# Rediscovering Ancient Greek Pigmentation

## An examination of Pre-Roman Ancient Greek paint pigments and why the public conception is still of a colorless antiquity.

A THESIS BY

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This thesis paper will discuss various questions relating to pre-Greco-Roman Ancient Greek paint pigments. In recent years discoveries of paint samples on Ancient Greek sculptures and architecture are becoming increasingly common, contradicting the stereotype that history has made of Ancient Greece having a pristine white aesthetic in their artwork. (Brinkmann, 2008) The various paint pigments that can be found throughout excavations in Greece, as well as the general history of pigments, create a new narrative when it comes to the art of Ancient Greece. Using various evidence such as pigment samples, artworks, textual primary sources, and scholarly research, this thesis will examine the history of paint and pigments commonly used throughout Ancient Greek Civilization and the manner in which they were produced. This thesis's purpose would be to bring that history together to exclusively discuss the paint pigments found in Ancient Greece. Additionally, this thesis explains the incorrect modern conceptions of Ancient Greek art relating to its coloring. First, the priority is to find what pigments were used in pre-Roman Greece altogether and make a comprehensible list of them in chronological order. Then look at how the pigments were made and how they were used. This leads to the final question of why Ancient Greek statues are now thought to be white despite the evidence that this stereotype is not true.

"I hereby declare upon my word of honor that I have neither given nor received unauthorized help on this work."

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## 1. Introduction

Despite the modern perception prevalent in public knowledge, Ancient Greece was a civilization of color.[1] White marble statues and the pristine aesthetics of the Neoclassical movement dominate public perception of ancient Greece's sculptural artwork and architecture prior to its subjugation by Rome in 146 BCE.[2] Archaeological evidence has consistently proven that this common public perception is misguided. Raw pigments, intact pigments on artworks, and written evidence from antiquity continue to be found to disprove the theory of a colorless antiquity.[3]

This thesis will examine the history of paint and pigments commonly used throughout Ancient Greek Civilization and the manner in which they were produced. It will then use the archaeological evidence of the extensive color palette of antiquity will amplify the work of other scholars and archaeologists who have consistently demonstrated that ancient Greek sculptural works of art were vividly painted with a variety of pigments. This thesis will address how the modern conception of ancient Greek sculptural art as marble white arose and why it persists. This thesis addresses questions such as: What were Ancient Greek paint pigments used for? Where did the pigment materials come from? What was their process of making pigments? When and where were pigments introduced to Greece? How is the paint preserved to the modern day? And finally, why is Ancient Greek art now known as being white and colorless when it was not intended to be so? This thesis intends to answer these questions fully and argue against the idea of a colorless past.

Drawing on scholarly articles, excavation reports, and published books, this thesis will address these questions to construct a history of pigments in Ancient Greece. The first section of this thesis will introduce the topic through its extensive history of scholarship from written sources from antiquity to modern research and the history of technological developments that

have been integral to the discovery of pigments and their compositions. The next section will study the pigments discovered in Ancient Greece in subsections organized by color. Within the subsection, each variation of the color's pigment will be in chronological order by period to answer the aforementioned questions about them. The final section will examine the controversies involved in the introduction of polychrome to ancient art, why exactly the public consensus is still that Ancient Greek art was colorless, and what has been done to combat this idea.

**2a. History of Scholarship: The Approaches and Questions**

The scholarship of pigments and polychrome of the pre-Roman ancient Greek world has been a long and arduous one. With many inventions, investigation methods, and controversies growing over the time of its development, the understanding of polychrome in the ancient world is constantly evolving. There are a few main approaches to the question of polychrome and pigment in antiquity. One is to focus on whether polychrome was even popular in Ancient Greece. This question has largely been answered as there is now a multitude of evidence and studies, which will be discussed throughout each section, proving that Greek artwork and architecture were commonly painted and what pigments they used. It was not an easy transition from thinking that the artwork was a pure and minimalistic aesthetic to one of lavish ornamentation and color. Many large controversies developed, and there was a large amount of pushback from scholars.[4] The discord peaked in the twentieth century when public knowledge of polychrome in Ancient Greek art started to grow, alerting more institutions and scholars to the research being done.[5] The extensive history of controversies on this topic will be discussed in a later section focused on why the general public still believes that Ancient Greece had a monochrome aesthetic.

The more modern approach that formed in the late nineteenth century and early twentieth century is to go into the research knowing that the artwork and architecture of Ancient Greece would have been painted with a variety of colors. The main question about their polychrome now is how it was used. Mechanically focused questions, such as applications, paint thickness and layering, translucency, media, finishes, and polishes, are still being researched. Of course, research is still being done on the vestiges of pigments found on the surface of things such as sculptures, wall paintings, architecture, and practical objects. The current understanding of ancient pigment and polychrome is still in its infancy and has a long way to go.[6]

There are two main approaches to dealing with pigments from antiquity in modern scholarly contexts. There are books such as *Blue: The History of a Color* (2000), *Black: The History of a Color* (2008), and *Red: The History of a Color* (2017), by Michel Pastoureau that give the overall history of a pigment color. The focus here would be on a color's time in ancient Greece, which is often only a section in these books. Another notable multi-volume series that utilizes the entire history of a pigment is *Artists' Pigments: A Handbook of Their History and Characteristics* (1986), featuring multiple authors.

The second approach is writing about a specific place or period within ancient Greece and about pigments found there. In 1935-36, Princeton University chemistry student S.W. Midgle Jr. wrote his thesis on identifying pigments scraped from terracotta pots excavated from the Athenian Agora. This revealed evidence of pigments used as decoration between the seventh and second centuries BCE. Soon after in 1937, Earle R. Caley served as the chemist on an excavation in the Athenian Agora, examining significant specimens of bulk pigments found in vessels or on vessels used for mixing. In the article, *"*Ancient Greek Pigments from the Agora,*"* (1945) written by Earle R. Caley himself, he analyzes the pigments found in bulk ranging from

the sixth to the first centuries BCE and compares them to the pigments found by S.W. Midgle Jr. This process is more common in articles than books, unlike the previous approach.

**2b. History of Scholarship: Important Studies.**

Research of pigments used in pre-Roman Ancient Greece dates far back to antiquity with ancient Greek philosophers. Theophrastus was an Ancient Greek philosopher born in 371 BCE and died in 287 BCE.[7] He was known as a naturalist philosopher and "the father of botany" for his extensive research and recording about natural materials of the world, and more specifically of Greece. In the third century BCE, his book *De Lapidibus* ("On Stones") was completed in his series of books published about the natural world. In this work, he talks about the various stones used in Ancient Greece. When writing about these precious and practical stones, he distinguishes which were often used for making pigments and the process of making them. It is crucial to have primary evidence of this sort about ancient pigmentation. Another primary text from antiquity is the *Naturalis Historia* ("Natural History") series written by Pliny the Elder in 77 CE.[8] Multiple volumes in his series have techniques and pigments used in antiquity dating to different periods in Greece.

A series of events and people from the eighteenth and nineteenth centuries to the modern day have significantly aided and hindered the study of polychrome and pigments from antiquity. Johann Joachim Winckelmann published his book *Reflections on the Imitation of Greek Works in Painting and Sculpture* (1756), which reinforced the misconception of Ancient Greek art as colorless.[9] He created the "Winckelmann ideal," representing an immutable concept of beauty that emphasized formal purity, sobriety, and rationalism. Winckelmann was of the early opinion that Greek art had been left blank in antiquity and associated it with light and purity. He perpetuated the "classical beauty" from artistic movements like the Renaissance and Neo-

Classicism. Winckelmann was one of the people who pushed back heavily on the idea of ancient art being polychrome.

Antoine-Chrysostome Quatremère de Quincy was an architectural theorist, archaeologist, and the head of the French art academy who coined the term "polychrome" about Greek architecture and art as a widely known scholar. He had notable works like *Olympian Zeus, or the Art of Ancient Sculpture considered from a new viewpoint* (1825), which described that the atlantes of the Temple of Zeus at Olympia were painted along with the whole temple.[10] After pushback from other scholars, Quincy compromised on his definition of polychrome in ancient Greek art. He undermines colors that would hurt the ideal of classical antiquity, describing the colors as minimal and neutral with gilded metals as the bright colors as pinnacle materials.

Jacques Ignace Hittorff was an architectural historian and archaeologist who published images using the new technique of chromolithography along with drawings of ancient architecture, particularly a polychrome model of the Temple of the Muses, exhibiting them at the Paris Salon in 1859.[11] He had done this before, making a model of Temple B from the Acropolis at Selinunte in 1851.[12] He used research from previous excavations and his own to recreate the temple in its original design with color. These models were met with strong opposition from other scholars, most of all Désiré Raoul-Rochette. At the time, he was a vehement polychrome denier and head of the French art academy, questioning the authenticity of Hittorff's polychrome models.

Excavations have been a large part of the material sample finds for ancient polychrome, specifically for material finds of pigment samples. Archaeologists have been uncovering and recording evidence of polychrome art since the eighteenth century. The earlier the excavation, the less likely the polychrome would have been reported on, but there are instances where it was presented. Archaeologists have also found bulk pigments in storage on sites like Earle R. Caley's

excavation in the Athenian Acropolis mentioned previously. Occasionally these types of material evidence will be found, like Sir Arthur Evans who found bags of bulk pigment stored in the Knossos Museum that had been found in either a townhouse or the palace at Knossos in 1900.[13] He found multiple pigment samples that dated back to Minoan Crete between 3000 and 1100 BCE. Or excavations carried out by the British School of Athens that found raw pigments near the House of Idols and the Temple in Mycenae, Greece that date to the Mycenean period in the thirteenth century BCE.[14]

Some authors take the approach of writing an article with a detailed analysis of one color from one period in ancient Greek history. Robert R. Stieglitz wrote the article, *"*The Minoan Origin of Tyrian Purple*"* (1994) about one of the richest colors of the ancient world. He explains the ancient technique of making Tyrian purple and how it made its way to Greece during the Minoan period. Stieglitz presents evidence that Tyrian purple might have been introduced to Minoan Greece earlier than currently recorded by analyzing archeological evidence of murex shells harvested to make the color that dates to the middle Minoan period.

Vinzenz Brinkmann is a German archaeologist who has dedicated his career since the 1980s to the reconstruction and understanding of ancient polychrome with a focus on Greece. He has made multiple recreations of The Archer from the West Pediment of the Temple of Aphaia on the island of Aegina in three variants, the most recent being made in 2019 and held at the Metropolitan Museum of Art.[15] He creates reconstructions of ancient statues showing off their colors and how they are understood to have looked. He also published his research, "The Polychrome of Ancient Greek Sculpture,*"* in 2008. His articles provide overviews, definitions, and methods of research done to find out more about ancient polychrome and pigments.

