Technology Transfer from Ancient Egypt to the Far East?

Alessandra R. Giumlía-Mair
AGM Archeoanalisi
Merano, Italy

Very special black patinated alloys were employed in the western ancient world for exceptionally precious objects. After the fall of the Roman Empire they were lost and forgotten in the West, but they survived in Asia. In Southern China they are known as *wu tong*. The same material is called *shakudō* in Japan, where it is considered characteristic of Japanese metal art. Related patinated alloys of different colours were employed in Roman Egypt and are found in 19th century Japan too. This paper will explore the possibility of and means of technology transfer from Egypt to Asia by examining the appearance, composition, manufacture and characteristics of the various finds, from the earliest to the latest in their historical contexts. Readers can expect a fair amount of technical detail about the composition of alloys, but without this kind of evidence, it is impossible to make the connections.

In the West, for many centuries, and even after the emergence of archaeology as an academic discipline and the re-discovery of the ancient world, nobody knew what these alloys really were. In 1982 Paul Craddock proposed a tentative theory based on the analysis of a small decorative Roman plaque, but only later, in 1993, did technical analysis firmly identify this very special material, known in Latin as *Corinthium aes*, i.e. the Corinthian copper alloy of the Romans, with a composition that is identical to Japanese *shakudō* (Craddock 1982; Craddock and Giumlia-Mair 1993; Giumlia-Mair and Craddock 1993).

The history of this alloy, however, begins in Egypt, at the beginning of the 19th century BCE. The famous daggers from the Mycenaean shaft graves are also decorated with it, but until recently their black decoration was thought to be *niello*, i.e. black metal sulphides with the appearance and the fragility of dark glass (La Niece 1983). However, as demonstrated by scientific analyses, niello was first used in the Black Sea area in the 5th – 4th century BCE (Giumlia-Mair and La Niece 1998). Only later — in the Roman period and until modern times — did it become common and was employed mainly on small decorative objects. The fact that the decoration on the Mycenean daggers is an altogether different material came as a surprise for the world of archaeology. After the fall of the Roman Empire, the black patinated material is mentioned in Syria. There are hints of its existence in Persia, India and Tibet; it is definitely present in China, Korea and Myanmar; and it reaches the peak of its fame in Japan, where it was employed on metalwork until the Meiji period.

Patinated alloys

The materials discussed in this paper are artificially patinated copper-based alloys containing small amounts of precious metals such as gold and silver. They were treated in aqueous solutions, so as to achieve various surface colors. This kind of patina is very stable and compact, it re-grows by itself when damaged — for example if scratched — and mostly shows a beautiful iridescence on the surface, especially when the alloy contains small amounts of arsenic and/or iron. Its production is closely connected with the history and evolution of alchemy.

The most characteristic of these alloys — and by now the best known — is a copper alloy containing around 1% of gold, often combined with 1% of silver and 0.5% of arsenic and/or iron. After the treatment in a solution of copper salts and other ingredients, this alloy acquires a beautiful black-purple or black-blue color, depending on the elements present in the alloy. Objects made of this patinated alloy are always inlaid with precious metals or metals in contrasting colors. In most contexts there are also cheap imitations that do not contain precious metals, but their properties are different. Nevertheless, it is difficult to distinguish the real thing from the imitations without appropriate

Fig. 1 [Color Plate VIII]. Example of Japanese shakudō, *artificially black patinated alloy containing small amounts of gold, treated in a chemical bath to achieve a purple-black or blue-black colour.* Tsuba *belonging to a* daisho *(pair of long and short swords) by Kazutomo, Edo period, 19th century CE. Autumn grass and deer. (Photo by author)*

examinations and analyses. One of the most important properties of Corinthian copper was that when the patina was damaged it regenerated by itself. However, this happens only if gold — for Egyptians the metal and the essence of the gods — is present in the alloy. The experiments performed on laboratory samples of this material demonstrated that just handling them with bare hands enhances their beauty and promotes

Fig. 2. Examples of Chinese wu tong *from Yunnan, now in the British Museum (Inv. № OA 1992. 11/9. 1-6). Wu tong is the Chinese equivalent of* shakudō. *The boxes for ink stones were produced at the end of the 19th century CE. (Photo by T. Milton, British Museum, from Giumlia-Mair and Craddock 1993, Fig. 25)*

Fig. 3. Sentoku *is a Japanese patinated copper-based alloy with Sn and Zn that can have various colour nuances between yellow and brown.* Tsuba *by Kanshiro, Edo period, 17th century CE, National Museum Tokyo. (Photo by author)*

a fast re-growth of the patina (Giumlia-Mair and Lehr 2003).

The purple-black colour — purple was the colour of kings and gods — the bluish iridescence, the mysterious recipes of the production process, the use of precious metals and the strange regeneration property imparted to these objects a magical aura. They were employed in rituals and ceremonies in temples and palaces of kings.

