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Integrated geophysical surveys for the knowledge of the amphitheatre in Rudiae (Lecce, Italy)

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***Abstract* – The ancient city of Rudiae is one of the largest Messapian settlements of Salento. It was inhabited from the 8th cent. BC until at least the 6th-5th cent. AD, with a very important phase between the late 6th to the 3rd cent. BC. At the beginning of 2nd cent. AD dates back the amphitheatre, recently excavated. Here different methods of geophysical prospecting (GPR, Magnetometry, ERT) are performed. The anomalies highlighted by the integrated geophysical approach have been verified and confirmed by subsequent archaeological excavations. In particular, the anomalies are ascribed to archaeological remains regarding the north-western aditus, the floor of the arena, and some streets and structures to the north and east of the building.**

I. INTRODUCTION

The ancient city of Rudiae, located approx. 2 km south-west of the historic centre of Lecce and known from literary sources for having given birth to the poet Quinto Ennio (239-169 BC), it is one of the largest Messapian settlements (ca. 100 hectares) of Salento [1,2,3]. The town developed from the Iron age (8th cent. BC) until at least the late Antiquity (6th-5th cent. AD). It had great importance from the late 6th to the 3rd cent. BC, as attested by the findings of the necropolis. At the beginning of the 4th cent. BC, probably the moment of maximum expansion of the city, dates back the construction of the city walls, which develops for a length of approx. 4 km. The walls are built using the opus quadratum technique, with double curtain of square blocks and filling in limestone pieces; however, in the western section of the city walls, excavation works have also highlighted a structure consisting of a single solid masonry in parallelepiped blocks placed alternately with the longer side (stretchers) or the shorter side (headers). The city walls that define the settlement of the Messapian age is still clearly visible for long stretches, except on the southern side. It is consistent with the morphology of the terrain, with semi-circular defensive towers and bayonet shaped stretches at the probable accesses to the city.

After the Roman conquest of Salento, in the first half of the 3rd cent. BC, Rudiae, which probably became a municipality after the Social War with the inscription to the Fabia tribe, still maintained a certain prosperity throughout the late Republican age, as documented by a series of structures and buildings (a place of worship, a portico perhaps pertinent to a public building, a paved street and hydraulic structures connected to the so called Nymphaeum) brought to light by excavations in the "Fondo Acchiatura".

In Roman times, Rudiae gradually lost importance in favour of the nearby Lupiae (Lecce), which developed especially from the Augustan age, when a program of monumentalisation of the city was started. In the same period Rudiae seems to suffer a contraction, with a concentration of the urban area in the central-eastern sector of the ancient city, where recent archaeological excavations conducted by the University of Salento and the company A.R.Va. s.r.l, spin-off of the same University, have brought to light the remains of an amphitheatre dated to the beginning of the 2nd cent. AD, built using a natural depression already used in the Messapian era (4th-3rd cent. BC) as a cistern (a lacus connected to a system of canalizations).

The building (85 x 70 m, with a major axis oriented in a north-west/south-east direction) had an arena of 50 x 35 m; the cavea, resting on the rock bench worked for the positioning of the seats, was 17.30 m thick and could accommodate almost 8,000 spectators. It is therefore a building with a "full structure", with the cavea divided into twenty wedges, ten on each side, separated by the radial corridors (vomitoria) at the summa cavea and by ladders, obtained in the thickness of the seats, in the ima cavea.

The building has the perimeter walls (those of the podium around the arena and the two aditus placed at the ends of the major axis) made of limestone blocks, coming from the nearby quarries. The entrance to the arena took place, in addition to the two aditus, also from two corridors at the medium axis, the only ones that reached the wall of the podium; these were probably accessible only to service personnel or ferocious animals during venationes. After a few centuries of use, the spoliation of the building began between the 4th and 5th cent. AD, when many blocks were reused for the construction of different structures.

As part of the interventions that concerned the amphitheatre, the CNR carried out geophysical prospecting campaigns through the integration of different

investigation techniques: Ground Penetrating Radar (GPR), Magnetometry and Electrical Resistivity Tomography (ERT). These measurements made it possible to document the presence of buried ancient structures and the situation of the first substrate, up to approx. 10 m deep.

