Risk Management of Archaeo-Palaeontological Collection from Sierra de Atapuerca Sites at CENIEH

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Abstract The National Research Centre on Human Evolution (CENIEH) hosts a palaeontological collection from Plio-Pleistocene sierra de Atapuerca (Burgos), declared a World Heritage Site by UNESCO in 2000. The aim of the Conservation & Restoration Laboratory of CENIEH is to assure the conservation collection in time, in order to arrest or minimize handling and preserve its high scientific and cultural wholeness. In this manner it becomes a priority to establish specific preventive conservation strategies. Thus, to achieve these goals it is necessary to review and update the CENIEH Plan for Preventive Conservation by developing every stage: documentation, context, risk assessment, proceedings design and verification. Summarizing the efforts of risk management must be focused on making scientific use compatible with conservation criteria.

1 Archaeo-Palaeontological Collection from Sierra de Atapuerca Sites at CENIEH

CENIEH is located in Burgos, in the north of Spain, within a few kilometers from sierra de Atapuerca World Heritage sites. It is part of the Human Evolution Complex, along with Human Evolution Museum, and an Auditorium.

The CENIEH belongs to the Spanish network of Unique Scientific and Technical Infrastructures (ICTS, in Spanish). This refers to large facilities, resources equipment and services necessary for the development of cutting-edge research of the highest

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quality. As a scientific institution its range of activities focus mainly on human evolution during the Late Neogene and Quaternary, which includes collaborative projects at sites and deposits from these periods around the world. In addition, CENIEH is responsible for conservation, restoration, management and recording its archaeological and palaeontological collection. The centre owns forefront technologies, and specialized technical professionals. Laboratories are oriented to different disciplines: Archaeometry, Archaeomagnetism, Geology, Cartography, Bioenergy & Motion analysis, Digital mapping & 3D Analysis, Luminescence dating, Cosmogenic Nuclid dating, Electro Spin Resonance dating, Microscopy & Micro-Computed Tomography, Uranium Series, Prehistoric Technology & Archaeology, and Conservation & Restoration.

One of the exceptional characteristics of the CENIEH is that it hosts heritage from sierra de Atapuerca Plio-Pleistocene sites. Due to this fact, it has a Collections, Conservation & Restoration Area that includes collection management and a Conservation & Restoration Laboratory, something that is usually linked to a museum context. In 2019, the CENIEH signed an agreement with the regional government of Castilla y León to manage Atapuerca collections. This has turned the CENIEH the principal storage center of the palaeontological and archaeological heritage from Atapuerca sites. The agreement also stablishes CENIEH as the institution managing the conservation, restoration and scientific research from these assets. Due to these facts, the number of items safeguarded at CENIEH in the last years has grown from approximately eighteen thousand to more than two hundred thousand. And this number continues growing.

Considering these circumstances, the Collections, Conservation & Restoration Area is facing an exponential increase of its activity, and its needs for material and staff resources. In this way, a refurbishment work took place at the three storage rooms hosted in two floors: An armored room with the most significant scientific collection, and two twin rooms where the main part of the collection is preserved.

Atapuerca sites were established as World Heritage by UNESCO in 2000. Currently, five different species of hominins had been found there. These remains are key specimens in human evolution research and two of them are only found in those sites. Due to this exclusiveness and the high scientific and cultural value, the collection have the highest significance.

The archaeo-palaeontological collection from Atapuerca sites are distributed in three groups: semi-fossil hominin bones such as *Homo antecessor*, *Homo neanderthalensis*, *Homo sp.*, and pre-neanderthals of Sima de los Huesos site; fauna semi-fossil specimens, like *Ursus dolinensis* or *Dolinasorex glyphodon*; and lithic assemblage of various raw materials, like quartzite, silex or sandstone. Palaeontological remains make up a high percentage of the collection.