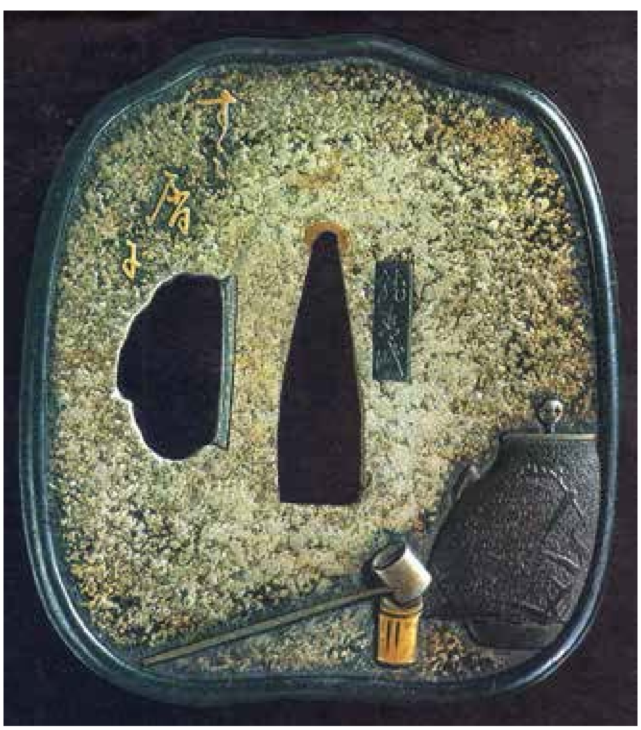
The best known of this family of black patinated alloys in Asia is found in modern Japan under the name of *shakudō* (赤銅) [Fig. 1], and its Chinese counterpart is called *wu tong* [Fig. 2] (Giumlia-Mair and Craddock 1993, pp. 40-45, Figs. 25-28). In other Asian countries there are more patinated and inlaid alloys similar to these, for instance the material that in Korea is allegedly called *ah dong* or *oh dong*, (Giumlia-Mair 2002) and a much later alloy, found in Mianmar, called *mylar* (van Bellegem et al. 2007), certainly derived from the Chinese *wu tong*. Very recently, not only black, but some artificially patinated alloys in different colors, such as for example red, yellow and orange, similar to other modern Japanese alloys, *sentoku* and *suaka*, were identified on Western objects dated to Roman times (Giumlia-Mair 2014; 2015; Giumlia-Mair and Mrav 2014). *Sentoku* (宣徳) [Fig. 3] is an artificially patinated Japanese copper-based alloy, containing tin and zinc that can acquire various colour nuances

Fig. 4. Suaka *or* Akagane *is an artificially red/orange patinated alloy, containing 1-2% of zinc and/or lead. Modern architectural fitting, Morimoto Kazari, Kyoto. (Photo by author)*

between yellow and brown. *Suaka* (素銅) (or *akagane* 赤金) [Fig. 4] is also artificially patinated and contains 1-2% of zinc and/or lead. It is characterized by an orange-red colour that can vary from light orange to dark red, depending on the composition.

A further, very appreciated, patinated Japanese alloy is *shibuichi* (四分一) [Fig. 5]. The name comes from its best known composition: copper alloyed with 25% of silver. In Japanese “shi bu ichi” means “one quarter.” This is a greyish-beige patinated alloy, but there are also *shibuichi* alloys (consisting of copper and silver) with colours that range from dark olive green to greyish. A very attractive variety of *shibuichi* is called *obore shirogane* and it is characterized by a distinctive very light and pale colour. Its very poetic and descriptive name means “white metal with the colour of the veiled moon.” All these alloys are either used as inlays or are themselves inlaid with other metals or other patinated alloys.

Fig. 5. Example of shibuichi. Tsuba *made of grey-beige* shibuichi, shakudō, *silver and gold. Seimin, 1769-1838. Genova, Museo d'Arte Orientale E. Chiossone. (Photo by A. De Luca, Rome, from* FMR *90 [1992], p.123)*



Early examples of *ḥmty km*

The name of the artificially black patinated alloy in ancient Egyptian is *ḥmty km* (pronunciation hemty kem), and it means “black copper” (Giumlia-Mair and Quirke 1997). The earliest patinated alloys containing gold and silver were produced for the pharaoh and the temples of the Egyptian gods in the mystical environment of the workshops attached to the temple of Ptah in Memphis in the course of the 19th century BCE. Some archaeological publications suggested that black patinated, inlaid objects were first employed around the middle of the 2nd millennium BCE, and that they came from the Near East (for instance Cooney 1966; 1968; Hood 1978, pp. 178-81; Laffineur 1990-91). However, apparently only two of the objects from the small group of patinated and inlaid finds from the Near East, Syria and Mesopotamia were analysed (Schaeffer 1939, pp. 107-13). Neither contains precious metals and thus may have served as inspiration, but do not seem to be direct predecessors of the Egyptian *shakudō*-type alloys.

The earliest scientifically identified objects made of this material are dated to the Middle Kingdom (19th century BCE) and appeared in Egypt at the time of the 12th Dynasty (Giumlia-Mair 1996; 1997). These are the well-known crocodile statuette, representing the Egyptian crocodile god Sobek (Ägyptische Sammlung, Munich, Inv. № ÄS 6080), and the statuette of the pharaoh Amenemhat III, (Ortiz Collection, Geneva, Ortiz 1994, № 37).

