

# The effect that the Bilbao atmosphere is having on Chillida's sculptures studied

June 6 2014

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Weathering steel is a steel specially designed to resist exposure to the open air. Yet in Bilbao some of the sculptures produced in this material, like Eduardo Chillida's Besarkada XI and Begirari IV, have not been preserved as was anticipated and have sustained some degradation. As explained by the research group in the UPV/EHU's Department of Analytical Chemistry, this degradation is due to the fact that the protective layer that is usually developed by this material has not been properly formed.

Since weathering steel is a material specially designed for exposure to the open air, it is widely used to create façades, bridges and railway lines. And sculptors have been using it for some time to create sculptures that are exposed to the elements. As Julene Aramendia-Gutierrez, a researcher at the UPV/EHU's Department of Analytical Chemistry, explained, the main feature of this type of steel is its "capacity to protect itself. When the steel comes into contact with oxygen, it develops a protective layer made up of various iron oxyhydroxides that act as a barrier. That way the metal protected by this layer is well preserved."

However, this material does not react in the same way in different atmospheres and can even fail to protect the material in certain conditions. That is the case of one of the sculptures of the Guggenheim Museum Bilbao: Besarkada XI, by Eduardo Chillida. "Its surface is rougher than it should be, it has lost some small fragments of material and does not have the colour it is supposed to have in theory," pointed out Aramendia.

In order to find out why the sculptures look very different from what had been expected, people in charge of the Guggenheim Museum Bilbao got into contact with a research group from the UPV/EHU's department of Analytical Chemistry, and the CAUTAPA project was set up. In addition to the sculptures at the Guggenheim, for the project they took into consideration other sculptures by Chillida that are exposed to the elements in different parts of the city: Buscando la luz IV, Elogio del Hierro III and Begirari IV.

## **The diagnosis using non-destructive techniques**

The analyses were conducted using innovative, non-destructive mobile techniques, “designed to cause as little damage as possible to the sculptures,” explained the researcher. Firstly, they used Raman spectroscopy to analyse the molecular structure of the surface. Secondly, by means of X-ray fluorescence they obtained information about the basic structure of the sculptures, both qualitative information “what elements the sculptures have on their surfaces” and semi-qualitative information “the proportion of each of the elements”. In some cases, they took microsamples to conduct a quantitative study at the Pierre-et-Marie-Curie University in Paris using an innovative method based on Raman spectroscopy.

The results of all these analyses revealed that the level of protection on the surface of the sculptures depends on the composition of the protective layer. Aramendia explained it thus: “The sculptures with the worst appearance had a protective layer containing a greater concentration of lepidocrocite, while those with a better appearance, by contrast, had a greater concentration of goethite. Lepidocrocite is a very unstable compound, while goethite is more stable and provides better protection against pollution.” In any case, all these impacts are on a microscopic scale and superficial, so “the damage sustained by the sculptures cannot be regarded as significant conservation damage.”

highlighted the researcher.

In the case of weathering steel, it is normal at the beginning for the lepidocrocite to prevail and that, as time passes, it should be converted into goethite. "However, in the samples analysed we saw that sometimes it does not happen like that," explained Aramendia. Specifically, they observed this unusual behaviour in the sculptures Besarkada XI and Begirari IV, which are, in turn, the worst preserved ones. What is more, in the case of Begirari IV, they saw an excessive reddish colour. Yet Buscando la luz IV and Elogio del Hierro III were a totally different case and have been preserved very well.

"We realised that what was preventing the lepidocrocite from turning into goethite were certain particles in the atmosphere of Bilbao, which is rich in silicates as well as natural dust and some particles from car exhaust fumes. These particles prevent lepidocrocite from developing into goethite," explained Aramendia.

The research group also studied other microscopic effects of the atmospheric pollution in Bilbao. They detected many iron sulphates and nitrates produced by the atmospheric SO<sub>2</sub> reacting with the material. "These compounds are highly soluble and we saw that, due to the rain, the material is gradually dissolved and precipitated on the ground." Another of the causes of the loss of material is calcium, "which exists in very large quantities in our atmosphere because the soil in our area has a very high lime content." In fact, a lot of gypsum was found on the surface of the sculptures. Gypsum can appear in three levels of hydration and that causes the volume to change. "This difference in volume may cause physical stress on the surface, and that could cause the material to become detached and break off."

Another of the conclusions of the research group was that apart from the atmospheric conditions, the steel alloy used to produce the sculpture

could be highly significant. For example, the sculpture Elogio del Hierro III was not produced using weathering steel, but Eco [steel](#), and this type of material responds very well to the atmosphere of Bilbao. "The alloy used for sculptures that are going to be located in Bilbao needs to be taken very much into consideration," added the researcher.

**More information:** J. Aramendia, L. Gomez-Nubla, K. Castro, J.M. Madariaga. "Spectroscopic speciation and thermodynamic modeling to explain the degradation of weathering steel surfaces in SO<sub>2</sub> rich urban atmospheres." (2014) *Microchemical Journal* 115: 138-145.  
[dx.doi.org/10.1016/j.microc.2014.03.007](https://doi.org/10.1016/j.microc.2014.03.007)

Provided by University of the Basque Country

Citation: The effect that the Bilbao atmosphere is having on Chillida's sculptures studied (2014, June 6) retrieved 9 April 2024 from  
<https://phys.org/news/2014-06-effect-bilbao-atmosphere-chillida-sculptures.html>

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