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THE IBERIAN TOWN OF ULLASTRET (CATALONIA). AN IRON AGE URBAN AGGLOMERATION RECONSTRUCTED VIRTUALLY

1. Introduction

The Iberian town of Ullastret in north-eastern Iberia is made up of the Iron Age settlements of Puig de Sant Andreu and Illa d'en Reixac (Fig. 1). These settlements, which are separated at their farthest point by 300 m, grew up from the second half of the 6th century BC around a large lake that was drained in the second half of the 19th century.

From the 4th century BC, the two settlements together occupied an intramural area of more than 15 ha, the largest population concentration known for that period in north-eastern Iberia. They formed a twin town that was the capital of the *Indiketes* tribe, a people mentioned in classical texts (Codina, Martin, de Prado 2012; Plana, Martin 2012; Burch, Varenna, Vivo 2014), and the political, economic, military and religious centre of a territory of approximately 2,775 km² (Sanmartí 2004).

The mass abandonment of the Iberian habitats of Ullastret occurred at the beginning of the 2nd century BC, after the Second Punic War and the arrival of the Romans on the Iberian Peninsula (Codina, Martin, de Prado 2012).

The Archaeological Museum of Catalonia, and in particular its branch at Ullastret, is charged with the custody of this archaeological complex. In recent years, this institution has committed to applying the new technologies in both the field of research and the dissemination of the heritage in its care. As part of this commitment, this project, which is founded on scientific knowledge, is developing tools based on cutting edge virtual reconstruction techniques to improve and facilitate our understanding of the archaeological remains.

2. From research to 3D modelling

The archaeological investigation of the sites that make up the Iberian complex of Ullastret began in 1947 with a few test trenches and, since 1952, it has been continuously studied. In addition to the projects undertaken during those first decades, the interdisciplinarity of the scientific studies applied to Ullastret since the 1980s has provided us with in-depth knowledge, not only of the Iron Age archaeological sites, but also of their immediate territory and other important aspects, including the palaeolandscape and palaeoenvironment.

Likewise, the incorporation of geophysical surveys into the archaeological investigation of the complex has contributed to a qualitative advance in our

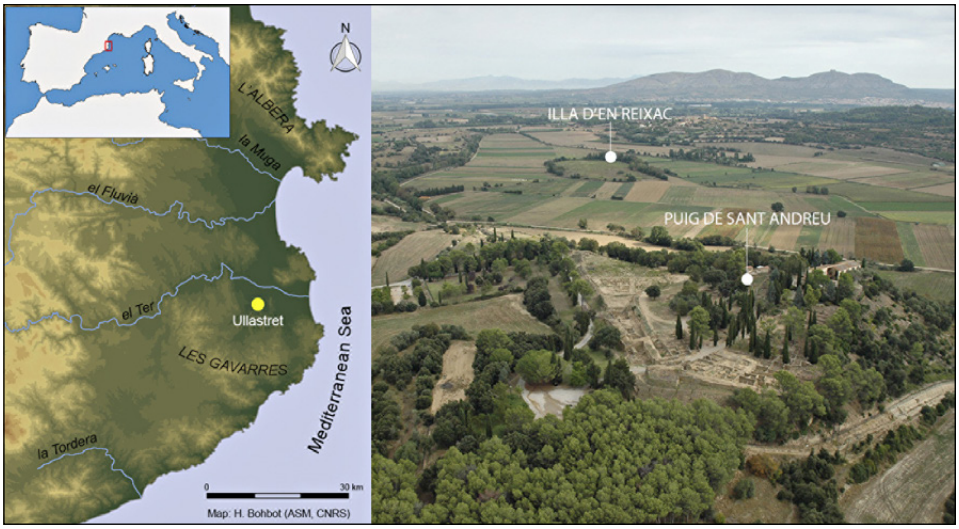

Fig. 1 – Map showing the location of the Iron Age complex of Ullastret.

Fig. 2 – Gradiometer response map (Eastern Atlas) and interpretation diagram of the geophysical data from Illa d'en Reixac (after Garcia-Garcia, de Prado, Principal 2016).

knowledge of the town's urban planning and defensive system (Garcia-Garcia, de Prado, Principal 2016), key aspects for tackling a virtual reconstruction project of these characteristics (Fig. 2). The data provided by the surveys carried out in the last decade, filtered through accumulated archaeological experience, have added more extensive and detailed knowledge of aspects that were already known, as well as revealing previously unknown structures. The analysis has been a joint undertaking of archaeologists and geophysicists, thus expanding the possibilities of interpreting and taking advantage of the data. The availability of data from multiple systems (ground-penetrating radar, magnetic, electric and electromagnetic) has greatly improved the reliability of the interpretations, as they allow comparative evaluations to be made of the interpretation hypotheses.