II. GEOPHYSICAL MEASUREMENTS AND RESULTS

The geophysical investigations conducted at the amphitheater of Rudiae by the Geophysics Lab and the Archaeological Mapping Lab of the Institute for Heritage Science of the CNR have allowed to document the first levels of the rocky bank, the presence of anomalies attributable to ancient buried structures and the thickness of the soil layers that covered them. The results were subsequently verified by archaeological excavations (Fig. 1), which in part were directed precisely by the interpretation of the anomalies documented during the geophysical surveys.

The GPR measurements have been performed with an IDS Ris Hi-mode system equipped with the dual band antenna at a nominal central frequency of 200-600 MHz. A grid of 0.25 m spaced profiles was performed in three areas (a total of 500 sqm): area A corresponds to a sector of the arena, while areas B-C correspond to the NW aditus. Each B-scan has a time window of 80 ns (600 MHz antenna) and 120 ns (200 MHz antenna), discretized using 512 samples. The processing of the GPR data consisted of zero timing, background removal, declipping, Kirchoff migration and bandpass filter. This processing was implemented by means of the GPRSlice code [4]. An average electromagnetic (EM)-wave velocity equal to 0.085 m/ns has been evaluated from the shape of the diffraction hyperbolas. Afterward, horizontal depth-time slices were obtained using the processed data. Each slice was retrieved by averaging data within a time window $\Delta t = 5$ ns, which corresponds to a soil thickness of about 20 cm.

Fig. 1. Aerial photo of the amphitheatre of Rudiae after archaeological excavations; A, crop marks referable to buried structures.

The electromagnetic characteristics of the materials present in the subsoil have influenced the maximum depth of investigation which was found to be approx. 2.5 m for the 600 MHz antenna and about 4.9 m for the 200 MHz one. Among the most interesting results is the detection of anomalies attributable to remains of the north-western aditus in areas B-C, referable both to structures of the side walls and to their collapse (Fig. 2, no. 1). The remains of the aditus appear documented from 25 cm up to a depth of ab
out 3 m, while the rocky bank is clearly visible, in area C, at a depth of about 3.5 m. To the north-east of this group of anomalies there is another one (Fig. 2, no. 2) that could be referred to a wall: it is not clear whether it is pertinent to the cavea of the amphitheatre or is a pre-existing straight structure, similar to those brought to light along the eastern side of the cavea. This anomaly is visible up to 1.5 m deep.

