The showcase of salt rocks from Cardona in the Barcelona Natural Sciences Museum: conservation and adaptation for passive climate control

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Abstract: The results of the conservation work carried out on an exhibition set-up dating from the early twentieth century are presented. The exhibition set-up consists of a wooden showcase containing about twenty evaporite rocks from the collection of the Museu de Ciències Naturals de Barcelona (Spain). The work involved the remedial conservation of the rock specimens and showcase, and the improvement of the original environmental control system using sustainability criteria. An interdisciplinary team worked on the different phases of the project, which included prior historical and environmental studies. The remedial conservation of all elements in the collection has improved its accessibility and the monitoring of the environmental conditions of the new installation has confirmed the efficiency of the proposed passive environmental control system.

Keywords: Showcase, passive environmental control, conservation, restoration, evaporite rocks

La vitrina de rocas salinas de Cardona del Museo de Ciencias Naturales de Barcelona: conservación y adaptación para el control climático pasivo

Resumen: Se presentan los resultados de la restauración de un conjunto expositivo datado a principios del s. XX, compuesto por una vitrina de madera y una veintena de rocas evaporíticas pertenecientes a las colecciones del Museo de Ciencias Naturales de Barcelona (España). Los objetivos de la intervención se centraron en el tratamiento directo de la obra y en la recuperación y mejora de su sistema de control ambiental original, aplicando criterios de sostenibilidad. Para llevar a cabo esta tarea, un equipo interdisciplinar trabajó en las diferentes fases de ejecución, que incluyeron estudios históricos y medioambientales previos. El tratamiento directo de las piezas logró mejorar la legibilidad del conjunto, mientras que el seguimiento de las condiciones ambientales de la nueva instalación, confirma la eficiencia del sistema de control ambiental pasivo propuesto.

Palabras clave: Vitrina, control ambiental pasivo, conservación, restauración, rocas evaporíticas

A vitrina de rochas salinas de Cardona no Museu de Ciências Naturais de Barcelona: conservação e adaptação para controlo climático passivo

Resumo: Apresentam-se os resultados do restauro de um conjunto expositivo datado do início do século XX, constituído por uma vitrina de madeira e cerca de vinte rochas evaporíticas pertencentes às coleções do Museu de Ciências Naturais de Barcelona (Espanha). Os objetivos da intervenção centraram-se no tratamento direto da obra e na recuperação e melhoria do seu sistema de controlo ambiental original, aplicando critérios de sustentabilidade. Para levar a cabo esta tarefa, uma equipa interdisciplinar trabalhou nas diferentes fases de execução, que incluíram estudos históricos e ambientais prévios. O tratamento direto das peças conseguiu melhorar a legibilidade do conjunto, enquanto o acompanhamento das condições ambientais da nova instalação confirma a eficácia do sistema de controlo ambiental passivo proposto.

Palavras-chave: vitrina, controlo ambiental passivo, conservação, restauro, rochas evaporíticas

Introduction

The Cardona salt rock exhibition set-up [Figure 1] is a valuable museum installation dating from the beginning of the twentieth century that consists of various specimens of salt rocks housed in a purpose-built showcase. It is registered as item number 1 in the mineralogical collection of the Martorell Museum (Barcelona, Spain). This museum, opened on 25 September 1882, is housed in the first building ever to be built expressly as a public museum in Barcelona. For this reason, Martorell Museum is one of the most historically significant of all the city's museums. Today it forms part of the Museu de Ciències Naturals de Barcelona (MCNB).

Figure 1.- General view of the Cardona salt rock showcase before the work began (M. Pérez – MCNB).

The specimens contained in the showcase are evaporite rocks originating from the Cardona salt mountain (province of Barcelona, Spain), which is regarded as one of the best examples of a salt dome in the world. Currently, this site is one of the most significant elements in the Central Catalan Geopark that forms part of UNESCO's network of world geoparks.

To guarantee their conservation, evaporite rocks require a stable controlled relative humidity (RH) (Waller 1992). Around the year 2000, the first signs of deterioration in the specimens were detected, which continued to worsen and began to affect the showcase. At the end of 2017, it was decided to subject the whole exhibition set-up to a thorough conservation process.

Work began with a climatic analysis of the interior of the showcase and a historical analysis of its construction and evolution. The results of these two initial studies shed light on the inherent problems involved in the conservation of the exhibition set-up and the causes of its degradation.