2.1 *Urban planning as a starting point*

All the information accumulated over the years has allowed us to define the urban planning model of the two inhabited centres, which became consolidated in the 4th century BC, when the Iberian town of Ullastret reached its maximum size.

Of the two nuclei that make up the town, Illa d'en Reixac is the only known Iberian settlement in north-eastern Iberia built on an island, in a lake connected to the coastal marshlands (Brill *et al.* 2010). This island, which occupied an intramural area of nearly 5 ha in its period of maximum occupation, was roughly oval in shape, with its longest side orientated from N to S. The ancient orography of the site was slightly hilly with a difference in elevation of some 10 m between the middle of the island and its shores. These geomorphological characteristics allowed the implantation of a pseudo-regular, densely-built urban layout, with a structure based on a central axis with an average width of 4 m, which symmetrically divided the habitable space into two halves (Fig. 2). On each side of this axis there was a series of perpendicular sloping streets running from W to E. They were more or less regular and in turn defined the different housing blocks, which were south-facing. In terms of the buildings, it has been possible to clearly identify those that correspond to what could be defined as a basic 40-50 m² unit consisting of one or two rooms, some of which were porticoed. We can also identify large buildings with complex ground plans and areas ranging from 700 to 1,200 m² organised around a large inner courtyard. These buildings are interpreted as residences of the elites.

This urban plan detected at Illa d'en Reixac was also used at Puig de Sant Andreu, although here the determining orographic factors were different. In this case, the site is a triangular-shaped hill, 53 m above sea level and 30-40 m above the surrounding land (Fig. 3). The slopes are more gentle on the western and northern sides and steeper to the S and E and the peak is in the

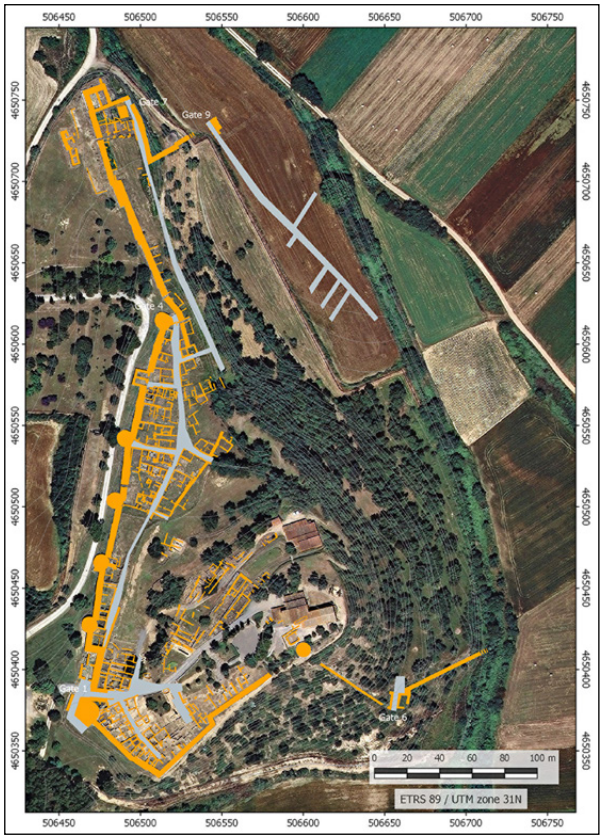

Fig. 3 – Orthophotomap with the urban layout detected at Puig de Sant Andreu.

middle of the southern part. The archaeological and geophysical investigations carried out to date have revealed that the urban layout of Puig de Sant Andreu is based on large, tiered terraces. Each of these terraces is accessed via a main gate – five have been documented to date – that lead to a central street running from N to S. This street is 3.50 to 4 m wide and running off it there are perpendicular secondary streets that lead to the internal face of the defensive wall. These delimit the different housing blocks and some of them are interconnected with the other terraces. The coexistence of basic domestic units and large aristocratic-type buildings is also documented at Puig de Sant Andreu (Codina, Martin, de Prado 2012).

The urban structures of these nuclei were protected by complex defensive systems. In the case of Illa d'en Reixac, in addition to the natural protection

offered by the surrounding lake, it also had a defensive wall that enclosed it completely. At Puig de Sant Andreu the wall is complemented on its more vulnerable western side with a monumental ditch cut into the rock.

