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Staff members also serve as adjunct faculty at the nearby Conservation Center of New York University, and the Fairchild Center is the site of seminars and internships for students from this and other graduate programs. Postgraduate fellowships are awarded annually to conservators and other researchers from institutions in the United States and abroad.

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Research Fellows in The Sherman Fairchild Center for Objects Conservation, 2001-2002

Svetlana Burshneva, Andrew W. Mellon Conservation Fellow (September 1–November 30, 2001), to study corrosion processes and products on archaeological metalwork, and conduct research on methods of analysis for ancient metals.

Maria Pia Di Bonaventura, L.W. Frohlich Conservation Fellow (September 1, 2000–August 31, 2002), to continue her research on molecular biological techniques used for the study of biodeterioration processes that affect works of art.

Ursula Kugler, Sherman Fairchild Fellow (August 1, 2001–July 31, 2002), to examine several Italian renaissance processional crosses decorated with severely deteriorated *basse taille* enamels, and to develop a conservation strategy for their preservation.

COLOR in recent and forthcoming SFCOC staff publications

Heywood, A. "The Use of Huntite as a White Pigment in Ancient Egypt," in *Colour and Painting in Ancient Egypt*, W. V. Davies, ed., London, 2001, pp. 5–9.

Kaplan, E., E. Pearlstein, E. G. Howe & J. Levinson, "Análisis técnico de qeros pintados de los Periodos Inca y Colonial," *Iconos* 2, 2 (1999), pp. 30–38.

Pearlstein, E., E. Kaplan, E. G. Howe & J. Levinson, "Technical Analysis of Painted Inka and Colonial Qeros," in *Objects Specialty Group Preprints, vol. 6, American Institute of Conservation*, Proceedings of the Objects Specialty Group Session, June 11, 1999, 27th Annual Meeting, St. Louis, compiled by E. Kaplan & V. Green, np, 1999, pp. 94–111.

Schorsch, D. "Precious-Metal Polychromy in Egypt in the Time of Tutankhamun." *Journal of Egyptian Archaeology* (forthcoming).

Schorsch, D., E. G. Howe & M. T. Wypyski, "Silvered and Gilded Copper Metalwork from Loma Negra: Manufacture and Aesthetics," *Boletín Museo de Oro* 41 (1996), pp. 145–163 (actual publication date 1/1999).

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Color is paramount in the visual arts as a means to communicate personal and cultural values, and although we tend to think of them as purely optical phenomena, there is a physical basis for the colors we experience. This issue of *met objectives* focuses on how artists choose colorants and media, and the ways they are manipulated during processing and application. A study of wooden, colonial period vessels from the Andes relates changes in pigments and the use of an exotic resin medium to stylistic innovations that reflect European influence, while a survey of polychrome Egyptian antiquities provides new data to dispel early misconceptions concerning the use of the brilliant, white pigment, huntite. The role of color in communicating cultural values, as seen on the precious-metal jewelry of Tutankhamun, is considered, while in our final article, different colorants used on medieval Islamic ceramics are discussed in terms of glazing strategies.

met objectives



Figure 1

The Use of Huntite in Ancient Egypt

Huntite, a white pigment prepared from the mineral of the same name, was first discovered on ancient Egyptian objects in 1974, when Josef Riederer of the Rathgen-Forschungslabor in Berlin found it on two types of New Kingdom ceramics. Since that time, further occurrences of the pigment, both in museum collections and in the field, have been reported. A more systematic survey of white pigments found on objects in its extensive collection of Egyptian antiquities, recently undertaken at The Metropolitan Museum of Art, has added significantly to our knowledge of how and when huntite was used (*Figure 1*).

The mineral huntite [$\text{CaMg}_3(\text{CO}_3)_4$] was first identified only in 1953. Before this time

it had probably been confused with magnesite or dolomite, which have similar chemical compositions. While generally found as a product of weathering on the surface of magnesium-rich rocks, huntite can also be found in caves as a product of precipitation or as a salt-lake deposit. The mineral is very white, soft, and talc-like to the touch. At high magnification, huntite is distinguished from related carbonates primarily by the extremely small size of its crystals, which are generally less than two microns long (*Figure 2*). This small particle size, the ease with which it disperses in water, and its bright white color, make huntite an excellent pigment.

At the time when Riederer discovered huntite used as a pigment there had been no

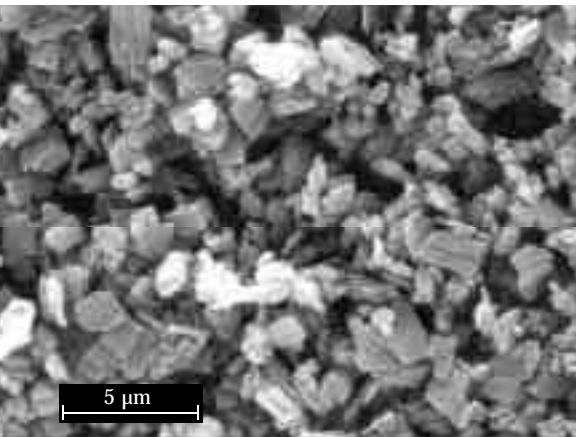


Figure 2

reports of its occurrence in Egypt as a mineral. According to the Egyptian Geological Survey and Mining Authority, however, several sources have been discovered recently. It is not clear which of these localities might have been exploited, but all would have been readily accessible to the ancient Egyptians. Outside Egypt, huntite has been identified on Early and Middle Minoan painted pottery (2600–1550 B.C.), but its source is unknown. Long distance trade during the Roman Period is suggested by the recovery of a box containing approximately one kilogram of pure huntite among the wreckage of a second to third

century A.D. shipwreck in the Gulf of Procchio on the north coast of Elba. Huntite is still used on rock paintings by Aboriginal artists in western Australia.

