NATURKUNDE MUSEUM STUTTGART

Pyrite Decay in the Historical Collection of the Stuttgart Natural History Museum in Germany

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Introduction

The fossils from Lower Jurassic Posidonienschiefer Formation of Baden-Württemberg, Germany, are famous around the world for their well-preserved anatomy and soft tissues. Many of them were found and prepared throughout the 19th and 20th century. Since 1972, the excavation area and the fossils are managed as cultural heritage.

The fossil collection of marine vertebrates of the State Museum of Natural History in Stuttgart (SMNS) is the oldest and largest from these black shale deposits, and is scientifically relevant. Unfortunately, pyrite decay affects almost the entire collection, endangering the integrity of the fossils. Since the collection is so large, it is ideal to follow and compare the different restoration treatments that have been carried out through history and also to see the evolution of this chemical reaction over a long time period.

A historical picture (E. Fraas, 1891) of an Ichthyosaur *Stenopterygius quadriscissus* (SMNS 3375) exhibiting pyrite decay

Restoration process and Monitoring

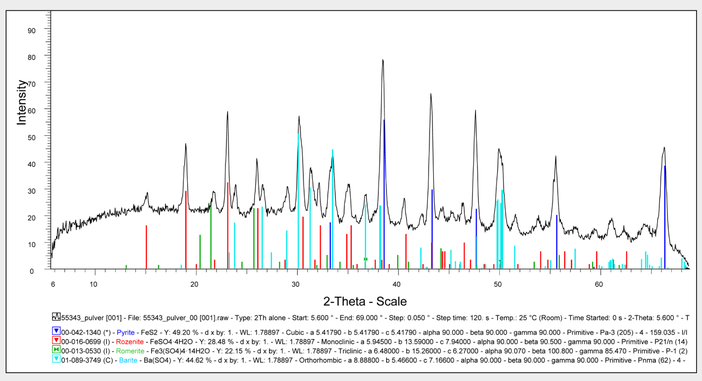
Attempts to restore these pieces have been carried out since the 19th century. Many of the damaged areas were covered with pigment, clay, or slate powder so that they were less visible and others were treated with highly toxic chemicals. Over the last 30 years, specimens with imperilled stability have been methodically restored. There is not a single restoration method for all the specimens, since each fossil needs a different treatment. Nevertheless, some procedures are similar for all cases, such as photographic documentation and sampling of damaged areas.

Since 2015, the specimens with pyrite decay have been monitored by taking photographs of the damage and making a comparison with their previous state. Monitoring the climatic conditions in the collection (relative humidity and temperature) has also been undertaken.

Restoration process of SMNS 3375: a) Photographic record; b) Sampling; c) Silicone mould of the damaged area; d) Cleaning; e) Reattachment of ribs; f) Impregnation of the fossils and sediment