Another person who conducts research and provides articles is Adeline Grand-Clement. She is a member of the Institut Universitaire de France. Her research is based on the perception

of color during antiquity and the modern reception of new facts about antiquity, like polychrome. She has published many articles on the history of scholarship in ancient colors on art and architecture since 2005. Some of these articles include "Colors and Classical Aesthetics in the 19th Century: Could Ancient Greek Art Be Polychrome?"[16] (2005) In this article, she focuses on the perception and reception of ancient polychrome specifically in the nineteenth century, presented through many means of scholarship like publications and reconstructions. In "*A*ncient Marbles Regain Colors: Contributions of recent research and ongoing debates," (2009) she argues how the events and research she lists have built the modern perception of polychrome on ancient art within the last few centuries.[17] "Colorful Greece: Antiquity Finds Color Again," (2010) is an article Grand-Clement wrote that focuses on the color of ancient art and the developments in technology and applications used to analyze pigments on sculptures and in ancient art.[18] These articles offer a wide view into the intense debates, controversies, and how perception has changed about this topic over the years.

Mark Bradley wrote "The Importance of Colour on Ancient Marble Sculpture," (2009) to investigate how significant pigment was to ancient sculpture. He emphasizes not to apply twenty-first century standards to ancient art to understand the composition and relevance of color in ancient sculpture. Bradly explains the technical developments in modern history that are used to examine paint pigment traces. While the article's focus is on ancient Roman art, the rich historical background knowledge it contains makes it a relevant source of information for the analysis of ancient Greek pigments. Bradly also references various Greek artworks such as the Parthenon Marbles, the Korai found in the Athenian Agora, and the Frieze Siphnian Treasury at Delphi.

In 2009, an international conference was organized by art historian Philippe Jockey and held at the French School of Athens.[19] It was held to discuss "The Arts of Color in Ancient

Greece... and Elsewhere.*"* (2009) The conference was held for scholars to share information and to take stock of what everyone researching polychrome and pigments knew currently and the results of their research. The opportunity to converse and communicate with people working in similar fields of research allowed them to compare methods and approaches that were being used around the world.

Some branches of research on ancient pigments and polychrome focus on one period in one area. In the article *"*Colourful earth: Iron-containing pigments from the Hellenistic pigment production site of the ancient agora of Kos*"* (2019) by Ariadne Kostomitsopoulou Marketou, Kelly Kouzeli, and Yorgos Facorellis reports on Hellenistic Kos, featuring a pigment making production site that yields significant material samples of pigments. They analyze the samples available to list and find the various pigments that would have been produced there and explain the production process they can observe from archaeological finds. Along with this, they find what compositions and minerals make up the pigments manufactured in the area. These pigments would have been produced in mass at this production site for trade throughout Greece. When articles focus on one site like this that would have been connected throughout ancient Greece, it explains a standard color scheme of the era. This article is relevant to Hellenistic Greece.

**3. Developments of Technology**

The technology used to investigate and identify pigments on artworks from antiquity has made feats since the eighteenth century CE when polychrome in ancient art and architecture was first discussed on a broader scale. In nearly three hundred years of scientific development, instruments of investigation have been invented and used in the search for ancient pigments and their construction. One of the earliest inventions was the microscope.[20] Having been used since the seventeenth century CE, microscopes allow the viewer to see traces of pigments left on artworks and architecture with the naked eye.

Lithography was invented in 1798 by Alois Senefelder and was used to picture archeological finds of artistic nature from antiquity. Lithography is a printing method using ink on flat plates to copy a drawing. Unfortunately, lithography is only in black and white and does not accurately portray some of these findings. It was not until the 1830s that chromolithography was invented, allowing colorful portrayals of art and architecture to be pictured.[21] A significant project that used chromolithography was picturing several Korai found in Athens at the end of the nineteenth century.[22] Before either method was invented, detailed drawings and models would capture the color of ancient finds. In 1751-53, painter James Stuart and architect Nicholas Revett were sent to Greece by the Society of the Dilettanti in Britain to bring models and architectural drawings for contemporary artists. They later published the book *The Antiquities of Athens,* which describes the color of multiple monuments and temples depicted in their drawings.[23]

Raking light is a technique that uses light to read shadows.[24] It is a light positioned at an extremely low angle that is nearly parallel to the surface and the light "rakes" over it to show shadows on the surface. It can reveal indentations of scoring, markings, and weathered pigment trails. When paired with a photograph, it can show past vestiges of pigments well enough. This was the beginning of using light as a technique to see ancient paint pigments. At the beginning of the twentieth century CE, The Metropolitan Museum of Art worked with James J. Rorimer to introduce the use of ultraviolet fluorescent light to determine the age of stone in ancient sculptures. In the 1960s, the Doerner Institute scientific lab in Munich, Germany, used ultraviolet fluorescent lighting to let the color on ancient sculptures show in photographs. This lab team would later take a successful photograph of the Alexander Sarcophagus from Sidon that showed off its vibrant polychrome. Ultraviolet florescence started to be used regularly to show the ghosts of pigment that were once on a surface in Ancient Greece in the mid-twentieth century CE.[25]

Pigments reflect this lighting in a manner that glows when shined on a surface that once had pigment on it. That includes if there was ever pigment there, even if it has since faded.

Raman spectroscopy is a technique that non-destructively finds the composition of ancient pigments.[26] Before this development, pigments were broken down using various chemicals to see if a reaction aligned with a particular element. This would destroy the pigment sample, something that is a finite resource. It only recently began being used on ancient pigments in the mid 1990s. With Raman spectroscopy, the composition can be seen and allows the viewer to discern a pigment's geographical origin, date of construction and use, and its formation process, all without disturbing the sample's integrity.

In the most recent technological developments, the rise of three-dimensional modeling has emerged. The first large-scale publication of this was in 2006. Between 2006 and 2008, Phillipe Jockey and Brigitte Bourgeois digitally reconstructed several ancient statues rather than using the materials to make plaster casts.[27] Plaster casting and painting the cast was the technique used for reconstructing models on a lifelike scale before digital enhancements evolved. Plaster casting involved handling the antiquities enough to put them at risk of damage. Any vestiges of pigment could be lost or altered from this process, making digital recreation more important. They collaborated with architect Fabricia Fauquet to create polychrome models of five Delian statues. They digitally reconstructed Aphrodite and Apollo statues, The Wounded Gaul, Artemis with the Stag, and the copy of Diadumenos. Digital reproductions like these can be easily amended if current information changes how it should have been painted.

Scientific changes and the ever-growing evolution of technology directly impact the understanding of the past. These developments have been groundbreaking for research in delicate material fields like the study of ancient pigments. It has also been integral to

reconstructing accurate models of ancient polychrome artwork. Now, the artworks can be accurately interpreted as they were meant to be when made in antiquity.

**4. Colors: Techniques of Creation.**

Ancient Greece as depicted now in the public view is one of grander and sparkling white marble. It is now known to some to have been a civilization of color. Their polychrome palette consists of assorted colors, hues, shades, and transparency. There was a wide range of materials on the Greek mainland and Crete that could be used in pigment making. What was not found in Greece was typically traded in from the East. Egypt made some of the first pigment making techniques for painting that would later make their way over to Greece in the Minoan or Mycenean periods and later in the Classical period.[28]

One technique of pigment making Egypt is credited with is lake making.[29] The technique involves taking a dye and adding a fixative that turns it into a pigment. It was to make it insoluble in water by interaction with a metal compound. By precipitating the water-soluble dye with metallic salt it makes it usable as a pigment. Egyptians were the first to fix organic dyes to a translucent or white powder base to make pigments that could be painted with. This solution of organic dyes and powders could also be mixed with hydrated clay to make an insoluble pigment. Because of its abundance in Greece, Greek painters often used chalk or alum to create the binding agent. This process would give the pigment stability so it could be painted with. This technique would be most often used in the Minoan period. New techniques would be developed in the later Minoan period into the Mycenaean period that forego the dye aspect of pigment making. Instead, they would powder the pigments and rehydrate them later for use.

The Egyptians also made some of the first hue making techniques that would be used by the Greeks. Their technique was to grind the material into a fine powder. According to Theophrastus, Egyptians had some of the finest pigment powders of the ancient world. To

control the hue of a color, they would control the consistency of the powder when grinding it. When grounded, the powder with larger particles would make the pigment a thicker consistency that would apply darker. The finer the powder was ground, the lighter the color became when applied. These powders could then be fixed with a binding agent to become a pigment suitable for painting.

The Minoan period was one of experimenting with new techniques and colors for painting. The wall paintings at the Palace of Knossos can attest to the grandeur and value of art in this period. The Minoans are credited with the technique used in wall paintings throughout most of Ancient Greece and later into Roman periods called stucco. They would apply paint to damp plaster that had been spread on the area to be painted and primed the area with lime. Another technique was to place an organic binding material on dry plaster before painting. It is hard to tell now what the exact material would have been in the second technique due to the disintegration of organic materials, but it may have been egg tempera, casein, or gum arabic.[30] The Minoan period set the principal standards for painting from the Bronze Age through the Hellenistic period in Greece. More traditional techniques of pigment making and painting would later be improved and adapted, but Crete did not stray far from the traditions of Minoan and Mycenaean cultures. The same value would only grow with time; the Classical and early Hellenistic periods of Greece are often referred to as "The Golden Era of Painting," as then Greece was still its own civilization before being conquered by Rome.[31]

The Ancient Greeks viewed color differently than we do in the modern sense. They valued the brightness and saturation of the colors more than they did the hue. They divided the spectrum of colors differently from modern standards, focusing more on a one-dimensional color palette than the spectrum of hues that are often presented today. They measured by brightness rather than hue. Transitional colors such as pink would be grouped with red, cutting out the

colors between the primary ones. They were not based on abstract categories but rather on visual qualities a color would bring to art.[32]

Often in Ancient Greece, statues or details of architecture were brighter in color the higher up they were placed. The brightness of the colors enhanced its visibility to the viewer's eye. Coloring artwork helped convey a piece's formal and narrative values by viewing it rather than reading about what it is trying to portray. The Ancient Greeks strived for realism regarding the human form in their sculptures and coloring would have gotten them closer to their goal of perfectionism. Coloring statues also showed off the depth of an artwork. Painting a thin layer of black in between the crevasses of clothing or fabric folds gives a three-dimensional aspect to the work. Reading the artwork would have been made easier by the addition of paint, since having it be monochrome may have left it looking flat. Vinzenz Brinkmann portrays this addition of color in his recreations of “The Archer” by showing the expected brightness and depth of how it was meant to be painted in antiquity. The addition of color to artwork and architecture enhances the experience for the viewer as it helps to distinguish and make it legible from far away. Light was also important to the viewing process. It was essential to the Greek aesthetic to show the color’s brightness at its peak on an artwork to appreciate it fully. The strong saturation and luminosity of a work of art is what made it a part of the Ancient Greek aesthetic.[33]

