NEW GEOARCHAEOLOGICAL RESEARCHES AROUND THE DANUBIAN ISLAND *PĂCUIUL LUI SOARE*

Glicherie CARAIVAN*
Radu DIMITRIU*
Constantin CHERA*
Corneliu CERCHIA*

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Abstract: *The eroded ruins of a Byzantine fortress (10th-13th centuries) still endure on the Danubian island* Păcuiul lui Soare*, between 355 and 357 km. A seismo-acoustic survey carried out along the Danube in front of the island outlined the presence of the fortress' ruins under the river waters. The exposed fortress on the* Păcuiul lui Soare *island has a surface of about 7500 m², while the underwater fortress is four times larger (28750 m²).*

Rezumat: *Ruinele erodate ale unei cetăți bizantine (secolele X-XIII) încă mai rezistă pe insula dunăreană* Păcuiul lui Soare*, între km 355 și 357. Un studiu seismo- acustic efectuat de-a lungul Dunării, în fața insulei, a evidențiat prezența ruinelor cetății sub apele râului. Cetatea expusă de pe insula* Păcuiul lui Soare *are o suprafață de aproximativ 7500 m², în timp ce fortăreața de sub apă este de patru ori mai mare (28750 m²).*

Introduction

On the Danubian island Păcuiul lui Soare, (coordinates: NE - 44° 8' 05.48"N; 27°28'14.33"E and SW - 44° 7'44.65"N; 27°28' 02.60"E), the ruins of a Byzantine fortress from the 10th-13th centuries are still present, many of which have already been eroded by the Danube River (**Fig. 1**).

* Glicherie CARAIVAN, Radu DIMITRIU, Corneliu CERCHIA: National Institute of Marine Geology and Geo-ecology (GeoEcoMar), Constanta, Romania**:** bd. Mamaia no. 304, email: gcaraivan@geoecomar.ro; dimitriu@geoecomar.ro; corneliu.cechia@geoecomar.ro

Constantin CHERA: Museum of National History and Archeology Constanta, Ovidiu Square 12, email: anroed@hotmail.com.

Fig.1 - Location of the Byzantine fortress on *Păcuiul lui Soare* island. DigitalGlobe.

In the northeastern part of the island, hidden in a dense forest, the wall ruins of the old Byzantine fortress are present up to the island shore, suggesting their continuity under the Danube waters. The fortress was built between 972 – 976 years B.P., by the Emperor John Tzimiskes' troops and reflects the Byzantine strength in the Lower Danube.

Although no Roman archaeological level was identified up to date, it is assumed that the Byzantines built the fortress on the ruins of an older city, reusing the building material. They also put into practice a new technique, proving the competence and ability of the manufacturers.

Two methods were used to stabilize the walls' foundation on the non-consolidated alluvial substrate: (a) a deep foundation, which required a large effort or a wooden (oak beams) sub-construction and a large amount of stone as well, or (b) the wall foundation was made of burned oak stakes stuck in the ground at regular intervals, over which the manufacturers placed oak beams, both longitudinally and transversely. The empty spaces were filled with mortar (masonry) - a mixture of lime, gravel and grated/shredded stone. In the case of *Păcuiul lui Soare* Byzantine fortress, the latter approach was used.

Modern underwater remote sensing techniques introduce many advantages to the underwater archaeology, particularly to the detection of submerged man-made structures of archaeological interest. This work presents the preliminary results of a seismo-acoustic and magnetometric survey in the Danube River aiming to find the ruins of a Byzantine fortress on the riverbed.

Material and methods

In the fall of 1987, a sedimentological and seismo-acoustic survey was carried out by GeoEcoMar on the Romanian Danube route. The seismo-acoustic profiling was conducted using the ultrasonic survey method with continuous recording (vertical sonar). A high-frequency transmitter generates a sound wave that propagates through the water layer with a speed of about 1500 m/sec and reflects at the water/sediment interface, being received by a transducer (hydrophone), located in the same place with the transmitter. The pulse length generated by the transmitter has a magnitude order of milliseconds and the issue rate of 1 second. The bottom reflected signal was recorded on an electro-sensitive paper, obtaining a continuous profiling during the vessel's trackline. An Ocean Sonics vertical sonar ORS-219 with dry recording paper and working emission frequency of 8 KHz was used during this survey. The equipment was mounted on a tug of 600 hp, with a maximum draft of 1.80 m. The optimal considered speed of the research vessel was around 13 km/h. The vessel's route followed the river sailing line to the *Păcuiul lui Soare* island's proximity (**Fig. 2**). The position and navigation of the vessel were carried out using a DGPS system with an accuracy of less than 1 m.

