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The Water Mine of the Casa del Rey Moro in Ronda (Málaga, Spain): a case of reconciling private tourism promotion and the generation of heritage knowledge

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Abstract

The tourist exploitation of heritage assets often generates tensions between the economic interests of their private owners and the demands of the protection exercised by public administrations. However, the generation of heritage knowledge, in addition to an unavoidable action of protection, can result in an increase in the tourism potential of the property: on the one hand, it consolidates and expands its cultural interest and, on the other, it produces documentation that can be used to optimise the promotion of its values.

The work carried out in the Mine that connects the Casa del Rey Moro with the Tajo in the town of Ronda is a case of this desirable conciliation between private tourism promotion and the generation of heritage knowledge. In a building of great geometric and constructive complexity, a vaulted staircase embedded in the cracks of the Tajo de Ronda, archaeological activities are proposed to reveal some of its historical keys. These archaeological activities require geometric documentation work and architectural analysis of the heritage, which is approached by combining analogue and digital resources (digital capture by scanner, photogrammetry, HBIM modelling).

The results obtained have made it possible to improve the tourist exploitation of the property both directly, by enriching the visit with explanatory material in different formats, and indirectly, through promotion in different media using techniques specific to this research.

Keywords: *heritage, graphic analysis, tourism, management, HBIM*

1. Introduction

The city of Ronda (Malaga, Spain) is one of the main tourist attractions in Andalusia and, as such, tourism is one of its main economic drivers. The richness of its cultural heritage and, in particular, its architectural heritage, is a fundamental part of its attraction for visitors and, therefore, its dimension as a cultural asset goes hand in hand with its consideration as an economic resource, especially in cases where it is privately owned. This double dimension sometimes generates tensions between the economic interests of its owners and the public cultural administration responsible for its protection. However, the generation of heritage knowledge, in addition to an unavoidable action of protection, can lead to an increase in the tourism potential of the property: on the one hand, it consolidates and expands its cultural interest and, on the other, it produces documentation that can be used to optimise the promotion of its values.

The Casa del Rey Moro is one of the representative buildings of the city's architectural heritage and is presented as such in its official promotional media (Tourism Delegation of the Municipality of Ronda, 2024).

Although the house that gives its name to the entire property is not open to the public at this time, its historic gardens (Vigil-Escalera Pacheco, 1995) and a unique architectural structure, the Water Mine, the subject of this communication, are open to the public (Figure 1).

Figure 1. Water Mine: outside (left) and inside (right).

The Water Mine is a structure designed to collect water from the Guadalevín River to supply the city and is fortified to protect its use in the event of a siege. Its construction dates back to the 14th century, during the Nasrid kingdom, and its uniqueness lies in the complexity of its structure, resolved by taking advantage of one of the cracks in the escarpments between the riverbed and the city platform, by means of flights of stairs covered with vaults that are interspersed between natural caves, excavated areas and built rooms forming a zigzagging linear route that links surprising spaces due to their contrasts in scale and constructive solutions.

The architectural complexity of the building makes it difficult to manage at different levels. Such is the case of the administrative authorisations for interventions on the estate, which required a precise spatial definition in order to obtain the corresponding favourable reports. In 1997, archaeological work was carried out (Amores Carredano, 1997), and progress was made, with the techniques available at the time, on a basic planimetry drawn up by the architect Fernando Mendoza, which inevitably had numerous inaccuracies, given that the data could only be taken with analogue and direct means of measurement.

For this reason, the management of the Water Mine and the actions of its owners for its conservation and adaptation for public visits required adequate graphic documentation, carried out with the means currently available. The definitive impetus for the work came from an archaeological intervention campaign planned as part of the general archaeological research project: "La Mina (Ronda, Málaga). Archaeological and architectural analysis of the Merinid monument" (Jiménez Martín, 2018). The work carried out, beyond fulfilling a documentary and administrative requirement, represents an opportunity to improve the knowledge and dissemination of the building as a heritage object and, at the same time, as a tourist resource.

2. Aims and objectives

The main objective of this work is to show a case in which the requirement for precise geometric documentation, architectural analysis, and archaeological study results in increasing the potential of a heritage asset as a tourist resource.

To achieve this objective, the architectural survey of the building was proposed, understood as a strategy of heritage knowledge and not as a mere capture of formal attributes, in line with its definition in the *Carta dil Rilievo*, which expressly states that *"the critical path of the construction process, and also the design process"* should be verified (Jiménez Martín & Pinto Puerto, 2003).

Firstly, therefore, the aim was to obtain the geometric documentation of the building, using advanced digital resources for metric capture. Simultaneously, it would be characterised by its spaces and construction systems by means of architectural and archaeological analyses.

Once these results had been achieved, completing the general objective, graphic documentation would be produced to support the dissemination of its values and the experience of the tourist visit to the building.

