

## ANCIENT WARRIORS AND THE ORIGIN OF CHINESE PURPLE

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In March 1974 during the sinking of wells for farmland irrigation near Xi'an, China, several farmers made one of the world's most remarkable archaeological finds: the discovery of an army consisting of more than 8000 life-size terra cotta figures of warriors and horses of the First Emperor of Qin. One of the most intriguing puzzles is the purple synthetic pigments ("Chinese Purple" or "Han Purple") found on the terra cotta soldiers.



Until the 19th century, most pigments were based on naturally occurring colored minerals and dyes, with three significant exceptions: Egyptian Blue ( $\text{CaCuSi}_2\text{O}_{10}$ ), Chinese Blue ( $\text{BaCuSi}_2\text{O}_{10}$ )/Purple ( $\text{BaCuSi}_2\text{O}_6$ ) and Maya Blue. The former two are alkaline-earth copper silicates, and because of this similarity it has been proposed that the Chinese pigments were derived from Egyptian Blue.

In our study, we analyzed clumps of pigment (above) from the Qin warriors and discovered that in spite of the structural similarity to Egyptian Blue, the micro-structural morphology of Chinese Purple is very different. Based on the morphology and the phase distribution in the clumps of the pigment, it appears that the process by which Chinese Purple was synthesized is very similar to that of barium-containing glasses. Combining these results with other archaeological evidence, we propose that the synthesis technology for the Chinese pigments was a by-product of high-refractive index glasses (artificial jades) produced by Taoist alchemists.

In summary, we argue that Chinese Purple was invented as a by-product of the technology originally developed for synthesizing barium-containing glasses, which, in turn, were invented for the purpose of imitating jade. The barium compounds were added to increase the refractive index of the glass, thus giving the glass a similar appearance as jade. The development of this process also benefited from two well-developed technologies in ancient china: the earlier Bronze making (adding lead compounds to reduce the melting temperature) and pottery making (advanced pottery kilns) technologies.