Three types of polychrome methods have been proposed when painting a sculpture. The sculpture may have been entirely painted, but because of poor preservation much of the pigment traces are gone from the stone or marble. This is the case with many artworks that are still being unveiled, leaving few pigment samples left on the statue to study. Some statues may have been entirely painted except for the skin if it was a human form. During the eighteenth century CE, this was a popular opinion since there was still heavy pushback against the idea of classical polychrome. Scholars compromised with each other by saying that there had once been some

color on statues and architecture, but it was muted and harmonious, focusing on the principal materials of marble or stone. This compromise was meant to keep intact the idealized past of Ancient Greece while acknowledging what could no longer be ignored; ancient artwork and architecture were painted. Now it is understood that antiquity had color, and Ancient Greece had a lot of it. Polychrome is now more accepted and acknowledged. Most artworks and architecture would have been polychrome; some even higher quality statues would have gilded metal details on them while also being painted.[34] There are still many debates over Greek polychrome, but the question of whether they were painted is no longer asked and the correct answer is no longer denied.[35]

With techniques to paint, there are techniques to apply and adhere pigments to the surface of objects. Porous materials such as limestone, sandstone, and volcanic rock would have been primed with plaster or stucco to adhere the pigments to the surface. This would allow painters to paint wall paintings called frescoes. Frescos needed a lime rich binding material to adhere the paint to the wall. Stucco was nearly always painted, so it can be assumed that if there is residue or evidence of stucco once being present on a surface it would have been painted as well. Terracotta is a porous material, but it was not primed with stucco or plaster. This allowed the pigment to settle into the porous surface and stay, which is why there is plenty of evidence of Greek vase painting that survives today.[36]

Pliny the Elder also describes the Ancient Greek masters as painting in the stucco manner. He mentions a less well-known way of adhering pigment to surfaces called encaustic painting. This technique was discovered by accident in the fifth century BCE by Greek ship repairmen. They attempted to fix holes in a ship by heating wax and adhering it to the holes to patch them. Noticing the shiny finish this produced, Greek painters would mix wax, resin, and pigment to heat up and produce an enamel like finish to their work after applying it to the

surface.[37] While there are literary sources that describe this process, there is little to no archeological evidence of it. There is, however, a rare depiction of it found on a Terracotta column-krater (bowl for mixing wine and water) currently on display at The Metropolitan Museum of Art dating to the middle of the fourth century BCE. It shows a painter painting in an encaustic manner. He stands next to a statue of Hercules and applies the paint to his signature lion skin with a spatula like object. The scene is set in a sanctuary with a boy tending to rods that will be heated up and used to spread the pigmented wax. It shows the painter and boy in a sanctuary with Zeus, Nike, and Hercules presiding over them to judge the painter's work. This is one of the few depictions that are known of the encaustic technique of painting and using pigments.[38]

With these many techniques, both from archaeological and literary sources, it is hard to deny that the Ancient Greeks were heavily involved in the painting process and development. They strived for realism in their art. It can be seen in the progression of sculptures from the Archaic period through the Hellenistic period. Adding a polychrome color palette was just another way to achieve the realism they longed for in art. There is a reason Pliny the Elder refers to the Ancient Greeks as "the ancient masters," since they developed techniques brought to them and invented some methods that are used far beyond Greek domination in the world.[39]

**4a. Colors: Red**

Red was one of the most abundant colors in the early periods of Ancient Greece. It is often the color used in prehistoric paintings along cave walls in Crete and Mainland Greece, marking it as one of the easiest pigments to come by. Red ochres are one of these first pigments. It is iron rich earth that gives it its varying hues and shades. It can range from a bright and vibrant vermilion color to a deep brown depending on how high the iron content of the earth is, making it particularly desirable for its versatility.[40] It can also be made darker and lighter

manually by burning either the raw clumps of earth or a powdered form. The technique used by the Minoans to powder it was described on Assyrian cuneiform tablets. To enrich the raw pigment materials, they would wash away the various impurities that came with iron rich earth. After a series of rinsing, the paste left over would be rounded off and flattened on one side to dry as a lump that would then be crushed and powdered.[41] Mixing it with powdered chalk or gypsum, often in the Minoan period, would lighten it into a pink color. The versatile use of this pigment was paired with the fact that it was plentiful in Greece keeping it inexpensive and accessible to most in the ancient world. Mineral pigments had to be specifically mined and were far more labor intensive than the clay like ochre colors found in top layers of dirt and along hillsides.

Red ochre was found before the Minoan period and used in many instances in Cycladic art. The Cycladic figures are found in droves on the island of Crete, later populated by the Minoans when Cycladic society fell. There is no written Cycladic text to explain the civilization, and there is little archaeology on their structures. The most abundant evidence that has been discovered is of the Cycladic figures. These figures are mostly of women, designed to lie down. They come in varying styles and sizes, all holding the same position with the arms crossed over the stomach and feet together. It is unknown exactly what their purpose was, and many scholars refer to them as fertility charms or a ritualistic purpose. Most of their pigments have decayed over the thousands of years in the ground, but a few remarkable samples survive to show their impressive paint job. The Metropolitan Museum of Fine Art holds a vast collection of these marble figures, some of which still have pigment traces visible for viewing.[42]

Cinnabar is another prehistoric pigment used in Ancient Greece. It is a mineral pigment that was used sparingly throughout the periods of Greece. It was much more expensive to produce and procure than red ochres, because the minerals are found mainly in volcanic areas. It

was used during the Minoan period and began to be traded to Crete from Asia Minor, Spain, and Colchis. Theophrastus explains how the red pigment was extracted from the mercury rich mineral. It was mixed with rocks constantly, grinding off the surface layer as a dusty powder as a manual way to extract the colorant.[43] A manufactured version of cinnabar is mentioned by Theophrastus that could only be made in the area above Ephesus in the Cilbians' territory. He describes the sand there as “glowing like kermsberry.”[44] The sand is collected, ground into a fine powder, and then washed in a copper vessel multiple times. The particles that floated were either discarded or could be used as a stabilizer in wall paintings, while the particles that sunk were cinnabar like particles.[45] Cinnabar would be used sparingly in the Minoan period, and by the Mycenaean period, it had fallen out of popularity and was being used scarcely. It had a brief stint in the Archaic period in the sixth century BCE at Pista as a painting for wood. By the classical and Hellenistic periods, it was used only in rich sites such as Athens or Carthage. It was the murex purple of mineral based pigments.[46]

Both Theophrastus and Pliny the Elder mention the arsenic based mineral realgar as a red pigment. Its formation is through combustion, and it was often imported to Greece from Asia, as it was uncommon to find it in Attica. It was first used in Ancient Greece during the late Minoan period throughout the history of an uncolonized Ancient Greece.[47] In a series of Minoan larnakes found in two ancient Minoan cemeteries, Maroulas and Armenoi, realgar is found as the red pigment used on multiple of them for decoration. It was found and identified using spectroscopy with X-ray fluorescence and Raman spectroscopy. The red pigment of purpurin was also found on these larnakes and in various wall paintings at the Minoan palace of Knossos. Purpurin was popular in the late Minoan and the Mycenaean periods. Its popularity waned after the Bronze Age period of Ancient Greece. Purpurin is a natural dye and pigment found in madder root, a plant native to Ancient Greece that was cultivated for colorant purposes.[48]

Sinopis is mentioned by Pliny the Elder, which was discovered in Pontus, Sinope of Greece. It is an iron rich pigment that is of the best quality when mined in Lemnos and Cappadocian quarries. It was also manufactured and traded out of Egypt and Africa as well. Pliny the Elder gives no specific year, referring to it being used by "the ancients." Sinopis was often used to tone other colors, being known as a duller color of red. It came in red, pale red, and intermediate red. It was primarily used in brush and wood painting rather than sculpture or architecture.[49]

**4b. Colors: Orange**

Orange is a color that was often mixed to achieve. By taking a red pigment and a yellow pigment, a desired orange could be combined. The Ancient Greeks did not have a term for orange, as they did not differentiate the transitional shades between primary colors. It would have been categorized under red or yellow depending on the saturation of the tint. Though the simplest way to get orange was by mixing, there are plenty of other ways to acquire a beautiful orange hue.

Hematite is another kind of iron rich earth ochre. It is often found as red ochre, but a range of factors can cause it to have a spectrum of colors. Like the Egyptian technique of grinding a pigment into powder, hematite can be ground as a raw sample. How finely the hematite crystals are ground will impact how orange tinted the pigment is. It can also depend on how the crystal shapes develop when forming. Different hues are found independently in regions and are often traded throughout the ancient world. This technique had been passed down from prehistoric times before the Minoan period and was used throughout the periods of Ancient Greece.[50]

Madder root was used to make an orange pigment in addition to its original red. The orange pigment of madder root was brought to Greece by the Egyptians around 1500 BCE, or

towards the end of the Minoan period. When using the Egyptian technique of pigment lake making, the original madder red pigment has an orange-pink glow. Making the dye version of purpurin insoluble not only changes its composition but also its color. It is not commonly used in Ancient Greece until the Classical and Hellenistic periods, being found on multiple clay figures in Demetrias in Macedonia.[51]

Introduced in the Classical period, pararealgar is a rare bright orange-red pigment. It was not native to Greece but was exclusively imported from Pontus by the Black Sea. It is an exceedingly rare and unstable pigment. There is only one sample archaeologists have found of its use in Greece on the late Classical marble throne in the "Tomb of Eurydice" at Aigai. Pararealgar was made through the process of photodegradation of the realgar pigment. When intense light is exposed to realgar, it breaks down the red mineral and turns it into an orange-yellow colored powder to be used as paint. Due to its light sensitivity, it is highly unstable, accounting for its lack of use and evidence.[52]

Another way to manufacture orange was to use acidic materials. By adding a muriatic like acid such as vinegar to a red iron containing pigment, it will turn that pigment into a yellowish color. By then heat treating the now yellow pigment will turn it a bright orange color. There is no exact known date for when this process was found, but it was found on figures from the early Hellenistic period.[53]

**4c. Colors: Yellow**

Yellow was a harder color to perfect in the ancient world given its pale hue that could easily mix and bleed from the surrounding color which would change it, or its sensitivity to light exposure. There was a range of different yellows used in Ancient Greece. Earth colors came in multiple shades, one of them being yellow ochres. Yellow ochres are on prehistoric cave paintings and the previously cited Cycladic figurines. Like red ochre, it is an iron based pigment.

When an iron based earth gets exposed to a mineral called goethite, it goes from a red-brown color to a yellow color that can range in hue depending on the amount of goethite in the mixture or how the process of washing out impurities, as mentioned with red ochres, affects the pigment. It will also depend on how much is ground in the Egyptian manner. As mentioned in the first step of manufacturing an orange pigment, adding vinegar to red ochre causes the reaction between it and the iron to turn the pigment into a lower quality yellow ochre. Yellow ochres could be found in abundance in Ancient Greece, making it an affordable yellow color used throughout all of Ancient Greece and beyond.