3. Methods

In order to achieve the proposed objectives, four phases of work were proposed: the compilation and study of the documentation, the elaboration of an architectural survey, the creation of an HBIM model and the production of graphic documentation for the dissemination and enhancement of the knowledge obtained. The compilation and study of the available documentation on the building includes, in addition to the references included at the end of the text, the photographic collection by Fernando Amores Carredano on the archaeological intervention carried out in 1997 and the planimetry carried out by Fernando Mendoza in the same year.

In order to begin the architectural survey phase, it was necessary to wait for the company that owned the Mine to clear and clean up the external undergrowth that had accumulated in recent years, which prevented visual recognition of the external elements and an adequate photographic record. Similarly, in order to take data from the interior, visits to the complex had to be interrupted for a day in the morning, in addition to removing objects and elements that hindered access to all parts of the building.

Once the preconditions had been resolved, and given the complicated accessibility of the building, various combined resources were used: from the handheld laser scanner for the interior to the photographic capture and the use of a topographic total station for the exteriors. Several captures were made in response to the different constraints imposed by the building:

- Interior point cloud made by handheld scanner (ZEB-REVO from GeoSLAM, with a capture speed of 43,000 points per second, range of 30 metres, relative accuracy of 6 mm and real-time processing)
- Point cloud resulting from a photographic shot of the exterior from distant points on the other side of the Tagus, which was subsequently processed using photogrammetry software (Samsung NX 3000 camera with 20 MP resolution and Samyang 14 mm f/2.8 lens).
- Point cloud resulting from a close-up shot of the exterior taken from the accessible roofs (Camera mentioned above).

- Photographic shot of the interior which, oriented by photogrammetric means (Leica TS02 FlexLine plus topographic total station), was used to add the textures to a mesh generated from the interior point cloud, resulting in a textured model.

After this, with the support of the control points taken with the topographic station, the clouds and the model were adjusted, oriented, georeferenced, and linked, which were the basis for obtaining a total of 35 projections, including plans, sections and elevations in a CAD software. Simultaneously, an analogue capture was carried out in which the constituent construction elements were identified and discretised, naming them and coding their basic heritage parameters (levels, construction function, material, chronology).

The third phase consisted of founding an HBIM model of the building in which the complexity of the insertion of the staircase into the terrain was presented. The model was created using the AUTODESK REVIT software. This model is required to be able to evolve over time, allowing the management of additional information that is generated as a result of its maintenance and conservation, or specific interventions that are developed.

Finally, the production of graphic documentation for the dissemination and enhancement of the knowledge obtained was resolved, enriching the visitor's experience. In the first instance, this work was carried out in an analogue form on visualisations of the point cloud model in various straight cylindrical projections.

4. Results

The presentation of the results is ordered according to the different actions proposed in the methodology for the achievement of the general and specific objectives set out.

4.1. Analogue capture

The analysis of the existing documentation was complemented with the exploration of this singular building by means of analogue drawings that made it possible to recognise the geometry and articulation of the constructive elements, to name elements and to detect situations of difficult interpretation that would require the support of digital capture. The usefulness of these drawings, which belong to the most established disciplinary tradition, is not invalidated by the exhaustiveness of the digital capture but complements it insofar as they represent a preliminary proposal for interpreting the complexity of the architectural space (Figure 2).

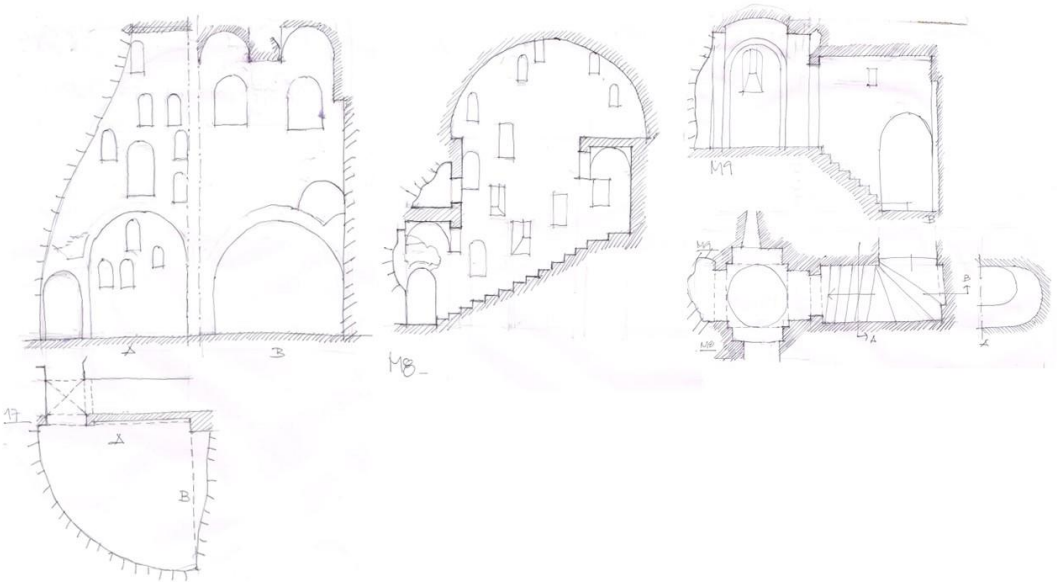

Figure 02. Analogue capture of the Water Mine spaces. Source: the authors (2019)

4.2. Digital capture

Digital capture was the fundamental resource for achieving the proposed objectives. The geometric and constructional complexity of the building required a precise capture of the sequence of spaces generated by the fusion of the natural elements of the steep terrain and the architectural structures embedded in its nooks and crannies.