Based on these results, a complete conservation project was designed aimed at ensuring the long-term preservation of the Cardona salt rock exhibition set-up. The project included the remedial conservation of the showcase and its content, as well as the remodelling of the whole installation to facilitate correct climate control and make it more accessible. The overall aims of the project were thus based on two overriding principles: the need to preserve the historical value of the exhibition set-up and ensure the sustainability of the environmental solutions to be adopted.

The aims of sustainable development are perfectly applicable and inherent to many of the Museum's activities including the conservation of its heritage. Its overarching objective is to protect and safeguard its contribution to the world's cultural and natural heritage at the same time as it attempts to reduce its environmental impact on the air quality and the amount of waste it generates. Likewise, the Museum aims to manage sustainably the chemical products it uses and improve its capacity as an institution to help mitigate the effects of climate change (UNITED NATIONS 2015, aims 11 to 13).

Previous studies

—*Historical analysis*

The complete results of the historical investigation of the Cardona salt rock showcase have been described in a previous work (Campeny *et al.* 2018). Here, we discuss only the data concerning the process of degradation of both the showcase and the specimens it contains.

According to the documents we studied, the showcase was designed expressly to display the salt rocks that were scattered around other showcases and storerooms of the Martorell Museum. It was built in yellow pine wood and glass, following an original design dated 1921 and signed by Dr. Francisco Pardillo, curator of geology at the time. [Figure 2 a]. When conservation work began, there was a panel housing flat sections of salt rock attached to the top of the showcase. This element was not part of the original design, nevertheless, it's present in documents from the 1940s. Therefore, it should be considered as a historical addition integrated in the current exhibition set-up.

The documentation indicates that Dr. Pardillo understood the environmental requirements of these specimens and

that the idea behind the construction of the showcase was not only to display all the relevant saline rocks in one place but also to guarantee their conservation (MUSEU DE CIÈNCIES NATURALS 1921).

Thus, the Cardona rock salt showcase must originally have had some passive control system of the relative humidity that prevented – or, at least, reduced – degradation of the specimens. Proof of this is the hidden compartment in the original structure of the showcase that was connected to its visible part via a series of openings in the wood. Glass trays filled with a humidity-absorbing material were placed in this compartment (Fernández, com. pers. February 2018) [Figure 2b].