The pigment limonite was primarily used in the Bronze Age. It is a hydrated iron oxide mineral like yellow ochre. Yellow ochres can be derived from limonite, but it does not work the other way around. Limonite creates a mustard yellow to brown-yellow pigment color depending on where it was mined, and it could be mined natively in Greece. It was used mainly in the Mycenean period, sometimes being mixed with quartz as its base stabilizer. X-ray fluorescence and mineralogical microscopic exams were performed on various pigments from Mycenae and a primary yellow pigment was used during that period.[54] Mycenae kept the technique of the Minoans to apply paint to wet plaster to adhere the color. Limonite was the main yellow pigment found in multiple plaster samples found in Mycenae, showing it to be a popular pigment used at the time. Limonite was not particularly popular in later periods, as the Ancient Greeks would move towards yellow ochre as its main yellow again after the Greek Dark Ages.[55]

Minium was a pigment mentioned by Pliny the Elder. It is crystals that form from the sulfides of arsenic. Pilny the Elder explains that this pigment was mistakenly found in the fifth century fire at Piraeus, Athens' port city. The crystals that make up minium were formed when the pigment ceruse was burned at an exceedingly high temperature, creating the crystals. Minium is created manually through combustion or naturally in hotter areas.[56]

Orpiment is a yellow pigment mentioned by Theophrastus. It was often called a golden pigment as its yellow hue mimics the golden color. Orpiment is a yellow arsenic sulfide mineral that gives off a rich pigment. It is not the most stable pigment and is soluble in water. It migrates into surrounding pigments easily over time as it degrades. It is first found in the Classical period of Greece during the fourth century BCE. It can be found in funerary art and regular art, often in popular sites like the Athenian Agora or Corinth.[57]

**4d. Colors: Green**

Green was a particularly difficult color in Ancient Greece. There were attempts to have multiple materials become green pigments, but it was a difficult color to perfect. The easiest way to get a decent green color is to layer blue and yellow. By applying multiple thin translucent layers of alternating blue and green paint, a green color will gradually appear. The layers had to be alternating, and they had to be light or risk not achieving a proper green tint. This process has been known in Attica since prehistoric times and can be seen throughout each period of Ancient Greece.

In the Minoan period, inorganic green earth was made. Green earth is the blanket term given to green pigments made from specific materials that have siliceous qualities. Ancient Greece had a few varied materials to make green earth pigments. Green earth could be made from burnt organic materials in the Minoan period. When mixing burnt organic materials with a strong stabilizing method like powdered quartz when the process was first made, it would take on a green hue. The quartz used in this process would mostly be quartz grain, a siliceous mineral. Silica is a connecting factor in all the minerals used to make green pigments.[58] Green earth would also have been made from grinding glauconite. It is found in shallow coastal areas. The Minoans had access to glauconite from the island of Crete, which naturally gave them plenty of it without the need for intense trade. Grinding up celadonite rocks would have prepared a green

powdered pigment. It is a mica based mineral with silicon found in volcanic areas. These are the prominent materials and ways to make green earth in Ancient Greece, starting in the Minoan period and used throughout the later Greek periods.

Malachite crystals were one of the most expensive ways to make green pigments and were not commonly used in everyday painting. It would have been reserved for more expensive sites and artwork. It only grew in ore veins in the Macedonian area, partially in the Lavrion mining district. Theophrastus mentions the malachite crystal to be a fake emerald, not giving it the same precious status. It is a copper carbonate mineral. Copper based pigments were not rare in Ancient Greece, but it was also not commonly used. It is rare in the Minoan and Mycenean periods; the few instances it was used on Crete would have been because of trade. It would become more widely used after the Greek Dark Ages. Theophrastus explains that malachite hit its peak of use by 340 BCE in the Classical period. Theophrastus would document a mineral like malachite called chrysocolla, also used to make green pigments. It was a copper mineral formed in oxidized zones of copper mines. Raw pigment made from chrysocolla was found in the Athenian Agora in particular.[59] When copper ore is exposed to open air, it oxidizes, giving it a green color. That green color can be harvested from the original ore and made into pigment powder by mixing and grinding.

Verdigris was known as the green of Greece in the ancient world. It is also a copper carbonate based mineral that forms after the oxidation of copper, bronze, or brass surfaces. Both Theophrastus and Pliny the Elder mention it as a bright, vibrant green pigment valued as one of the finest green pigments of the time. It was often used as a status symbol to show wealth and prestige in art. However, they do not give a date of its introduction to Greece. It is hard to base its dating on when it appears in ancient art because of its high instability. No modern evidence has been found in excavations due to this. Its base of copper carbonate is highly superficial and

inorganic, leaving it unstable when exposed to water and air. It degrades quickly compared to other green pigments. Producers would manufacture verdigris by intentionally leaving out and speeding up the corrosion process on copper, bronze, and brass materials. Diluted vinegar would gently remove it from the surfaces of these metals to harvest the copper carbonates, which were dried out, crushed into powder, and mixed with a stabilizing base.[60]

**4e. Colors: Blue**

Blue is a complicated color to come by naturally. It is not often found in organic settings, which is reflected in the limited use of natural resources in blue pigment. Before the middle of the Minoan period, organic resources for blue pigments were all the Ancient Greeks had. Azurite was the first blue of the Minoans. It was first found in Neolithic tombs, suggesting extremely early use of the pigment on Crete. Like verdigris, it is another form of copper carbonate. The difference is that azurite's color ranges from pale to dark blue, which could be found in nearby mineral sources. It was the primary blue pigment in Cycladic society and early in the Minoan period. It was labor intensive to manufacture into pigments as its ground texture was a gradual texture. It took a long time and intense labor to ground out the sandy texture into one more suitable for painting. Azurite fell out of popularity during the Mycenean period and after was used for cosmetic reasons rather than painting.[61]

The Minoans were the first and one of the only civilizations to use glaucophane as a blue pigment. Glaucophane is a double-chain silicate mineral found particularly in subduction zones with metamorphic rocks.[62] It was used in the Minoan period with its height of popularity in 1700 BCE. It is used as the blue pigment in the Thera Frescos. Before 1700 BCE the blue pigments found were only this and azurite. Alongside Glaucophane, the sodium rich mineral riebeckite was used. It was popular alone in the Cycladic and Minoan periods, but after the introduction of Egyptian blue, it was found alongside the synthetic pigment.[63]

After 1500 BCE in the Minoan period, Minoans began to trade with Egypt for the first synthetic pigment in the world, Egyptian blue.[64] Egyptian blue was created in Egypt in 3300 BCE and became one of the most popular blue pigments in the ancient world. It was favored in ancient Mesopotamia. It is a manufactured calcium copper silicate by combustion. When heating a mixture of silica, any copper compound, and calcium carbonate with salt, it would fuse and create a paste that could be dried out and ground into powder.[65] Egyptian blue would be imported to Greece long before producers began making the pigment natively. Because it was low in labor and made of local materials, it was not that expensive, keeping it accessible. To change the hue of the blue, it would be ground to a different fineness and then painted on in layers.

Egyptian blue is unique in that it can be found in both poor and rich sites on various kinds of media like funerary monuments or grand architecture. The Minoan Hagia Triada Sarcophagus uses Egyptian blue as its colorant.[66] The Hagia Triada Sarcophagus is dated 1370-1320 BCE and is one of the finest pieces of evidence archaeologists have of Egyptian blue in Greece. From the sarcophagus being buried in a chamber tomb, it has a remarkable level of pigment preservation. It was not exposed to the degenerative qualities of weathering and shows a lack of decomposition in the pigments. Egyptian blue is used as decoration on the sides of the sarcophagus as well as on the clothing of the people depicted.[67]

Egyptian blue can be found in early Ancient Greek periods and later ones. It can be found in traces on the Parthenon marbles from the Athenian Acropolis. X-ray and ultraviolet fluorescence were used on the sculptures, revealing glowing pigment traces. Egyptian blue had been found to glow in a bright luminescent way that is recognizable as a pigment trace. The British Museum of Fine Art used a technique called visible-induced infrared luminescence to confirm the presence of pigment in 2009 CE. There are hardly any traces of pigment left on the

marbles that can be seen by the naked eye, as they had gone through various intense cleanings involving chemicals that destroyed a lot of the final traces. [68]

Lapis was not found as a pigment material in Greece until around 1300 BCE in the Mycenaean period on various wall paintings. Making pigment out of lapis would have been extremely expensive, making it scarcely used. Lapis was one of the best gems aesthetically to the Ancient Greeks, and they would sometimes trade with Persia for lapis that had sparkling gold flakes in them, describing lapis as appearing. The mining and powdering process was also labor intensive, leaving it inaccessible to most artists for paint pigments.[69] Cyan and indigo were also expensive, and only imported into Greece. It is left undated when the pigments arrived in Greece, but Theophrastus mentions them as being traded from Egypt, Cyprus, and Scythia.

**4f. Colors: Purple**

Purple pigments are one of the most expensive colors in history due to the labor needed to make them. Early in Greek history, purple was either made by mixing blue and red pigments in a powder form or by light layering until the tone was right. In some areas, their earth ochres can produce a dark red with a blue tint. This is called purple ochre and is often derived from the iron oxide mineral hematite. When mixing the dark red color of purple ochre with a white pigment or base, it becomes a violet colored pigment.[70] This was the only purple the Ancient Greeks had until the early Minoan period.

Murex purple was the most expensive pigment color in the ancient world. It was heavily labor intensive and hard to domesticate on a large scale. Murex purple was not made from a plant or mineral but from the slime secretions of mollusks in the Murex family's hypobranchial glands. Greece traded with the Phoenicians after its production. The Phoenicians discovered the dyeing capabilities of murex mollusks in 1600 BCE and figured out the best process to harvest them. It was used as a dyeing agent until the incorporation of lake making by the Egyptians, which then

could turn it into pigment. Murex purple was introduced in Greece in the early Minoan period. By 1600 BCE, murex purple was used in wall paintings and frescos, the earliest being the Thera wall paintings.[71]

Purples in the ancient world depicted wealth and status. It would also be associated with the gods and divinity; high ranking officials and their families would wear the color. Priests would wear it in cult practices on their clothes, and patrons commissioned artists to paint with it to show what they could afford. In the third century BCE, a pound of Delian murex purple was worth the same amount as pure silver.[72]

The process of making murex purple is intense, and it is labor intensive. It is less physically demanding, but it takes a long time to produce. One murex mollusk only produces a few drops of its slime, and to make murex purple on a commercially available level thousands were needed. Since it comes from a living creature, it is domesticated by breeding and fishing. Murex mollusks lived in shallow parts of the Mediterranean Sea. They would be gathered by leaving a basket of berries in the water to attract them. The mollusk would be crushed whole if small enough to harvest the secretions, and the shell would be picked out later. If the mollusk were large enough, the hypobranchial glands would be removed and harvested that way. The color can change based on the mollusk type used in the murex family, deepening its red or blue tint. The mass of crushed mollusks and glands would be placed in a large vat with salt water and boiled for nine days. Liner B tablets explain the use of Murex purple in the Mycenaean period and describes the best place in Greece to produce it would be in Lanconia, and it is best traded from Tyre, Asia, and Menix, Africa.[73]

**4g. Colors: Black**

Black was a simple color to come by in Ancient Greece. Black was the earliest made of carbon or burning organic materials. By drying out decomposed organic material, it can be

ground and used as a pigment when added to non-pigmented powdered base materials. The typical organic material that was used was wood turned into charcoal. This pigment was used throughout Greece's periods and before in the Neolithic era. During a brief stint of time in the years 370 to 306 BCE, fossilized ivory or regular ivory was used as a black pigment described by Pliny the Elder. It was made by Apelles of Kos, and he called it elephantinon. Due to its limited material and labor, it stopped being produced less than one hundred years after its creation.