The crocodile statuette [Fig. 6] is ca. 20 cm long and is intricately inlaid with gold wires depicting the scale pattern of the body and the features of the god. The inlays are made of *electrum*, the gold-silver alloy

Fig. 6. Egyptian crocodile god Sobek made of ḥmty km, *inlaid with* electrum, *found at el Fayum. Ägyptische Sammlung Munich, Inv. № ÄS 6080. (Photo by author)*

Fig. 7. *Statuette of pharaoh Amenemhat III, found together with the crocodile of Fig. 6 in el Fayum, now in the collection Ortiz in Geneva. H.: 26.3 cm. This portrait is the largest object made of* ḥmty km *identified up to now. The head cloth was made of gold, the loincloth was probably of silver rich* electrum. *(Photo by author)*

widely used in Egypt for precious objects. The copper-based alloy employed for the body, analysed by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), has the following composition: 86.5% Cu; 3.00% Sn; 0.74% Pb; 0.03% Zn; 0.44% Fe; 0.41% Ni; 1.51% Au; 0.92% Ag; 1.54% As (Giumlia-Mair 1996; 1997).[1] The X-ray Diffraction (XRD) analysis of a small sample of the black surface layer showed that the patina consists of cuprite with some metallic gold.

The superb statuette [Fig. 7], allegedly found at El Fayum in the same hoard with the crocodile and other pieces, faithfully reproduces the features of Pharaoh Amenemhat III (1842–1794 BCE), as they are known from the many portraits of the king. He was originally wearing a loincloth made of silver, as the remains of a sheet in the thin groove under the navel suggest. On the temples there are still some remains of the hanging gold sheet representing the head cloth of the pharaoh that originally was fixed with tiny rivets on the breast, over the nipples and in the middle of the back, where small holes are still recognizable. The very shiny purple-black patina is still perfect and slightly iridescent, except on the area of the body that was covered by the loincloth and had not been polished. The results of the ICP analysis are: 86.6% Cu; 1.3% Sn; 0.7% Pb; 0.2% Zn; 0.5% Fe; 0.3% Ni; 2.9% Au; 1.1% Ag; 0.038% Co; 0.80% As. The XRD analysis of the patina revealed cuprite and some metallic copper. The low amount of tin present in the alloy of both statuettes is sufficient to confer better working and casting properties to the metal, but before patination the alloy still has a coppery-red color. Gold, silver and arsenic are present in considerable amounts, and they compare well with the percentages determined in the early examples of Japanese *shakudō* alloys (Oguchi 1983; Harris 1993; Notis 1988; La Niece 1991).

From the early period, only one more object decorated with *ḥmty km* from outside of Egypt was analysed. This is the scimitar (or *khepesh*) from Balata Sichem [Fig. 8], near Nablus in Palestine (Ägyptische Sammlung, Munich, Inv. № ÄS 2907). Atomic Absorption Spectroscopy (AAS) analysis of the scimitar from Balata Sichem carried out on the actual sword showed that the metal is bronze containing 11.9% of tin, 0.7% of arsenic and only traces of other elements. The blade of the scimitar could be hardened by hammering and is an efficient weapon. The black inlay is copper containing 2.97% Sn, 0.56% Pb, 0.5% Fe, 0.5% Au, 0.2% Ag, 3.1% As, and other elements at trace level (Giumlia-Mair and Quirke 1997).

The largest example of *ḥmty km* identified up to now is the massive portrait of Amenemhat III (H.: 26.5 cm). All other objects and statuettes identified up to now are either much smaller and lighter or are made of common bronze and only inlaid with sheets or wire details made of *ḥmty km.* The analyses carried out up to now on later Egyptian examples of black copper showed that the gold content or in general, all alloying components, are lower than in the earlier objects. The real evolution in the use of the black patinated alloys seems to be the fact that the artisans managed to use less precious metals and nevertheless to achieve a black, stable and iridescent patina on their objects. This continues in the later production and in other contexts.

Some of the hieroglyphic texts seem to suggest that there were imitations and fakes of *ḥmty km* in circulation

Fig. 8 [Color Pate VIII]. Khepesh *from Balata Sichem, detail of the lotus flower. Ägyptische Sammlung Munich, Inv. № ÄS 2907. This important piece demonstrates that* ḥmty km *circulated in regions under Egyptian influence. (Photo by author)*

Fig. 9. Inlaid, head- and armless statuette in the Louvre, Inv. № E27430, stylistically dated to 1075–664 BCE or 1994–1650 BCE, representing a woman wearing a gold embroidered clinging dress. The material is only an imitation of ḥmty km. *(Photo by author)*

(Giumlia-Mair and Quirke 1997). This demonstrates that only a few artisans were able to produce this fascinating material, and that there were artisans who tried to imitate it without much success. Cheaper fakes on which pitch or other black mixtures and resins were applied to imitate the black patina are relatively common, and much easier to spot than patinated imitation alloys. A good example for an imitation of patination on a different alloy, difficult to recognize without analyses, is an inlaid head- and armless female statuette [Fig. 9] of uncertain date (Louvre, Inv. № E27430) (Giumlia-Mair 2002, p. 320, Fig. 2), that contains only 2% As and 5% each Sn and Pb (Mathis, 2011, p. 130).

The number of analysed pieces made of real *ḥmty km,* a rare and precious material, is very low: up to now only around 14 pieces of "real" *ḥmty km* have been scientifically identified, while 7 more pieces were found to be ancient imitations (Giumlia-Mair and Craddock 1993; Craddock and Giumlia-Mair 1993; Delange 2007; Mathis 2011). Therefore, any hypothesis on the development or the evolution of these alloys in the course of an entire millennium would be based on a far too small number of observations to be of any value or significance. Nevertheless, in the late periods there seems to be a more evident decrease of precious metals in the analysed black patinated pieces, and this also is true for the examples found in Mycenaean contexts.