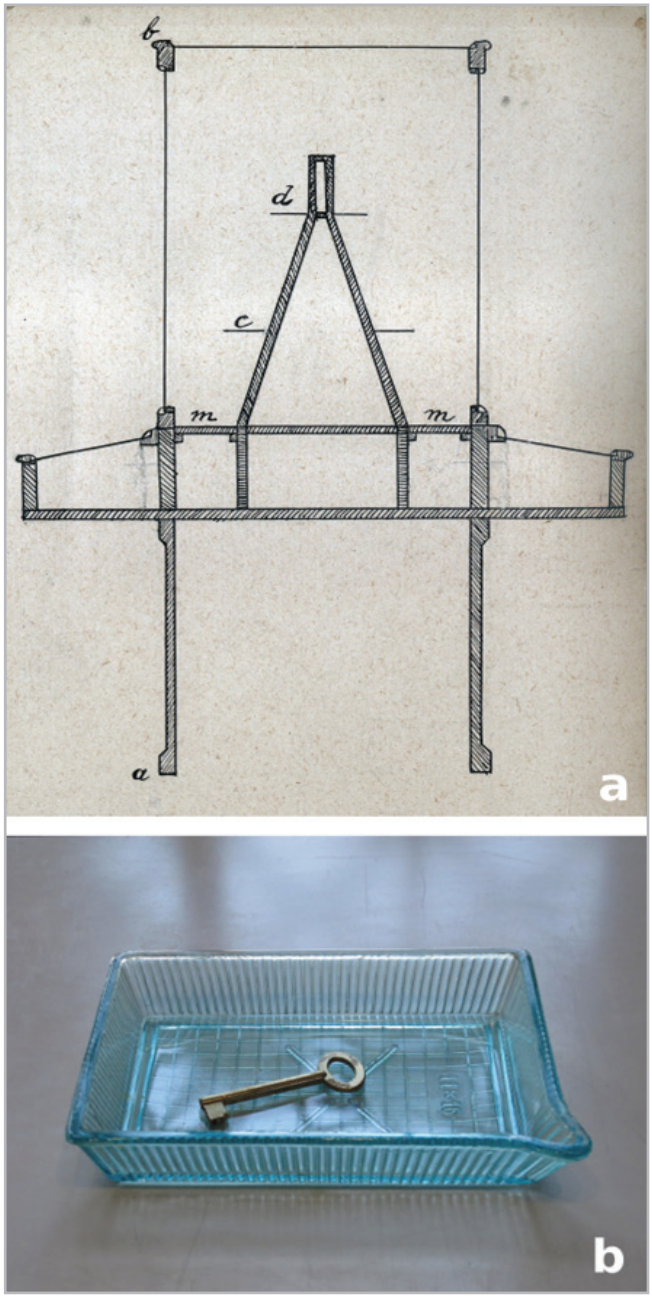

Figure 2.- a: section of the original design of the showcase dated 1921 (F. Pardillo – MCNB); b: the only glass tray that would have contained the absorbent material that has been preserved (M. Pérez – MCNB).

This simple design with a little maintenance would have guaranteed a certain environmental stability inside the showcase. If so, Cardona rock salt showcase could be one of the first documented examples of a conditioned showcase, since similar designs cited in the bibliography date from the 1930s (McIntyre 1934; Michalski 1985).

Nevertheless, a series of modifications of the original design would eventually ruin the showcase's environmental efficiency. The first alteration consisted of a number of lamps placed directly on the glass roof of the showcase, which inevitably increased the internal temperature. Subsequently, the inside of the showcase was painted with household gloss paint and the openings were sealed up with a synthetic silicone putty hindering access to the specimens. As well, from that moment onwards the glass trays with the absorbent material were no longer used. The combination of all these interventions could have triggered the degradation of the salt rocks (Tétreault 2017; Lankester and Thickett 2013; Thickett *et al.* 2008).

Along with these modifications of the showcase, the salt rocks were subject to cleaning work carried out by non-specialist personnel, of which no record has survived (Masriera 2006).

— *Environmental analysis*

The results of the environmental analysis were vital for understanding the specific environmental conditions inside the showcase. They also helped to explore the evolution of the degradation of the specimens and finding an environmentally acceptable and suitable solution to the problem.

It is worth noting that there is no climate control system in the hall in which the Cardona rock salt exhibition set-up is displayed. Likewise, both in the room and throughout the Martorell museum building, poor thermal and humidity insulation were detected. This building stands near Barcelona city centre, around 1 km from the sea in an area with a Mediterranean climate. The city is characterised by a microclimate in which periods of great humidity with relative humidity (RH) as high as 90% that alternate with very dry periods in which the RH drops to just 15% (Moreno 1993).

In the environmental study, the data obtained from inside the showcase were compared with data from the exhibition hall in which it is displayed and data from a nearby showcase housing non-salt rocks and other minerals.

The statistical analysis of the main indicators (Herráez *et al.* 2014) revealed that the humidity inside the showcase was stable but very high, varying between 74.6 and 81.1 % [Table 1].

	RELATIVE HUMIDITY (%)				TEMPERATURE (°C)	
	Annual maximum	Annual minimum	Max. daily fluctuation	Max. seasonal fluctuation	Annual maximum	Annual minimum
Cardona salt rock showcase (1)	81.1	74.6	3.4	5.3	31.5	11.8
Exhibition hall (2)	82.2	40.8	21.1	39.3	31.7	11.5
Showcase 23 (3)	75.0	35.5	9.0	16.8	30.8	11.8

Table 1.- Annual environmental results from inside the showcase (1) from the inside hall in which the showcase is displayed (2), and from inside a similar showcase located in the same hall but with no saline specimens inside (3). Data from 2016 (before the conservation work began). M. Pérez - MCNB.

Thus, inside the showcase a microclimate was recorded with high relative humidity throughout the year, despite the fluctuations recorded in the exhibition hall. Furthermore, whilst the annual humidity inside the salt rock showcase in 95% of cases oscillated between 77% and 79%, in the nearby showcase – similar but with no saline specimens – the humidity never exceeded 75% at any time in the year. Consequently, the effects of the accumulation of saline specimens under the RH conditions in the Cardona rock salt showcase are clear.

Conservation intervention

— *Examination and condition*

Visual examination combined with environmental analysis were crucial for understanding the degradation dynamics of this museum piece and for proposing possible solutions.

