

further from the truth. Their elementary composition based on ochre (or other natural minerals), charcoal and water (as an agglutinant or solvent), makes them rather fragile and vulnerable. If they have reached our days, after an existence of 14,000 or 20,000 years, like the paintings at Altamira, it is owing to the fact that they have been immersed in favourable or virtually non-aggressive environmental conditions. The cause for these is the natural stability of cave environments and because, at Altamira, a roof collapse sealed the cave entrance about 13,000 years ago. Thus it is necessary to maintain the microclimate – certain humidity and temperature regimes – and in general, maintain the natural conditions that have existed in the cave until the present time, in order to guarantee the survival of our early art. These conditions and their stability can be changed both directly by actions inside the cave and indirectly by actions in the area outside which affect the interior (area of influence or impluvial area).

The temperature, humidity and their combined action create the greatest risks of deterioration and destruction. A rise in the inside temperature with the consequent fall in the humidity can by itself result in pigment peeling off the rock surface. The water vapour that condenses on the paintings or the rock may cause the pigments to be washed away or result in the precipitation of an opaque layer of calcite over the paintings. A rise in the temperature in a humid environment could increase the presence or activity of microorganisms; these are also favoured by artificial lighting and by the entry of visitors (who spread microbial flora and fauna). In conclusion, there are many well-known problems that arise when the fragile dynamic balance between humidity, temperature and water conditions, and those which affect fungi and bacteria, are broken. And yet this balance has been broken, changing the natural environmental conditions, in every cave open to the public, and it continues to be broken.

#### **Cueva de Altamira: an extremely popular ancient monument**

Cueva de Altamira was the first place where Palaeolithic art was identified, in 1879 (Heras 2002). The finding was greeted with certain scepticism as it raised new questions about human evolution, which at that time was still poorly understood, and about the intellectual



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## **CUEVA DE ALTAMIRA AND THE PRESERVATION OF ITS PALAEOOLITHIC ART**

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### **A Summary or Introduction**

It might be thought that Palaeolithic paintings have some special characteristic which makes them particularly long-lasting, and because of this they are almost eternal. Nothing could be

capabilities of the so-called Cave Men. Together with these arguments, another reason why many scientists did not accept the antiquity of the paintings was their excellent state of conservation and their freshness, which made them believe that they must have been painted quite recently.

The interest in preserving Altamira had an early beginning. Its discoverer, M. Sanz de Sautuola, who was convinced of the age, importance and attraction of the paintings, had a gate fitted in the cave entrance even before publishing his find, in order to impede any irresponsible acts to the art. Santillana del Mar Town Council established from the start that all visitors should be accompanied by a municipal guide. Nevertheless, the problems of conservation had started even before the cave was discovered.

Cueva de Altamira is formed in limestone karst in a stage of senility. Collapses in it must have been occurring for thousands of years, owing to the flat horizontal structure of the limestone beds. These roof falls have been recorded during the human occupations in the Palaeolithic and also in modern times, in the first part of the 20<sup>th</sup> Century. In fact, after the cave had remained hidden and undisturbed for millennia, its discovery could hardly have been more violent; quarrying the rock from above the cave with explosives must have opened the hole which allowed entry to the cave again. However, the explosions must also have fractured the rock strata in the roof of the cave, leading to the major collapses that happened in the entrance hall around 1875 and in 1925 (during the archaeological digs). The fear that a general collapse might affect the Polychrome Ceiling meant that between 1940 and 1965 large concrete supporting walls were built (imitating natural strata) to strengthen its stability. These walls created a new "chamber" where the Polychrome Ceiling was enclosed and isolated from the rest of the cave. From this moment on, there was a change in the environmental factors – temperature, humidity, ventilation, etc. – so that a short time later, the consequences for the cave and the paintings became noticeable. In 1955 some prehistorians and art conservers suggested reducing the number of visitors, but despite the controversy being opened, the tourist use of the cave continued to be promoted. In this way, the prehistoric cave became a great monument for the 20<sup>th</sup>

Century, a tourist attraction of the first order. As well as being an artistic and cultural landmark, Altamira was important for its economic results and the image it gave to the promotion and development of the region.