Black copper in the Mycenaean area.

Some of the most famous and precious Mycenaean objects are made of artificially black patinated alloys. However, at the time of the discovery of the daggers from the Shaft Graves in Mycenae many decades ago (Evans 1929), the black patinated inlays were interpreted as early examples of *niello* (Laffineur 1974). *Niello* consists of black metal sulphides of various composition inserted hot in molten or semi-molten status in a keying on the surface. At that time *niello* was the only black material known to be applied on metals. The earliest scientifically identified examples of *niello* are dated much later, to the 4th century BCE, and are found in Bulgaria and on the north coast of Asia Minor, i.e. in the Black Sea area (Giumlia-Mair and La Niece 1998). Believing that the black patinated inlay was *niello*, analysts of some of the objects — e.g., the crocodile from el Fayum — thought they had detected some sulphur (Müller 1987) when in fact there was none, as later, more precise analyses demonstrated (Giumlia-Mair 1996).

The connections between Egypt and the Minoan and Mycenaean world had begun early and are manifold (see for instance Hankey 1981; Davies and Schofield 1995; Kelder 2009; 2010 etc.). The Minoan paintings at Avaris are only the most visible sign of a Minoan presence in Egypt (see, e.g., Bietak 1992, 1995; 2006; 2008; Schneider 2008; 2010). In Crete and mainland Greece are innumerable traces of strong Egyptian influence (see, e.g., Helck 1979; Kelder 2009; Giumlia-Mair 2011, Cline 1998; Giumlia-Mair and Soles 2013, etc.). Possibly the artisans who produced the Mycenaean daggers and other black decorated items were Egyptians or at least artisans who had learnt their craft in Egyptian workshops and made luxury weapons and other objects for Mycenaean warriors and notables (Cline 2013). The motifs on the Mycenaean daggers are clearly Egyptian.

The Mycenaean daggers from the Shaft Graves in Mycenae, and from other Mycenaean contexts, show generally a central black patinated panel, inlaid with gold and silver, and applied as inlay on the actual bronze blade [Fig. 10]. The first to be analysed was the

Fig. 10. Mycenaean dagger, private collection. The black patinated midrib contains Au, Ag and As, and is inlaid with gold and silver figures of dead enemies laying between rocks. In the Mycenaean world this material was called kuwano. *(Photo by author)*

dagger belonging to a private collection. Ogden (1993) found that the blade of the dagger was bronze, but the black inlaid panel contained 93% Cu, 5% Sn, 1.7% Au, 0.53% Ag and 0.5% As. Subsequent analyses on other Mycenaean pieces and fragments all demonstrated that their patination had been carried out on alloys containing small amounts of precious metals that acquire a dark nuance when treated in weak aqueous solutions. In a more recent analysis of the same dagger, this author used X-ray Fluorescence Spectrometry (XRF) to check the composition of the inlays and to study the patina growth. The results generally confirmed Ogden's data (Giumlia-Mair 2013). The blade is made of bronze with ca. 13% Sn and traces of As and Fe. The black inlays are copper containing around 5% Sn; 2.5% Au; 0.5% Ag, 0.5% Fe and traces of As. The gold inlays contain around 11% Ag, 3% Cu, while the "silvery" inlays are electrum, the gold-silver alloy, and contain silver with 16% Au and 3% Cu. Two tiny samples of black and green patina were taken from the dagger for XRD analysis. The black patina is cuprite with some metallic Au and small amounts of paratacamite, a copper chloride. The green patina on the blade is malachite, i.e. copper carbonate.

A further important object dated to this period and belonging to a Mycenaean context is a cup [Fig. 11], discovered in the 1940s during the French excavations at Enkomi on Cyprus (Archaeological Museum of Cyprus, Nicosia, Inv. № 4207) (Schaeffer 1952, pp. 379-86; Figs. 116-22, Pl. CXVI). It is dated to the period between Late Helladic II and the beginning of Late Helladic IIIA, i.e., shortly after 1425 BCE, and its Aegaean and Mycenaean characteristics and style are very clear. Made of silver, the cup is decorated with the black patinated alloy and gold. The silver of the cup contains 9.5% Cu and around 4% Au, while the gold of the inlays contains around 3% Cu and 8% Ag. The black inlays are made of copper containing around 6% Au, 2% Ag; 0.3% As and 0.4% Fe (Giumlia-Mair 2012).

Fig. 11. Silver cup from Enkomi, Cyprus, now in the National Archaeological Museum, Nicosia, Inv. № 4207. The cup is decorated with black and gold bull heads, lotus flowers, rosettes, arches and dots. The black material is kuwano. *(Photo by author)*

Cups in the National Archaeological Museum in Athens were non-destructively examined by XRF, which demonstrated that some gold and silver were present in the inlays. A more precise analysis by AAS of a small fragment of black inlay from one of the silver cups gave following results: 53.3% Cu, 8.73% Au, 2.83% Ag, 2.42% Sn, 0.27% Fe, 0.03% Ni; 0.02% Zn, 0.22% As, 0.33% Sb, and no detectable Co and Pb (Demakopoulou et al. 1995). There can be no doubt that the black decorated Mycenaean objects are made of black copper.