Since the first reported discoveries of huntite on Egyptian objects, there has been speculation on the extent of its use in ancient Egypt, and the degree to which it was consciously valued for its superior visual qualities. Initially, the pigment seemed to appear with disproportionate frequency on the clothing and regalia of royal figures and deities, and this was offered as evidence that it was a special and rare commodity, possibly imported. Its identification primarily on New Kingdom wall paintings in the Theban region had prompted others to believe that huntite first came to be used during this period. In fact, it was the discovery of huntite on a Middle Kingdom relief in the Metropolitan Museum, thought to have been recarved and repainted some five hundred years later during the New Kingdom, that initially prompted the study of huntite in the Sherman Fairchild Center.

The assumptions that huntite first came into use in the New Kingdom, and that it was reserved exclusively for important

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Figure 1. (Cover) Anonymous rishi coffin. Egyptian, Thebes, Assasif, CC 64.10, Second Intermediate Period, Dynasty 17–early Dynasty 18. Painted wood, l. 218 cm. Gift of the Earl of Carnarvon, 1914 (14.10.1). Detail with mourning women.

Figure 2. Scanning electron photomicrograph of huntite specimen from Austin, Lander Co., Nevada.

Figure 3. The occurrence of huntite on objects examined. Predynastic Period–Early Dynastic Period (ca. 4500–ca. 2649 B.C.). Old Kingdom (ca. 2649–ca. 2150 B.C.). First Intermediate Period (ca. 2150–ca. 2040 B.C.). Middle Kingdom (ca. 2040–ca. 1640 B.C.). Second Intermediate Period (ca. 1640–ca. 1550 B.C.). New Kingdom (ca. 1550–ca. 1070 B.C.). Third Intermediate Period (ca. 1070–ca. 712 B.C.). Late Period–Roman Period (ca. 712 B.C.–476 A.D.).

New Evidence for the Use of Ultramarine as a Pigment in Ancient Egypt

Already in the Predynastic Period, the semi-precious stone lapis lazuli was exported from Afghanistan to Egypt, where it was used for beads, inlays, amulets, and small statuary. Lapis is also the basic constituent of the high-quality, blue pigment ultramarine, but it has never been found used as such in ancient Egypt or elsewhere in the Mediterranean world until at least the sixth century A.D. Aside from the brief appearance during the New Kingdom of a cobalt-based pigment for post-fired painting on pottery, Egyptian blue, a synthetic analogue of the copper-calcium-silicate mineral cuprovraite, is the only blue pigment thought to have been used in ancient Egypt. Recently, in the course of a routine examination, traces of ground lapis were discovered on a fragmentary, indurated limestone statue of a royal woman of the Seventeenth or early Eighteenth Dynasty. Since it was excavated at Thebes (1915–1916) by Ambrose Lansing, the figure has been in the collection of the Department of Egyptian Art. Analyses of blue pigments on other securely provenanced Egyptian antiquities known to be in as-excavated condition should establish whether this occurrence represents an isolated experiment, or is evidence of an on-going, but still unrecognized, tradition.

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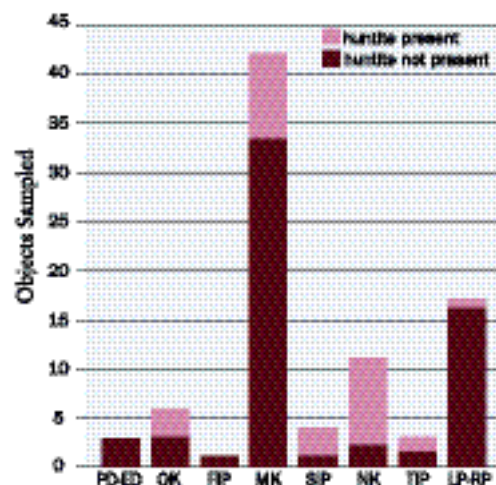
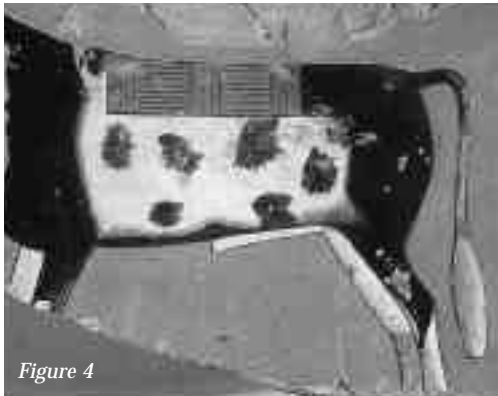


Figure 3



al *per se*, and wished to use it even when its superior qualities were not evident.

Pure huntite does appear on a finely crafted, wooden figure of Senbi from Meir and on delicately carved and painted reliefs from the tomb of Meketre at Thebes (Figure 4). In the latter case, there is evidence suggesting a conscious decision to choose huntite for its bright, white appearance. Whereas the less brilliant pigment, calcium carbonate, was mixed with charcoal black for the gray backgrounds, huntite was reserved to paint the figures. Huntite was used in a similar manner on some of the Museum's Second Intermediate Period anthropoid coffins, on which dull, off-white, calcium carbonate backgrounds provide the foil for the linen clothing of the figures painted with the more luminous pigment (Figure 1).

imagery or high-status customers, were proven incorrect by the survey of the Egyptian collection, in the course of which over one hundred white pigment samples from eighty-six objects dating from the Predynastic Period through the Roman Period were studied. Samples of white pigments were removed and analyzed using transmitted light microscopy, followed, when necessary, by energy-dispersive X-ray spectrometry and X-ray diffraction analyses. The results make clear that huntite was already in use during the Old Kingdom, and that it was available to both provincial and royal craftsmen.