Therefore, in the 1960s, the ceiling with the polychrome bisons was enclosed in a space of 300 cubic metres, isolated from the rest of the cave. This isolation, which was at first considered favourable, reduced even more the margin for the delicate physical, chemical and microbiological balance needed to preserve the paintings.

The idea was that visitors would satisfy their curiosity for seeing the underground world by being guided through the rest of the cave, where they might also see some engravings or paintings. For this purpose, the natural bouldery floor of the cave was transformed into a wide and comfortable path (by digging it out, filling it in, making steps...). At the end of their visit, they would then be happy with a quick view of the spectacular polychrome paintings. The cave was altered in an attempt to reduce the presence of the public in the Hall of the Paintings and thus limit their impact on such a small volume of air. The cave suffered from this decision, and a banal multi-colour lighting system was installed, disguised behind rocks.

The cave was the tourist pride of the region, and one of the most visited ancient monuments in Spain; more than 100,000 people a year after 1964, and over 175,000 visitors in 1973. The effect of this multitude could have been extremely serious. The paintings must have suffered sudden large oscillations in the humidity and temperature, producing physical, chemical and microbiological risks that would increase at the same rate as the visits, and which would have caused their destruction.

#### Preservation of a fragile heritage

Although different reports had, since 1955, warned about altering the microclimate inside the cave and the need to reduce the number of visits, it was not until the risk of losing the paintings became self-evident that the authorities considered ending the system of tourist exploitation of the cave. The preservation of the cave became a political dispute between the local and regional administration on the one hand and the

national government on the other, and received a great deal of public attention. In this situation, in 1978 the Spanish Government took over the ownership of the cave and in 1979 founded Altamira National Museum and Research Centre (Altamira Museum) as an efficient instrument for conservation, research and management of the cave. The cave was closed that same year. They decided against the artificial forced air conditioning that had proved so disastrous at Lascaux Cave (Montignac, France). Instead, a team led by the Professor of Physics, Eugenio Villar was given the task of studying the environmental parameters and conservation of the paintings. The natural microclimate of the cave was analysed in the absence of visitors and finally, following a mathematical model, the number of people who could visit the cave daily without affecting the interior climatic pattern was fixed. Altamira was opened again in 1982 for a small daily limit of visitors: only 8,500 a year, in groups of five accompanied by a guide, allowing them only ten minutes in the chamber with the Polychrome Ceiling (Villar 1984).

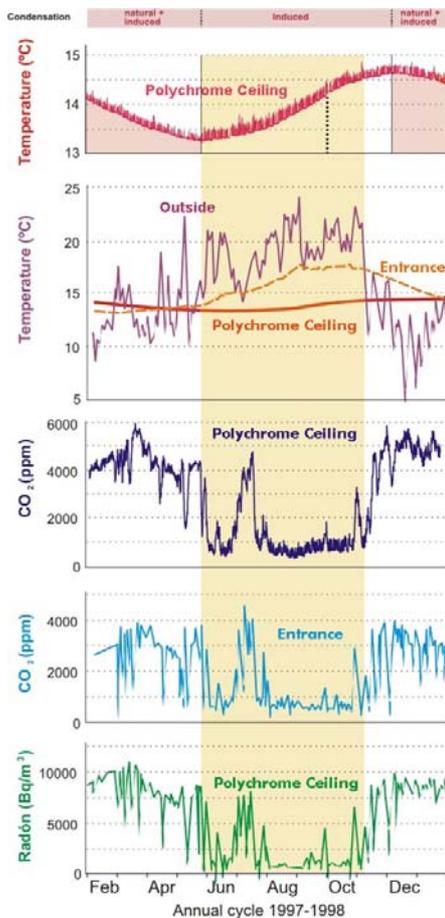


Figure 1. Some environmental parameters that affect the conservation of the polychrome paintings of Altamira.

