

# ERT survey at the Roman Bath in Sagalassos (Turkey)

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**Abstract – Results related to ERT surveys at the archaeological site of Sagalassos (Turkey) were presented. Data analysis demonstrate the conservation state of the Roman Bath and suggest the restoration interventions.**

## I. INTRODUCTION

The archaeological site of Sagalassos is located in the southwestern Turkey, about 100 km north of Antalya, and 30 km from Burdur and Isparta (Fig. 1). The ancient ruins of Sagalassos are 7 km from Ağlasun on Mount Akdağ, in the Western Taurus mountains range, at an altitude of 1450–1700 metres. In Roman Imperial times, the town was known as the "first city of Pisidia", a region in the western Taurus mountains, currently known as the Turkish Lakes Region. Already during the Hellenistic period, it had been one of the major Pisidian towns.

Human settlement in the area goes back to 8000 BC, before the actual site was occupied. Hittite documents refer to a mountain site of Salawassa in the fourteenth century BC and the town spread during the Phrygian and Lydian cultures. Sagalassos was part of the region of Pisidia in the western part of the Taurus Mountains. During the Persian period, Pisidia became known for its warlike factions.

Sagalassos was one of the wealthiest cities in Pisidia when Alexander the Great conquered it in 333 BC on his way to Persia. It had a population of a few thousand. After Alexander's death, the region became part of territories of Antigonos Monophthalmus, possibly Lysimachus of Thrace, the Seleucids of Syria and the Attalids of Pergamon. Archeological record indicates that locals rapidly adopted Hellenic culture.

The Roman Empire absorbed Pisidia after the Attalids and it became part of the province of Asia. In 39 BC it was handed out to Galatian client king Amyntas, but after he was killed in 25 BC Rome turned Pisidia into the province of Galatia. Under the Roman Empire Sagalassos became the important urban center of Pisidia, particularly favoured by the Emperor Hadrian, who named it the "first city" of the province and the center of the imperial cult. Contemporary buildings have a fully Roman character.

Around 400 BC Sagalassos was fortified for defence. An earthquake devastated it in 518 and a plague circa 541-543 halved the local population. Arab raids threatened the

town around 640 and after another earthquake destroyed the town in the middle of the seventh century, the site was abandoned. The populace probably resettled in the valley. Excavations have found only signs of a fortified monastery—possibly a religious community, which was destroyed in the twelfth century. Sagalassos disappeared from the records.

In the following centuries, erosion covered the ruins of Sagalassos. It was not looted to a significant extent, possibly because of its location.

Explorer Paul Lucas, who was traveling in Turkey on a mission for the court of Louis XIV of France, visited the ruins in 1706. After 1824, when Francis Vyvyan Jago Arundell (1780–1846), the British chaplain at Izmir and an antiquary, visited the site and deciphered its name in inscriptions, Western travelers began to visit the ruins. Polish historian of art, count K. Lanckoroński produced the first map of Sagalassos. However, the city did not attract much archaeological attention until 1985, when an Anglo-Belgian team led by Stephen Mitchell began a major survey of the site (for more see [www.sagalassos.be](http://www.sagalassos.be)).

The researches carried out by the IBAM-CNR in the area of Roman Bath at the archaeological site of Sagalassos (Ağlasun -Turkey) have led to create an innovative system for the documentation, representation and preservation of archaeological contexts. The scientific rigour and precision of the traditional instrumental mapping together with the use of new technologies and geophysical methods have produced high- definition 3D models of the monument as tools to store and manage scientific information. For geophysical survey two physical parameters were measured, the electrical resistivity and self potential in order to obtain their distribution in a three-dimensional volume. The aim of geophysical survey was to obtain information about the roman bath structure stability.

## II. RESULTS AND DISCUSSION

With the aim investigate the integrity of the Roman Bath structure, the ERT survey was conducted in an area 78 m x 127 m (Fig. 1a). A Syscal kid switch with 24 active channels georesistivity-meter was used. The ErtLab software was used for 3D resistivity inversion [1] and a matlab code was used for 3D self potential inversion [2]. Fig. 1b shows the electrical resistivity model at six

different depths. It is possible to note a low resistivity zone (10-60 ohm m) probably linked to the presence of a flow of water coming from the north. Part of water flow is directed towards the thermal baths and it spreads within them. It is possible also to evidence the fault line that crosses the baths. The 3D images of electrical resistivity can easily be visualized by 3D contouring of iso-resistivity volumes (Fig. 1c).