Of the forty-two Middle Kingdom objects sampled, huntite was found on nine. These include objects from royal contexts, such as the reliefs from the Eleventh Dynasty temple of Mentuhotep II at Deir el-Bahari at Thebes, as well as privately commissioned, provincial works, including coffins from a cemetery at Meir in Middle Egypt. Huntite continues to appear frequently in the Second Intermediate Period, and in the succeeding New Kingdom and Third Intermediate Period. The results of the survey suggest that the pigment was used less often during the Late, Ptolemaic, and Roman Periods, but analyses of additional samples are necessary before such a conclusion can be justified (Figure 3).

Huntite samples were sometimes found to contain calcium carbonate or calcium sulfate, the two white pigments more commonly used in ancient Egypt. In some cases, these mixtures certainly reflect the presence of natural impurities in the huntite itself or contamination from a calcareous ground or stone substrate, but elsewhere may be an indication that the Egyptians valued huntite as a materi-

Huntite was not found on any of the objects included in the survey that were excavated at Lisht, site of the royal residence and funerary monuments of the early Twelfth Dynasty. This curious fact provides further evidence that relates to a theory regarding the origins of the famous wooden models of ships, workshops, houses and offering bearers found in Meketre's tomb at Thebes (Figure 5), recently put forth by Dorothea Arnold, Lila Acheson Wallace Curator in Charge, Department of Egyptian Art. Meketre began his career in Thebes under King Mentuhotep II, who unified Egypt in the Eleventh Dynasty. Meketre still chose to be buried there, even though he also served the founder of the subsequent dynasty, Amenemhat I, who moved the capital to Lisht during his reign. According to Dr. Arnold, Meketre's models were carved in the region of Lisht in the new northern style of the Twelfth Dynasty. The question of where the polychromy was applied remains open, but the absence of huntite on the models does suggest that they could have been painted at Lisht, even when some aspects of their painted decoration seem more typically Theban. As more data from specific sites and contexts can be brought in evidence, the "demographics" of huntite should continue to provide a valuable tool for the elucidation of similar stylistic and chronological questions.

Figure 4. Relief fragment. Egyptian, Thebes, tomb of Meketre, Middle Kingdom, Dynasty 12, Reign of Amenemhat I. Painted limestone, l. 21.8 cm, h. 51.5 cm. Rogers Fund, supplemented by contribution of Edward S. Harkness, 1920 (20.3.162). Detail with cow.

Figure 5. Offering bearer. Egyptian, Thebes, tomb of Meketre, Middle Kingdom, Dynasty 12, Reign of Amenemhat I. Painted wood, h. 86 cm. Rogers Fund and Edward S. Harkness Gift, 1926 (26.7.1396).



Color and Resin on Andean Qeros

Wooden drinking vessels known as *qeros* were used in the Peruvian highlands for the ritual consumption of maize beer during the centuries before the Spanish Conquest, and still today have a role in traditional Andean ceremonies (Figure 6). With the arrival of the Spaniards in 1543, and as a result of the cultural hegemony they imposed, came a gradual blending of Western and local traditions that is reflected in both the materials and imagery used for the decoration of *qeros* during the colonial period. In the preceding Inka period, *qeros* were usually incised with linear, abstract motifs. These monochrome patterns probably correspond to colorful emblems, called *tocapu*, on Inka textiles. On the early colonial *qeros*, animal and insect motifs carved in horizontal registers are filled with bright, colorful inlays (Figure 7), while in later times entire surfaces were covered with complex scenes employing a subtle and more extensive palette. On many of these late colonial *qeros*, traditional Inka mythological and ritual themes are evoked through a variety of figurative, floral, and faunal images using a narrative, painterly style that clearly derives from European art.

In 1994, conservators in four New York institutions—The Metropolitan Museum of Art, the Brooklyn Museum of Art, The American Museum of Natural History, and the former Museum of the American Indian (Smithsonian National Museum of the American Indian, Washington, D.C.)—began to study the approximately 150 *qeros* of late Inka and colonial date housed in their collections. While the primary focus of the instrumental analyses was the identification of the colorants and binding media, practical aspects of applying the colorful, glossy inlays to the wooden vessels were also considered.

Analysis of the pigments was undertaken with X-ray diffraction at the Fairchild Center, followed by more extensive investigations using Fourier transform infrared spectroscopy (FTIR), electron microprobe, and polarizing light microscopy by Richard Newman of the Museum of Fine Arts, Boston. His work, funded by a grant from

the Andrew W. Mellon Foundation to the Brooklyn Museum, confirmed the presence of a range of inorganic and organic pigments, including cinnabar, orpiment, lead white, indigo cochineal, and several copper salts, as verdigris.

The medium used with these pigments—purportedly an exudate from *Elaeagrostis* *pastoensis* Mora, a shrub with a range restricted to the mountains of southern Colombia—was also investigated. The resinous exudate, known locally as *mopa mopa*, was mentioned already by eighteenth and nineteenth century European naturalists who traveled through the region and observed native craftsmen using this unusual material to apply color, gold leaf, or varnish to wooden objects, gourds, and leather. The craft, known as *barniz de Pasto*, is still practiced in Pasto, a small city in southern Colombia.

FTIR, mass spectrometry, and gas chromatography analyses of inlays from numerous *qeros* were compared to analyses of unpigmented *mopa mopa* collected in the field by the Colombian botanist Dr. Luis Eduardo Mora-Osejo. Indeed, the results indicate that the binding medium is the *Elaeagrostis* *pastoensis* Mora exudate, mixed with a semi-drying oil. Analytical techniques and visual examination, however, could not explain how the pigmented *mopa mopa* was inlaid into carved recesses and how some of the brilliant coloristic effects were achieved.