Digital capture by handheld scanner provided a point cloud that, although devoid of colour and texture attributes, offered geometric characterisation. This cloud was complemented by photogrammetric capture, from which the most representative orthophotographs were obtained (Figure 3).

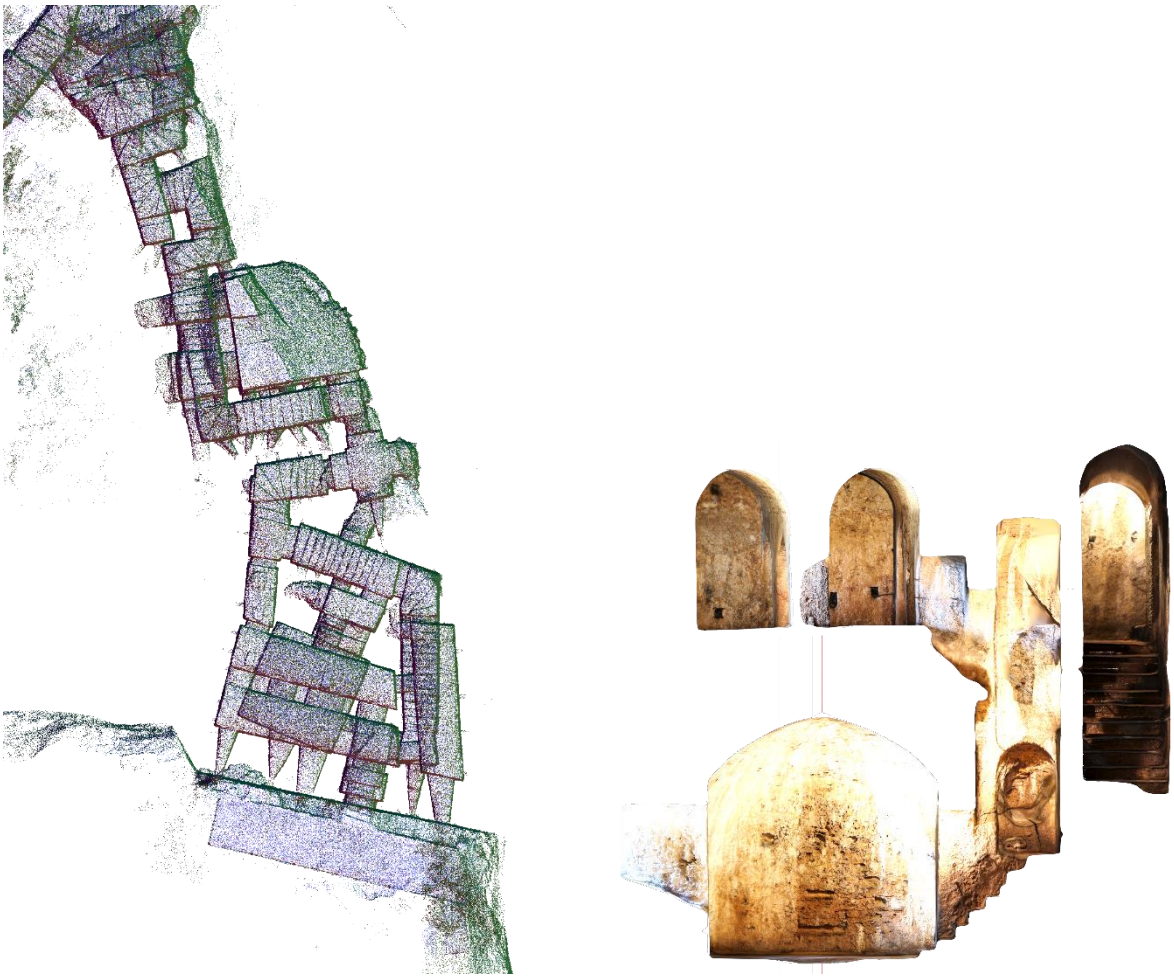

Figure 3. Left: Plan view of the result of the point cloud of the handheld scanner. Right: Orthophotography resulting from the photogrammetric treatment of the photographic shots. Source: the authors (2019)