Black copper in Classical Greece

Literary sources demonstrate that in Mycenaean times the name of this material was *kuwano* (Giumlia-Mair 1995; 1997). In Classical times and later the word *kyanos* that derives directly from the Mycenaean *kuwano,* seems to indicate a patination treatment and not the material, but there are several passages in Classical Greek texts that use the terms "Corinthian copper," "Corinthian works," and "Corinthian ware" to indicate a patinated and inlaid material; the same terms are employed in Latin in Roman times.

Why this material was called "Corinthian" can only be hypothesised, as none of the Greek and Latin authors that use this term explain the origin of the name. The most probable explanation is that in Corinth there were one or more specialised workshops that produced objects made of black copper. The excavations in the metal artisan quarters of Corinth uncovered the remains of a basin, fed by the fountain of Peirene, as described by Pausanias (Geographia, 2, 3, 3).[2] He stated that "Corinthian copper was dipped, when red-hot, into the water of the spring Peirene." "Dipped" is the translation of the Greek verb *bapto* that means to dip, but also to colour, to dye, and it is the term used by the Alexandrian alchemists, when they colour metals by dipping them into acids or other solutions.

Up to now no ascertained examples of black copper from Classical Greece have been identified, but the name of the material in Roman times and the literary sources leave no doubt that in Classical times and later there was a continuity in the production of the black patinated alloys inlaid with precious metals.

***Corinthium aes*, the Roman black copper**

Corinthian copper seems to have been in great fashion in the first century BCE, either when in 146 BCE Greece became a province of the Romans and Greek works of art were brought to Rome or, perhaps, when queen Cleopatra followed Caesar to Rome with her exotic court in 46 BCE. In the same period, Egyptian gods and cults begun to spread first in Rome and then in all corners of the empire.

In the Latin literature of the imperial period many passages mention precious Corinthian ware, in particular vessels, statuettes and similar ornamental items (cf. Mau 1901; Murphy-O'Connor 1983). Collectors paid enormous sums to obtain them, and did not hesitate to use less than honest ways to satisfy their passion for these objects, as many ancient sources testify (Seneca, *Brev. Vit., 12,2*; Propertius, *3, 5, 3;* Suetonius, *Aug., 70, 2;* Pliny the Elder, *Nat. Hist., 34, 6*). The recipes for the production of the precious alloys were a jealously kept secret, and even in Roman times not many workshops were able to produce them. As in Egypt, imitations and fakes existed in the Roman empire (Pliny the Younger, *Epist., 3, 6, 3*; Pliny the Elder, *Nat. Hist., 34, 6*; Martial, *Epig., IX, 59, 11*), and black inlaid materials produced without precious metals were apparently sold as "real" Corinthian ware. Some of these "fakes" have been identified. Two are still unpublished Roman medical instruments that might belong to sets, made of common bronze, but inlaid with silver and black wires. The black details do not contain gold, but only some arsenic and traces of iron. The analysed examples were found one in the Roman town Aquileia, in Northern Italy, and the second in Cologne, Germany, the ancient Roman *Colonia Claudia Ara Agrippiniensium.*

Evolution in the patination techniques

In the course of the 1st century BCE – 1st century CE an important evolution can be noted in the production technique of this material: in this period luxury objects with more complex patinations in several colours appear for the first time. Polichromy is achieved not as it was done before, just by combining bronze with the black patinated alloys and gold and silver, but by using new alloys, patinated in red, orange and yellow. It is important to emphasize that the most impressive objects made of patinated alloys are mostly somehow connected to Egypt or at least with North Africa, and it is very likely that they were produced by Alexandrian artisans or workshops. Nevertheless, it is also possible that some Alexandrian artisans moved to Rome and other centres, and supplied rich Romans with the luxury objects they so passionately craved.

Two magnificent examples of patinated objects that can be connected to the Alexandrian school are the vessels found in the 19th century at Egyed in Hungary (Giumlia-Mair and Mrav 2014). They are a jug and a skillet [Fig. 12], both black patinated and inlaid with precious metals. They must have originally belonged to the inventory of a nearby sanctuary, built for the cult of Isis or in general for Egyptian deities. Regrettably, their owner, Count Festetics, wanting to know if they were of precious metal, gave them to a local goldsmith who poured on the vessels various acids, among them also *aqua regia*, and badly damaged the silver inlays and the patina. Nevertheless, the beauty and the intricate inlays of the vessels are still recognisable. The body of the skillet is a copper-based alloy with a gold content of around 2%, 0,5% Ag, around 0,5% As, and small amounts of iron. The gold coloured inlays are made of a gold alloy containing 3,5 % Ag and 2% Cu. The silvery inlay is of a relatively good silver alloy containing around 16% Cu, but also around 3% As. The silvery colour in this kind of alloy results from the pink of the high copper content being counterbalanced by the presence of arsenic that confers a silvery colour to copper. A third kind of inlay of a dark crimson red colour, made of copper containing low traces of lead and arsenic, was used to depict some of the details of the various flowers in the scrolls. The alloy employed for the jug is slightly different from that of the

Fig. 12. The Corinthium aes *vessels from Egyed, National Museum Budapest (Magyar Nemzeti Múzeum), Inv. №№ RR 10/1951.104 and RR 10/1951.105. The artificially patinated body of both is inlaid with alchemistic alloys, containing arsenic and other metals, described by Alexandrian alchemists. (Courtesy of the Hungarian National Museum, photo by András Dabasi. From Giumlia-Mair and Mrav 2015)*