2 Conservation Needs of the Collection

The main degradation processes of palaeontological heritage cost by from physical properties, chemical composition, and their interaction with soil during burial. Particularly in bones, hygroscopicity and anisotropic nature trigger mechanical weakness in unstable environments. The CENIEH collection general state of conservation is heterogeneous, due to the diversity of archaeological contexts, pre-depositional and post-depositional burial processes, excavation procedures and old restoration treatments. In addition, the main use of collection is scientific research, which implies a real and potential mechanical deterioration risk due to improper handling. Thus, the main conservation needs are related to three factors: nature of collection, scientific use and environmental features at CENIEH. The key guidelines to consider attending to these factors are:

1. Stability of microclimatic conditions, avoiding fluctuations of relative humidity (RH) and temperature (T). Suitable parameter ranges are around: 50% RH and 20 °C, respectively (Michalsky, 2007).
2. Low luminous impact, avoiding IR and UV radiation.
3. Reduce or avoid VOCs (Volatile Organic Compounds) and prevent biological plagues.
4. Adequate physical conditioning that prevents from mechanical damage.
5. Avoid dissociation.
6. Minimize handling.
7. Conservation training for researchers. This is one of the highest challenges: Generally, researchers in human evolution are not aware of the necessity to apply special conservation procedures to the palaeontological heritage.

According to these requirements, the Conservation & Restoration Laboratory prioritizes:

- Accessibility and storage capacity.
- Consultation protocols and upgrading database, to prevent dissociation.
- Care and prevention against potential accidents.
- Maintenance of stable microclimatic conditions.

3 Preventive Conservation and Risk Management of the Collection

It is of utmost importance to find a balance between scientific needs (study and analysis) and heritage conservation. By prioritizing safeguard actions, we avoid losing not only the original material itself but also the scientific information that it could provide in future. In this manner, it is urgent to design specific preventive conservation strategies, starting by risk management.

The aim of the Conservation & Restoration Laboratory is to assure the safeguarding of the collection in time, preserving its scientific and cultural wholeness for future generations. To manage and preserve a collection of these special features it is necessary to develop risk assessment, which implies identification and evaluation of potential threats based on the magnitude of the most likely risk and its probability (Michalsky, 2004). Taking into account the environmental context at the storage rooms (and their outside influence), a risk classification has been made considering nature and use of the collection. In addition, a classification has been made to asses the cultural significance. Then, we have two scenarios: one for the armored room that is a security room of 50 m^2, and another for the storage rooms 1 and 2, each 120 m^2.

To classify the risk, we followed the guidelines from the *IPCE* (Spanish Cultural Heritage Institute). The two factors that influence the risk assignation are: the probability of happening and the severity of damage. The incidence of these factors is graded on a numerical scale from 1 to 5 that allows to make a quantitative description (IPCE, 2009, IPCE, 2019). The probability of happening could be defined as low, medium, or high. The severity of damage could be light, severe, or very severe, depending on the actions that are needed to stop it: (preventive conservation, remedial conservation or restoration treatments).

Based on the risk evaluation results mentioned before, we included an evaluation of the priority actions. A table shows the priority of each risk from little importance to high importance, depending if the risk does or not need immediate actions (Table 1).

Table 1 Risk evaluation of the armored room

Armored Room—Vault				
Risk	Probability	Severity	Valuation	Priority
Dissociation Physical damage (use & conditioning)	Low Low	Very severe Very severe	3 3	Moderated Moderated
Vandalism	Low	Very severe	3	Not important
Catastrophic events (fire, floods) Incorrect climatic conditioning (RH & T fluctuations, light, pollutants)	Low High	Very severe Very severe	3 5	Moderated Very important
Damage by outside conditions	Low	Light	1	Not important
Biological damage	Low	Light	1	Not important
Negligence in monitoring and control proceedings Inadequate maintenance Absence / Deficiencies of the conservation project, or cultural use	Low Low Low	Severe Light Very severe	2 1 3	Medium Moderated Medium

The evaluation made from the armored room determines that the highest risk is the incorrect environmental conditioning and the consequence of having fluctuating microclimatic conditions: relative humidity and temperature. On the other hand, due to the big size and homogeneity of the collection, the risk assessment made from the storage rooms 1 and 2 determines that dissociation is its highest risk. Below, physical damage by handling and inadequate conditioning is the second concern caused by its scientific use.