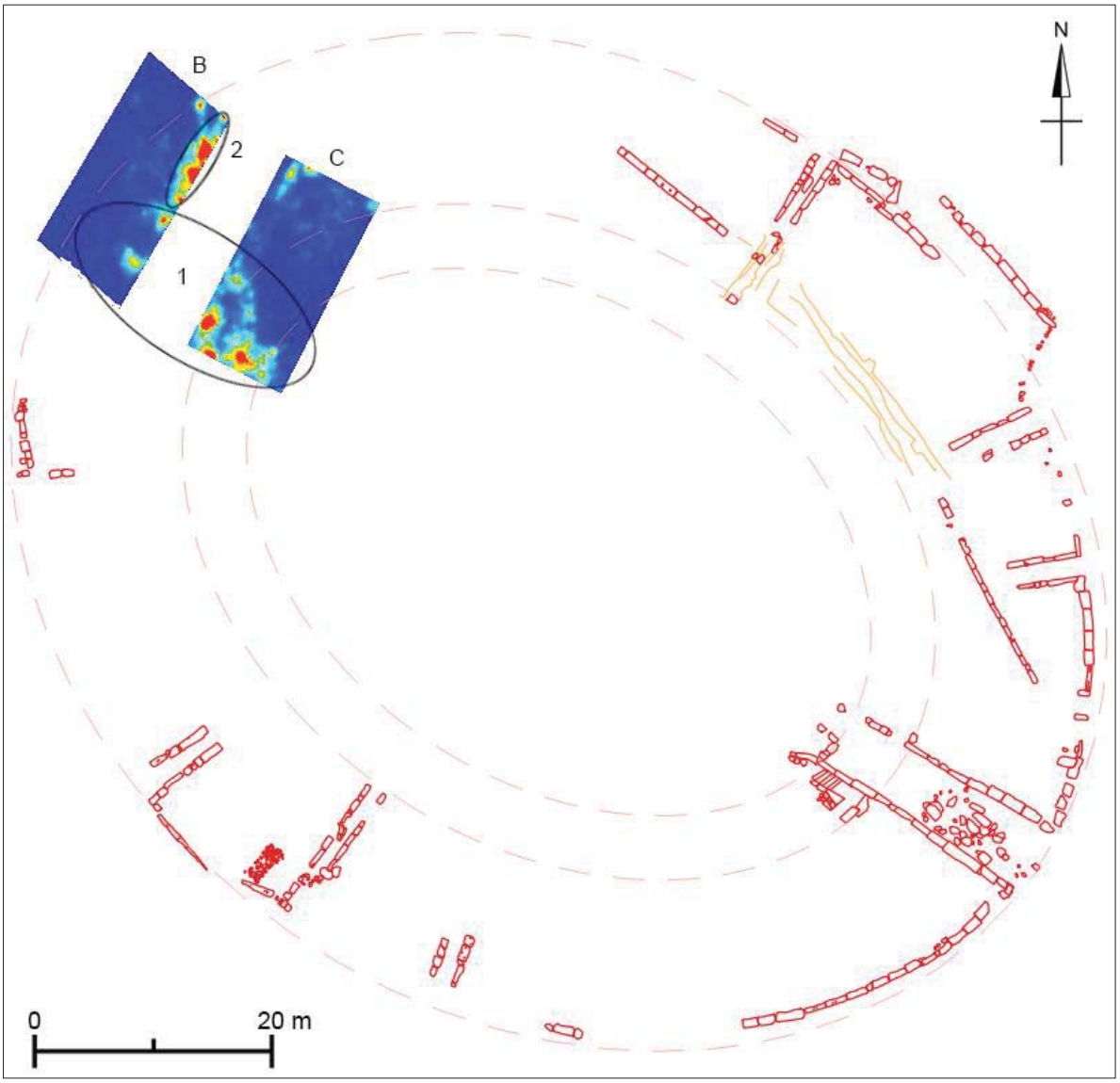

Fig. 2. Aree B-C: time slices at a depth of 88-103 cm (600 MHz antenna).

Geomagnetic investigations used the Gradiometer Bartington 601, equipped with 4 fluxgate sensors that allow to acquire the magnetic gradient simultaneously on two lines spaced of 1 m. Six areas (A-F) were investigated, for a total surface of 1,500 sqm, two of which (B and F) correspond to the area of the north-western aditus. In particular, in area F two anomalies are visible (Fig. 3, no. 1) perhaps relative to the side walls of the aditus and to the limits of the access road, while little more to the north-east two other anomalies are noticed (Fig. 3, no. 2) that could refer to a structure near the amphitheatre. In the other investigated areas, immediately to the north and east of the building were identified anomalies related to road axes, partly brought to light by excavations, and wall structures that document the urban layout affecting the area surrounding the monumental complex; this is also shown by evident crop marks shown by some recent aerial photos in the area immediately in the north-west of the amphitheatre, and referred precisely to the buried remains of buildings (even with courtyards) and stretches of ancient roads (Fig. 1, A).

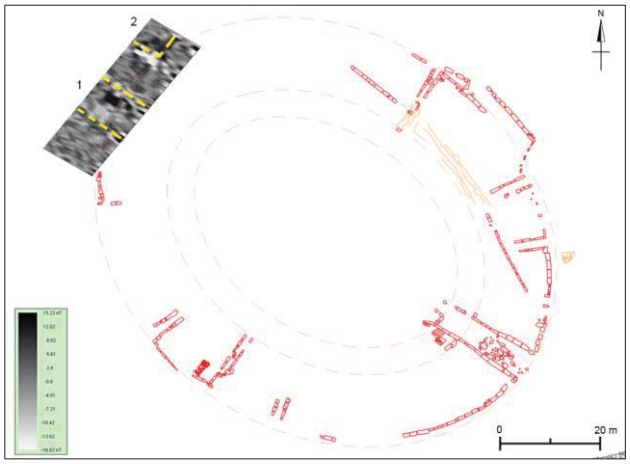

Fig. 3. Magnetometry results in area F, with data interpretation in yellow.