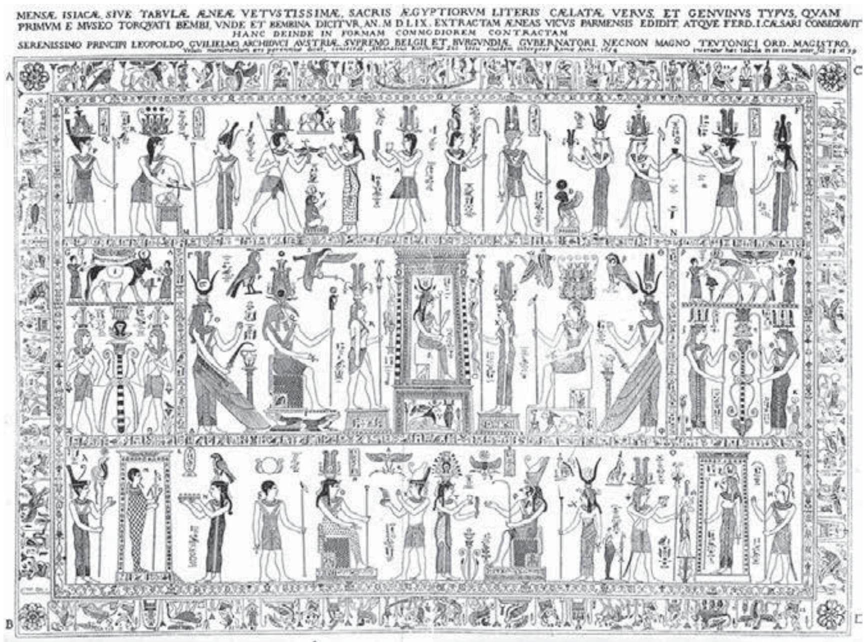


Fig. 13. The Mensa Isiaca (74 x 123 x 7 cm), in the Museo Egizio in Turin, was allegedly found in Rome. It is an altar top decorated with complex and colourful inlays in seven different colours. The German Renaissance scholar Athanasius Kircher had this drawing, showing all details of the inlays, done for Leopold Wilhelm Archduke of Austria.(drawing from Leospo 1978)

skillet: it contains around 1.5% Au, but also 2% Sn and very low traces of Pb. The silvery inlays are made of a silver alloy with around 14% Cu and with a noticeable amount of 2,5-3% As. The gold inlays are mainly Au, with around 6% Ag and 2 % Cu.

The presence of small amounts of gold in the black patinated vessels indicates that these are "real" Corinthian ware and not an imitation, while the presence of arsenic suggests that the artisans who produced them had a fair knowledge of the special alloys described in the texts of the Alexandrian alchemists (Berthelot 1888/1967, 1893/1967), which were not in the repertoire of "normal" metal workers. This fact, together with the choice of motifs, representing Egyptian deities with their attributes on the jug, and a Nilotic scene with animals, flowers and plants, typical for the Egyptian landscape, on the skillet, seem to indicate that both vessels might have been manufactured by Romano-Egyptian artisans or, at least, by artisans who learnt their skills in the famous workshops of Alexandria in Egypt.

Another object that shows similar characteristics is the Mensa Isiaca [Fig. 13], an altar table top (74 x 123 x 7 cm; Museo Egizio, Turin, Leospo 1978), allegedly found in Rome, and recently analysed (Giumlia-Mair 2014; 2015). The piece shows characteristics and alloys similar to those of the vessels from Egyed. The main figure in the centre of the altar is the goddess Isis, but the table is inlaid with a large number of spectacular multicoloured figures of various Egyptian gods, the pharaoh and his wife performing various rituals, and animals and objects belonging to Egyptian mythology and iconography [Fig. 14]. The way they are depicted with finely worked inlays closely resembles the figures of Egyptian gods on the vessels from Egyed. The alloys employed for the inlays are artificially patinated in various colours, such as black with different shades of iridescence, red, orange and yellow. The composition of the black and the red patinated alloys is very similar to the ones identified on the vessels from Egyed, while the silvery inlays are complex alloys of various composition, but containing 2% of arsenic, as in the case of the silvery inlays on the vessels from Egyed. The golden inlays are made of copper containing around 12% of tin and silver, and 5-6% of gold. Some of the golden details also contain around 2-3% of arsenic. The figures are strikingly similar to the figures on the jug from Egyed in clothing and headgear. The sixteen crowns on the shoulder of the jug are identical to some of the crowns worn by the figures on the Mensa Isiaca, and many of the garments and attributes of the

Fig. 14. Detail of the Mensa Isiaca. The pharaoh is offering a bird to a goddess sitting on a throne and wearing a red dress decorated with silvery stars. The black, red, yellow and orange inlays of the Mensa Isiaca are artificially patinated The body of female figures is made of a yellow patinated alloy never encountered before: Cu containing 12% of Sn and Ar, 5-6% of Au and ca. 2% of As, a typical Alexandrian alchemistic alloy. (Photo by author)

figures can be found on both objects, represented in an identical way. The obvious difference is that the figures on the jug are simply depicted with gold wire, while the figures on the altar table are larger, and intricately inlaid in various colours by using sheet inlays, often themselves completely covered with the finest inlays made of multicoloured wires, but their similarity is surprising.

The Mensa Isiaca was allegedly found in Rome, but it might have been produced in an Egyptian workshop or by Alexandrians who worked in Rome as specialised metalworkers. The vessels from Egyed and the magnificent altar top were perhaps produced by different artisans or at slightly different times, but certainly in the same workshop, and by artists who were definitely using the same figure templates.