A field trip to Pasto to observe and interview *barnizadores*, in combination with subsequent replication experiments, has been crucial for gaining an understanding of the



Figure 7



Figure 6

Figure 6. Qero, Peru (?), Colonial Period. Wood, pigment, *mopa mopa*, h. 20.0 cm, dia. 16.6 cm. Arthur M. Bullowa Bequest, 1993 (1993.35.53).

The qero project was designed as a multidisciplinary study of qero materials and methods of manufacture involving conservators, scientists, and Andeanists. The project is currently addressing questions that relate to qero chronology, regional workshops, and the use of indigenous materials. In addition to the author, principal conservation investigators are: Ellen Pearlstein (BMA), Emily Kaplan (NMAI), and Judith Levinson (AMNH). Curatorial participants are Diana Fane, Curator Emerita (BMA), and Professor Tom Cummins, University of Chicago. Many others have contributed to this project, notably Emilia Cortes, Associate Conservator, Textile Conservation, and former conservation students at the Institute of Fine Arts, Stephanie Hornbeck, Odile Madden, Eugenie Milroy, and Sarah Nunberg.

Figure 7. Qero, Peru (?), Colonial Period. Wood, pigment, *mopa mopa*, metal inlays, h. 21.6 cm, dia. 17.0 cm. Arthur M. Bullowa Bequest, 1993 (1993.35.14). Detail with parrot.



Figure 8

working properties of the resin. It has also served to clarify the various processes used to produce the smooth, glossy inlays characteristic of the colonial period *qeros*. The *barnizadores* demonstrated all phases of *barniz* production, from the early stages of preparing the resin, to its application on a host of substrate materials. In brief, the *mopa mopa* is processed in boiling water, and then by kneading and grinding, and the mechanical removal of woody impurities. It is ready for use when it attains the consistency of chewing gum. Following the introduction of pigments, the *mopa mopa* is stretched to form paper-thin, flexible sheets (Figure 8) that are then cut to shape and applied in layers. These generally opaque, pigmented sheets are adhered with finger pressure and heat.

After observing the *barnizadores* at work it was apparent that while the pigmented *mopa mopa* on the *qeros* had probably been prepared in a similar manner, the methods of application differed. On the *qeros*, the stretched sheets of resin were forced into carved recesses and then compressed or heated to create an even surface. Details were pressed into these inlays using small pieces of *mopa mopa*, some in the form of drawn strings. In addition, glaze-like effects were created using translucent and semi-translucent layers applied over pigmented surfaces or directly to the wood substrate.

The results of the analyses and replication experiments make it possible to relate developments in post-Conquest styles of *qero* decoration to additions to the palette and to new methods of applying these

pigments. In late Inka or early colonial times, when *mopa mopa* first came to be used on *qeros*, only a few pure pigments and simple mixtures were added to the resin. For the most part these inlays are opaque.

A far broader range of colors is seen on the late colonial *qeros*, which were decorated with overall narrative scenes. On one of the most colorful examples at least fourteen different colors can be recognized, including four distinct shades of green. This was made possible, in part, by the introduction of new pigments, including those based on organic dyestuffs, and the formulation of complex mixtures dependent not only on the nature of the colorants, but also on particle size and concentration. Some of the new pigments, such as lead white and verdigris, were probably introduced by the Spaniards, while others were traditionally used in the Andes but appeared only gradually on *qeros*.

On these later vessels the optical qualities of the *mopa mopa* were used to create additional hues and luminous effects. Although images were still applied as inlays, new techniques of manipulating the resin layers contributed to the more nuanced, painterly style that came to replace the emblematic approach of the earlier *qeros*. For example, a technique employing *mopa mopa* layers that vary in thickness was developed to achieve different shades of the same color. In a two-tone rendering of *chinchircuma* leaves (Figure 9), inlays and an



Figure 9

Figure 8. *Barnizadores Maestro Obando and his mother stretching mopa mopa into sheet form during processing, Pasto, Colombia, 1994.*

Figure 9. *Qero, Peru (?), Colonial Period. Wood, pigment, mopa mopa, h. 20.6 cm, dia. 17.4 cm. Arthur M. Bullowa Bequest, 1993 (1993.35.17). Detail with chinchircuma leaf.*

Figure 10. *Qero, Peru (?), Colonial Period. Wood, pigment, mopa mopa, h. 22.0 cm, dia. 16.1 cm. Arthur M. Bullowa Bequest, 1993 (1993.35.26). Detail with tan and grey hair.*



Figure 10

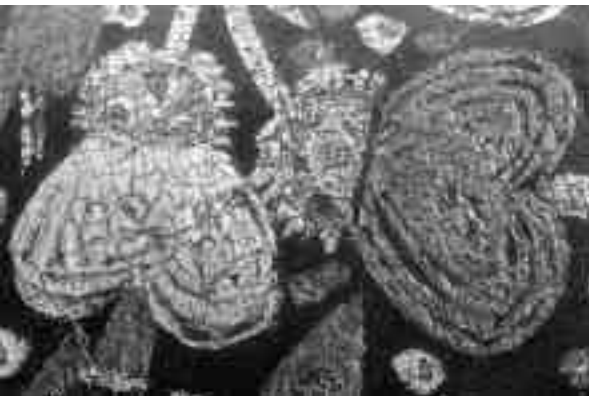


Figure 11

applied film of the same pigmented resin were used for the veins and the flesh, respectively. Where the resin is thick and opaque, in the carved grooves that delineate the veins, it displays its intrinsic, light green color. In the surrounding flesh, the *mopa mopa* is thinner and slightly translucent, and appears a darker

green due to the color transmitted from the underlying wood.