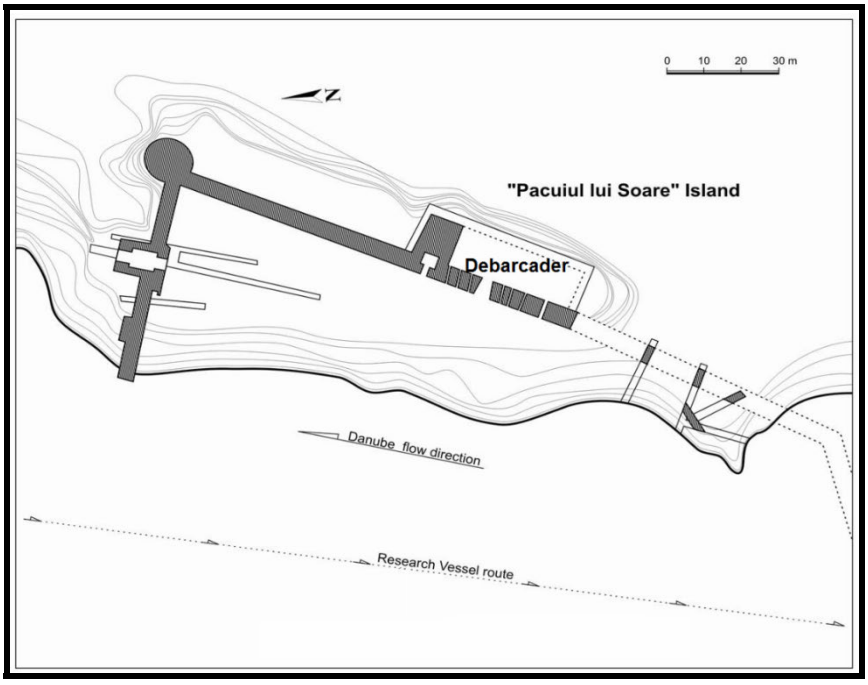

Fig. 2 - ***Păcuiul lui Soare*** **Fortress GPS position - 44° 7'56.13"N; 27°28'16.35"E.**

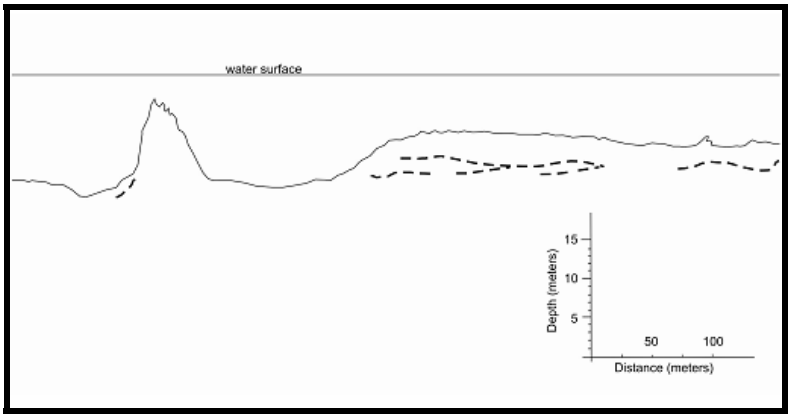

Fig. 3 - The NE - SW profile, between: NE - 44° 8' 05.48"N; 27°28'14.33"E and SW - 44° 7'44.65"N; 27°28' 02.60"E.

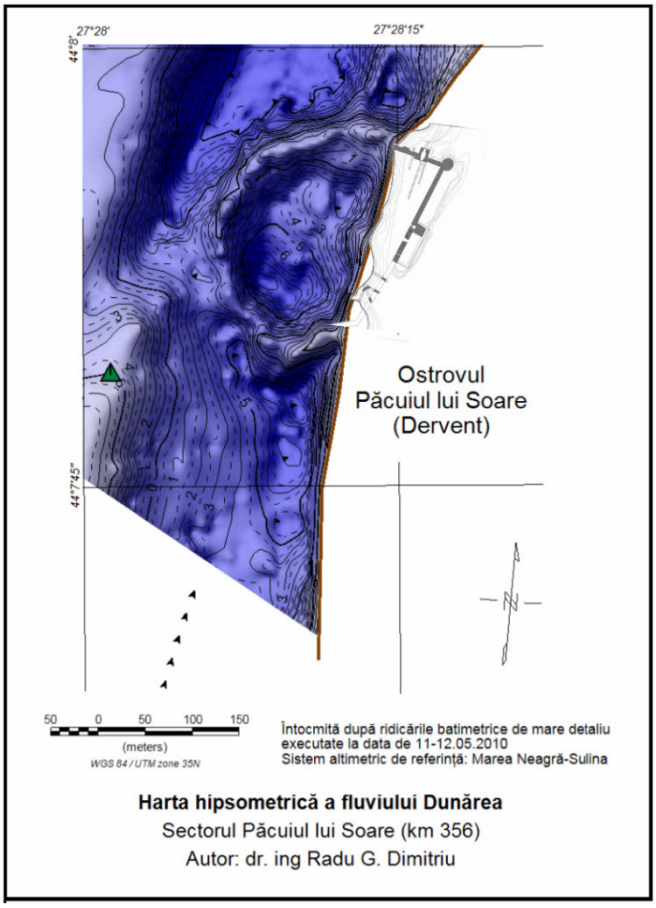

Fig. 4 - Hypsometric map of the Danube River in front of the island.