The yellow and orange alloys contain zinc; therefore, they could not have been produced before Roman imperial times, when the first brasses came into circulation. The very first brass coins are known from Asia Minor and were issued by King Mithridates (135–63 BCE), but in the Roman world the first issues were those of Caesar in Macedonia in 44 BCE (Bahrfeldt 1905, p. 42; 1909, pp. 78-84; Istenič and Šmit 2007). As soon as the coins arrived to Egypt the alchemists begun to experiment with the previously unknown gold-colored alloy and managed to produce new patinated alloys.

Other red patinated inlays are known from Roman objects, for instance appliqués (Museo Archeologico, Naples, Inv. №№ E812 and E1118) and a vessel (Inv. № E2541) from Herculaneum. A Roman *strigilis* (i.e. a tool for cleaning the skin) from the Roman town Sicca Veneria in Tunisia (Louvre, Inv. №. BR1582) has an orange patination. The object is copper containing 19% of zinc and traces of iron and arsenic; its composition is very similar to that of the orange inlays on the Mensa Isiaca, containing up to 20% of zinc and traces of iron (Mathis et al. 2005). The pale yellow patinated alloys of the Mensa Isiaca, employed for the body of female figures, gods such as Ptah, the personification of rivers and some more details, were never encountered before. They are made of brass, containing small amounts of tin, silver and arsenical copper. The gold-colored alloys of the Mensa consist of copper containing 12% Sn, around 12% Ag, 5-6% Au and around 2% As. The silvery colored parts can have different compositions: many contain some gold (1-2% Au), in these cases the silver content is around 50%, with variable amounts of tin and arsenic. The silvery alloys of lesser quality are copper containing up to 10% Sn, 3% As, and around 3% Ag, while for the central figure of the goddess Isis a better quality alloy (80% Ag, 6% each of Cu and Sn, 2% Au and 2% As) was employed. Recipes for alloys with a composition very similar to those of the Mensa Isiaca and the vessels from Egyed can be found in the texts of the Alexandrian alchemists (Berthelot 1888/1967, 1893/1967) and in the alchemistic texts of the Leyden and Stockholm papyri (Halleux 2002).

After the fall of the Roman Empire this very sophisticated material disappears from the West. Apparently only in remote provinces or even outside of former imperial regions did this knowledge survive for a short while, as suggested by two examples of Anglo-Saxon fittings dated to around the 9th century CE, one from Bawsey, Norfolk, and the second unprovenanced, which seem to have been still decorated with rivets made of a black patinated alloy (Stapleton et al. 1995). Working knowledge of this recipe, would have been possessed by very few craftsmen and probably disappeared in the West, not only because of lack of customers, in the turmoils of Late Antiquity. Nevertheless some texts of the ancient alchemists survived and were brought to the Near East. The ways through which Corinthian copper might have reached China and other Asian countries are numerous and manifold.

Early Greek and Roman contacts with Asia

It is widely believed that the "Silk Road" had been opened in the 1st century BCE from Chang'an (Xi'an) through Kashgar, Merv, Ctesiphon, Palmyra, Damascus, Tyros, Petra and Alexandria, or through Zeugma, Antiochia and the Mediterranean to Rome. Goods from the East traded on these important routes included not only silk, but also ivory, spices, clover, pears, flowers, rhubarb, peaches, almonds and *ferrum sericum* (Chinese cast iron), in exchange for glass, metal objects, artificial precious stones, amber, coral, wool, linen, grapevine, chives, cucumber, figs, safflower (*Carthamus tinctorius*), sesame, walnuts and pomegranate. The silk roads were also a conduit for knowledge and ideas (Needham 1984).

However, some educated Greeks and Romans had travelled east much earlier and wrote about the world beyond the Caucasus. The earliest one we know was the historian Herodotus (5th century BCE), who went to far away Scythia, beyond the Black Sea. He knew about what are today Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, Kyrgyzstan, and possibly Mongolia, and mentions the regions of the Achaemenid empire up to India and Xinjiang. Ctesias from Cnidus was a Greek physician at the court of the Persian king Artaxerses II Memnon (405–398/97 BCE) and wrote several books about Persia and India.

The campaigns of Alexander the Great, which took him into Central Asia and the western borders of India in the 4th century, had significant consequences for east-west interaction, embodied after his death in the

Graeco-Bactrian and Graeco-Indian kingdoms. The geographer Megasthenes was sent by King Seleucus of Syria as ambassador to King Chandragupta Maurya and wrote a book on his travels in which he also described Taprobane (Sri Lanka). The historian Diodorus Siculus (1st century CE) refers the story of Iambulus, who also went from Ethiopia to Taprobane and returned to Greece via Persia (Diod. *2, 4*). After Strabo, the pharaoh Ptolemy Euergetes sent Eudoxus of Cyzicus from Egypt to India, where he had numerous adventures (Giumlia-Mair et al. 2009).