Manganese rich minerals could be used to make a black pigment. Typically, manganese makes a brown pigment rather than a black one due to its iron content. When manganese does not contain iron, it becomes black. The Ancient Greeks would have used the mineral pyrolusite. It started showing up as a pigment in the Bronze Age Mycenaean period.[74] The Mycenaean period also had a way to make grey. It was to mix copper, tin, and calcium with carbon.

Micon and Polygnotus were both celebrated Athenian master painters. They used a black pigment made from dried grape husks. This pigment was called tryginon and gave off a vivid black color. It is mentioned as being used in the fifth century BCE by Pliny the Elder, crediting these two with the creation of it. By charring the pomace of a grape, it made a decent black pigment. They would first press the grapes for juice before gathering the solid mass of the grape and burning it. The husk includes the skin, seeds, pulp, and stems of the grape.

**4h. Colors: Brown**

Brown pigments were often used as natural colors in art and architecture, particularly flesh and hair tones. A layer of brown would be added to the hair of a sculpture before being layered and added onto until the color the painter wanted was achieved.[75] The earliest brown pigment was ochre. Ochre appears brown with a low amount of iron present in it. It was used in the prehistoric era and throughout other periods of Greece. Greece was native to every ochre type and color, making it inexpensive and easily attainable with a low labor cost. This type of ochre

would be found with ruddle, a softer mineral related to hematite. It can come in different shades of brown depending on where it is geographically. Ruddle specifically is mentioned by Theophrastus in his treatise. Unlike black, manganese needs a higher iron content to produce brown. This is its generic form to have iron in it. It was used in the Minoan period and is one of the few browns used. It was common to find it being used similarly to brown ochre.

**4i. Colors: White**

White is a color every artist needs. It was often used to tone other colors and change their shades. It is a blender of colors as well, making sure two colors merge naturally in the painting. The Ancient Greeks had a few main white materials to make white pigment. Kaolinite and calcium carbonate were minerals used in the Minoan period to make white pigment. Kaolinite is a soft, chalk-like textured white mineral. When crushed, it does not need to be added to a base material like chalk or ground quartz due to its already soft properties. Calcium carbonate is made by grinding chalk, limestone, or white shells down into a fine powder while wet to make a paste to grind out the coarse impurities.[76]

Theophrastus mentions several white pigments in his treatise *On Stones*, but Psimythion is the earliest. Psimythion was manufactured in Greece as early as the sixth century BCE. When ground, it is a white powdery substance of lead carbonate used as a pigment and in medicine. It is a synthetic white pigment made by suspending metallic lead over a fermenting liquid, often wine, which prepares it to be harvested from the metallic lead. It is known to some as the first lead white pigment.

Theophrastus also mentions Usta and Melian. Usta was accidentally created by the same fire at Piraeus that created minium pigment. The first person recorded to use it was Nicias of Athens, a politician in the fifth century BCE. Raw lumps of ceruse were in a storage jar at the agora and subsequently burned in the fire. When ceruse was exposed to the fire, the combustion

process occurred, which changed it to usta.[77] Melian was a white pigment produced on the island of Melos in Greece. It was prominently used in the Classical period. It is described by Theophrastus as being a bright white color when painted. It is formed through the acid sulfate alteration of rocks. This process rids the mineral of its iron, causing it to turn white or transparent. It is made of melian earth, a mixture of kaolin and silicon.

White lead would be produced in Greece in the fourth century BCE. It is used as the primary white pigment after its introduction to Greece. It has a thick and heavy texture, making it suitable for painting. It is made of basic lead carbonate and is extremely toxic to the human body. Inhalation or consumption of it would be detrimental to a person's health overall, and it would cause many painters and manufacturers to become ill. There were separate ways to produce white lead. One way to add carbon dioxide is to quicken the corrosion process of lead. Adding carbon, like manure or fire fumes, would speed up the process. Another way was by suspending a lead brick over a cask of vinegar. After ten days, the cask would be opened and the mildew on the lead brick would be scraped off to be pounded in a mortar. It would then be strained, and what was left was white lead.[78]

**5. Where Did All the Color Go?**

After reading about all the various paint pigments available in Ancient Greece, it is valid to wonder what happened to them. Why does the public still think of Ancient Greek art as being sparkling white marble when all these pigments were available, and why are they still displayed without color? In museums and collections, marble statues are often depicted without color and no mention is made of them being painted. Temple walls still standing today are monuments of marble and stone in their natural shades. When a marble work is pulled from the ground during an excavation, it is removed without color. With how much evidence, both literary and physical, there is on a painted Greek society, there should have been no doubt about the validity of

polychrome art. However, there have been hot debates and extreme discourse on the topic. This section will answer these questions. Where did all the color go?

Pigment is a fickle thing over time. Some pigments last longer than others in the decomposition and erosion process. Depending on the materials used to manufacture pigment, some decompose more than others. It also depends on what color the pigment is as some shades fade quickly or break down more easily. Earth tones like reds and browns have a higher probability of surviving than other colors due to their mineral makeup. Pliny the Elder recognizes this in chapter twelve of his book series, saying, "Colors are either somber or florid, these qualities arising either from the nature of the substances or their mode of combination."[79] By acknowledging that the process of creating pigment changes it fundamentally, it also acknowledges that its ability to stay stable changes. All ancient pigments are sensitive to light, oxygen exposure, humidity, and weather. Greece is not the best place for preserving pigment exposed to the elements, especially for hundreds of years being buried underground or improperly stored.[80]

Pigments are extremely sensitive to certain elements. Iron containing mineral pigments, like ochres and earth pigments, are the colors that manage to survive the best. That does not mean they are untouched by the many years of improper storage. When a piece of artwork has been buried, there is a chance that the ground alters the pigment colors. The mineral content in the pigment begins to secrete into the surrounding dirt, discoloring it. This makes it harder for historians today to get an accurate picture of what the artwork may have looked like in polychrome. Copper containing pigments are sensitive to this, meaning that colors like verdigris that have a high copper content are at risk of decomposition faster than other colors. Lighter colors are sensitive to light and burial conditions. This is the reason that some of the best-preserved works from ancient Greece are found within tombs rather than buried straight into the

dirt. The light can fade a pigment when it is not safely stored or displayed.[81] In the time before "new archaeology" was founded, the techniques of excavation and storage were not conducive to the preservation of pigment traces. Statues and other works of art were often not stored properly, allowing the already fragile paint remnants to erode further until the traces were just a ghost of a vestige. Bright and colorful pigments would sometimes be unearthed along with a statue, but due to improper storage, they would fade quickly. This, along with the natural degradation from time and the earth, would be the starting point of Ancient Greek art and architecture being seen as monochrome.

Excavation and preservation techniques would be the next destroyer of colors. As previously stated, there were problems with storage. Most pigment is extremely light and weather sensitive and back when regulations on these topics were looser, things were stored wherever with less care. This improper storage would affect the hue, saturation, and visibility of pigment. Lake colors are at risk of fading because of the process of making them. Its reliance on being insoluble in water causes it to disintegrate and fade rapidly.[82] When this was found to be the case, the pigment left on statues would be painted in watercolor to save where they were, knowing that it would eventually fade with time. These watercolor drawings would be largely ignored by scholars at the time as proof of a polychrome palette.

Storage would not be the only incorrect handling of ancient pigment. When archaeologists unearth artwork like a sculpture, the sculpture was put through a rigorous cleaning process. Earth tones like red and brown mostly survived on the surface and some colors would over time turn into these colors. Because of this, it would occasionally be mistaken for dirt and scrubbed off. Later when new techniques were developed, chemicals would be added to the cleaning process. Because at the time no one was looking for pigment traces, it was not recognized as something to look out for when treating it. In 1937 CE, Sir Joseph Duveen donated

a large amount of money to The British Museum on a campaign to observe the present condition of the Parthenon marbles.[83] The treatments used on the marbles damaged the surface level of the sculptures and chemically removed some pigment traces. Harsh cleanings like this were common until the twentieth century CE when new archaeology swept across excavations and more conservative approaches to preservation were developed. Some places, however, still practice rougher cleanings if there are no pigment traces visible.

There is the problem of a lack of literary evidence for painted works of art. There is a trend in antiquity that no one wrote something down when it was common knowledge amongst the common people. When everybody knew that art and architecture were painted because it was so mundane that they saw it every day, no one thought to reference or explain it in detail in a great amount that could survive today. There are, of course, literary sources like Theophrastus and Pliny the Elder that are some of the only documentation of pigments, but there are other literary sources not in the scholarly field of works. It can be seen referenced in entertainment commodities like plays and poems. In Euripides' play Helen, Helen wishes to be washed clean of her life and body to be blank, ready to be repainted like a statue. In this comparison, it can be interpreted that the statue starts blank and devoid of anything perfect or imperfect, like the clean slate Helen wishes for herself after her kidnapping by Paris. She wants to start blank and be painted like a statue would have been which can be interpreted as it being common to see colored statues.[84] The poet Anacreon wrote the Anacreontea, a book of sixty poems attributed to life, love, and wine.[85] Within these poems, fragment sixteen shows the comparison of a woman and a painted statue or image.

