Mock Mini Grant Proposal: Using Experimental Archaeology to Replicate Han Purple

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ARCH0295 Crafts and Production in the Ancient World: Making Material Culture

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Introduction:

As one of the rare artificial pigments of the Ancient World, Han purple has stunned historians for decades. Chemically, the color can be known as barium copper silicate ($BaCuSi_2O_6$); however, simply having the chemical formula hasn't answered the question of how the Ancient Chinese developed Han purple. There's no written record of the process of creating this purple, leading to the purpose of this study: to use experimental archaeology to try and recreate Han purple using local resources (Patel 2007). Given an understanding of where this pigment was mostly found, it's theorized that heating silica (found in sand) with copper (extracted from relatively abundant azurite) and barium can create Han purple.

This project would aim to test various combinations of these ingredients and different heating methods in hopes of replicating the purple. Verifying the similarity between the replicated purple and the original should be quite simple by comparing the chemical composition. The pigments can be compared with confirmed Han purple pigments and analyzed using Raman microscopy (RM), energy-dispersive X-ray (EDX), analytic spectroscopy, and polarized light microscopy (PLM). These methods are traditionally used when conducting pigment analyses (Cheng 2007).

Discovering how this pigment was made can open doors to answering: How did the Chinese discover this synthetic compound? With its similarity to Egyptian blue, can understanding its origin support the theory that this was a trade of knowledge between the Egyptians and the Chinese? Or was it accidental? Even beyond the origin of this amazing artificial dye, understanding its creation can help contextualize the economic state of China during the color's usage and perhaps with its iridescent properties, shine a light on how the pigment can be used now (Pozza 2000).

Background

Purple. The color of royals. The color of wealth.

Throughout history, the color purple has always been more than just a pretty aesthetic; instead, it was a symbol of status in many societies. Even today, purple maintains its association with power; for example, cardinals are also known as purpurates for the purple birettas they receive while climbing ranks. However, this association has little to do with the color itself; rather, it has to do with the lack of purple in nature, making developing large quantities of the pigment extremely costly, labor-intensive, and time-consuming. Before the development of Han purple, the standard practice involved crushing thousands of mollusks and slowly boiling them to extract the dye. It's estimated that five thousand adult mollusks would be needed to dye one woolen cloak (Gillis 2010). Consequently, only the richest could afford to wear purple clothing or own purple items–that is until Han purple was invented.

While the name suggests that Han purple was invented during the Han era, it was invented almost eight hundred years earlier in the Western Zhou dynasty (1045-771 BCE). Archaeologists had simply first discovered the pigment on Han dynasty artifacts like the terracotta warriors and misnamed it Han purple (Eno).

The Han Dynasty was the second imperial dynasty of China, following the Qin Dynasty, and ruled China from 206 B.C. to 220 A.D. As one of the most powerful dynasties China has ever had, trade, art, and innovation flourished during this period. Most notably, they opened trade with the West through the Silk Road in 130 B.C. and paper was invented in 105 A.D (National Geographic). These trade routes and technological advancements massively increased the wealth of the nation, improving quality of life for all. About ten percent of the population lived in cities, with most of them being artisans and traders or officials and garrison soldiers. The rich lived lavishly, flaunting their wealth and were well-educated, while life for the poor was cramped and difficult. Merchants, however, were not well respected as their profession was viewed as greedy and immoral. Despite this, with the rapid growth of the Silk Road, merchants were often extremely wealthy (Lixing 2017). For the other ninety percent of the population in rural areas, the social hierarchy mattered less. While they worked tirelessly, agriculture was a respected industry allowing most farmers to be well fed and sheltered. Taxes were even reduced for rural inhabitants, further improving their living conditions (Chen 1984).

