerical simulation of the hypothetical initial (i.e. before the landslide) slope.

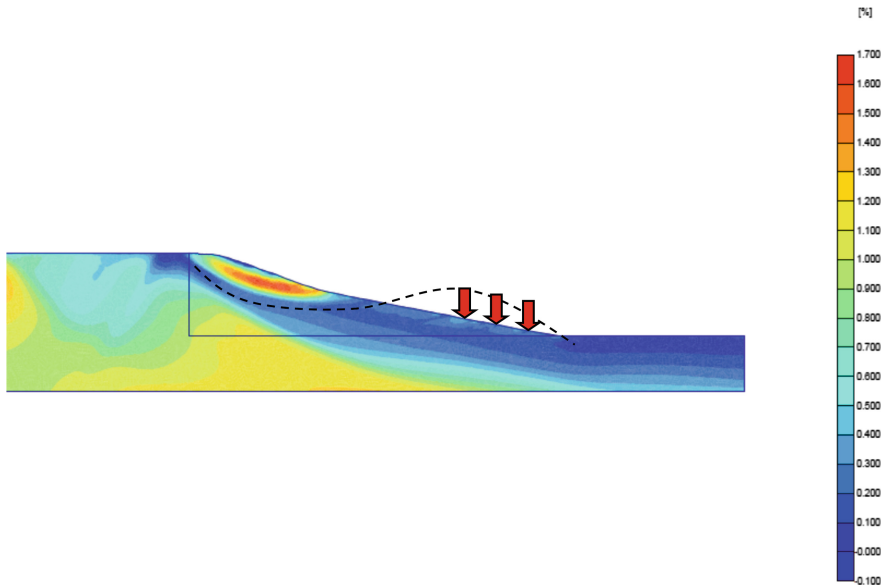


Fig. 11. Indicative numerical results (i.e. shear strains) of the examined initial slope. The dashed black line shows the estimated ground surface after the occurrence of the hypothetical landslide, a surface that roughly coincides with the current state of the slope (see Fig. 9). Red arrows show the probable locations of ruins of ancient Helike according to this new theory.

Figure 10 shows the two-dimensional finite-element model that has been developed for the numerical simulation of the instability of the hypothetical initial (i.e. before the landslide) slope. The simulations have been performed with the finite-element package PLAXIS2D. Figure 11 shows some indicative numerical results (in terms of shear strain) that demonstrate that the slope is definitely unstable under severe seismic conditions (despite its stability under static conditions). The huge ground mass that fails in Fig. 11 is in a very good agreement with the ground mass shown as a peak in Fig. 9 (around 2500 m away from the top of the hill).

5 Conclusions

Since the verification of the exact location of ancient city of Helike remains one of the greatest mysteries of the science of Archeology, the present study has established a new theory according to which the main part of Helike has been completely covered by the ground mass of a deep-seated earthquake-triggered landslide that took place during the strong earthquake of 373 BC. In order to establish this theory, apart from the historical data, all the available geodata (topographical, seismotectonic, geological, and geotechnical) for the specific area have been collected and evaluated on a GIS, while a preliminary geotechnical earthquake engineering study has been carried out which mainly includes numerical simulations of seismic slope instability.

It is evident that the verification of this new theory will be potentially performed in the future after the execution of various surveys, studies, and excavations.

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