Results and Conclusions

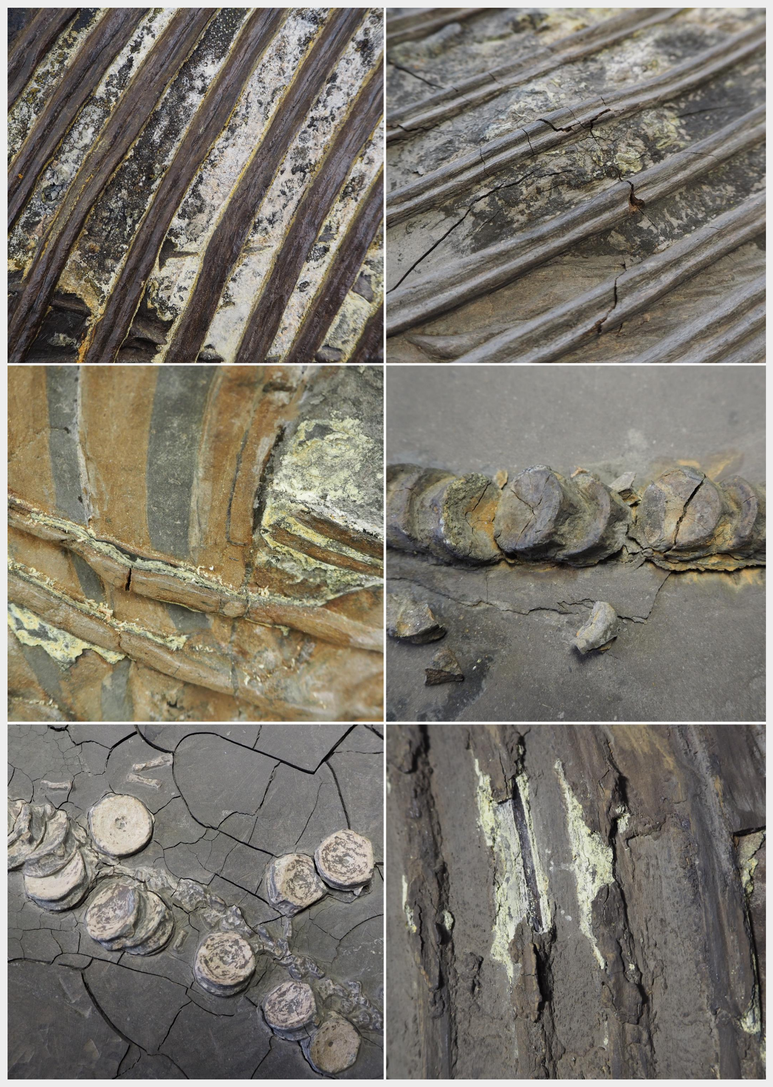
Samples of 5 specimens were analysed with EDX and X-ray powder diffraction and the outcome shows that the efflorescence is composed of highly hydrated secondary pyrite minerals.



Diffractogram of a sample from SMNS 55343

Top: SMNS 14846. Below: SMNS 55343. L: restored. R: one year later

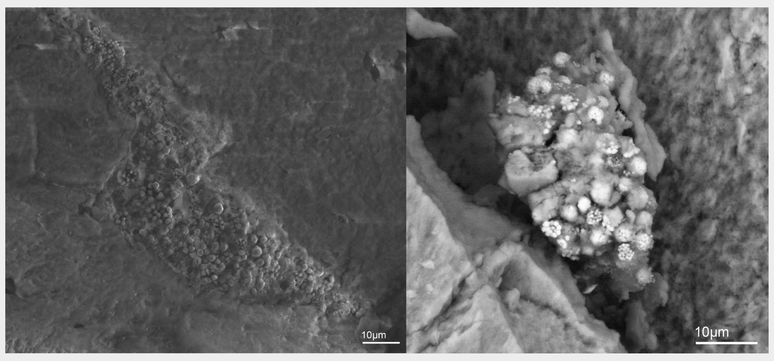
Restoration is not the solution to pyrite decay and should be done only in cases where the stability of the fossil is at risk. After restoration, the damage is repaired. However, over time, some pieces begin to show signs of disintegration again. To preserve and undertake a preventative conservation, the collection must be in an air-conditioned facility in which the relative humidity does not exceed 45 %. Creating a microclimate with low relative humidity and oxygen to slow down the reaction is an option, but application to big specimens is difficult.



Various types of damage from pyrite decay

Pyrite and Pyrite Decay

Pyrite is one of the most common sulphide minerals on earth and normally has a stable cubic structure. The pyrite that formed during the fossilization process in the Posidonia Shale often has an amorphous or microcrystalline (framboid) structure mixed with other clay minerals that gives rise to many cavities in which humidity and oxygen accumulate and begin to oxidise. But what is pyrite decay? The basis of this decay is a chemical reaction. Pyrite in the presence of oxygen and humidity can form iron sulphates and sulfuric acid and this interferes with the stability of fossils. The damage to the fossil caused by this chemical reaction include cracks, efflorescence, blistering, and decomposition of the fossils and, in the worst cases, the process ends with their complete destruction. Usually the ichthyosaurs show this damage in the area of the ribs and in stomach contents.



SEM image of pyrite framboids

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