ἄγε, ζωγράφων ἄριστε,

γράφε, ζωγράφων ἄριστε,
Ῥοδίης κοίρανε τέχνης,

ἀπεοῦσαν, ὡς ἂν εἴπω,
γράφε τὴν ἐμὴν ἑταίρην.
γράφε μοι τρίχας τὸ πρῶτον
ἁπαλάς τε καὶ μελαίνας·
ὁ δὲ κηρὸς ἂν δύνηται,
γράφε καὶ μύρου πνεούσας.
γράφε δ᾽ ἐξ ὅλης παρειῆς
ὑπὸ πορφυραῖσι χαίταις
ἐλεφάντινον μέτωπον.
τὸ μεσόφρυον δὲ μή μοι
διάκοπτε μήτε μίσγε,
ἐχέτω δ᾽, ὅπως ἐκείνη,
τὸ λεληθότως σύνοφρυ,
βλεφάρων ἴτυν κελαινήν.
τὸ δὲ βλέμμα νῦν ἀληθῶς
ἀπὸ τοῦ πυρὸς ποίησον,
ἅμα γλαυκόν, ὡς Ἀθήνης,
ἅμα δ᾽ ὑγρόν, ὡς Κυθήρης.
γράφε ῥῖνα καὶ παρειὰς
ῥόδα τῷ γάλακτι μίξας·
γράφε χεῖλος, οἷα Πειθοῦς,
προκαλούμενον φίλημα.
τρυφεροῦ δ᾽ ἔσω γενείου
περὶ λυγδίνῳ τραχήλῳ
Χάριτες πέτοιντο πᾶσαι.
στόλισον τὸ λοιπὸν αὐτὴν
ὑποπορφύροισι πέπλοις,
διαφαινέτω δὲ σαρκῶν
ὀλίγον, τὸ σῶμ᾽ ἐλέγχον.
ἀπέχει· βλέπω γὰρ αὐτήν·

τάχα, κηρέ, καὶ λαλήσεις.

Greek text of Anacreon's *Anacreontea*, Fragment 16

"Come, best of painters! Paint, best of painters, master of the Rhodian art! Paint my absent girl according to my instructions. First paint her soft black hair; and if the wax is able, make it smell of perfume. Paint her whole cheek and then her ivory brow beneath her dark hair. Do not part her eyebrows nor run them together, but let her keep, as in real life, the black rims of her eyes meeting imperceptibly. Now make her eyes as they are, from fire, both flashing, like Athena's, and moist, like Cythere's. Paint her nose and her cheeks, mingling roses and cream. Paint her lips like Persuasion's, provoking kisses. Under her soft chin let all the Graces fly around her marble-white neck. Dress the rest of her in robes of light purple, but let her skin show through a little to prove the quality of her body. Enough—I can see her! Soon, wax, you will be talking too."

Translation of Anacreon's *Anacreontea* by David A. Campbell

`This is the contents of fragment sixteen of Anacreon's Anacreontea gives insight into how a statue may have been painted based on the common beauty standards of the time. The man longs for the perfect woman for him, calling for the best painters to paint him the woman he desires. The hair of statues would have been a deep brown or black, pale or white skin, rosy colored cheeks, and colored clothing. This is a good example of casual mentions of painting and sculpture. Something that would have been common to the people of Ancient Greece, but a mystery to modern scholars who must determine the validity of polychrome artwork.

Another reason that polychrome and Ancient Greek pigments have been erased from the public understanding is from three hundred years of misidentifications and stubborn scholars who hung onto an idealistic view of Classical Greece that never truly existed. In 1506 CE, the Laocoon group marble statue was unearthed, devoid of any pigment with which it had once been decorated.[86] Its color had disintegrated while underground, and any vestiges left over had been harshly cleaned off. This would be the first misinterpreted artwork that would spread on a large scale. More artwork would be found in the years afterward, perpetuating what is known as the myth of whiteness in ancient art. These findings would then influence the Neoclassical art movement that took over Western aesthetics in the eighteenth and nineteenth centuries.

Neoclassicism is a revival of ancient classical architecture and art, but it was missing its color. This would only perpetuate the idea of a colorless antiquity further. In modern years, the Neoclassical aesthetic still influences buildings used and seen today that further cement the idea of monochrome in the public's mind.[87]

Among scholars in the eighteenth and nineteenth centuries, there was a heated debate about whether the Ancient Greeks used color or not. The Neoclassical movement had convinced everybody that classical antiquity was blank, and that it was the attractive option. By this point, the Western culture of chromophobia had taken root in scholars unwilling to believe in a polychrome ancient world.[88] Little funding was given to the pursuit of finding pigment on sculptures at the beginning of the search. Pigment began to become noticed in the eighteenth century, but scholars continued to deny it until the development of archaeological sciences made it impossible to. At first, the use of color was downplayed as somber or inferior quality works. At one point, it was said that color was only used on statues from the Archaic period.

J. J. Winkelmann was a perpetrator of the myth of whiteness in ancient art. He believed Classical Greek art to be the superior art, and he would not hear of polychrome being on it. When he published the book “Gedanken” in 1756, he authenticated the myth and cemented its place in scholarly circles. It was later coined as the Winkelmann ideal of the characteristics he gave for Classical Greek art.[89] There was an undeniable beauty, formal purity, sobriety, and rationality to the pure white marble of the sculpture they would find. The blank Greek art became the model for beauty in architecture and the appreciation of art. This perpetuation of Classical beauty is still harmful to the understanding of ancient art today, but it is now actively being worked against.

**6. Conclusion: Bringing Color Back**

There has been a great deal of fighting to correct the damage done by past misunderstandings. Since the nineteenth century scholars such as Antoine-Chrysostome Quatremère de Quincy and Jacques Ignace Hittorff made early strides to get the idea of polychrome on the table for discussion. They were mostly dismissed, but because archaeologists were finally taking notice of the pigment still present in artwork, it was getting harder to deny that ancient art was colored. It was the finding of nineteen korai at the Athenian Acropolis in the 1880s with visible pigment on them that the tides turned in favor of those arguing for polychrome. They were the first archaeological findings of pigment that were published in chromolithography.[90] After this finding, people started to pay more attention to polychrome.

Plaster casts would be made of artwork to display polychrome sculptures in museum exhibits. Starting in the nineteenth century, plaster casts were done directly on the surface of ancient sculptures, leading to further pigment degradation. It was the best way to accurately recreate these artworks at the time. From the pigment left intact on the original sculpture, scholars could make educated guesses on the design of various patterns and ornamentation found on it. They would also refer to similar statues, other samples from the same era, or statues found geographically in the same place to piece together an accurate reconstruction of appropriate appearances for the plaster cast recreation. These reconstructed painted plaster casts would then be displayed in museum expeditions alongside their original counterparts in an attempt to correct the public's knowledge of ancient sculpture.

In 2003, Bunte Gotter created a traveling exhibition, "Gods In Color, " showcasing their understanding of polychrome. The exhibition's first stop and sponsor is the Liebieghaus villa in Frankfurt, Germany. It has a sculptural museum and has been a pioneer in campaigning for the public’s education on ancient polychrome. The exhibition has traveled throughout Europe to

proudly display ancient sculptures alongside modern recreations in their original colors. The exhibit has featured recreations by acclaimed scholars studying polychrome, such as Vinzenz Brinkmann and Ulrike Koch-Brinkmann, who have dedicated their careers to perpetuating the knowledge of ancient polychrome. They have displayed such sculptures as The Archer from the Aphora Aigina pediment c. 480 BCE, the So-Called Persian Rider c. 490 BCE, and a plethora of other ancient statues alongside their modern recreations. The exhibition collaborates with many recreation efforts to showcase a plethora of polychrome sculptures from across the ancient world to the modern public.[91] Similarly, in 2008, Paul Getty of the Getty Museum put on an exhibit called "The Color of Life," which featured colored plaster casts of ancient artwork, many of them originally displayed in the "Gods In Color" exhibition.

As recently as 2019, reconstructions of polychrome sculptures were being made. Vinzenz Brinkmann recreated the sculpture of The Archer c. 480 BCE, an Archaic period statue that would be brightly painted, showing off the bold hues valued highly in Ancient Greece. The painted ornamentation and decoration featured on the clothing became visible through ultraviolet light and light raking over the surface of the sculpture. Much of the sculpture's original pigmentation has been lost. Still, multiple painted statues and pigment samples on the West Pediment of the Temple of Aphaia on the island of Aegina could be examined. This was used to make educated guesses on the missing colors of the statues. Several intact samples of red and blue pigmentation were found as background colors, with red ochre and madder found on multiple statues, making a flesh tone. Since all of these sculptures were found together at the same site from the same building, it can be inferred that all of them had similar coloring for a uniform look. There are currently three variants by Vinzenz Brinkmann, the latest one being from 2019. The newest one is currently considered the most accurate, as scientific technological developments have allowed a more accurate analysis of the original sculpture's appearance.[92]

Vinzenz Brinkmann is also responsible for reconstructing the marble funerary stele of Phrasikleia in 2010. It is currently held in the Metropolitan Museum of Art on a permanent loan from the Liebieghaus Sculptural Museum, where the exhibition “Gods In Color” was first held. It is the funerary monument of a young unmarried girl named Phrasikleia by Aristion of Paros. Many of the main pigments used on the sculpture were revealed using ultraviolet absorption spectroscopy and X-ray fluorescence spectroscopy. It showed red and brown madder and ochres, as well as lead white, which was used in the sculpture's hair, flesh, and eyes. Red and yellow iron oxides and orpiment were found on the garment with gold leaf and lead tin foils supplemented on once gilded ornamentation, such as a constellation of stars on the back. Hematite was found as dark red to show depth in the clothing folds and the underside of the sleeves. The Athens National Museum would later find cinnabar mixed with the garment's pigment for a vivid red. Missing colors, detailing, and the statue's polished finish were inferred from other archaeological analyses of similarly dated Egyptian mummy portraits.[93]

An information campaign has been going on for decades, from the late 1990s to now. Scholars and museums are trying to correct the wrong ideas perpetuated for hundreds of years. Ancient polychrome was initially conveyed through graphic reconstructions of watercolor paintings or engravings, with significant pushback by the scholarly community starting in the sixteenth century. These recreations were seen as exaggerations and not taken seriously until the nineteenth century. After awareness grew, physical recreations through plaster casting and painted copies became popular. They were often viewed in museum exhibitions as more institutions and scholars insisted that research be done on the subject. Museums have started to display full exhibitions on ancient polychrome to educate the public about the truth. With the rise of three-dimensional models and paintings, it is easier than ever to view ancient sculptures in their prime. Given that most of the public population still thinks of the Neoclassical idealism of

Classical Greece, there is still a long way to go. But with all the evidence of pigments listed above, along with the perpetual information campaign, it is now undeniable the lengths of how colorful Ancient Greece had been.

Notes

1. In the revisions of this thesis, I utilized Grammarly https://app.grammarly.com/ on 4/14/2025 to double-check for spelling, typographical errors, and errors of writing style. I used the following prompts: (a.) please provide a list of spelling errors; (b.) please provide a list of typographical errors and errors of style.it was used only as a corrective tool, not a generative tool.
2. There are five different periods of Ancient Greece before being conquered by the Romans that will be focused on for archaeological and written evidence in this thesis. The Minoan period (3000-1450 BCE), the Mycenean period (1600-1100 BCE), the Archaic period (800-500 BCE), the Classical period (500-323 BCE), and the early Hellenistic period (323-30 BCE) before 146 BCE. The Archaic period (800-500 BCE) is being omitted from lack of written and archaeological evidence from the period. Rome conquered Greece in 146 BCE after the battle of Corinth when Macedonia fell under Roman control.

   Neoclassism is an art movement that swept through Western cultures during the eighteenth and nineteenth centuries that relied heavily on the perceived aesthetics of artwork in classical antiquity.