In Fig. 1c, the  $\rho$  data set is displayed with iso- $\rho$  volumes using two threshold values ranging respectively from 1500 to 2000 ohm m and from 10 to 60 ohm m. This kind of visualization allows to emphasize both the bedrock variation depth (ranging from about 5m to about 12m in depth) and the water flow. In order to better understand the stability condition of Roman Bath the area 1 was subdivided in two sub areas labeled respectively zone 1 and zone 2 (Fig. 2a). Fig. 2b shows the electrical resistivity model at eight different depths. It is possible to note the probable ancient drainage system in the first slices (+9m) posed at about 3m in depth (referring to the current living surface). It is characterized by an high resistivity values ranging from about 4000 ohm m to about 5000 ohm m. These values suggest that the system empty and partially collapsed.

A low resistivity zone (10-60 ohm m) indicate probable water flow coming from the north. Due to the collapsed ancient drainage system the water path is random and therefore the water diffuses randomly along paths that for centuries was opened in the building. Other high resistivity zones (labelled "C") are visible on the roof.

These zones are probably related to a fractures system. It is possible also to evidence the fault line that crosses the baths.

In order to better understand the distribution of the water on the roof a vertical distributions of resistivity are shows in Fig. 2c. Fig. 2c shows the electrical resistivity model at four different vertical sections that crossing the Roman Bath structure. It is possible to note the probable ancient drainage system. It is characterized by an high resistivity values ranging from about 4000 ohm m to about 5000 ohm m. These values suggest that the system empty and partially collapsed.

A low resistivity zone (10-60 ohm m) indicate probable water distribution on the roof. Other high resistivity zones (labelled "C") are visible on the roof. These zones are probably related to a fractures system.

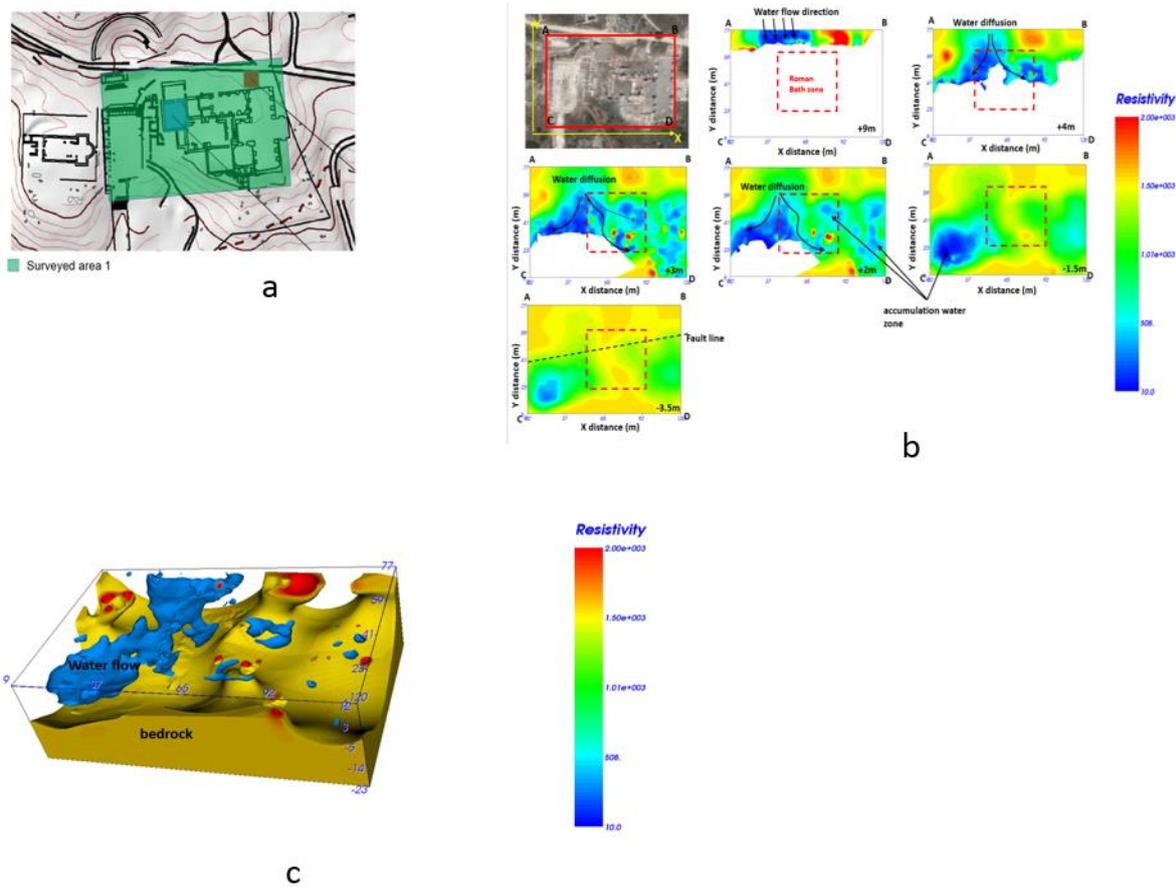


Fig. 1. a) ERT Profiles; b) 3D electrical resistivity distribution in the subsoil; c) 3D iso - resistivity volume