4.3. Architectural analysis

In parallel to the analogue and digital captures, a constructive analysis of the complex was carried out, producing a data table that catalogues and serves as an inventory of all the elements identified and analysed. Through this analysis, the existence of four parts or buildings with homogeneous characteristics has been determined, which appear to be linked to each other with a great deal of continuity. This continuity is the result of the use of similar construction techniques, even though they responded to different historical stages, from the initial Merinid construction to the intervention of the 19th-century garden or the later alterations to facilitate tourist visits. Initially, the La Mina building has been related to the rest of the property by differentiating between three large groups of buildings:

- The Mine, designated as ED-000
- The Garden, designated as ED-001
- The House, designated as ED-002

These three groups are closely related and interdependent, as the Garden reformed the access to the Mine and incorporated it as part of its structure, the Mine penetrates the House, and the latter is the result of successive reforms that have resulted in the current state.

Within the "mine" building ED-000, we have differentiated three parts: by their orientation, internal constitution, and homogeneity in the constructive and spatial treatment. These three parts do not correspond to different construction stages since, in principle and based on the available data, they have been developed with great continuity. Following the description made in 1997, four parts have been distinguished (Figure 4):

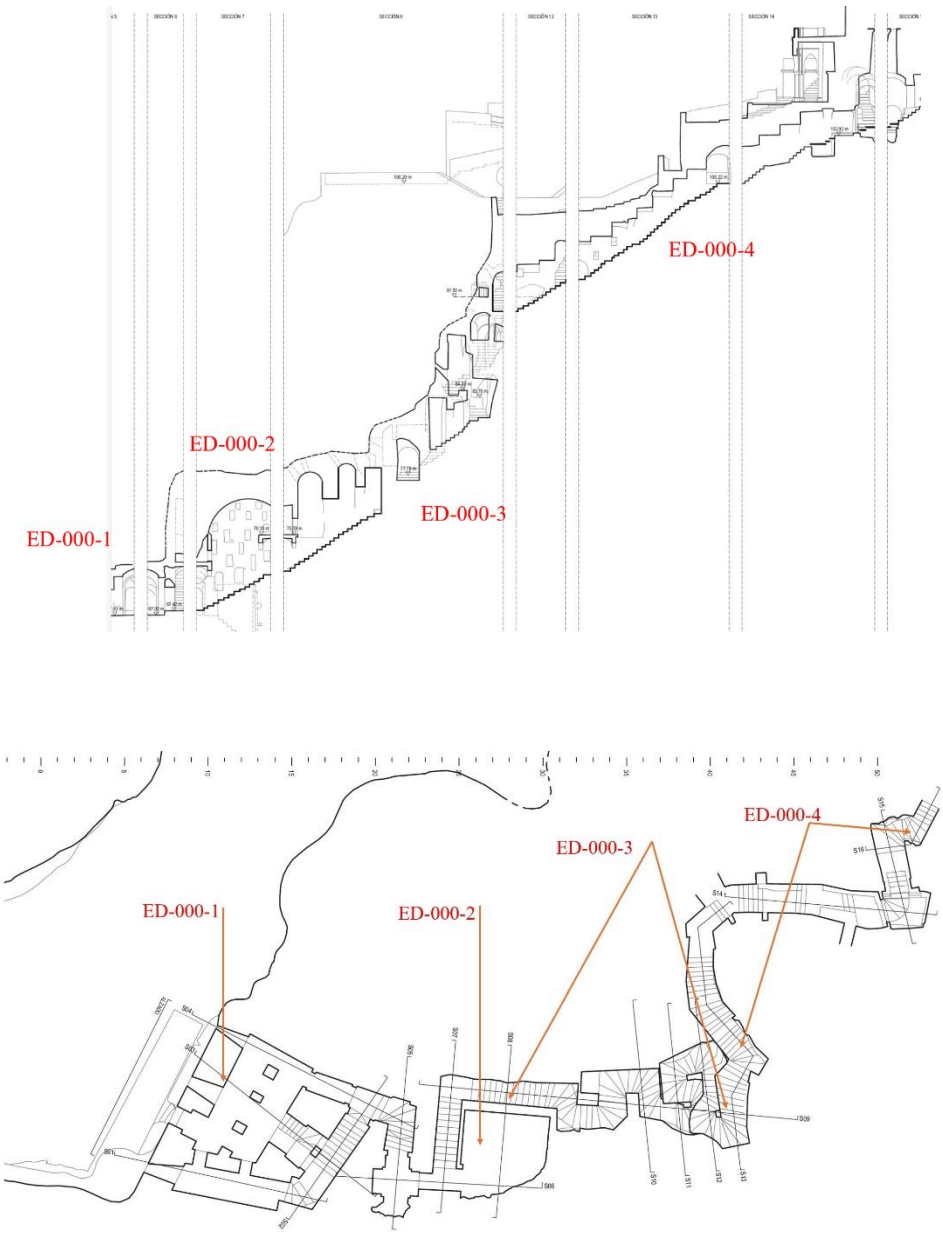

Figure 4. Section and plan of the complex where all the partial projections have been superimposed and unfolded in horizontal and vertical projection. Identification of the parts of the Mine (EC-000). Source: the authors (2019)