The showcase and the specimens had deteriorated greatly. In all the 26 salt rock specimens active processes of deliquescence were apparent, and stalactites, granules, crusts and whiteish deposits had formed. As well, efflorescence, subflorescence, flaking and sanding processes had all begun [Figure 3].

Figure 3.- Detail of the condition of the saline specimens before work began. a: example of flaking. b: one of the rocks affected by sanding (M. Pérez – MCNB).

To diagnose the causes of these damages it is important to take into account the fact that the thermodynamic stability of the salt rocks is determined by their deliquescence relative humidity point (DRH). Once this threshold is exceeded, the mineral begins to absorb water vapour and forms a saturated solution that leads to an equilibrium between the three phases: the solid rock salt, the solution and the environmental water vapour. If the environmental relative humidity (RH) rises progressively above the DRH, the solid phase of the minerals dissolves completely and the solution becomes even more diluted. If the environmental RH drops, the water begins to evaporate from the solution until the saturation reaches the DRH. Below the DRH, the solution is unstable and the solid phase can only co-exist with the water vapour. In this way, any gradual drop in the environmental RH below the DRH point will provoke the evaporation of the solution leading to the dehydration and subsequent crystallisation of the salt (Steiger *et al.* 2014; Waller 1992).

The DRH, also known as the saturation relative humidity point, varies between types of saline mineral. Table 2 gives the DRH of the specimens preserved in the salt rock showcase: 24 specimens of halite (NaCl) and two of sylvite (KCl).

If these data are compared with the RH and temperature records obtained from inside the showcase [Table 1], the cause of the active degradation of the deliquescence detected in the specimens can be clearly attributable

	0°C	10°C	20°C	30°C	40°C	50°C
NaCl	75.9	75.6	75.4	75.2	75.0	74.8
KCl	88.3	86.7	85.0	83.5	82.1	80.7

Table 2.- The deliquescence point of the saline rocks in the Cardona salt rock showcase expressed in % of average temperature from 0 to 50°C (taken from Steiger *et al.* 2014, Table 4.6, 279).

to incorrect environmental conditions, at least for the specimens identified as halites (NaCl) that represent 24 of the total of 26 specimens in the case (Campeny *et al.* 2018).

The formation of stalactites, granules, crusts and efflorescences is associated with phases of crystallisation and indicates that, during certain moments of the degradation process, slower transitions to drier periods below the limits of the deliquescence threshold took place.

Thus, it is evident that the fluctuations in the environmental RH around the DRH points of the specimens inside the showcase and the subsequent crystallisation-dissolution cycles were the cause of the degradation detected.

No major conservation issues were observed on the outside of the showcase. There was no evidence of attacks by wood-boring insects nor of any other type of biodegradation, probably due to the type of wood and the saline environment inside the showcase (the high turpentine content of yellow pine makes it fairly resistant to attacks by woodworm). Moreover, a saline environment helps prevent the proliferation of many of the fungi that habitually attack wood (Willson and White 1986). According to the results of the analysis, the concentric spots on the surface of the showcase glass, which at first sight resembled fungi, were found to be saline encrustations without any biological activity (Suarez and Sadurní 2018).

The most serious degradation that was obvious from outside the showcase was the saline crystallisation and efflorescence on various parts of the wood surfaces. The cause of this degradation was the loss of saline liquid provoked by the deliquescence of the rocks, losses that were absorbed by the case. The hygroscopicity of the wood had allowed a part of the saline liquid to migrate throughout the whole showcase. Depending on the environmental conditions in the exhibition hall, the salts contained in this liquid emerged and solidified at various different places both inside and outside the showcase. It is worth adding that, besides the obvious aesthetic alteration of the showcase, the solidification of salts within the wood's pores led to ruptures in its internal structure that weakened it and accelerated its ageing (Blanchette *et al.* 1994; Catelli *et al.* 2016).

The dismantling of the central part of the showcase revealed that much of the liquid produced by the deliquescence of the rocks had not evaporated and had gradually dampened the inside of the case. This had led to the deformation of some of the main wooden structural elements and to the complete putrefaction of others, which, all in all, was threatening the physical stability of the whole structure.

The most rotten part was the base of the centre part of the case. Of all elements, this was the most isolated from the environmental conditions in the exhibition hall and never dried out, even during the driest periods of the year. Thus, the humidity it retained was returned to the showcase and provoked further deliquescence of the rocks. This phenomenon explains the particular conditions of the showcase that were recorded during the environmental study.

