ARCHAEOLOGICAL SURVEY AT THE LUGO ROMAN WALL USING GPR (Galicia, NW Spain)

Casas A., Lázaro R., Vilas M., Rivero L. and Pinto V.

Dpt. Geoquímica, Petrologia i Prospecció Geològica

University of Barcelona (Spain)

C/ Martí i Franques s/n 08071-Barcelona

1. - INTRODUCTION

Commissioned by the Spanish Authority of Culture a geophysical survey using GPR has been carried out in the Roman City Wall of Lugo (Spain). The purpose was the inspection of the City Wall and surrounding areas with the aim of detecting hidden structures of the original building. The starting point of this project was the detection of two double-branch steps during consolidation works in one tower of the City Wall. Besides, historical notes informed us about the presence of other steps unearthed after collapses near the Obispo Aguirre gate. This facts, together with the achievement of the 'Plan Integral de Conservación y Restauración de la Muralla de Lugo' (Integral Plan for the Maintenance and Restoration of the Roman City Wall of Lugo) lead to undertake the placement of new hidden steps and whichever original structure of the building, by means of non-destructive techniques.

Some longitudinal and transverse profiles were recorded at the upper ring road, as well as inside and outside the base. The existence of some structures related to the construction of the City Wall were recognised: double access steps to the round turrets, galleries, ramps, inner walls inside later towers, and fillings at the top of reconstructed towers. Further excavations have found eight new steps and one inner wall at the indicated locations. Archaeological and conservative works are still in progress.

Geophysical data have been useful to the restoration studies. Through these surveys, the efficacy of the GPR for the detection and placing of archaeological sites by non-destructive testing has been proved. Difficulties in the interpretation of the profiles because of the complex archaeological environment have been avoided by using an adequate data handling process.

2. - THE ROMAN CITY WALL OF LUGO

The city of Lugo (Lucus Augusti), was founded in 14-13 BC. During the second half of the III century, the construction of the City Wall with a defensive ditch started.

The City Wall consists of a 2200-m perimeter body with trapezoid section and a width, at the upper ring road, between 3.30 and 5 m (Figure 1). Height ranges between 8 and 12 m depending on topography changes. Eighty-five round turrets were built in order to reinforce the defence, remaining at the moment only eighty, complete or truncated.

Some of the towers were built contemporaneously with the City Wall, and the rest were added later to increase the protection in defenceless areas. The masonry of the City Wall is compound by a framework of shale rough stones, lime, sand and rubble, called 'opus caementicium'. Inside and outside is covered by panes of tabular shale and granite broadstones reused from other buildings.

The accesses to the upper ring road by the original steps were perpendicularly included in the City Wall, following the fleche axis (perpendicular line to the City Wall in the centre of the tower). The steps have a frontal flight of some steps, and then they diverge into two symmetric opposite sections, parallel to the ring road. From the ground to the first steps, probably there were wooden ladders (Figure 2). Nowadays, there are not remains in the framework of the excavations. Access to the old city is through ten gates (4 of roman origin and 6 latest, built until 1921), and access to the ring road is by means of five new steps and one ramp.

3. - METHODS

The survey was carried out with a pulse EKKO IV instrument from Sensors and Software, Inc provided with a set of biestatic antennas. Centre frequencies used were 50 and 100 MHz, with transmitters of 400 and 1000 V.

A total of 4027 m profiles were taken in several directions in relation to the ring road, and inside and outside the base of the wall in order to find archaeological remains (especially roman steps and sewers):

Longitudinal profiles in the ring road, with 50 and 100 MHz antennas. The purpose was to detect anomalies of different scale and depth: 100 MHz for the smallest and shallowest (like double access steps to the towers), and 50 MHz for deeper and greater structures, as galleries and gates.

Transversal profiles in the ring road, in order to give a third dimension of some local anomalies and in the fleche of the towers, with the aim of detecting galleries and inner walls.

External profiles: These profiles have been recorded with the aim to recognise the basal structure and foundation. Measured close to the wall at a distance of 1 m, and over the external sidewalk that is tangential to the towers. Data obtained in those profiles were correlated with borehole drilled in the prospected area.

4. - RESULTS

The general structure of the City Wall, with a heterogeneous infill of slaty rock, sand and lime mortar, brings about several irregular reflections in the basis level. For this reason, some test profiles with different frequencies were measured, in order to determine the characteristics of signal caused by known objects and to have a set of patterns. Correlating radargrams with mechanical drillings identified the basement of the City Wall. From the interpretation of GPR data some structures were recognised:

- Steps: Excavations in five towers discovered the presence of double access steps. A test over one section of the ring road with possible presence of such step showed that 100 MHz is the appropriate frequency to detect these anomalies. The signal found agrees with theoretic calculated models for similar structures at different scale. Anomaly generated is V-shaped with a hyperbolic signal appearing under the apex as the slope increases (Figures 3 – 4).

- Inner walls: In order to make a test over known remains, our team had access to a building site over an old convent pulled down. The foundation remained intact and could be observed in some places. The same anomaly could be seen in a tower where the existence of this separation wall is known (Figure 5): a set of intense multiples under the unearthed wall. On the opposite, original towers do not show this pattern of anomaly because they were built contemporary with the City Wall. We found walls in seven towers.

- Galleries and blocked up gates: During the survey, a team of archaeologists found an artificial gallery under a building site near Puerta Miñá: a sewer of roman origin. In order to test the capabilities of detecting this type of structures, a short profile with 100 MHz antennas was taken under the gate, locating its position close to a present-day sewer. Several profiles located inside and outside of the City Wall, and in the Diputación of Lugo garden. The profile showed two different layers separated by an intense reflector, delimiting the separation between the surface infill from substratum. A hyperbolic signal of small amplitude appeared in the bottom level. This anomaly did not affect the above continuous reflector, and was identified as roman sewer.

- Ramps: Long continuos dipping reflectors have been observed in some longitudinal profiles. We interpret these reflections as access ramps used during the building of the City Wall. This hypothesis is supported by analogy with similar structures seen in the remains of the Roman Wall of Girona. These layers cannot be seen on the 50 MHz profiles because of the lower resolution power of this frequency.

- Basement of the City Wall: Three levels with different response have been detected over the ring road in the 50 MHz profiles: body of the wall, sand-clay basement and bedrock.

- Recent structures: Several anomalies related to anthropogenic causes have been detected during the survey (ancient collapses later rebuild of some towers and unauthorised disposals).

5. - CONCLUSIONS

Using GPR the existence of some structures tied up to the construction of the City Wall have been recognised: double access steps to the round turrets, roman galleries, ramps, inner walls inside later towers and fillings at the top of reconstructed towers. Further excavations have found eight new steps and one inner wall at the places indicated by the geophysical survey.

Figure 1. Map of Lugo Roman Wall

Figure 2. Scheme of the double-branch steps

Figure 3. Radargram of a step

Figure 4. Photograph of a discovered step

Figure 5. Radargram of a tower with inner wall

Figure 6. Radargram of a roman sewer