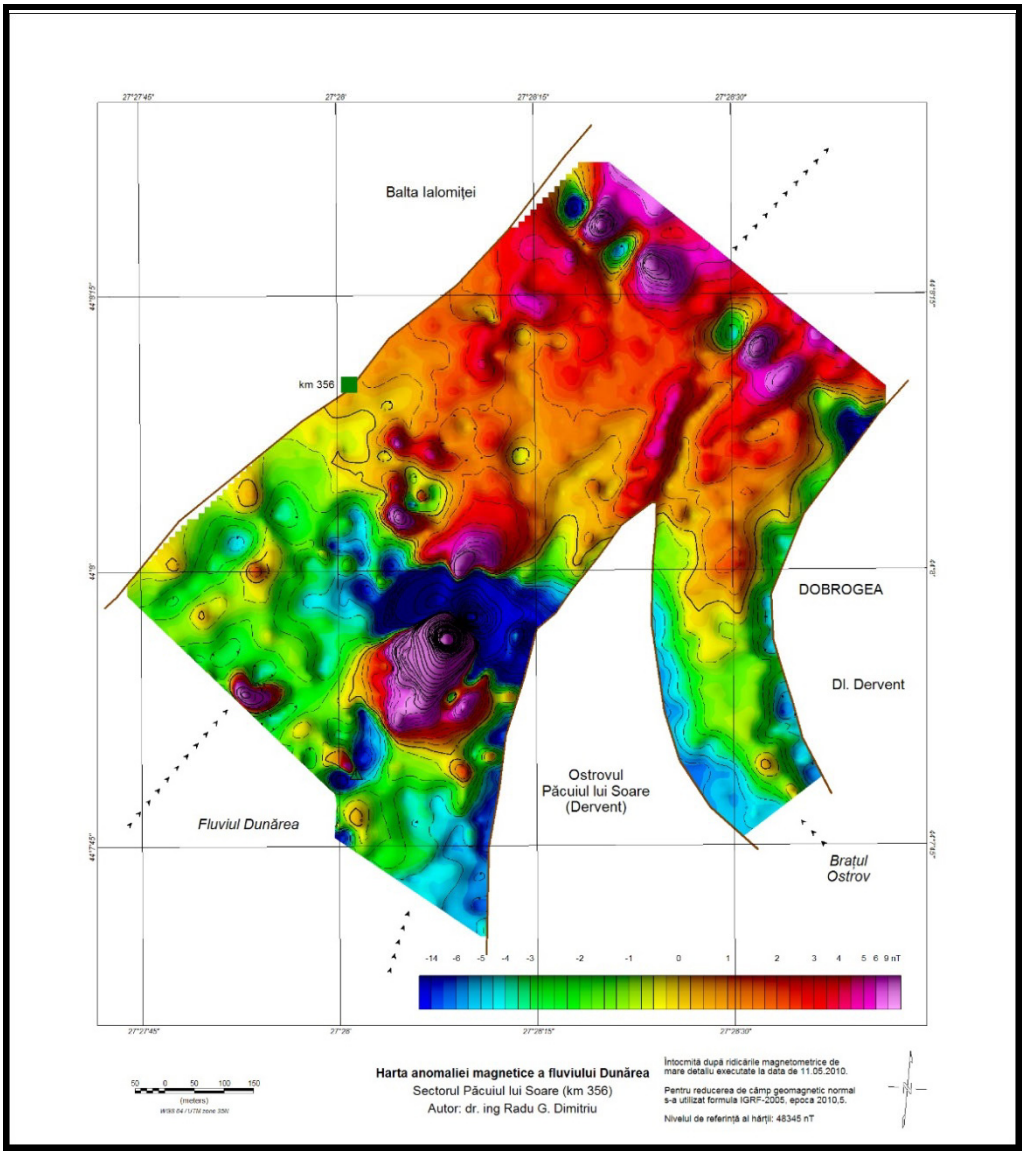

Fig. 5 - Magnetometric anomaly map in front of *Păcuiul lui Soare* Island.