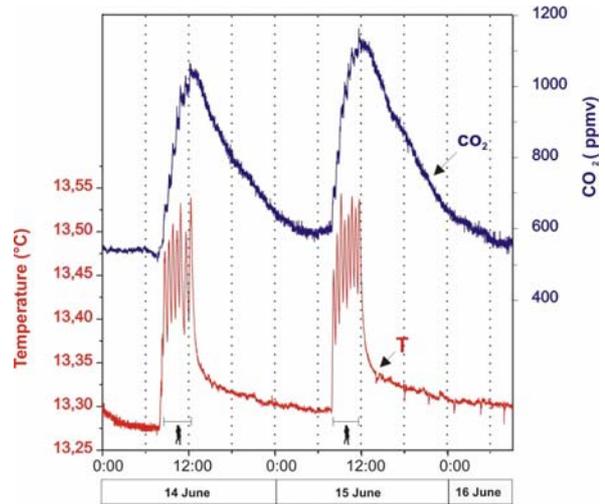


Figure 2. Repercussions of visitors under the Polychrome Ceiling (8 groups of five people –accompanied by a guide– for 10 minutes).

To summarise, the greatest importance was given to controlling the temperature as the key factor in the underground system (changes in temperature affect the ventilation by convection, the relative humidity, physical and chemical reactions on the rock surface, and the microbiological community). A mathematical model was created, conjoining interior and exterior climatic parameters and the alterations caused by the presence of people so that they would not lead to accumulative changes inside the Hall of the Paintings. According to this mathematical model, and with the proposed regime of entries and visits, the temperature, humidity and CO<sub>2</sub> level would return to their “natural” values each day, during the hours while the cave was closed, and the weak natural annual oscillations would be maintained. Without assessing its application, this regime of visits proposed in 1982 continued in practice until 2002, when it was decided to close the cave of Altamira again to make a new diagnosis of the conservation conditions.

For several years, at the request of Altamira Museum, the Council for Scientific Research (CSIC) has been collaborating directly in the analysis of Altamira’s conservation. A team, led initially by Dr M. Hoyos (deceased in 1999) and at present by Dr S. Sanchez-Moral (Sanchez-Moral et al. 1999, 2002; Heras Martin et al. 2004), is carrying out a series of studies to assess the present situation, and has noticed some differences from what was believed previously. In 1999 they concluded a phase of the project in which they assessed the environmental parameters with the

existing regime of visits. This is currently being complemented with a study of the closed cave, which started in 2004. Improvements in the instruments now available (more accurate, reliable and easier to handle and use), the possibility of monitoring different parameters permanently, and some variations in concepts and criteria, has allowed them to see that the visits regime being applied produced a slight increase in the temperature and this did not return to normal each day. This is in contrast to what the previous model predicted. Equally the CO<sub>2</sub> level in the air displays an annual cycle with some differences from what was noted in the earlier study. However, where the present research shows greatest difference is in the importance given to the humidity (absolute and relative), to its changes and to the impact made by the entry and presence of people in a humid environment, permanently above saturation point. This increases the total volume of condensed water in the Hall of Paintings significantly. Furthermore, this condensation is produced mainly on the ceiling, precisely where the paintings are, accelerating the processes of calcite formation and corrosion. Therefore, the physical and chemical properties of the water, both in liquid and vapour form, are fundamental to control the processes of mineral solution and precipitation, and to define the dynamic balances in the cave system (Figures 1 and 2).

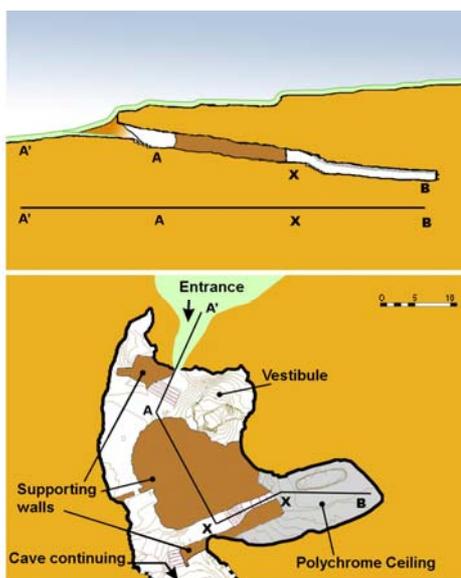


Figure 3. Ground plan and profile of the first section of the cave of Altamira in its current state.