In 141 B.C., Emperor Wu rose to power and ruled for a record fifty-four years. Wu eventually became known as one the greatest emperors as during his rule he elevated China to one of the most powerful nations in the world (History). Aside from his impressive territorial expansions, Wu is largely known for his religious innovations and patronage of the arts. He revived Confucianism, which later led to the growth of Taoism, and increased cultural contact with Europe. It was also during this time when Emperor Wu elevated purple's status in a "larger effort by scholars during the Former Han Dynasty to create a unified philosophical understanding of the universe from an inherited variety of disparate strands of thought, but it also served to provide a legitimate—and prominent—place for purple in official and ritual life" (Lai 1991). Challenging red as the color for royals, Wu's usage of purple eventually marked the beginning of purple's association with royalty throughout East Asia. Previously, colors like red had more strongly reflected power and royalty as it was one of Confucius's five colors (black, white, red, yellow, and green) (Dusenbury 2015).

Prior to Wu's affinity for purple, the color was mainly used for coloring pottery or glass beads in the Zhou dynasty. Often remembered for the success and stability of their early centuries, the Zhou dynasty is now split into two eras: the Western Zhou period and the war-riddled Eastern Zhou period. Thus, it is fitting that such technological advancements in synthetic color compounds occurred during a time of unity and peace. Located in modern-day central China, this period of uninterrupted domestic peace that lasted about three hundred years (1045-771 BCE) can largely be credited to a series of strong rulers who maintained strict political, religious, and social control (Eno). Commonly known as the "Mandate of Heaven", Zhou dynasty emperors developed this political ideology to justify their rule, claiming that their power was a gift from God (Marshall 2015). To further ensure social order, a feudal system that predates, but closely resembles the European feudal system, was put in place. With varying ranks and jobs, people settled into their given roles and worked endlessly to support the ecosystems they inhabited. As a strong empire with passive members of their society, this is where theories of how Han purple was developed originated.

There are three popular theories. As mentioned earlier, the Western Zhou period was peaceful, united, and powerful, creating a perfect opportunity for trading with other nations. Thus the first theory suggests that Han purple is a marker of the transfer of knowledge between the two societies predating the Silk Road. The eerily similar chemical composition between the two pigments has led Heinz Berke, a chemist at the University of Zurich, to pioneer the theory in 2000 (Berke 2000). However, while the two civilizations have had contact, it doesn't seem like there was enough to warrant the transfer of such a complex technology. Furthermore, while similar, Han purple uses barium instead of the calcium found in Egyptian blue, and there's no clear reason why the Chinese would make this complicated substitution. Berke has since moved away from his theory, but many still believe it could've been a possibility. Perhaps the Chinese could better access barium or perhaps the Egyptians and Chinese had better contact than what archaeologists are currently aware of.

The second theory is much simpler and argues that the pigment's development was an accidental creation by glass makers. The presence of barium was fairly common in Chinese glass at this time, so chemically, it seemed possible that craftsmen stumbled upon this discovery. Bob Brill, a scientist at the Corning Museum of Glass, has led the most research on this. By attempting to follow the process of glassmaking, Brill was able to develop purple and blue hues from varying quantities of barium. While convincing, no further evidence has been able to prove or disprove this theory (Hugh 1992).

The third theory combines work from Berke and Brill suggesting that the pigment was accidentally discovered while alchemists tried to make imitation jade. The disappearance of Han purple shortly after the Han dynasty is an unanswered mystery that the other two theories don't quite address. However, in the mid-2000s Zhi Liu poised his theory to address that mystery. Like Brill's theory, the discovery was accidental, but by Taoist alchemists. As mentioned earlier, the emperors of the Han dynasty had devoted time and energy to unifying a philosophical understanding within their state. As part of this shift, Taoism became extremely popular and so did the use of jade (with its strong role in Taoism). The process of creating imitation jade is quite similar to the glassmaking process presented by Brill, so it wouldn't be too farfetched to believe that purple was an accidental creation. Additionally, the end of the Han dynasty also signified a decline in Taoism, which would explain the decline in the usage of Han purple (Liu 2007). Interestingly, Berke has publicly stated that he doesn't believe in Liu's theory as the usage of purple had less to do with philosophical beliefs and more to do with nobility, while Brill has simply state that he thinks it's an interesting proposal. Regardless, these three theories have only added to the mystery of Han purple and make it all the more appealing to study.

By 2024, there hasn't been much progress in uncovering the truth about Han purple. Few papers have been published in the last five years (I counted two), with only one analyzing the pigment itself. Furthermore, it doesn't seem like anyone has attempted to recreate the pigment outside of a lab. Thus, this proposal aims to replicate the pigment in hopes of addressing the gaps in the origination of Han purple.