The fairly severe corrosion of the metallic elements of the showcase [Figure 4] including the hinges, nails, screws and brackets is attributable to the humid and saline environment present inside the showcase (Selwyn 2004).

Figure 4.- a: condition of one of the iron brackets that supported the glass shelves. b: one of the most corroded copper hinges (M. Pèrez and A. Casalod).

— *Conservation and documentation*

The detailed description of the conservation and documentation processes of both the showcase and the salt rocks has been detailed elsewhere (Campeny *et al.* 2018). All the rocks were treated individually following the criteria established by the MCNB protocol, which mirror those used habitually in accurate conservation procedures (AMERICAN INSTITUTE FOR CONSERVATION 1994; EUROPEAN CONFEDERATION OF CONSERVATOR-RESTORERS ORGANISATIONS 2003, Appelbaum 2009). Due to the scientific value of the Museum's collections, priority is given to questions regarding minimal intervention and integrity of the original (Pérez-Azcárate 2019).

The conservation process of the showcase, which was completely dismantled, was performed *in situ* [Figure 5]. The most notable task was the replacement of the most deteriorated parts that were no longer able to fulfil their structural function.

Given that the reconditioning work aimed at preserving the specimens would alter the internal

Figure 5.- The dismantling of the showcase. a: removal of the specimens after their original positions were recorded. b: after the removal of the display pyramid, the highly degraded inside of the showcase, greatly affected by the humidity, became apparent. c: a sheet protecting the wooden struts supporting the base was removed. d and e: the base of the showcase had also greatly deteriorated (D. Fernández – MCNB).

structure of the showcase, the whole procedure was documented in detail by to-scale digital sketches.

Reconditioning the showcase to meet the environmental needs of the saline rocks

The diagram in Figure 6 details the new internal structure of the showcase. The main novelty is a drawer containing material designed to absorb the humidity, which is hidden beneath the pyramidal stand [Figure 6, nº 2]. This drawer, manufactured from 8-mm-thick aluminium sheeting, is filled with 10 kg of silica gel conditioned at 30% HR (Thickett and Luxford 2007) [Figure 6, nº 13]. Two circular openings on both sides of the drawer were incorporated for maintenance purposes [Figure 6, nº 3]. They are hermetically sealed by a double layer of aluminium with an O-ring closed with a butterfly nut. The drawer is connected to the glass case via several holes made in the wooden strut attached to the display pyramid [Figure 6, nº 10].

The other new element in the climate control system is the air cushion whose function is to absorb the changes in pressure in the glass case caused by fluctuations in temperature and humidity in the exhibition hall [Figure 6, nº 9]. This cushion is made from a multilayer sheet of aluminium and polyethylene (PE-AL-PE) connected to a suction valve from which a PVC tube leads to the drawer. Halfway along the tube there is a second valve – a shut-off valve – that enables the cushion to be sealed off and removed if necessary [Figure 6, nº 6, 7 and 8]. All these elements that help regulate the pressure in the glass case are concealed in the stand on which the central part of the showcase rests.

The final part of the reconditioning work consisted of improving the isolation of the glass case to ensure the stability of the environmental conditions in the interior and prevent the entry of dust and dirt. This was carried out by placing neutral silicon joints along all accessible surfaces and along the contact points between the drawer and the glass case. The air inside the showcase was then dried using dry argon [Figure 6, nº 12].

Results

It is important to remember that incorrect environmental conditions caused permanent damage to the salt rocks, such as deliquescence of certain specimens. Nevertheless, the magnitude of this deterioration could not be evaluated precisely because no detailed documentation regarding the characteristics of the specimens when they arrived in the collection had been conserved (size, weight, photographs, etc.).

Despite this, none of the specimens had to be consolidated nor was it necessary to perform any other type of conservation treatment to improve their