Together with this, the colonies of certain microorganisms are one of the greatest risks

for the preservation of the paintings, because of the difficulties for their prevention, the seriousness and irreversibility of their possible negative effects, and the even greater difficulty for their correction and eradication. So far, only the bacteria that can be cultivated in the laboratory had been identified, but the application of molecular techniques at Altamira (based on the sequence of the ribosomal RNA gene 16S and 23S) has enabled numerous previously-unknown microorganisms to be detected. These include both the metabolically active and others not active at the time of sampling (more than 70% of those identified so far). The intense colonisation by bacteria produces a stratified biofilm made up of *Bacillus*, *Acidobacteria*, *Actinobacteria*, *Sphingomonas*, etc., all of which are sensitive to any alteration in the ecosystem. At Altamira, the bacteria appear to neutralise the spread of fungi, but both are the current main risk for the preservation of the prehistoric art in any cave, and this does not seem to be a matter which has been sufficiently analysed and considered in the case of the caves with prehistoric art that are open to the public.

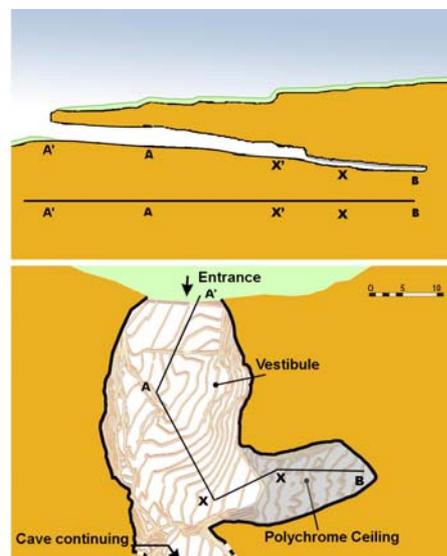


Figure 4. The topography of the first section of the cave of Altamira during the Paleolithic occupations (20.000-13.000 B.P.). Topographic model created for the facsimile in the museum: known as *Newcave* of Altamira.

The present closure of the cave, which commenced at the end of 2002, has the overall aim of analysing the situation without the disturbance of visits. When the study is taken into consideration together with the assessment made in 1999, it will produce a new diagnosis on the conservation of

Altamira. Among the conclusions or consequences of this diagnosis, in reference to the management of the cave, there must be a new regime for public access and visits compatible with its preservation. This could be a new mathematical model which integrates the natural variations and the disturbances caused by the visits; a system for constant assessment and correction; a definition of the thresholds of risk and alarm for each parameter, and the measures to take in each case; preventive proposals for the vegetation and soil cover above the cave, etc. Logically, also in this case, one of the aims is to make the public access to this heritage site compatible with its preservation.

**Conservation, research, diffusion ... Altamira Museum (Lasheras and Heras 1999; Lasheras et al. 2002)**

The studies carried out so far, as well as the new Museum buildings, opened by their Royal Highnesses the King and Queen of Spain in 2001, form part of the same Museological Project, started in 1993 and still in force. The permanent exhibition in the new museum includes a copy of the cave: the *Newcave* of Altamira. This has been conceived in an original way, as it reproduces the entrance hall – the habitat area in Palaeolithic times – and the area with the Polychrome Ceiling, recreating the appearance it had when the cave was occupied (Figures 3 and 4).