Modifications to this technique are visible in the detailed execution of hair and flowers on a late colonial trophy-head *qero*. In the rendering of these motifs, the first step was the application of black pigment to the wood. Grooves defining their contours and details were then cut through the black surface layer, revealing the brown substrate. For the hair, a semi-translucent layer of tan *mopa mopa* was applied over the entire surface, to produce a subtle alternation of tan and gray (Figure 10). In the same fashion, *mopa mopa* layers of varying thicknesses applied over black pigment and the wood substrate were used to modulate tone and transparency in the red and yellow petals, an innovation clearly inspired by European concepts of form and light (Figure 11).

Figure 11. *Qero*, Peru (?), Colonial Period. Wood, pigment, mopa mopa, h. 22.0 cm, dia. 16.1 cm. Arthur M. Bullowa Bequest, 1993 (1993.35.26). Detail with flowers.

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Precious-Metal Polychromy in the Time of Tutankhamun

When ancient craftsmen selected raw materials, guided by the patrons who commissioned their work, these choices were based on cultural as well as practical considerations, and although the more abstract, motivating factors often elude modern viewers, they sometimes can be discerned. For more than four millennia, the precious metals of Old World antiquity—gold and silver, and electrum, a naturally occurring alloy of the two—were used in Egypt for the manufacture of ritual objects and personal possessions, and when found in juxtaposition, these materials sometimes afford us a glimpse of cultural values assigned to them in ancient Egyptian society. Some of these values are particularly evident on jewelry found in the tomb of Tutankhamun (r. ca. 1336–1327 B.C.), who ruled Egypt in a time of unparalleled power and prosperity, characterized by an intense production of luxury goods for the king and his court.

Only on rare occasions can the pairing of gold and silver be related to ancient perceptions of their relative worth. Texts indicate

that gold and silver were not distinguished as separate metals before the middle of the Old Kingdom, which may be reflected in the manufacture of objects that combine the two metals without regard for their nature or coloration. In Egypt, silver was always less common than gold, and from the time it was first considered a distinct metal, it was also more highly esteemed. By the New Kingdom, however, gold clearly had taken precedence in temple offering lists, a shift represented perhaps in a unique combination of gold and silver that expresses relative social or professional standing. On a golden barque model from the tomb of Queen Ahhotep, dated to the early Eighteenth Dynasty, silver oarsmen work under the watchful eyes of a helmsman and two supervisors, obviously of higher status, who were cast in gold.

The physical properties of alloys, including color, are largely dependent on their composition. In the case of gold and silver, which are mutually soluble in all proportions, all possible alloys are suitable



Figure 12

Figure 12. Scarab pectoral. Egyptian, Thebes, Valley of Kings, tomb of Tutankhamun, New Kingdom, Dynasty 18. Gold, silver, stone, glass, h. 14.9 cm. Cairo, The Egyptian Museum (JE 61884). The pectoral is thought to illustrate stages of transformation that the king, wearing a moon disk, undergoes after death, a voyage that parallels the sun's night journey through the underworld. The moon is represented by a silver disk on a gold crescent. (Photo: MMA Egyptian Expedition).

for the mechanical and metallurgical processes generally practiced in antiquity, and Egyptian metalworkers were free, therefore, to consider color as a criterion in choosing a precious-metal alloy.

Polychromy is usually defined as “the art of employing colors in decoration, especially in architecture and statuary.” When considering ancient Egyptian works of art, the term *precious-metal polychromy* may be used to denote a style, associated with royal jewelry of the highest quality, that exploits the decorative, coloristic, and symbolic values of gold, silver, and electrum. While manifest most richly during the reign of Tutankhamun, *precious-metal polychromy* has its roots in the arts and aesthetics developed in the time of his immediate predecessors. This sensitivity to the expressive possibilities offered by metal colors appeared, not coincidentally, in the years following the systematic production of glass in Egypt and the development of new faience glazes.

In ancient Egypt, the moon and ritual purity were associated most closely with silver, while gold was linked to the sun and solar deities, and to rebirth. Gold and silver were also symbolically paired with the flesh and bones of the gods. These correspondences are known from religious texts, however, and are rarely seen reflected in extant works of art. Silver was not particularly favored for images of Egypt’s major moon deity, the ibis-headed Thoth, while on the other hand, the god Nefertem was represented in silver far more frequently than any other deity, a correlation that finds no parallel in textual sources. The use of gold and silver with reference to their symbolic values can be demonstrated for the first time only during the reign of Tutankhamun. Many of the king’s gold *cloisonné* inlay pectorals that feature solar imagery make visual reference to his throne name, Nebkheperure, “lord of the evolutions of the sun,” and when components of silver or electrum are present, these jewels evoke the sun’s lunar aspect, illustrating an evolutionary stage that occurs during its nocturnal voyage through the underworld (*Figure 12*).

The coloristic use of silver can be seen on the back panel of Tutankhamun’s *Golden*



Figure 13

Throne, which depicts the royal couple in a floral pavilion with the rays of the *aten* disk entering through an opening in the roof (*Figure 13*). Against a background of gold sheet, the flesh of the figures is represented using dark red glass, while other details, such as their jewelry, their hair and head-dresses, the trim of their garments, and the pavilion and its furniture, are indicated with glass and semi-precious stones in colors that mirror representations in wall paintings. The finely pleated, white linen garments and white sandals are rendered in chased silver.

To its ancient inhabitants, Egypt was not a single entity, but the union of “the two lands,” a duality expressed in texts, and

Figure 13. Golden Throne. Egyptian, Thebes, Valley of the Kings, tomb of Tutankhamun, New Kingdom, Dynasty 18. Gold, silver, wood, stone, glass, h. 102 cm. Cairo, The Egyptian Museum (JE 62028). (Photo: MMA Egyptian Expedition).

Figure 14. Shrine pectoral. Egyptian, Thebes, Valley of the Kings, tomb of Tutankhamun, New Kingdom, Dynasty 18. Gold, silver, glass, h. 14.5 cm. Cairo, The Egyptian Museum (JE 61946). Nekhebet, wearing a feathered white crown, is on the left, with Wadjet, wearing the red crown, on the right (Photo: MMA Egyptian Expedition).