3. This is also referred to as “The Myth of Whiteness” among some articles and

   Searches.

4. The controversies will be discussed more in depth in a later section. There is a plethora of them that warrant its own sub section within discussing why the modern conception of art from antiquity is white.
5. A couple of prominent figures that pushed against the idea of polychrome in ancient art were Johann Joachim Winckelmann (J. J. Winckelmann) and Desire Raoul Rochette-Watson. They were both strongly opposed to the growing concept of polychrome in ancient art.
6. Mark Abbe makes this claim in his article *“Politura and Polychromy on Ancient Marble Sculpture.”* He makes this claim since it has only been less than three hundred years since the concept of color in ancient art had begun to be seriously discussed in scholarly contexts. Scholars are now just documenting the remains of pigment traces found in art and architecture from antiquity. Scholars are still discussing and questioning application techniques, the thickness of which paint was applied, the translucency and boldness of color, medias, finishes, and polishes that could have been used in antiquity.

Abbe, Mark. “Politura and Polychromy on Ancient Marble Sculpture.” *CLARA* 5 (May 26, 2020). https://doi.org/10.5617/clara.v5i0.7984.

7. Theophrastus was a Greek philosopher that was born in 371 BCE and dies in 287 BCE in Athens, Greece. He made many treatises pertaining to subjects on stones, botany, physics, and ethics. He studied at Plato's school and later under Aristotle.

   Translation and commentary of Theophrastus's *De Lapidibus* by D. E. Eichholz (Oxford Clarendon Press, 1965)

8. Pliny the Elder was a Roman natural philosopher and author, leading him to making his series of books "*Naturalis Historia."* It contains thirty-seven books total, but this thesis looks only at book thirty-five, "Book XXXV. An Account of Paintings and Colors." Despite Pliny the Elder being Roman, he cites multiple pigments and artists from the Greeks and explains their origin and composition, making him an appropriate primary source for ancient Greek paint pigments.
9. Winckelmann, Johann Joachim. *Reflections on the imitation of Greek works in painting and sculpture.* La Salle, Ill: Open Court, 1987.
10. A.-C. Quatremère de Quincy, *Le Jupiter Olympien, ou l'art de la sculpture antique,* Paris 1814, frontispiece
11. Pictures of these temples can be found within the published book of his reconstructions, *"Restitution Du Temple D'Empédocle A Sélinonte, Ou L'Architecture Polychrôme Chez Les Grecs. Par J.J. Hittorff, Architecte. Avec Un Atlas."* (1851, Hittorff)
12. *"Restitution Du Temple D'Empédocle A Sélinonte, Ou L'Architecture Polychrôme Chez Les Grecs. Par J.J. Hittorff, Architecte. Avec Un Atlas."* (1851, Hittorff)
13. Seventeen samples of raw blue pigment were found in Knossos town houses and palace, later were bagged, and placed in the Knossos Museum to be stored.

    Filippakis, S. E., B. Perdikatsis, and T. Paradellis. "An Analysis of Blue Pigments from the Greek Bronze Age." Studies in Conservation 21, no. 3 (1976): 143–53. https://doi.org/10.2307/1505697.

14. The British School of Athens found five samples of raw blue pigment in Mycenae; 3 more samples were found by Heinrich Schliemann's excavations in the area.

    Filippakis, S. E. et al, *"An Analysis of Blue Pigments from the Greek Bronze Age."* 143-53

15. Vinzenz Brinkmann, "Reconstruction of a marble archer in the costume of a horseman of the peoples to the north and east of Greece, from the west pediment of Temple of Aphaia, Variant C" 2019, Marble stucco on PMMA, natural pigments in egg tempera, tin, wood, gold foil, The Metropolitan Museum of Art, New York, https://www.metmuseum.org/art/collection/search/853792
16. This article is advertised in it's French title,

Grand-Clément, Adeline. “Couleur et esthétique classique au XIXème siècle : l’art grec antique pouvaitil être polychrome ?.” Itaca: Quaderns Catalans de Cultura Clàssica, 2005, 21, pp.139-160. Ffhal01886777f

17. This article is advertised in it’s French title,

    Grand-Clément, Adeline. “Les Marbres Antiques Retrouvent Des Couleurs : Apport Des Recherches Récentes et Débats En Cours.” Anabases 10 (2009): 243–50.

18. This article is advertised in it’s French title,

    Grand-Clément, Adeline. “La Grèce bariolée : l’Antiquité retrouve des couleurs.” Travaux & documents, 2010, Journée de l’Antiquité 2009-2010, 36, pp.131–148. ffhal-02184482f

19. This is a review and overview of the conference held by Jockey and the topics discussed for further reading.

    BRECOULAKI, HARICLIA. Review of COLOUR IN ANCIENT ART, by P. Jockey. The Classical Review 69, no. 2 (2019): 602–5. https://www.jstor.org/stable/26796645.

20. Microscopes themselves were developed in the late sixteenth century, around 1590, by Hans and Zacharias Janssen by placing multiple lenses within a tube to magnify the image of what the microscope was placed over. It was not used to observe ancient paint pigment traces until the seventeenth century.
21. Godefroy Engelmann of Mulhouse is credited as the inventor of chromolithography, a process of using plates covered in colored ink to press the image onto paper, in 1837. This process was expensive to print pictures, and it was scarcely used for anything less than large scale projects.
22. Grand-Clément, Adeline. “Couleur et esthétique classique au XIXème siècle : l’art grec antique pouvaitil être polychrome ?.”
23. Stuart, James, and Nicholas Revett. “The antiquities of Athens.” London: Haberkorn, 1816.
24. Brinkmann, Vinzenz. "The polychromy of ancient Greek sculpture." The color of life: Polychromy in sculpture from antiquity to the present (2008): 18-39.
25. Brinkmann, Vinzenz. "The polychromy of ancient Greek sculpture."18-39.
26. For further reading on how ramen spectroscopy is used for analyzing paint pigments, read “Colourful Earth: Iron-Containing Pigments from the Hellenistic Pigment Production Site of the Ancient Agora of Kos (Greece).”

    Kostomitsopoulou Marketou, Ariadne, Kelly Kouzeli, and Yorgos Facorellis. “Colourful Earth: Iron-Containing Pigments from the Hellenistic Pigment Production Site of the Ancient Agora of Kos (Greece).” Journal of Archaeological Science: Reports 26 (August 2019): 101843. https://doi.org/10.1016/j.jasrep.2019.05.008.

27. Grand-Clément, Adeline. “Les Marbres Antiques Retrouvent Des Couleurs : Apport Des Recherches Récentes et Débats En Cours.” 243–50.
28. Barnett, J.R., Sarah Miller, and Emma Pearce. “Colour and Art: A Brief History of Pigments.” *Optics & Laser Technology* 38, no. 4–6 (June 2006): 445–53. https://doi.org/10.1016/j.optlastec.2005.06.005.
29. For further reading on this technique and lakes, refer to this article,

    Barnett, J.R., Sarah Miller, and Emma Pearce. “Colour and Art: A Brief History of Pigments.” 445-53

30. For further reading on Minoan plaster refer to this article.

    Westlake, Polly, Panayiotis Siozos, Aggelos Philippidis, Chryssa Apostolaki, Brendan Derham, Agni Terlixi, Vasilios Perdikatsis, Richard Jones, and Demetrios Anglos. “Studying Pigments on Painted Plaster in Minoan, Roman and Early Byzantine Crete. A Multi-Analytical Technique Approach.” Analytical and Bioanalytical Chemistry 402, no. 4 (August 16, 2011): 1413–32. https://doi.org/10.1007/s00216-011-5281-z.

31. Avlonitou, Lydia. “Pigments and Colours: An inside Look at the Painted Decoration of the Macedonian Funerary Monuments.” *Journal of Archaeological Science: Reports* 7 (June 2016): 668–78. https://doi.org/10.1016/j.jasrep.2016.03.017.
32. Grand-Clément, Adeline. “Gold and Purple: Brilliance, Materiality and Agency of Color in Ancient Greece.” *Essays in Global Color History*, December 31, 2016, 121–38. https://doi.org/10.31826/9781463236632-011.
33. Brinkmann, Vinzenz. "The polychromy of ancient Greek sculpture." 18-39
34. Typically, the practice of gilding metal onto stone was reserved for statues of the gods. The cult statues of different gods that were in their sanctuaries. The statue of Athena Parthenos is a good example of gilded statues of the gods.
35. Abbe, Mark. “Politura and Polychromy on Ancient Marble Sculpture.”
36. Blume, Clarissa. “When Colour Tells a Story – The Polychromy of Hellenistic Sculpture and Terracottas.” Essay. In Circumlitio : The Polychromy of Antique and Mediaeval Sculpture, 144–165, n.d.
37. For further reading on stucco, refer to this article. It also includes a section on coloring bronze sculptures using metal gilding and the various materials present.

    Bradly, Mark. “The Importance of Colour on Ancient Marble Sculpture.” Art History 32, no. 3 (June 2009): 427–57. https://doi.org/10.1111/j.1467-8365.2009.00666.x.F

38. For a look at the image, visit The Metropolitan Museum of Art’s website. It is

    Terracotta column-krater (bowl for mixing wine and water) ca. 360–350 BCE At: New York Met Gallery

39. Pliny the Elder refers to Greek artists as “the ancient masters” in Book XXXV chapter 37

40. Westlake, Polly et al. “Studying Pigments on Painted Plaster in Minoan, Roman and Early Byzantine Crete. A Multi-Analytical Technique Approach.” 1413–32
41. Kostomitsopoulou Marketou, Ariadne, Kelly Kouzeli, and Yorgos Facorellis. “Colourful Earth: Iron-Containing Pigments from the Hellenistic Pigment Production Site of the Ancient Agora of Kos (Greece).” *Journal of Archaeological Science: Reports* 26 (August 2019): 101843. https://doi.org/10.1016/j.jasrep.2019.05.008.
42. To view these pigment traces on Cycladic statues and to read the Metropolitan Museum’s detailed essay on the subject, refer to their website page linked below.

    “The Painted Details on Early Cycladic Marble Figures in the Leonard N. Stern Collection.” The Metropolitan Museum of Art, May 30, 2024. https://www.metmuseum.org/About-The-Met/Collection-Areas/Greek-and-Roman-Art/Cycladic-Art.