**Photo 1. The *Newcave* of Altamira in the museum. Image taken facing the cave entrance: rendition of the vestibule, the original mouth of the cave and, in the forefront of the archaeological excavation. (© Photo: Museum of Altamira/ P. Saura).**

The cave has suffered great changes since it was abandoned by its last inhabitants about 13,000 years ago. These began with the roof

collapses that occurred soon after that time and which sealed the entrance until the 19<sup>th</sup> Century. The replica reconstructs the form of the cave, using archaeological and geological information, by interpolating this information on a highly precise 3D topographical model. The *Newcave* is not an imitation of the original, and its viewing cannot be a substitute for this. Instead, it is a means of informing and educating about the original. Two main reconstructions/restorations made in the replica bring us nearer to understanding the Palaeolithic cave: the reconstruction of the original large cave entrance (Photo 1), and the removal of the modern walls built between the entrance and the Hall of the Paintings to support the roof (Photo 2). The replica makes it clear that everyday life was carried out in the daylight zone, and not in the darkness of the cave. It also shows the absence of physical barriers – and the importance of the shade – to separate the living space from the area for the Art, as if to separate the common area from that reserved for myths, rites, the transcendent and the sacred.



**Photo 2. The *Newcave* of Altamira in the museum. Image facing the back of the cave: rendition of the vestibule without the modern walls built at the entrance, the vestibule and the room with the polychrome paintings. Toward the left, the stratum of the Polychrome Ceiling is visible. (© Photo: Museum of Altamira/ P. Saura).**

The reproduction of the paintings is a totally faithful copy of the original, even in the techniques used and the pigments employed: ochre and charcoal. A few defects that have occurred since the art was done thousands of years ago have been corrected, improving the visibility of some of the paintings and engravings, especially in the case of some figures which went unnoticed by most visitors. A view of the maximum number of figures is necessary to understand all the symbolic content accumulated over such a long time in such a small area. This replica has been based on the observations and studies

made on the original and the new photographic record that has been obtained.

This reproduction has been helped by the application of modern computerised technology, in the topography and modelling as well as in the shaping and manufacture of the final copy (an accuracy of over 40,000 exact points per square metre). This has enabled the natural architecture of the cave to be restored to exactly how it was 15,000 years ago, according to the archaeological and geological research carried out. In this way, both the natural roof falls and the modern alterations and building work suffered by the cave to make it visitable (walls, paths, steps) have been “restored and returned” to their original appearance.

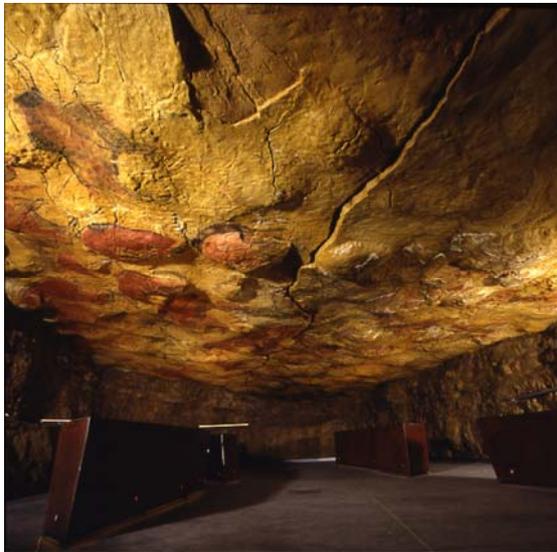


Photo 3. The Polychrome Ceiling in the *Newcave* of Altamira.

It must be remembered that the *Newcave* is not intended to contribute to the preservation of the original, and that is not its use – we have already explained what affects the preservation and what needs to be done for that. It is a response to the great general interest in this masterpiece of Prehistoric art. The *Newcave* should be understood simply as a way to know Altamira, like a huge book that explains exactly what the cave was like during the Palaeolithic, and shows it in one amazing “three-dimensional illustration”. It is intellectually accessible and attractive to anyone, to all kinds of people with curiosity or interest. The *Newcave* is not an instrument of conservation, but a large book written with museological, educational, scientific, technological and aesthetic care.