Research Design:

To maintain the highest level of authenticity, this experiment will be conducted in China. More specifically, this study will be conducted in or near the former capital of the Western Zhou period, Fenghao (Fang 2023). Located in the middle of modern-day China, Fenghao was a political, economic, and cultural hub–harboring great innovation and trade. Artifacts from this period using Han purple were generally found in tombs, with hundreds of them being found in Fenghao. All of these factors point to this region being a likely culprit for the origination of Han purple. The city's ruins are now found in Xi'an, Shaanxi, China (Fang 2023).

Continuing with Brill's and Liu's theory, this experiment will follow the steps of ancient glass-making as there are written records for these processes. While the exact date for the origin of glass is unknown, archaeologists believe manufacturing began between the Warring States Period and the Western Han Dynasty. Some experts believe it started during the Western Han Dynasty; however, either way, glass-making was a relatively new craft by the time Han purple was made–lending credence to the accidental discovery theory (Gan 2021). Interestingly, lead-barium glass became the most popular form of glass used by the Ancient Chinese until the end of the Han Dynasty (which follows with the usage of Han purple). With weaker properties than other more traditional forms of glass, it's suggested that lead-barium glass was used as imitation gemstones rather than for its glass properties. If this were the case, it wouldn't be hard to believe that alchemists would be constantly experimenting with the quantity of various coloring agents to achieve the most authentic replica. Most notably, copper was found to be a coloring agent for reddish glass beads (Gu 2020). Remember that the chemical composition for Han purple is known as barium copper silicate (BaCuSi2O6), so by experimenting with lead-barium glass and copper pigmentation, it'd be a matter of time before someone had stumbled upon Han purple.

Unfortunately, there isn't much research or literature as to how the Ancient Chinese created their lead-barium glass, but it is known lead and barium were readily available (large mines) and bronze products were extremely popular (Kim 2012). Thus, the Chinese would use waste from bronze shops to create glass, and after analysis of that glass, there were strong traces of lead and barium. For this project, I will assume this to be the process of creating lead-barium glass. The most popular method of manufacturing involved core-formed kiln-casting, and press-to-shape, so to replicate this process, kiln-casting will also be used (Wang 2016). However, for consistency a modern kiln will be used, as recreating an ancient kiln could introduce unaccounted variables that may interfere with the production of glass. The bronze waste can be acquired from existing local bronze shops; however, creating our own bronze waste might be the best option to ensure consistency across all samples. It can then also be confirmed that all bronze was locally sourced, best emulating the Ancient Chinese. Thus the only variable that will be tested is the amount of copper added. The initial test will have no copper as a benchmark for pigment, then afterwards increasing amounts of copper will be added until a pigment is visible.

Once visible an expert will analyze the glass using Raman microscopy (RM), energy-dispersive X-ray (EDX), analytic spectroscopy, and polarized light microscopy (PLM)

(Cheng 2007). This should decompose the replicated pigment to its chemical composition, allowing a direct comparison to Ancient Han purple. As a relatively simple procedure, this experiment can be copied by various people to hopefully validate the results.

Conclusion:

By recreating the pigment through experimental archaeology, this study aims to explore the origins of Han purple with an emphasis on its social impact during its time. Because so much uncertainty surrounds the production of Han purple, it was assumed that the pigment may have been an accidental creation from Ancient Chinese glass production. Thus, the experiment tried to replicate accident by following the process of developing the popular lead-barium glass. Copper was identified as the main pigment alterer, so it became the only variable that would be adjusted. Then with the use of various microscopic techniques, the chemical composition of the synthetic pigment would be compared to existing samples of Han purple. If they match, this project could prove to answer many mysteries that surround the pigment and craft production of the time.

Furthermore, the confirming any theories surrounding Han purple's creation—whether through trade, accident, or alchemical experimentation—could shine light on the complexity of historical technological advancements, their cultural implications, and contextualize these great dynasties. Therefore, this research not only serves as an insight to just a color, but as an insight to the resourcefulness of Ancient China that could open the doors to more research in the arts and material production.

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