Results and discussion

The longitudinal seismo-acoustic profile made in front of the fortress, showed an informative vertical picture of the Danube bed. A mound-like feature is obtained on the seismo-acoustic profile to the northern wall of the fortress. This feature appears as a sharp rise of the Danube bottom having a length of about 40 m and a height of 9 m compared to the surrounding riverbed. The minimum water depth of the river was only 4.5 m. This feature is developed on a bathymetric background of 14-15 m. The acoustic character of the seismo-acoustic

profile suggests the hard nature of the raised feature, compared with the usual "anti-dune" morpho-dynamic structures of the sedimentary bed (**Fig. 3**). The presence of the well-shaped depressions of the Danube bed downstream and upstream of the underwater raised feature illustrates the hydrodynamic conditions, induced by the fortress walls' undermining and flooding (**Fig. 3**). Upstream of the main bed lifting, some small positive ruin-shaped irregularities are found on the Danube bottom, with a height ranging from 1.00 to 1.50 m (see **Fig. 2** and **Fig. 3**). The seismo-acoustic profile also showed two sub-bottom discontinuous reflectors from 3 to 5 m below the riverbed, indicating the existence of different lithological characteristics lenses. The Byzantine fortress walls located on the island of *Păcuiul lui Soare* end sharply at the bank of the Danube, suggesting the underwater continuity of the ruins under the Danube River waters. The seismo-acoustic survey conducted on the Danube River near the *Păcuiul lui Soare* island brings an important geophysical argument supporting this hypothesis. The sub-bottom discontinuous reflectors identified on the seismo-acoustic profile could represent the wooden foundation on which the fortress walls were built. With the Danube flow regime changes, the left side of the island was subject to enhanced erosion, causing sub-digging of the foundation's structure. In 2003, when the Danube water was at very low levels, the wood beams network was clearly visible.

On the eastern right bank of the *Păcuiul lui Soare* island, where a narrow branch separates the island from the Dobrogean land, the erosion was less destructive. Therefore, the structures were preserved in good condition (for example, the wharf, and see **Fig. 2**).

Magnetometric and bathymetric studies

A short but dismissive geophysical mapping of the site was also carried out in May 10-12, 2010, during the cruise along the Danube River of the R/V "Istros", operated by GeoEcoMar Institute. The geophysical research covered a 1.2 km long section of the river and the last 0.6 km of the Ostrov secondary arm. It consisted of synchronous single-beam, dual frequency bathymetry and high resolution magnetometry. The total length of the geophysical lines was around 53 km for the bathymetry and 23 km for magnetometry.

The bathymetric map (**Fig. 4**) gives a detailed view of the riverbed and undoubtedly highlights the submerged extension of the byzantine fortress on a wide, semicircular surface (250 m length along the river and 180 m off the *Păcuiul lui Soare* island). The height of the submerged fortress walls, highlighted by bathymetry, is ranging from 2 m to over 8 m above the riverbed (**Fig. 4**).

The exposed fortress on the *Păcuiul lui Soare* island has a surface of about 7500 m^2, while the submerged fortress is four times larger (28750 m^2).

Despite the huge magnetic bipolar anomaly due to a modern (recent) river shipwreck, which lies on the northern foothill (flank, side) of the fortress wall, at over 12 m water depth, the total field magnetic mapping was able to positively distinguish most of the submerged walls. This is probably due to the presence of fired bricks and/or allochthonous raw construction materials, with above average magnetic properties, within the walls' structure (**Fig. 5**).

Conclusion

The previous underwater seismo-acoustic survey carried out in front of the *Păcuiul lui Soare* island fortress and the recently made bathymetric and magnetometric researches provide strong arguments that the remnants of the city extend in the Danube River.

Therefore, further geo-archaeological research is required in the studied area, through a comprehensive interdisciplinary program, involving sedimentological and geophysical studies, in conjunction with direct observations, specific to underwater archaeology. The proposed survey will lead to a better understanding of the history of the city as well as the sedimentary-hydrodynamic evolution of the island.

BIBLIOGRAPHY

BARNEA & STEFĂNESCU 1971 - I. Barnea & St. Stefănescu, *The history of Dobrogea.* Vol.III. *Byzantines, Romans and Bulgarians at the Lower Danube*, Bucharest, 1971.

PANIN *et al*. 1977 - N. Panin, G. Salomie & V. Varodin, *Bathymetrical research on the Black Sea continental shelf*, St.cerc.geol. - Geofizica 15 (1977), p.57-73.

CARAIVAN & ENESCU (1988) - Gl. Caraivan & G. Enescu, *Observații seismoacustice în zona "Păcuiul lui Soare"*, Pontica 22 (1988), p.85-87.

CARAIVAN, FULGA & CHERA 2010- Gl. Caraivan, C. Fulga & C. Chera, *Underwater geoarchaeological survey in front of the Danubian island Păcuiul lui Soare (Romania) using remote sensing techniques – preliminary results.* Proceedings of the 19th CBGA Congress, Thessaloniki, Greece, 2010, p.519-524.