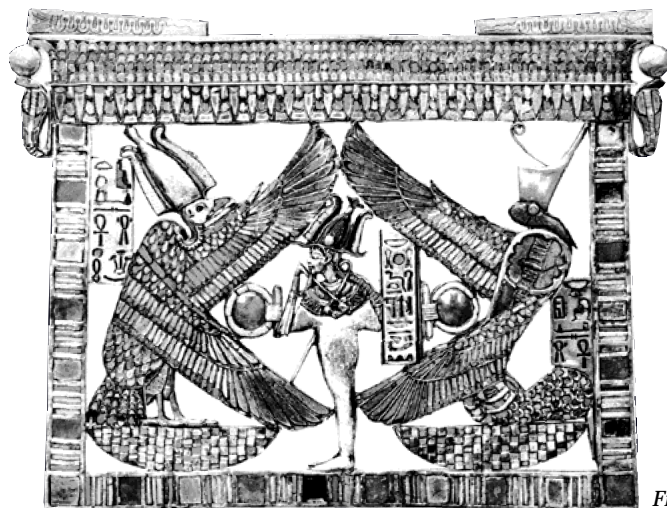


Figure 14

visually through juxtapositions of regional deities and totems. As ruler of Upper Egypt and Lower Egypt, the king wore a white *hedjet* crown and a red *deshret* crown, and so they appear, white and red, in painted representations. Silver and gold were used on several of the king's pectorals to confer these characteristic colors to the crowns of Upper and Lower Egypt, traditionally worn by the goddesses Nekhebet and Wadjet, respectively (Figure 14).

The choice of gold to represent the red crown on Tutankhamun's jewelry was not incidental. For the ancient Egyptians, gold had a red aspect, and during the New Kingdom at least two methods were employed to produce red gold, which is most often seen contrasted decoratively with yellow gold. Several types of objects that combine components of red and yellow gold were found in Tutankhamun's tomb, including a pair of leather sandals encrusted with yellow-gold lilies and papyrus umbels, and red-gold rosettes, as well as faience inlays (Figure 15). Works that emphasize surface texture, such as a gold *ajouré* plaque showing the king in his chariot, embody a different aesthetic. The plaque was made from a pierced and chased sheet of red gold to which yellow-gold granules of varying sizes were applied, while similar works present yellow-gold surfaces textured with red-gold granules.

Tutankhamun's so-called coronation pectoral presents precious metals in another type of decorative arrangement. Two gold alloys that differ in silver content were chosen for the disks forming a frieze along its bottom edge (Figure 16). This subtle alternation of metal colors is echoed in the contrast between the relative warmth of their inlaid semi-precious stone backgrounds: cool blue

stones were placed with yellow-gold, and orange stones with white, silver-rich gold. Such fine distinctions may parallel linguistic developments that reflect greater availability of gold from more diverse sources and new processing techniques. A single word for gold was used in Egypt until the New Kingdom, when a multiplicity of terms begin to appear in texts, describing qualities as diverse as origin ("gold of the desert") and form ("gold in lumps or nuggets"), in addition to color ("green gold").

Sophisticated *objets de vertu* produced during the first half of the New Kingdom, and particularly those dating to the time of Tutankhamun and his immediate predecessors, are characterized by an expanded palette, facilitated by the introduction of glass and the formulation of new faience glazes in the early Eighteenth Dynasty. Virtually all earlier *cloisonné* and bead work was canonical in its use of dark blue lapis lazuli, orange carnelian, and different varieties of light blue stones, or occasionally blue faience, while in the New Kingdom, white, yellow, deep red, and apple green faience and opaque glasses of many colors supplemented a now broader palette of semi-precious stones. The vitreous materials provided new and more reproducible colors, while innovation can be noted in the elaboration of faience and glass-forming techniques. The new role of precious-metal colors on Tutankhamun's jewelry clearly reflects the same interest in these colorful materials that encouraged experimentation in these other industries, as well as the desire to exploit color more fully as a means of expression in the manufacture of small works of great elegance.

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Figure 15. Sandal. Egyptian, Thebes, Valley of Kings, tomb of Tutankhamun, New Kingdom, Dynasty 18. Gold, red gold, faience, l. 30 cm. Cairo, The Egyptian Museum (JE 62681). The red coloration on the gold sequins results from the addition of a small amount of iron to the gold when molten. (Photo: MMA Egyptian Expedition).

Figure 16. Shrine pectoral. Egyptian, Thebes, Valley of Kings, tomb of Tutankhamun, New Kingdom, Dynasty 18. Gold, electrum, silver, stone, glass, h. 11.5 cm. Cairo, The Egyptian Museum (JE 61941) In this photograph, the subtle contrast between the different alloys used for the disks is obscured by tarnish. (Photo: MMA Egyptian Expedition).



Figure 15



Figure 16

Considering the Color of Minai Ware

In medieval Persia, *minai* was a general term for enamel and enameling, while in modern times *minai* ware has come to refer to a group of Islamic ceramics characterized by their enamel painting and abundant figural decoration. A few examples inscribed with dates establish that these wares were produced between 1179 and 1219, at the end of Seljuk rule in Persia (Figure 17). Inscriptions on *minai* vessels also point toward the city of Kashan, a leading ceramic center during this period, as their place of manufacture.