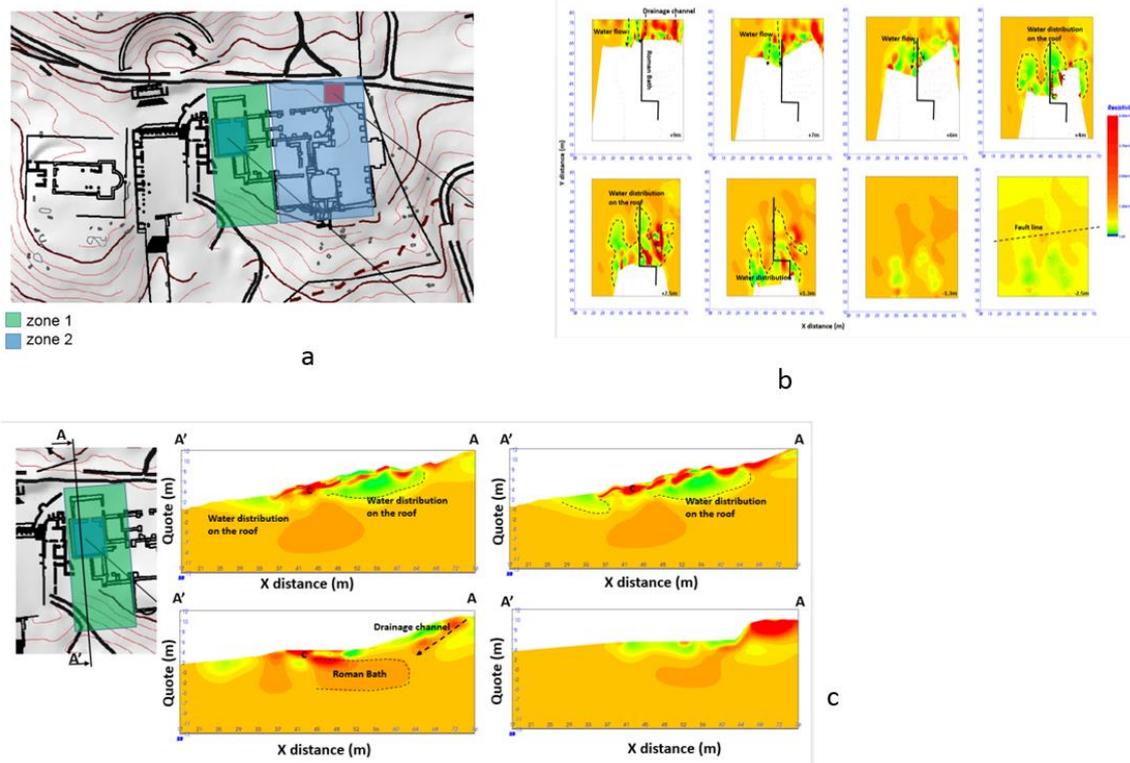


Fig. 1. a) ERT surveyed areas; b) 3D electrical resistivity distribution in the subsil; c) 3D electrical resistivity distribution crossing the roman bath

### III. CONCLUSIONS

The results of the archaeo-geophysical survey at the archaeological site of Sagalassos are presented in this paper. During the summer of 2015, a geoelectrical survey was conducted using Dipole-Dipole array in two areas.

In the area 1 results indicates the problematic that affect the structure of Roman Bath. First one there is an uncontrolled water flow from the north hits the wall structure of the baths. ERT results show zones on the vault where the water stagnates. In these zones, the stability analysis showed a probability of collapse that could occur within 2 years.

Given the low values of the self potentials, the water flow velocity is fairly reduced. The flow velocity likely increases during the rainy season thus increasing the danger of collapse. Another problem linked to the

presence of water is related to the formation of ice during the winter. In the zones of water stagnation, this phenomenon leads to an increase in the volume of water and consequently to an increase of the probability of collapse.

### REFERENCES

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