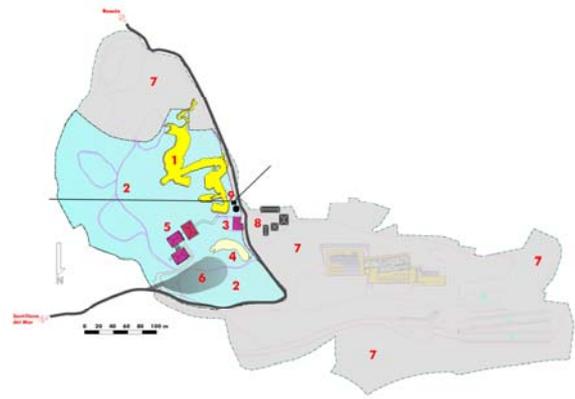


Figure 5. 1985. Museum of Altamira and the Cave of Altamira. 1. Cave of Altamira (included on the World Heritage list). 2. Widening of the buffer zone with complete protection and control (by the Museum). 3. Building constructed in 1924 and renovated for the Museum in 1979. 4. Cave of Stalactites (no archaeological remains nor prehistoric art). 5. Building and footbridge constructed in 1970 for tourism and renovated for the Museum in 1979. 6. Parking area. 7. Present-day buffer zone for complete protection (Museum boundaries). 8. Three houses and a cattle barn built in 1960 – 1980. 9. Water tank, electric transformer and electric lines over the Cave of Altamira.

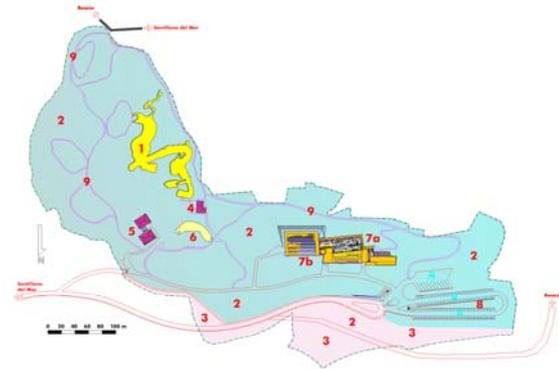


Figure 6. 2006. The Cave and Museum of Altamira. 1. Cave of Altamira (included on the World Heritage list). 2. Present day buffer zone for complete protection (Museum boundaries). 3. Museum property outside the museum precinct. 4. Unused building. 5. Building from 1970 renovated for temporary activities of the Museum. 6. Cave of Stalactites (no archaeological remains nor prehistoric art). 7. Main building of the Museum -7a- and the new Cave of Altamira -7b-. 8. Parking area. 9. Pedestrian paths: buffer zone for complete protection and control, open to visitors of the museum as the Park of Altamira.

During the development of the Museological Project – of which the *Newcave* is the best known part – practically all the conservation measures to prevent anthropic risks have been successfully achieved. The land directly above the cave has been acquired so that the area belonging to the museum has increased from 50,000 m<sup>2</sup> in 1985 to 160,000 m<sup>2</sup> in 2001. This means there is complete control over the vegetation cover above the cave, prevention of wastes being deposited in its impluvial area, eradication of three houses and a farm from nearly above the cave, deviation of traffic from the impluvial area (altering the

existing road layout and car park), removal of a water tank and electricity power lines above the cave... The museum as an instrument for the management of the cave, and the development of the Museological Project for conservation, research and diffusion of Altamira, have made it possible to affirm that the preventive measures for the preservation of Altamira are now much better than they were before 1993 (Figures 5 and 6)

### Conclusion or Continuation?

We believe that we should preserve historic heritage to make use of it; that is, to know it and to see it, to enjoy it intellectually and culturally now and in the future. And a basic criteria applied to the conservation and use of Altamira is that it should be accessible to the greatest possible number of people, as long as the presence of this number of people is not in itself a factor of appreciable deterioration, and as long as this number is determined as a result of scientific studies on the conservation of the art. These are the studies currently being carried out which, when they conclude, will allow us to establish a new regime for public access, suitable for the preservation of Altamira, included in the list of World Heritage since 1985.

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