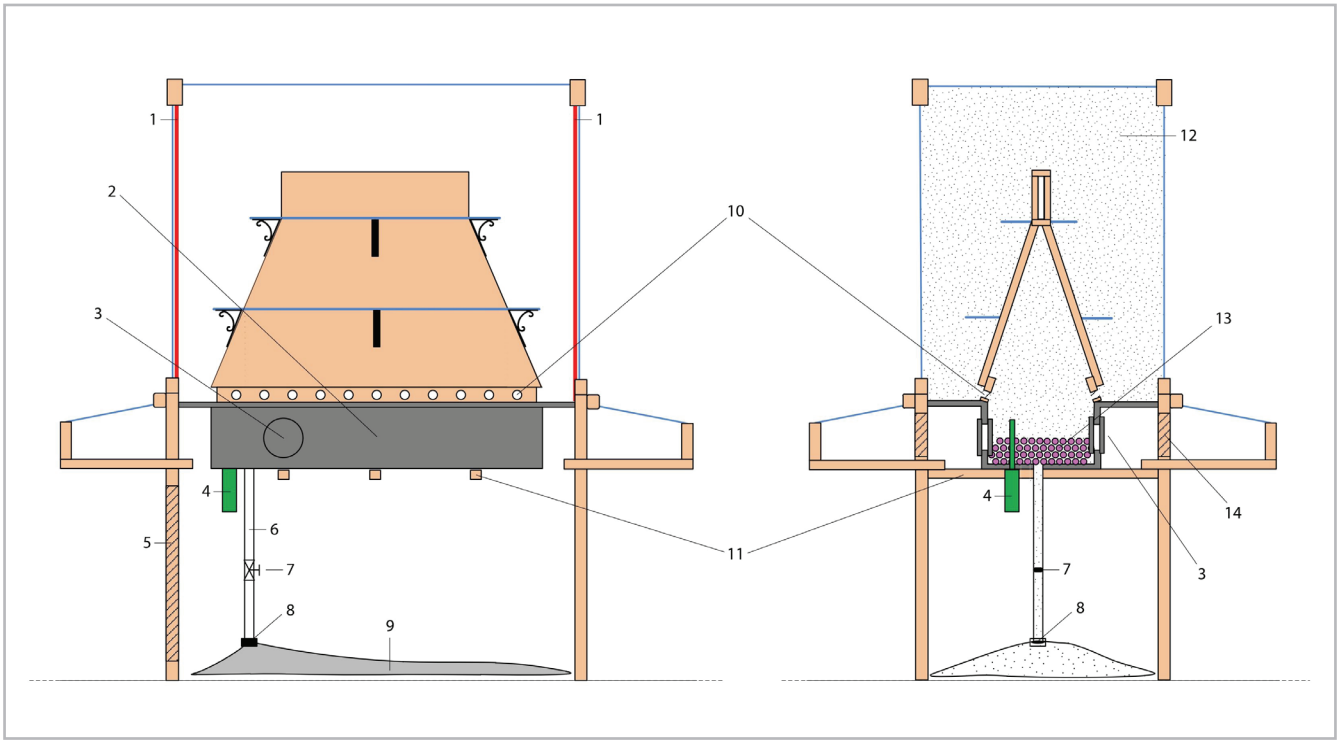

Figure 6.- Design of the new elements incorporated in the climate control system: 1. Steel strut; 2. Aluminium drawer; 3. Opening for access into the drawer. 4: Datalogger; 5: Opening for access to pressure cushion; 6: PVC tube connecting the cushion to the drawer; 7: Shut-off valve; 8: Pressure valve; 9: PE-AL-PE multilayer pressure cushion; 10: Holes connecting the drawer to the glass case; 11: Wooden struts supporting the weight of the structure; 12: Argon gas: 13: Silica gel; 14: Access to the opening of the drawer (D. Fernández & M. Pérez – MCNB).

physical resistance. The mechanical cleaning aimed to remove layers of dirt and the evident product of recent crystallisation greatly improved the aesthetic appearance of the specimens and their legibility [Figure 7].

