The inner beauty of Roman Egyptian blue: micro-CT and mineralogy

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Egyptian blue was the first synthetic pigment made by humankind. It mostly consists of the mineral cuprorivaite, which is a calcium-copper-silicate ($CaCuSi_4O_{10}$). This study reports the results of a mineralogical and computer tomographic study of Egyptian blue finds from the Roman sites of Aguntum in East Tyrol, as well as from Retznei and Wagna (formerly Flavia Solva) in southern Styria, Austria. The aim is to expand our understanding of the material processing and production technology of the artificial pigment Egyptian blue. Samples of Egyptian blue pellets were investigated with respect to their elemental composition and spatial distribution of the calcium-copper-silicate cuprorivaite $CaCuSi_4O_{10}$.

A thin section (with three cut layers) of an Egyptian blue pellet from Aguntum was examined using optical microscopy (OP), micro-X-ray fluorescence analysis (μ-XRF) and scanning electron microscopy coupled with energy dispersive X-ray spectroscopy (SEM-EDX). The pigment's initial composition as well as the manufacturing process seem to be the decisive factors for the quality of the final product. A relationship between the presence of trace iron (Fe), titanium (Ti), and sulfur (S) with the quartz and copper source of the initial raw material mixture is discussed.

In addition, micro-computed tomography (μ-CT) of three Egyptian blue finds (Aguntum, Retznei, Wagna-Flavia Solva) was performed, revealing several concise differences between the samples. The pellets from Aguntum and Retznei contained a significantly higher content of cuprorivaite and smaller crystals than the sample from Wagna-Flavia Solva. The spatial distribution of individual mineral phases was analysed with μ-CT-3D images. Here, the connective density, average particle size as well as spacing between individual particles of specific phases can be visualised. This confirms the semi-quantitative measurement of a phase's proportion to the total volume of a sample.

Concerning clues about the initial raw material mixture of the pellets, the results show that chalcosine and possibly quartz from beach sand were used as source for the Egyptian blue pellet from Aguntum. In addition, μ-CT data indicate that the pellet from Retznei contains the highest amount of cuprorivaite, followed by the sample from Aguntum, while that from Wagna-Flavia Solva contains the least amount of cuprorivaite.