2.2 *The virtual modelling and reconstruction process*

The Iberian town of Ullastret virtual reconstruction project is based on exhaustive archaeological research that attempts to preserve historical rigour throughout the process. This aspect is fundamental if we wish to build a practical application based on solid, verified scientific knowledge. Its development has been inspired by the text of the London Charter, which establishes a series of principles for the use of 3D visualisation methods and results by researchers, educators and cultural heritage organisations.

The reconstruction is based on a specific moment in the history of the town, around 250 BC, as this is the best-known period in scientific terms and allows us to come closest to depicting the true situation. Although it would have been interesting to create a sequence to include some of the earlier phases, we have only partial knowledge of these. It would therefore have been very complicated to try and define basic aspects, such as the urban structure of the settlement, for the virtual reconstruction.

A multidisciplinary team was set up to develop the project. It was supervised from the Ullastret branch of the Archaeological Museum of Catalonia and technical coordination was by the Catalan Cultural Heritage Agency, which worked together with a graphic design and 3D modelling studio. Many specialists in different fields (architects, anthropologists, hydrogeologists, shipbuilding specialists, etc.) have also collaborated with the aim of defining with the maximum precision and detail the multiple aspects that had to be taken into account to create this reconstruction with the utmost scientific rigour.

The first step in the reconstruction was based on an exhaustive compilation of all the available archaeological information. Nevertheless, it must be taken into account that in certain areas it was necessary to use comparative, theoretical and/or experimental models, in some cases not archaeologically verified. While these are based on well-founded hypotheses, they may be subject to change in future reviews. Therefore, in addition to compiling the interpreted archaeological data, one of the important tasks in this first phase was to agree on how to recreate that which did not exist from a point of view that could be considered tangible.

Once those data had been validated from a scientific point of view, they were structured in thematic terms and sent to the studio commissioned to undertake the virtual 3D modelling and texturisation following a pre-established work sequence. The first element worked on was the geomorphological structure of the settlements and the palaeolandscape, as it was fundamental to contextualise the town in its geographical environment. To model the

Fig. 4 – Virtual reconstruction of Illa d'en Reixac and its environment.

landscape, the vegetation existing in that period was taken into account and special attention was paid to the transformative action exercised by humankind through the creation of communication routes, farming, the extraction of mineral resources, etc. Immediately afterwards came the structure of the town itself, first based on the recreation of the defensive structures (the wall and ditch) and then the urban framework, defining streets and reconstructing volumetrically and individually each of the different types of constructions and buildings that made up the town (Fig. 4). Finally, the movable elements in the interior of the buildings, as well as other types of artefacts, were reconstructed and incorporated. These were based on the objects of material culture found in the excavations and conserved in the collections of the monographic museum of Ullastret. We also reconstructed those objects that, due to their organic nature, have not been found archaeologically, but that we know existed thanks to indirect evidence.

In technical terms, the model was based on the 3D cartographic database of the Cartographic and Geological Institute of Catalonia. This allowed the generation of a geometric mesh to represent the relief, introducing in this case the ancient lake of Ullastret, which was drained in the 19th century. The topographic maps drawn up of the archaeological complex in recent years were also used as complementary information. Next, three-dimensional sketches were made using the Cinema4D and 3D Studio Max applications, basically for the architecture and landscape. To process the objects, based on vector drawings, they were exported to a 3D format and, using the Maya software, the model was generated, adding texture and colour. Once these had been

created, one of the particularities of the project was that the normal IT tools from the fields of architecture and archaeology were not used; instead, for the final stage of the virtual reconstruction process, it was decided to use Unreal Engine 4. This is a videogame development engine that is excellent for creating landscape environments and giving graphic photorealistic quality to the images, in this case using textures created from photographs of real elements. It also allows the project to be exported relatively easily to immersive virtual environments, such as multiscreen projections, 360º video and, in particular, virtual reality headsets.

The virtual models were checked scientifically throughout the working process, starting with the initial phase in which only a volumetric level was reproduced and ending with the final hyperrealist image. This development allowed us to introduce the opportune corrections that, in some cases, meant making substantial changes to certain erroneous elements that had been based on preconceived and widely accepted and disseminated ideas.

3. The practical applications of virtual modelling

The objective of the modelling was not limited to the creation of a visual representation. Having evaluated the different options in technical and economic terms, it was decided to develop two practical applications: an immersive room in which to project an audiovisual of the virtual reconstruction and a Virtual Reality (VR) experience with HTC Vive headset (Codina *et al.* in press). We are also working on other possible applications, some of them aimed at offering new and innovative teaching resources to educators.