- The Tower, which we have identified as ED-000-1, formed by the two-storey defensive structure closest to the bottom of the Tagus. It is made up of rooms on two levels and connecting staircases between them.
- The building of the Sala de la Aguada, labelled ED-000-2, consists of a large central room, perimeter stairways, and transit and connection spaces with the previous one.
- The zigzagging staircases, labelled ED-000-3, are formed by a set of flights of stairs that span the greater height between the previous hall and the garden terraces, adjusted to the narrower space between the two crags, which makes it necessary to turn numerous times to allow them to develop. This is the most complex area in terms of construction, but it is where the greatest ingenuity and skill on the part of the builders can be seen.
- The stairway of the inclined tunnel, marked ED-000-4, is made up of much more continuous and less broken flights of stairs, covered by stepped barrel vaults that rise up to the highest space between the crags, where they separate again. It is the part most transformed by the garden project.

4.4. Planimetric survey and HBIM model

In addition to the documentary value of the point clouds of the complex, the textured model and the associated orthophotographs, a collection of plans, an HBIM model and an associated data table have been synthesised.

The planimetry has been produced in CAD and consists of horizontal plan projections (floor plans), vertical projections (elevation-sections) and identification plans of the construction elements. This collection provides the basic material for the development of the archaeological intervention project and for any of the administrative management and maintenance operations of the building. The collection printed in PDF is made up of 38 plans in A3 format, the result of graphic surveys carried out in CAD. Each plan depicts a horizontal cross-section of the rock and the building, as well as vertical sections. One of the sections has been laid out in A2 to describe the complete development of the staircase by unfolding the previous vertical sections. Four sections of the most singular spaces have been included, incorporating the orthophotos corresponding to the vertical faces.

In addition to the collection of descriptive plans, there is a collection of 15 floorplans where the building complexes and construction elements are identified by means of the symbols, up to a total of 146 construction elements (Figure 5). These elements are presented in a table in EXCEL format, where the basic properties and characteristics of each building element are listed (Figure 6).

This table, which can grow with each analysis developed or new data to be incorporated, reports the characterisation of the elements in the HBIM model (Figure 7). The HBIM model was initially developed to solve the fitting of the stairs in the terrain and is currently being developed to complete the rest of the Mine's structures.

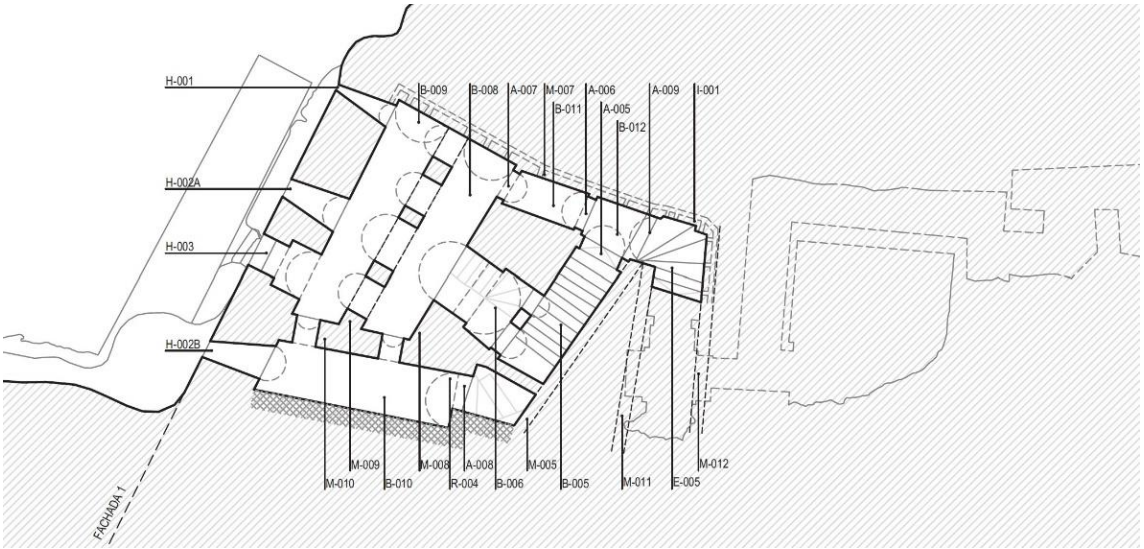

Figure 05. One of the plan projections of the Mine's spaces with the code of each architectural element identified, registered and catalogued. Source: the authors (2019)