Much of our current understanding of *minai* techniques, and of medieval Islamic ceramic technology in general, comes from the 1309 treatise of Abu'l Qasim of Kashan. Qasim's text dates to a time when *minai* ware was no longer produced, but his descriptions of underglaze-decorated, luster, and *lajvardina* wares suggest many of its materials and methods. A more complete understanding of the

decorative techniques used on *minai* ware, however, can only be obtained through the examination and analysis of the ceramics themselves. To this end, thirty pieces of *minai* ware, mostly fragments chosen for ease of sampling, were evaluated using four methods: surface examination under magnification, reflected light microscopy of mounted glaze cross sections, open architecture X-ray diffraction analysis for the identification of crystalline phases, and scanning electron microscopy–energy-dispersive X-ray spectrometry for elemental analysis. The results suggest that *minai* decoration was painted using both inglaze and overglaze techniques, a combination not previously documented.

All *minai* vessels have an overall opaque base glaze that is typically white, but sometimes turquoise. Inlaze decoration is applied over an unfired base glaze, and during firing the pigments sink into the molten glassy matrix. The colorants are



usually quartz or clay, that raise the melting point of such mixtures and thereby inhibit dissolution at the high temperatures required to fuse the base glaze. Overglaze decorations such as enamels are applied to the surface of a fired base glaze. Enamels contain frit—a glass that has been fused, cooled, and powdered in preparation for use—that melts during a second firing and binds the pigments to the glaze surface. The temperature and duration of this firing are reduced by increasing the ratio of fluxes to refractories so as to minimize remelting of the underlying base glaze. The lower firing temperatures used for the enamels permitted a particularly broad palette on *minai* ware, including black, red, pink, blue, turquoise, purple, white, green and yellow. Discussion here will be limited to three of the most common colors, black, red, and blue, each prepared from a distinct combination of pigment, frit, fluxes, and refractories, to best produce the desired effect (Figure 18).

Figure 17. Minai decorated ceramic bowl. Iran, Seljuk period, dated 1186. Glazed composite body, dia. 21.5 cm. Fletcher Fund, 1964 (64.178.1). An example of the *minai* style with “large-scale miniature” figures in a simple, narrative scene. This bowl is exceptional for its turquoise base glaze, and inscriptions, which include the date and the name the artist, Abu Zaid of Kashan.

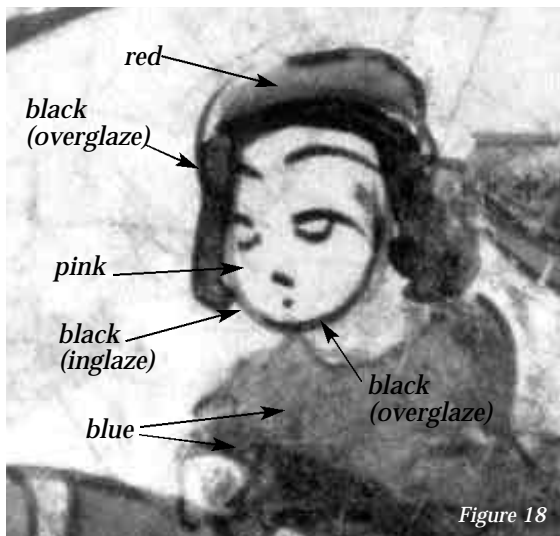


Figure 18

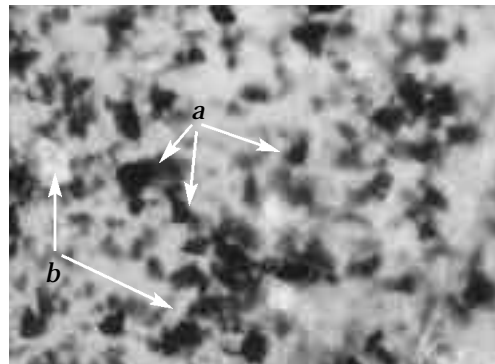


Figure 19

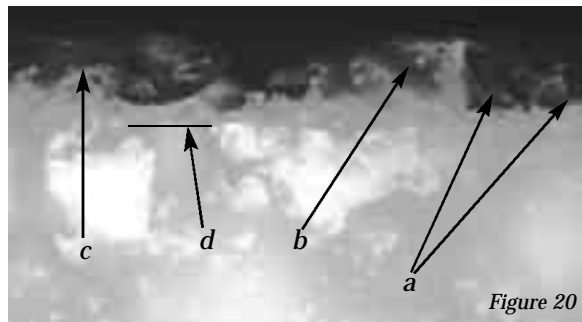


Figure 20

The black pigment was identified as the mineral chromite $[(\text{Fe},\text{Mg})(\text{Cr},\text{Al})_2\text{O}_4]$. Ground chromite particles are elongated, angular, and measure approximately sixteen microns in length (Figure 19). The particles are generally black, but in thin splinters can appear brown, and in the glaze layers they are often surrounded by green halos caused by the dissolution of iron in the glassy matrix during firing. This characteristic helps to distinguish chromite blacks from the manganese-based blacks commonly seen on medieval Islamic ceramics. The physical evidence obtained in this study supports the conclusion that the chromite found on *minai* ware is the black pigment Qasim refers to as *muzzarad*. This term translates literally as “in the way of armored plating,” implying a hardness consistent with the coarse, sharp-edged nature of chromite. The lack of significant rounding of particles in the glaze layers is indicative of a high melting point, a property Qasim may be describing when he states that *muzzarad* “comes out of the fire shiny black.”

Chromite is found on nearly every piece of *minai* ware, used either for inglaze underdrawings that establish the design, or

as part of the overglaze decoration. In cross sections, the inglaze black appears as a thin layer of pigment mixed with quartz lying at or just beneath the surface of the base glaze. The addition of quartz to colorants is a general practice that is described by Qasim, but he does not specify its role as a refractory.

Black enamels form well-defined layers on top of the base glazes and average sixteen microns in thickness. For overglaze painting, chromite was mixed with frit in addition to ground quartz. During firing, the frit melted and formed a transparent, glassy phase surrounding the colorant and refractory (Figure 20). Elemental analysis indicates that this frit contained both lead and alkaline fluxes. Qasim’s recipe for black enamels includes *muzzarad* and frit, without any mention of added refractories or fluxes. This could reflect a change in technique, although these components may have been understood to be present in, or mixed with, the other ingredients.