The risk assessment provides the path to continue making decisions. To control the microclimatic environment, the access to the storage rooms has been designed through a double door with a middle cabin to stop the current flow between the entrance and the inside room. Furthermore, the air conditioning system is independent from the rest of the building and a device has been installed per storage room. In addition, each air conditioner can be manually adjusted to achieve maximum daily fluctuations over ±1 °C and ±3% RH. Nevertheless, in the armored room these optimal ranges are not always possible to achieve due to its great influence from external environmental conditions. For that reason, the current target is to adjust the air conditioner to these circumstances and improve its isolation in the near future.

Moreover, a wireless system for data acquisition and monitoring has been installed in the storage rooms. The system sends an alert if detects values of relative humidity and temperature that exceed the optimal range considered for the conservation of collection. Thanks to all these features it is possible to understand the behavior of the storage rooms by making statistical analysis of data.

Consequently, the main goal is to change from an uncontrolled environment influenced by external conditions to a controlled environment (Fig. 1).

Furthermore, risk assessment of the storage rooms 1 and 2, determines that the main objective is to slow down dissociation and physical damage due to scientific studies. With this purpose, we have been designing a physical conditioning with a double purpose: following the conservation criteria and permitting consultation of the collection. The objective is reached by using non-reactive and chemically stable materials, adapting design to each morphology, minimizing handling and avoiding mechanical damage. For this purpose, we have been using storage conditioning materials, known for their suitability:

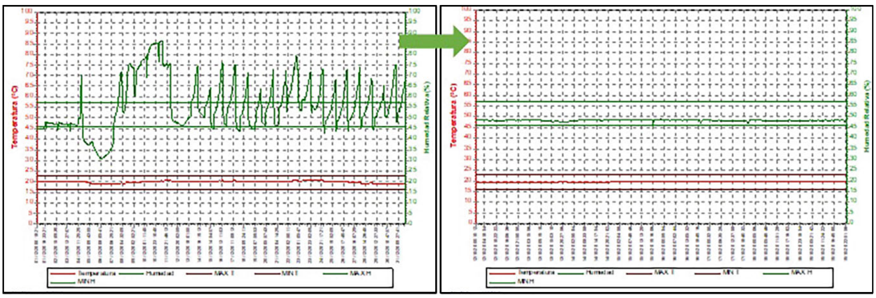

Fig. 1 Comparison of unstable and stable environmental data recorded at the armored room

- Polyethylene foam that absorbs vibrations and shocks.
- *Volara*® and *Tyvek*® in contact with heritage in order to avoiding mechanical injuries like abrasion.
- *Fome-cor*® foam core that provides stability and an aesthetic design.
- Polypropylene stacking boxes with hinged lids and upper side access that protects from dust, radiation and chemical or physical damage.
- Individual polyethylene transparent boxes that provide see-through vision and permits separate specimens.

The design and materials election is the result of experience and conditioning tests made over the years. Clearly, what works in our scientific collection might not work in a different context; for that reason it is important to test conditioning materials in each particular case. A great part of these polymeric materials is submitted to an accelerated aging test thanks to the *POLYVEART* research project from the *IPCE* (Ministerio de Cultura, 2021).