LAVE ELEMENTO	CLAVE EDIFICIO PERTENENCIA	ELEMENTO	SUBELEMENTO	MATERIALIDAD	SISTEMA CONSTRUCTIVO	DESCRIPCIÓN	OBSERVACIONES
:-001	ED-000-1	Cimiento	Alambor	Compacto de calicostrado	Carga y defensa	Base talud alambor hacia el río que sirve de cimiento de la torre y defensa ante crecidas. El achaflanado del alambor en el centro para batir el acceso a la puerta	Conserva huellas de agujas, mechinales y tablazón del encofrado del talud del alambor. Los escalores E-001 están labrados sobre el alambor.
:-002	ED-000-2	Cimiento	Plataforma	Compacto de calicostrado	Carga y nivelación	Base de nivelación del terreno natural para asiento dela torre	Borde interior indeterminado
M-001	ED-000-1	Muro	Fachada	Ladrillo y mampostería	Carga y defensa	Muro de fachada de la torre hacia el río.	La parte superior del muro se encuentra arrasada. Esta parte formaba un pretil de la Terraza de la Conquista. En su extremo este presenta un chaflán.
H-001	ED-000-1	Ventana	Saetera	Fábrica de ladrillo	Iluminacióny defensa	Hueco vertical asaeteada de gran altura	Sirve de evacuación de desague de Sala del Manatial
H-002A	ED-000-1	Ventana	Medio punto	Fábrica de ladrillo	Iluminación	Hueco bajo arco circular abocinado	Iluminación de sala de armas
H-002B	ED-000-1	Ventana	Medio punto	Fábrica de ladrillo	Iluminación	Hueco bajo arco circular abocinado	Iluminación de anexo a sala de armas
H-003	ED-000-1	Ventana	Medio punto	Fábrica de ladrillo	Iluminación y defensa	Hueco bajo arco circular abocinado de acceso al matacán que lo protege	El hueco se encuentra parcialmente cegado con fábrica de ladrillo a modo de pretil deprotección ante la desaparición del matacán
H-004A	ED-000-1	Ventana	Saetera	Fábrica de ladrillo	Iluminación	Hueco simple vertical asaeteado y abocinado	Ilumina escalera E-002
H-004B	ED-000-1	Ventana	Saetera	Fábrica de ladrillo	Iluminación	Hueco simple vertical, decorado con alfil y sobrearco, asaeteado y abocinado	Ilumina escalera E-002
H-005	ED-000-1	Ventana	Saetera	Fábrica de ladrillo	Iluminación	Hueco simple vertical, decorado con alfil, asaeteado y abocinado	Ilumina la Sala del Pozo
H-006	ED-000-1	Desagüe		Fábrica de ladrillo	Desagüe de aguas	Hueco simple vertical	Salida de agua de exceso de Sala del Pozo
H-007	ED-000-1	Ventana	Saetera	Fábrica de ladrillo	Iluminación	Hueco simple vertical	Iluminación de la Potera
H-008	ED-000-1	Puerta	Medio punto	Fábrica de ladrillo	Acceso	Hueco de Poterna formada por arco circular	Hueco en espesor del muro con reundido para recibir portón fortificado.
H-009	ED-000-1	Ventana	Saetera	Fábrica de ladrillo	Ventilación e iluminación	Hueco abocinado de iluminación y ventilación delespacio de tránsito a Sala de Aguada	El exterior se observa en el informe de la intervención realizada en 1997, actualmente semienterrado.
M-002	ED-000-1	Muro		Ladrillo y mampostería	carga	Muro lateral a escalera E-001 sobre elel carga la bóveda B-002	Alinea la escalera con el otro muro que es la peña
M-003	ED-000-1	Muro		Ladrillo y mampostería	carga	Caja formada por cuatromuros que recibe las cargas de la bóveda B-007	Presenta huellas de mechinales o entregas de estructura complementaria del ingenio que servía de noria delposible pozo allí existente
M-004	ED-000-1	Muro		Ladrillo y mampostería	carga	Muro sustentante de la bóveda B-005 acodalado por los arcos A-004 y A-005	Tiene practicado varios huecos de medio punto hacia la escalera de acceso a la Sala de los Secretos facilitando su iluminación desde la fachada
M-005	ED-000-1	Muro		Ladrillo y mampostería	carga	Muro sustentante de la bóveda B-005 acodalado por los arcos A-004 y A-006	
M-006	ED-000-1	Muro		Ladrillo y mampostería	carga	Muro sustentante de la bóveda B-011 acodalado por los arcos A-006 y A-007	
M-007	ED-000-1	Muro		Ladrillo y mampostería	carga	Muro sustentante de la bóveda B-011 acodalado por los arcos A-006 y A-007. Contiene una canalización de evecación de aguas sobrantes de la Sala de Aguada que transcurre empotrado	Muro de regularizacion de la peña.