Red enamels, also found on nearly every *minai* vessel, were colored with hematite $[\text{Fe}_2\text{O}_3]$. The properties of this mineral are consistent with those of the red pigment that Qasim referred to as *qamsari* and *bukhari*,

Figure 18. *Minai ceramic bowl fragment. Iran, Seljuk period, late 12th–early 13th century. Glazed composite ceramic body, dia. 10.0 cm. Bequest of William Milne Grinnell, 1920 (20.120.141). A typical fragment from the study group. The quick, crisp strokes defining the facial features, hat, and costume are common to all minai vessels, though not all are as confidently drawn as this example. Inglaze black underdrawing can be seen below the pink enamel along the proper right side of the face.*

Figure 19. *Surface of inglaze black pigment. The sharp, angular chromite particles (a) are mixed with angular grains of quartz (b). Because its refractive index is similar to that of the glaze, the quartz particles can often only be recognized by their outlines, as defined by the surrounding black pigment.*

Figure 20. *Cross section of black enamel with underlying white base glaze. The dark chromite particles (a) are visible at the bottom of the enamel layer, mixed with fine, transparent quartz (b). A glaze (c) has formed, fusing the embedded particles together. The surface of the base glaze is indicated by (d).*

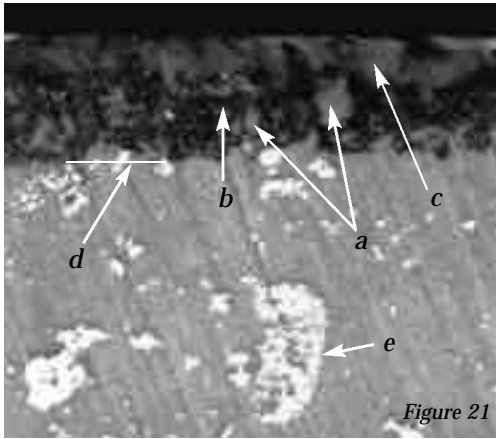


Figure 21

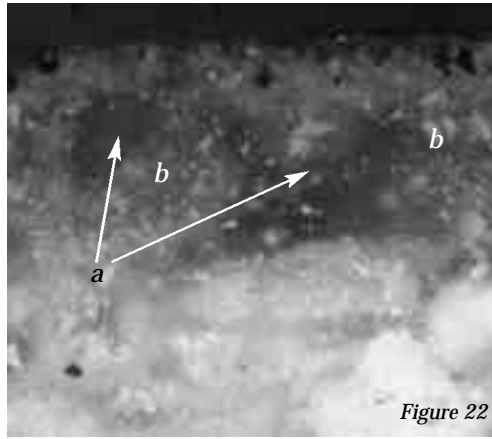


Figure 22

Figure 21. Scanning electron photomicrograph of a cross section with red enamel over white base glaze. This layer consists of a dense mixture of hematite (a) and ground quartz (b). The frit component of this enamel has formed a glassy surface layer (c), that appears lighter in this back scatter image due to the presence of lead. Underneath the surface of the white base glaze (d) particles of the tin oxide opacifier can be clearly distinguished (e).

Figure 22. Cross section of blue inglaze decoration with white base glaze. A few particles of glassy blue frit (a) are visible within regions of blue-stained glaze (b).

names that derive from cities known as centers of iron mining. The red enamel layers measure approximately twenty-four microns in thickness and contain pigment and quartz within a glassy phase (Figure 21). To produce intense, highly saturated reds, hematite was finely ground to a particle size of approximately two microns, which greatly increases the pigment's surface area and solubility. The detection of elevated levels of silica and alumina suggests that a substantial amount of quartz and possibly some clay were added to deter dissolution during firing. The analytical results also show that the frit contained alkalis and lead, and is therefore similar in composition to that used for the black enamels. By comparison, the amount of frit incorporated in the red overglaze colors was much lower. This formulation helps to even further retard the dissolution of iron in the glassy phase, but has the disadvantage that only a thin glass layer develops, which barely covers the hematite and quartz particles. The difficulty of balancing the physical properties of these raw materials sometimes resulted in inhomogeneous and poorly fused enamels that appear rather matte and unsaturated.

Another common colorant used on *minai* ware is cobalt, a pigment much valued during the Seljuk period for its rarity and beauty. Qasim refers to its deep blue color as *lajvard* and to the pigment more specifically as *Sulaimani*. His text describes recipes for blue base glazes used on *lajvardina* vessels,

in which the amount of cobalt specified is similar to the low levels (< 2%) detected on *minai* ware. In cross section, the cobalt typically appears as a deep-blue stain that penetrated far below the surface of the base glaze, suggesting that it was applied with the inglaze technique (Figure 22). The presence of a few discrete, blue, glassy particles indicates that the cobalt was prepared as a frit. Fritting has a number of advantages for highly soluble pigments such as cobalt, as it can reduce the amount of pigment needed, discourage bleeding, and produce a more homogeneous color. The survival of unfused, colored frit, in and of itself, suggests a higher melting point than that of the base glazes. This observation is consistent with the low lead levels detected in these particles. In contrast, the base glazes were formulated using both lead and alkaline fluxes.

The polychromy of *minai* ware has traditionally been accepted as enamel decoration, although its exact nature was never fully researched. The evidence observed in this study confirms the use of overglaze painting on *minai* ceramics, but also strongly suggests that some pigments, such as cobalt and chromite, were applied using an inglaze technique. The presence of this long-established method, together with the newly developed enamel technique, helps place *minai* ware within the context of changing ceramic technology in the Islamic world at the end of the twelfth century.

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