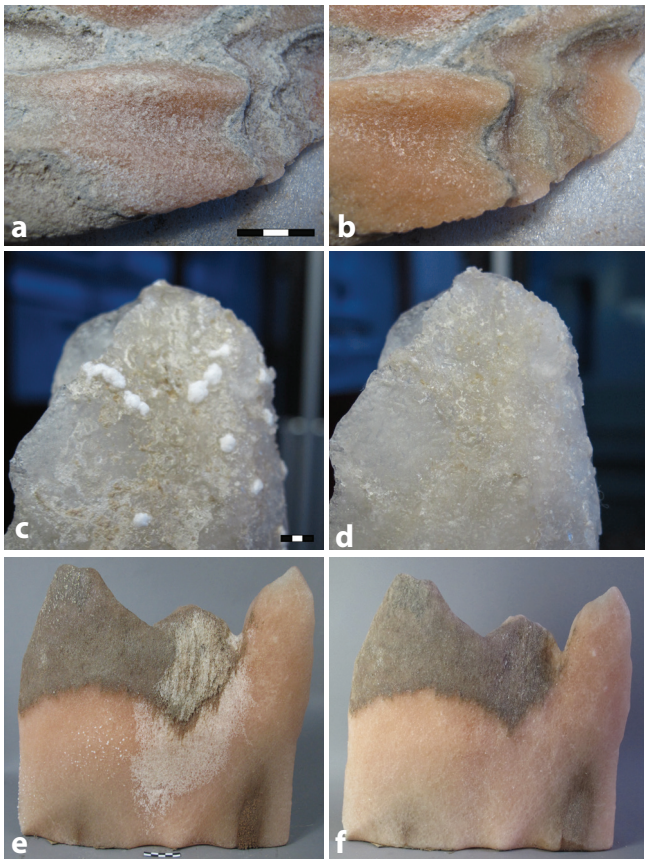

Figure 7.- Some of the salt rock specimens before (left) and after (right) the conservation work (M. Pérez – MCNB).

Nevertheless, further deterioration caused by incorrect environmental conditions could not be stopped, or even slowed down, by any remedial conservation treatment. Thus, to avoid further deterioration it was essential to recondition the showcase in order to achieve and maintain the environmental settings needed for the conservation of the specimens.

The results of the conservation treatments of the showcase are evident from both a structural and an aesthetic perspective. On the one hand, the substitution of the rotten wood and the corroded nails and screws has improved the stability of the showcase, an essential requirement given that the salt rocks weigh in total 142.3 kg and the upper panel 40 kg. On the other hand, the substitution of the warped wooden elements has improved the external aspect of the showcase as well as its functionality and capacity to isolate the specimens it contains.

The steel struts that were added help support the upper panel and guarantee the stability of the showcase when its doors are open [Figure 6. nº 1]. These elements are hidden by wooden braces, not visible from the outside, and do not affect the original appearance of the showcase.

Thanks to the conservation work, the main problems affecting the aesthetic and functional features of the showcase that were putting the exhibition set-up at risk have been resolved.

On the whole, the results of the conservation work satisfy the requisites established at the beginning of the intervention, i.e. the original design of the showcase was respected as much as possible, the work performed is environmentally sustainable and access to the rocks has significantly improved.

From the outside no differences in the exhibition set-up 'before and after' are appreciable. Some of the internal elements of the showcase that had to be replaced to adapt it to the new environmental control were already in an advanced and irreversible state of degradation and were carefully documented before being removed.

The conservation work has restored the function of the two openings in the glass showcase that enables the specimens to be extracted safely by the MCNB staff if they need to be studied or checked. Good access to specimens is a key element of any museum display case (Ruijter 2010). Likewise, the passive climate control system is easily accessible for maintenance and monitoring since one of the panels at the base of the showcase was modified so that it could be opened to allow access to the internal structures and components.

An evaluation period of two months was established for the passive climate control system, which takes readings every 30 minutes. Weekly reports showed that, whilst in the exhibition hall the RH was over 85%, the maximum RH in the showcase was 48.7%.

After these positive results, environmental conditions in the showcase were monitored using the RH and temperature data collected every hour from both inside and outside the showcase and reporting the results monthly (García-Diego *et al*. 2016). Currently, the data from inside the showcase indicate that, even though the RH is progressively increasing, it is still within the critical limits in terms of the deliquescence of the salt rocks [Table 3].

Approximately a year after its initial installation the silica gel was changed for the first time without problems given that the drawer containing the gel could be opened easily. The results show that the reconditioning work has managed to stop the active deterioration that was affecting both the rock specimens and the Cardona salt rock showcase.

The reconditioning did not require the installation of any active climate control infrastructure, thereby fulfilling the sustainable requisites established at the beginning of the project. Additional energy costs were thus avoided and,

	RELATIVE HUMIDITY (%)				TEMPERATURE (°C)	
	Maximum	Minimum	Max. daily fluctuation (daily range)	Max. seasonal fluctuation (seasonal range)	Maximum	Minimum
Cardona salt rock showcase (1)	68.5	39.2	10	16	30.0	9.2
Exhibition hall (2)	87.5	40.6	28	45	30.6	8.7

Table 3.- Main statistical indicators of the environment inside the showcases (1) and in the exhibition hall in which it is located (2). Data taken between October 2018 (end of conservation work) and April 2020. M. Pérez - MCNB.

overall, the sustainability of the solution was maximised and the financial and maintenance costs were kept to a minimum (Neuhaus 2013).