Regarding design and arrangement, we decided to classify palaeontological remains by taxonomy anatomical order. Also, it has been stablished a signal code that avoids risk of dissociation. For small size human remains with a complex morphology, -cranium fragments, vertebra or tooth-, it has been used transparent polyethylene boxes in order to individualize them. This provides visualization and minimize handling. Then, the boxes have been held with *Volara*® to immobilize them inside the storage containers. *Volara*® is a polyethylene foam that is soft, flexible and easy to adapt to the shape needed in each case. Also, for bigger specimens remains it has been created pillow-like holders according to the size of each remain. These holders are made with Tyvek® (high-density spunbound polyethylene fibers) and little polyethylene balls. This solution provides the perfect accommodation for the specific specimen morphology. It is important to create trouble-free solutions that are easy to implement; so the process can be systematized while also taking into account the special characteristics of each fossil (Fig. 2).

Regarding the codification system of storage containers, the content information is located outside the boxes: nature, taxon, raw material, technological description or anatomical element, and topographic reference. The topographic reference provides the location of each container in a storage room, a cabinet, and a shelf. Inside the storage containers lid, a photograph shows the correct content distribution to avoid dissociation.

Conversely, a collection consultation procedure at CENIEH has been defined. This procedure determines loan terms, exhibition and sampling (for destructive and non-destructive analysis). Procedures must systematize loan and consultation demands; they should be a safe channel which singles out requests in order of relevance. The relevance is measured by the importance of the scientific research application and the significance on the requested collection. Besides the consultation demand, a conservation technical regulation mandatory compliance is obligatory: researchers must sign it before having access to the specimens requested. The regulation defines how must be handle the collection and the objects allowed in the consultation room.

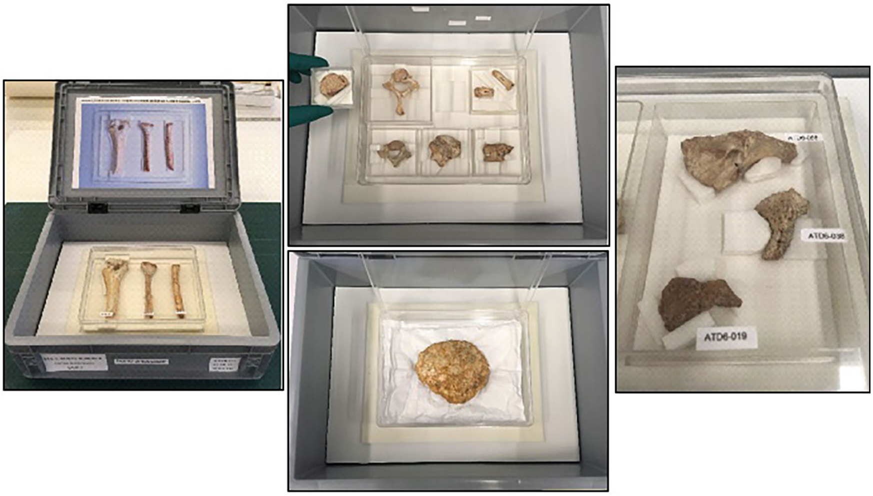

Fig. 2 Physical conditioning of the hominin semi-fossil collection at the armored room

Concerning analysis requests, these are assessed depending on the necessity of taking a sample and if the exam is destructive or non-destructive. Safeguarding of the heritage is always the priority: the Conservation & Restoration Laboratory must approve the analysis by a technical report about the state of conservation, the significance, and the real and potential impact over the preservation in time of the specimen.

4 Conclusions

Risk management is an essential part of the Preventive Conservation Plan. Is the strategy that allows to understand better an institution and learn which are its strengths and weaknesses. At the Conservation & Restoration Laboratory, we are conscious that safeguarding in short, medium, and long terms the Atapuerca world heritage collection is a challenge. Our greatest struggle, beyond achieving an adequate micro-climate, is on risks derived from its large number and scientifical use: dissociation and mechanical damage. Therefore, user training and awareness-raising are our best assets for the future to avoid or minimize the loss of heritage.

We are aware that things that works now could not work in the future; so periodic evaluations of control are a need. Verification is necessary to solve problems and improve the system. Because our global objective is to preserve cultural heritage in time, the best tool to assure we reach the goal is a solid preventive conservation plan.

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