43. Caley, Earle R. “Ancient Greek Pigments from the Agora.” Hesperia: The Journal of the American School of Classical Studies at Athens 14, no. 2 (1945): 152–56. https://doi.org/10.2307/147009.
44. The technique was found by the Athenian Callias. He worked in a silver mine and studied the sand at Ephesus, believing it to have gold flakes in it from its unique glow. From trying to pan out the gold is how he found this process of manufacturing cinnabar. This took place in 405 BCE.
45. Translation and commentary of Theophrastus’s De Lapidibus by D. E. Eichholz (Oxford Clarendon Press, 1965)
46. Brecoulaki, Harikleia. “‘PRECIOUS COLOURS’ IN ANCIENT GREEK POLYCHROMY AND PAINTING: MATERIAL ASPECTS AND SYMBOLIC VALUES.” Revue Archéologique, no. 1 (2014): 3–35. http://www.jstor.org/stable/24751260.
47. Kakoulli, Ioanna. 2002. “Late Classical and Hellenistic Painting Techniques and Materials: A Review of the Technical Literature.” Studies in Conservation 47 (sup1): 56–67. doi:10.1179/sic.2002.47.Supplement-1.56.
48. A larnax (pl. Larnakes) is a small, closed casket used in the Minoan period. It forms individual or groups of graves in Minoan cemeteries.

    Pavlos E. Fovakis, Theodoros Ganetsos, Nikolaos G. Daskalakis, Study and Analyses of Pigments in Minoan Larnakes from the Peripheral Unit of Rethymnon (Crete) Applying Non-Destructive Techniques: Preliminary Results, Archaeology, Vol. 9 No. 1, 2021, pp. 94-100. doi: 10.5923/j.archaeology.20210901.15.

49. Sinopis (Sinopia) is now more commonly known as “Pompeian red” as it is found to be used abundantly in Pompeii wall paintings. The new name was coined in the eighteenth century after the wall paintings were uncoverd.

50. Maravelaki-Kalaitzaki, P., and N. Kallithrakas-Kontos. "Pigment and Terracotta Analyses of Hellenistic Figurines in Crete." Analytica Chimica Acta 497, no. 1–2 (November 2003): 209–25. https://doi.org/10.1016/j.aca.2003.08.035.
51. Excavations of Hellenistic cemeteries by the 13th Ephorate of Prehistoric and Classical Antiquities at the sight of Demetrias, Macedonia in 1995b revealed a large amount of Hellenistic clay figurines that had pigment still on it.

    Tsatsouli, Konstantina, and Elisavet Nikolaou. 2017. "The Ancient Demetrias Figurines: New Insights on Pigments and Decoration Techniques Used on Hellenistic Clay Figurines." STAR: Science & Technology of Archaeological Research 3 (2): 341–57. doi:10.1080/20548923.2018.1424302.

52. Brecoulaki, Harikleia. "'PRECIOUS COLOURS' IN ANCIENT GREEK POLYCHROMY AND PAINTING: MATERIAL ASPECTS AND SYMBOLIC VALUES." 3-35
53. This process does not work if the red iron containing pigment has already been heat treated.

    Davy, Humphry. "Some Experiments and Observations on the Colours Used in Painting by the Ancients." Philosophical Transactions of the Royal Society of London 105 (1815): 97–124. http://www.jstor.org/stable/107361.

54. Profi, S., L. Weier, and S. E. Filippakis. "X-Ray Analysis of Greek Bronze Age Pigments from Mycenae." *Studies in Conservation* 19, no. 2 (May 1974): 105. https://doi.org/10.2307/1505624.
55. Brysbaert, A. and Vandenabeele, P. (2004), Bronze Age painted plaster in Mycenaean Greece: a pilot study on the testing and application of micro-Raman spectroscopy. J. Raman Spectrosc., 35: 686-693. https://doi-org.umw.idm.oclc.org/10.1002/jrs.1204
56. To read more about the process of finding minium, refer to Piney the Elders *The Natural History* book XXV chapter 20.
57. Caley, Earle R. "Ancient Greek Pigments from the Agora." 152-56
58. Kostomitsopoulou Marketou, Ariadne, Kelly Kouzeli, and Yorgos Facorellis. "Colourful Earth: Iron-Containing Pigments from the Hellenistic Pigment Production Site of the Ancient Agora of Kos (Greece)."
59. Raw lumps of pigment powder were found in terracotta storage pots in the Athenian Agora. For more information on these stored pigments, refer to Caley, Earle R. "Ancient Greek Pigments from the Agora." 152-56
60. Another less popular way to harvest the copper carbonate was to leave it over a wine less and let the vapors loosen the material from the surface of the metal.

    Caley, Earle R. "Ancient Greek Pigments from the Agora." 152-56

61. For further reading on aspects of early pigments like azurite, refer to Brecoulaki, Harikleia. "'PRECIOUS COLOURS' IN ANCIENT GREEK POLYCHROMY AND PAINTING: MATERIAL ASPECTS AND SYMBOLIC VALUES." 3-35
62. Subduction zones are areas that occur when two tectonic plates collide with each other underwater that forces one plate to go under the other, pushing it into earth's mantle. This causes metamorphic rocks to form under intense pressure, causing blueschist facies to form in the metamorphic rocks. This is what Glaucophane is.
63. Filippakis, S. E., B. Perdikatsis, and T. Paradellis. "An Analysis of Blue Pigments from the Greek Bronze Age." Studies in Conservation 21, no. 3 (1976): 143–53. https://doi.org/10.2307/1505697.
64. Another name for Egyptian blue is blue frit.
65. The calcium carbonate that was widely used at this time in Egypt was lime, and it is what best produced it. It would still work with other calcium carbonates, but it would be of poorer quality. This process would become widespread on the Silk Road. When Rome fell, the exact recipe would be lost to the ancient world.
66. The Hagia Triada Sarcophagus is the only Sarcophagus found by archaeologists in the Minoan period that is made in a fresco like manner by applying pigment to wet plaster rather than painting directly onto the marble/stone.
67. Hagia Triada Sarcophagus, currently held in Heraklion Archaeological Museum in Crete, Greece
68. For further information on conserving the Parthenon marbles and finding Egyptian blue, refer to the British Museum's website for their page on it.

    Weglowska, Kasia. "Paint and the Parthenon: Conservation of Ancient Greek Sculpture | British Museum." British Museum. Accessed January 30, 2025. https://www.britishmuseum.org/blog/paint-and-parthenon-conservation-ancient-greek-sculpture.

69. Lapis sapphires were even more rare and valuable, only being found in the bronze age as pigment.

    Profi, S., L. Weier, and S. E. Filippakis. "X-Ray Analysis of Greek Bronze Age Pigments from Mycenae."

70. Filippakis, S. E., B. Perdikatsis, and T. Paradellis. "An Analysis of Blue Pigments from the Greek Bronze Age." 143-53
71. Barnett, J.R., Sarah Miller, and Emma Pearce. "Colour and Art: A Brief History of Pigments." 445-53
72. Purple was important to the gods as well. In a ritual called "the big oath" where someone would travel to a shrine of Demeter and Kore cloaked in a purple cloak to give the goddesses an oath, signifying someone aligning themselves with the gods. Purple would represent the gods in this ritual, taking the person under their protection. For more about the symbolic meaning of purple, refer to this article.

Grand-Clément, Adeline. “Gold and Purple: Brilliance, Materiality and Agency of Color in Ancient Greece.” Essays in Global Color History, December 31, 2016, 121–38. https://doi.org/10.31826/9781463236632-011.

73. Tyrian purple is another name for Murex purple mostly used in Rome because they traded with Tyre in Asia for it.

    Stieglitz, Robert R. “The Minoan Origin of Tyrian Purple.” The Biblical Archaeologist 57, no. 1 (March 1994): 46–54. https://doi.org/10.2307/3210395.

74. Westlake, Polly, Panayiotis Siozos, Aggelos Philippidis, Chryssa Apostolaki, Brendan Derham, Agni Terlixi, Vasilios Perdikatsis, Richard Jones, and Demetrios Anglos. “Studying Pigments on Painted Plaster in Minoan, Roman and Early Byzantine Crete. A Multi-Analytical Technique Approach.” 1413–32
75. Brecoulaki, Hariclia, and Giovanni Verri. ““From the Face and the Expression of the Eyes” : Multidisciplinary Studies of Pigments in Ancient Greek and Roman Painted Surfaces.” JD. Technai, no. 14 (2023). https://doi.org/10.19272/202310501003.
76. Westlake, Polly et al. “Studying Pigments on Painted Plaster in Minoan, Roman and Early Byzantine Crete. A Multi-Analytical Technique Approach.” 1413–32
77. Asia would later produce an improved version of usta called purpurea. This was considerd the best version made from mutated purple flowers.
78. Translation and commentary of Theophrastus’s De Lapidibus by D. E. Eichholz (Oxford Clarendon Press, 1965)
79. Translation of Pliny the Elder’s The Natural History Book XXXV by Karl Friedrich Theodor Mayhoff, 1906
80. Grand-Clément, Adeline. “La Grèce bariolée : l’Antiquité retrouve des couleurs.” pp.131–148.
81. Brinkmann, Vinzenz. "The polychromy of ancient Greek sculpture."18-39.
82. Anything that is not a hot dry climate would cause lake colors in particular to fade rapidly when re exposed to oxygen and humidity which is common in Greece. This is the same for any pigments, but pigments that went through the lake making process are vulnerable.

    Brecoulaki, Hariclia, and Giovanni Verri. ““From the Face and the Expression of the Eyes”

83. Sir Joseph Duveen or “Lord Duveen” was a wealthy art and antiquities dealer that donated large sums of money to the British Museum. He was a trustee of the museum and had his own gallery there called “The Duveen Gallery” that would go on to house the Parthenon marbles. While he had been trying to do right by the ancient architectural sculptures, in the end his efforts were in vain as the preservation and cleaning techniques used would damage the surface layers of the sculptures.
84. Bradly, Mark. “The Importance of Colour on Ancient Marble Sculpture.” 427-57
85. Anacreon was a Greek lyric poet that lived in the sixth and fifth century BCE known best for his drinking and erotic lyric poems.

86. The Laocoon Group is a marble statue of Laocoon and his sons being strangled by sea snakes, a scene from the *Iliad.* It is currently on display at the Vatican Museum in Italy.
87. Grand-Clément, Adeline. “Couleur et esthétique classique au XIXème siècle : l’art grec antique pouvaitil être polychrome ?.”
88. Chromophobia is the word used to describe the idea that color was a foreign, unpure concept. It was seen as dangerous and superficial while the color white was seen as pure and the ideal of beauty. This took place during the Neoclassism movement and stuck in scholarly groups.

    Grand-Clément, Adeline. “La Grèce bariolée : l’Antiquité retrouve des couleurs.” pp.131–148.

89. For further reading on the domino effect of J. J. Winkelmann and Neoclassism, refer to this article.

    Netti Rossana, “The colours of the ancient Greek architecture” (2019) Cultura e Scienza del Colore - Color Culture and Science, 11(02), pp. 14–24. doi:10.23738/CCSJ.110202.

90. Chromolithography was incredibly expensive to print and at this point, no one cared to fund publishing for pigment traces as there had not been a large enough find to consider it.
91. To view the official website for the “Gods in Color” exhibition, refer to here.

    “Dne-Frontend-Builder.” Switch to deutsch. Accessed April 19, 2025. https://buntegoetter.liebieghaus.de/en/.

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