Regarding this last point, during the conservation work carried out on the Cardona salt rock exhibition set-up a series of actions were applied that met the sustainability criteria that are increasingly becoming part of the everyday running of our museums (Staniforth 2010). Some of the other procedures used in museums to reduce their environmental impact include a reduction in the amount of electricity and heating and cooling gases in control climate systems, and limits put on work-related trips and the transport of objects (Madan 2011). This project did not involve the transportation of the material outside the Museum and was conducted by professionals from the immediate geographical area. The control of the humidity does not require any energy consumption and no system for controlling the air temperature was installed. The MCNB employs an officially recognised waste disposal supplier to separate and recycle all the waste generated by its conservation projects.

The dissemination and publication of the results of the conservation work also help promote sustainable development objectives that include the increase in the transparency regarding how the Museum works, the promotion of similar projects in other cultural institutions, and, finally, the transfer of ecologically rational technological solutions (UNITED NATIONS 2015, Aims 16 and 17).

Finally, it is important to remember that the conservation works of the upper panel were not completed. This is where flat sections of salt rocks, which are undergoing the same deterioration process as seen in the other specimens before the conservation work, are on display.

Conclusions

The conservation work described here has managed to halt the active deterioration of the Cardona salt rock exhibition set-up, the main aim of this project. The direct and individual treatment of the specimens has improved the aesthetic appearance of these saline rocks. The environmental conditions of the exhibition hall in which the showcase is displayed were analysed and found to be adverse given that they greatly exceeded the threshold of deliquescence of the saline minerals on display. The passive environmental control system that has been installed in the showcase has managed to conserve the specimens since, according to the data gathered once the conservation work had finished, it has kept the RH below critical levels. The environmental solution employed avoids energy costs and was applied following sustainable criteria, thereby helping fulfil the sustainable development objectives established for museums. The monitoring of the condition of the showcase through a preventive conservation program will ensure its long term preservation.

Finally, in each of the phases of the project the original appearance and main structure of the showcase were respected, and all the work carried out was documented in great detail. Therefore, this intervention preserves the scientific value of the collection of salt rocks from Cardona in the MCNB and safeguard the historical value of the showcase, one the oldest such pieces in the Museum. The project took into account at all times the conservation of the Cardona salt rock exhibition set-up as a whole. Thus, the approach of the conservation works helped maintain the delicate balance between the scientific use of natural history collections and the conservation of their heritage value.

Acknowledgment

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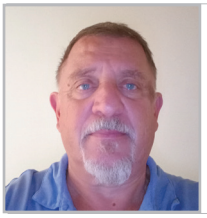

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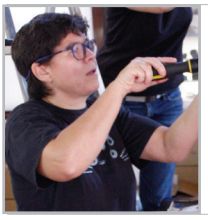
Desde 1993 ejerce como director de las empresas creadas o cocreadas por él, siempre relacionadas, de una manera u otra, con el mundo de la museografía y especializándose en la conservación preventiva de patrimonio al intervenir directamente en los procesos de instalación, almacenaje, manipulación, embalaje, conservación y transporte de bienes culturales. Cabe destacar la colaboración, en 1996, con Nieves Valentín (IPHE) y Shin Maekawa (The Getty Conservation Institute) en el proceso de realización de la primera vitrina hermética con atmosfera transformada en territorio europeo que actualmente aún está en pleno funcionamiento sin que se haya realizado ningún tipo de mantenimiento. De este proyecto nació el servicio de anoxia para la conservación de bienes patrimoniales siendo pioneros en nuestro país. Actualmente dirige Nordest y se encuentra involucrado en el análisis del estado de conservación de las colecciones de los museos de Catalunya así como se encuentra participando en la manipulación de piezas arqueológicas de gran formato para el museo Arqueológico de Barcelona, entre otros proyectos.



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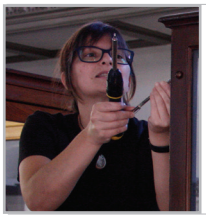

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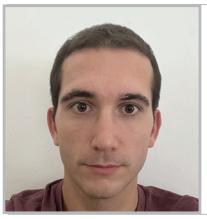

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