Figure 6. Table of registration and cataloguing of identified architectural elements related to the planimetry. Source: the authors (2019)

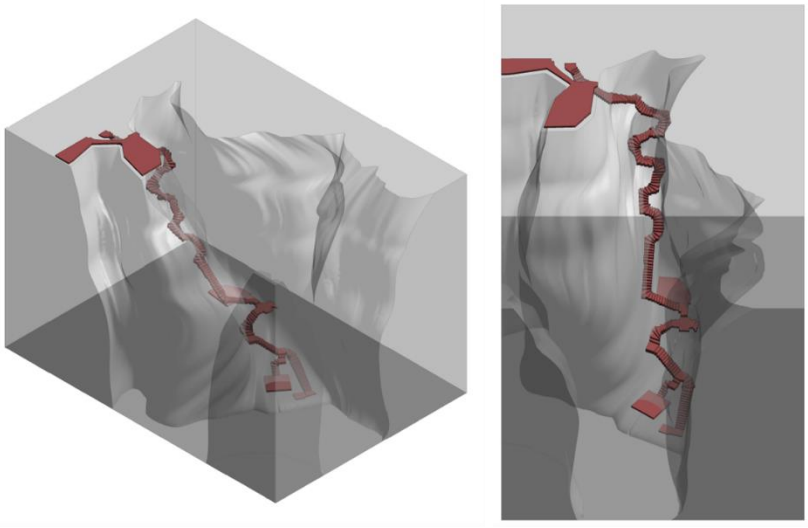

Figure 7. Water mine stairs HBIM model. Source: the authors (2019)

4.5. Production of materials for dissemination

The work carried out has made it possible to contribute to the knowledge of a building as unique as the Water Mine and, with this, to have historical data, architectural information, and graphic resources with which to produce material for the dissemination of its heritage values and to enrich the visitor's experience. The archaeological-architectural analysis has made it possible to specify the denomination and interpretation of the different spaces. The graphic documentation has been useful in the preparation of explanatory panels of the various interventions that have been open to visits (Figures 8 and 9).

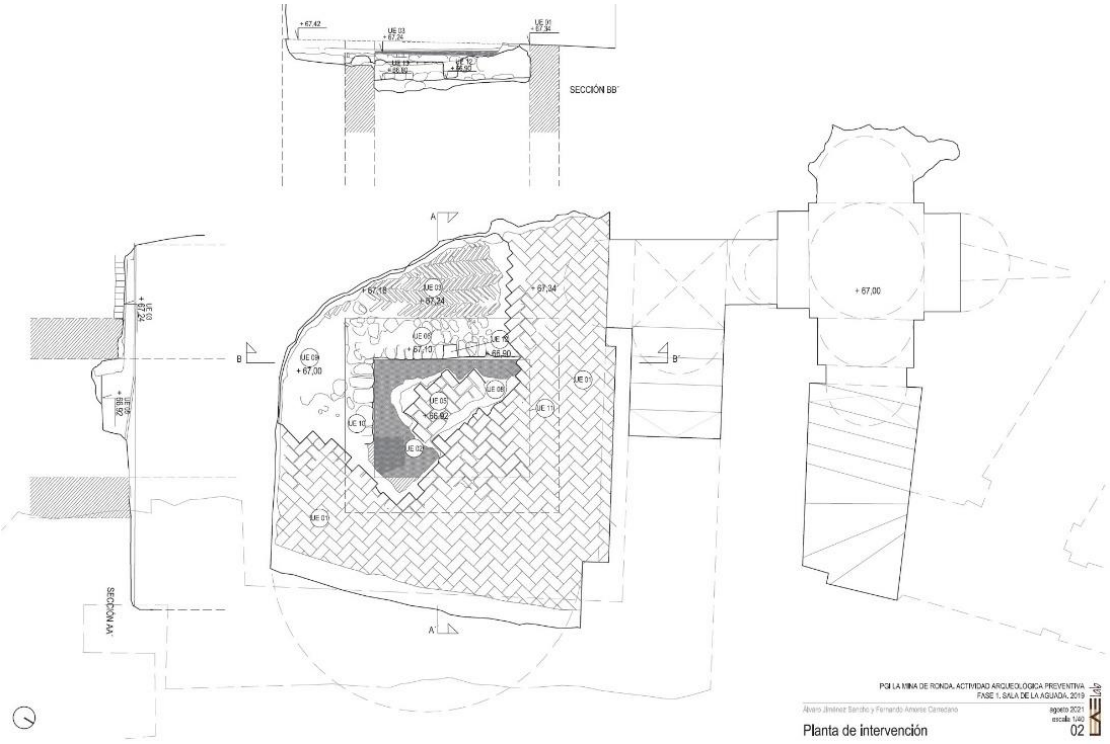

Figure 8. Planimetry of the archaeological intervention carried out in the spatial area E-000-2, Sala de la Aguada. Source: the authors (2022)