To create these applications, it was necessary to adapt the 3D model by simplifying the polygonal mesh, in one case to achieve a fluid movement of the images (the immersive room audiovisual) and in the other to be able to use the application in real time (the VR device).

3.1 *The immersive room*

This room takes its inspiration from the Cave Assisted Virtual Environment (CAVE) technological concept. This system is based on the creation of an audiovisual projection room conceived to provide an immersive virtual reality experience that can be viewed collectively (Fig. 5). Examples of this concept have existed for many years, in some cases on a theoretical and experimental level, for example the 3D modelling of the agora of Segesta (Albertini *et al.* 2014), and in others as an informative application for the general public at archaeological sites and museums, such as at the well-known caves of Dunhuang (Weidenhausen, Stricker 2000).

The project developed at the Ullastret branch of the Archaeological Museum of Catalonia consists of a multiscreen projection visible on three

Fig. 5 – Immersive room at the Ullastret branch of the Archaeological Museum of Catalonia.

of the room's four walls, accompanied by a three-dimensional audio system synchronised with the movement of the images, creating an enveloping effect for the viewer. In this respect, the sound has been carefully crafted to achieve sonorous textures that accompany the different virtual spaces appearing in the projection.

The room has an area of approximately 10 m² with the aim of reproducing as accurately as possible the size and features of a room in a common Iberian house, such as the one in the projected audiovisual. The floor has also been made of recycled crumb rubber to simulate the room floors and street surfaces of the Iberian town. This material also has properties that, together with the technical treatment given to the walls and the ceiling, optimise the acoustic features of the room.

The audiovisual projected in the room lasts for six minutes and has been created entirely from the digital model with an itinerary filmed by virtual cameras. The spectator takes a dreamlike journey to the Iberian town, passing through its streets and entering empty houses. The story is narrated by an ancient inhabitant from an elite family, who recalls some of the dramatic moments of life in his town. In this respect, the narrative concept and structure attempts to distance itself from the traditional linear audiovisual description that explains and contextualises a site. To achieve this objective, the Ullastret branch of the Archaeological Museum of Catalonia already has an audio guide service and a mobile app that allows visitors to tour the site and access the basic information on the archaeological complex. As such, the audiovisual is conceived as a complement and a particularly useful tool

Fig. 6 – VR Experience #ullastret3D with the HTC Vive headset.

for contributing to the knowledge and interpretation of this heritage from a more empathetic approach.

3.2 *Virtual reality using VR devices*

Thanks to cooperation with a creative technologies company, the audiovisual created for the immersive room was adapted for a VR Experience with HTC Vive headset (Fig. 6). Unlike the audiovisual room, these devices offer a complete and absolutely realistic immersion in which the person can move about naturally in a life-size virtual space. In this case, the experience allows a certain limited interaction with the virtual environment, meaning that no two users will have an identical visual experience.

This VR device application is not conceived to be available permanently in the Ullastret museum itself, given that the initial concept is identical to that of the immersion room and, although the experience is more immersive and is perceived differently, it would be a duplication of the same resource. Moreover, the way the application is currently conceived means that public use of the headsets would require space and personnel resources that most museums would find it difficult to provide. Therefore, to date this application has only been available at specialist congresses and cultural heritage dissemination activities.

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ABSTRACT

The Iberian town of Ullastret (6th-2nd centuries BC), in the NE of the Iberian Peninsula, is one of the most important Iron Age archaeological sites in the north-western Mediterranean. It consists of two residential areas, Puig de Sant Andreu and Illa d'en Reixac. Separated by only 300 m, together they make up the capital of the Iberian tribe known as the *Indiketes*, mentioned by classical authors such as Avienus, Ptolemy and Strabo. Decades of continuous archaeological investigation, and especially the geophysics surveys undertaken in recent years, have given us an overall view of the urban structure of this *dipolis* and its immediate territory, which was occupied and exploited intensively starting mainly in the 4th century BC. This high degree of theoretical knowledge led us to propose the creation of a virtual reconstruction of the whole complex, as well as its contextualisation in its geomorphologic and landscape surroundings. This 3D modelling is an excellent research tool that permits the formulation/validation of hypotheses for architectural reconstruction. It is also especially useful for the creation of applications that add to our knowledge of this heritage site and aid in its presentation and dissemination.