Geo-electric data were collected using a Syscal kid swich device (IRIS Instruments) supporting 24 electrodes with two reels of 55-m-long connecting cable with 5-m maximum separation between electrodes. In order to investigate the whole area of the amphitheatre special ERT arrays were used [5,6,7,8]. A dipole-dipole axial array was used. A total of 9 profiles were measured. The instrument has been used both in active mode, for the acquisition of the physical parameter electrical resistivity, and in passive mode, for the acquisition of the spontaneous potential physical parameter.

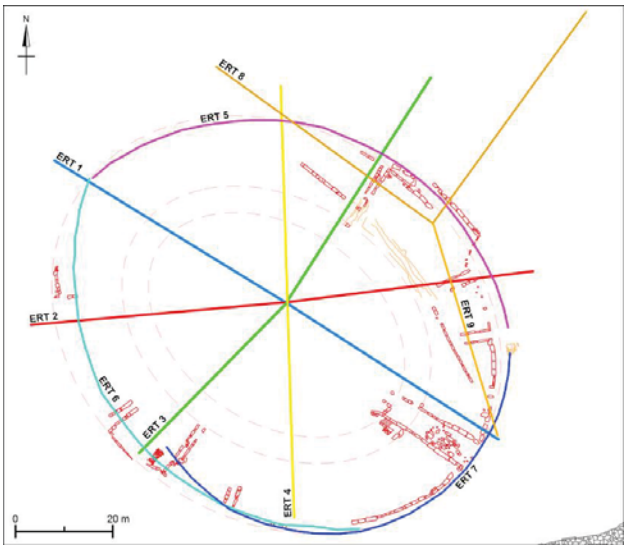

Fig. 4. Location of ERT profiles.

The four ERT profiles measured inside the amphitheatre showed, as can be seen from the 2D models of resistivity distribution (Fig. 5), the presence of a heterogeneous subsoil with resistivity values between 20 and 10000 ohm m. In particular, it is noted that the rocky bank has resistivity values between 700 and 1000 ohm m and its top is placed at depths up to 3.5 and 4.0 m (black dotted line). In correspondence of the arena it is evidenced therefore a covering of debris materials that reaches even 3.5-4.0 m of thickness, while in correspondence of the cavea the 2D models evidence anomalies of resistivity (A) with values between 200 and 10000 ohm m, to document how the rocky bank rises progressively towards the plain of the countryside.

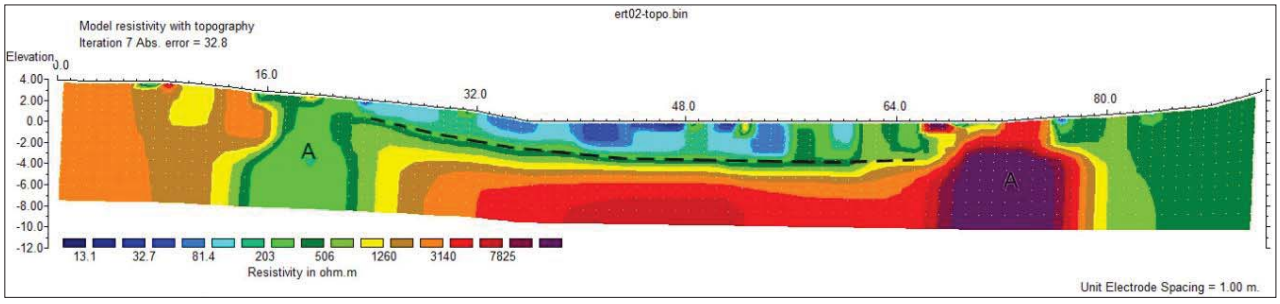

Fig. 5. 2D model of distribution of the physical parameter of electrical resistivity (ERT2).

III. CONCLUSIONS

In this paper, the results of geophysical prospecting performed in the area of the amphitheatre of Rudiae using different methods (GPR, Magnetometry, ERT) are presented. This approach revealed the effectiveness of the integrated methods to identify a series of anomalies that could be ascribed to archaeological remains. In particular, the remains of the north-western aditus, the floor of the arena, and some streets and structures to the north and east of the building have been documented. The results of the investigations, confirmed by subsequent archaeological excavations, have also been georeferenced in the archaeological map of the area through a DGPS survey.

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