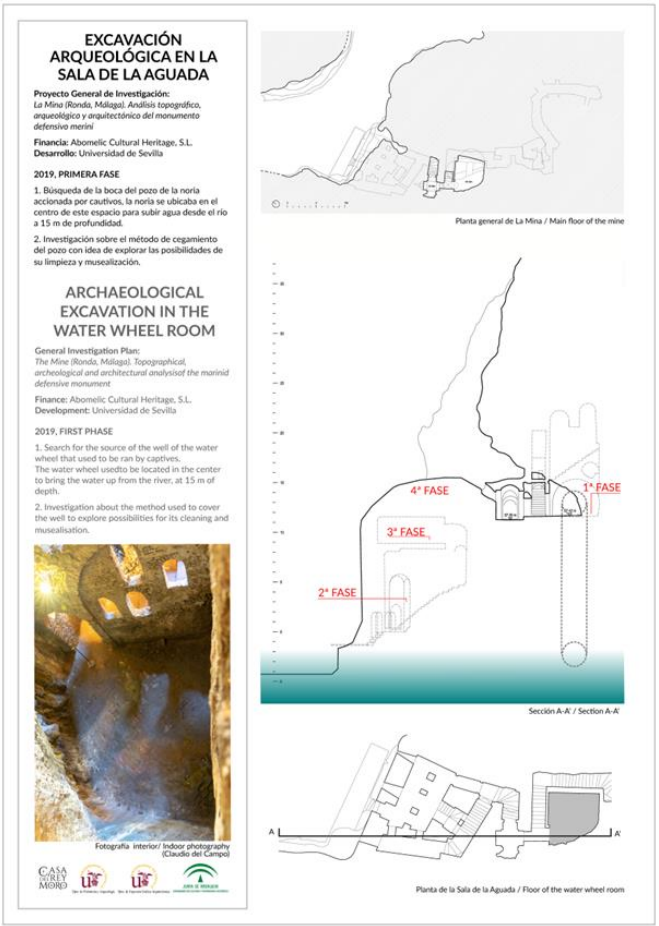

Figure 9. Explanatory panel based on the architectural survey. Source: the authors (2019)

Also, to disseminate the results of the analyses, allowing an understanding of the whole as the result of a complex constructive process, difficult to understand if not through a synthetic but rigorous graphic representation, in this case, developed analogically based on metric data obtained from the point cloud (Figure 10).

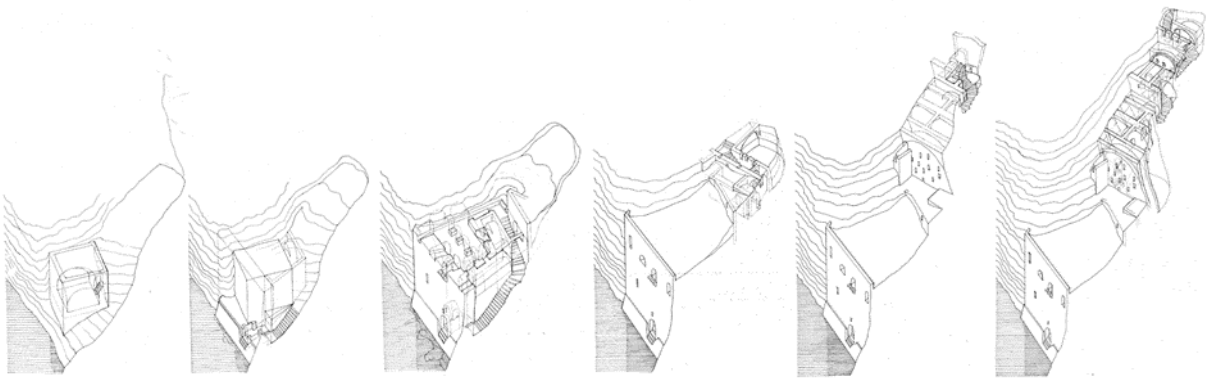

Figure 10. Architectural analysis drawings. Six of the ten steps explaining the construction process of the architectural structure of the Ronda Mine. Source: the authors (2019)

The resonance of the uniqueness of this work has reached the media, such as television, with the production of programmes in which the narration about the building is supported by a point cloud (López Pulido & Pecos Palacios, 2023).

5. Conclusions

Digital techniques for the geometric capture of immovable cultural heritage properties are becoming increasingly faster, more accurate and easier to use. However, the documentation of cultural heritage goes beyond simple geometric recording, requiring the analysis of graphic and non-graphic sources to support the generation of models. The integration of analysis and geometric capture, expressed in terms of "architectural survey", requires the integrated and non-exclusive use of analogue and digital techniques. Based on these principles, a graphic model of the Water Mine of the Casa del Rey Moro in Ronda (Malaga, Spain) has been generated, in which analogue and digital capture (3D scanning, photogrammetry) is integrated with analogue and digital architectural analysis (HBIM model) to produce documentation of a property of great heritage complexity (geometric, accessibility, visibility due to the growth of vegetation, archaeological, historical, etc.) aimed at improving its knowledge and facilitating the conservation and musealisation actions promoted by its managers.

6. Funding

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