We begin to obtain even more substantial information on routes and exchanges in Roman times. An important work dated to the end of the 1st century BCE and the beginning of the 1st century CE called the Parthian Stations (*Stathmoi Parthikoi*), written by Isidore of Charax, describes the itinerary of the caravans through Parthia, with all the toll stations between Antiochia in Syria to Zeugma on the River Euphrates, to Seleucia, the Caspian Sea, through Turkmenistan, Afghanistan, and Pakistan to *Alexandria Arachoton* (Qandahar). The text was apparently ordered by emperor Augustus, when he was planning the war against Parthia (<http://www.parthia.com/doc/parthian_stations.htm>; Belfiore 2004, App. B, pp. 205-59; Giumlia-Mair et al. 2009).

Some scholars even argue that there were frequent sea travels between Graeco-Egyptian traders from the Red Sea coast to China, and that Romano-Egyptians founded colonies in Guangzhou and Hangzhou in the 3rd century CE (Needham 1984, p. 89). The well-known pilot's book in Greek, the *Periplus of the Erythrean Sea*, dated most probably to the mid-1st century CE, describes in detail the navigation and trade from Roman Egyptian ports along the coast of the Red Sea, the Persian Gulf and the Indian Ocean. If initially the Indian Ocean trade had hugged the northern littoral, once the value of the seasonal changes in the direction of the monsoon winds was understood, it became possible to make more rapid voyages across open water. There is substantial archaeological evidence about Roman trade with India, including deposits of Roman coins, amphorae that must have contained products from the Mediterranean, and more.

Fig. 15. The page representing Central Asia in Ptolemy's Cosmographia in the National Library of Naples shows the place called Turris Lapidea, *Stone Tower in Latin. The name is written around a mountain in a valley to the east of Ferghana. (Photo from Ptolemäus 1990)*

Of particular interest for the early history of the overland "silk routes" is the information contained in geographic notes compiled by Marinos of Tyre (1st–2nd centuries CE), which have come down to us via Claudius Ptolemy's *Geographia* (ca. 150 CE). Ptolemy supplemented Marinos with a good many other sources, some based on accounts of sea travel all the way to Southeast Asia. Marinos' record of the travels of Maes Titianos (Ptolemaeus 1990, I, 17.5), a Syrian merchant whose agents went overland to a place called the "Stone Tower" in Central Asia [Fig. 15], has been exhaustively analyzed (without settling some questions about the details of his route) in the attempt to pinpoint exactly what was the "first Silk Road" and in particular where that Stone Tower was located (P'iankov 2015; Dean 2015, with references). Beginning at Hierapolis on the Euphrates Maes' agents headed in direction of Bactria, stopped there to meet the caravans from India, and then continued to the "international market" of the Stone Tower. There they met merchants coming from China (Seres).

So there are various possibilities as to how knowledge of specific metal technology could have gone from the Mediterranean world (Egypt, or other areas of the Hellenistic and Roman world) to the Far East, as early as the beginning of the Common Era.

Zosimos' recipes

An important alchemistic text can explain how this very special patinated material came to Asia. The alchemist Zosimos from Panopolis in Egypt, then part of the Roman Empire, lived around the end of the 3rd century CE or perhaps a bit earlier; he was so important for ancient alchemy that later alchemistic texts call him "the divine Zosimos." We do not know much about his life, but have an important corpus of his texts and his correspondence with a woman alchemist he calls Theosebeia in which he discusses the principles of alchemy. Regrettably many fragments of his writings survive mostly in fragments, copied into the texts of later alchemists; so it is difficult to attribute them to Zosimos with any certainty. In the main corpus there are no descriptions of artificially patinated alloys, but a significant recipe for the production of black patinated alloys survives in one of the later copies of his work (Cambridge University Library, MS Mm 6.29) (Berthelot 1893/1967). This is a 15th-century copy of a 10th century CE translation into the medieval Syriac used by Jacobite monks. It is important to note that alchemistic texts were always faithfully copied in exactly the same way, without leaving out any word, but sometimes adding comments and details on the various processes.

The relevant text states: "To make a thin strip of black metal sheets or Corinthian alloy in the manufacture of images or statues you want to make black. It works the same on statues or trees or birds or fishes or animals or any objects you want. Cyprian copper (i.e. unalloyed copper), one mina, silver, 8 drachmas, gold 8 drachmas...". Then various similar detailed recipes for different kinds of artificially patinated alloys follow. All use the typical vocabulary and the signs and symbols employed by alchemists, such as for example the sun with one ray for gold, or the half moon for silver [Fig. 16]. A further important symbol employed in the manuscript is a circle with an inscribed cross or "heavenly wheel" that has been interpreted as the representation of the four cardinal directions and the alchemical elements combined with the sun and the moon (Burkhardt 1996, p. 71). In this manuscript, this symbol, often erroneously translated as gold, means instead the treated substance that the alchemists called "their" gold: the preparation called the "ferment" or the "seed" of gold, that had special properties. In this case this preparation is the alloy described above (one mina of copper, 8 drachmas of silver, 8 drachmas of gold = 82.6% Cu, 6.9% Ag and 6.9 % Au), a small part of which had to be added to copper to achieve the right composition for patination (Giumlia-Mair 2002, pp. 318-19). 1:10 would be the proportion necessary to obtain the kind of composition of patinated alloys mostly used in Roman times. Besides the recipes for black patinated alloys, the manuscript also gives various other recipes to obtain different colors on copper-based alloys. The most relevant ones in this context are the recipe for "male images" with a red patination and the one for "female images" that "resembles female flesh. It glows whilst it shines." The recipes and the descriptions seem to fit the composition and the look of the inlays of the Mensa Isiaca (Giumlia-Mair 2014).

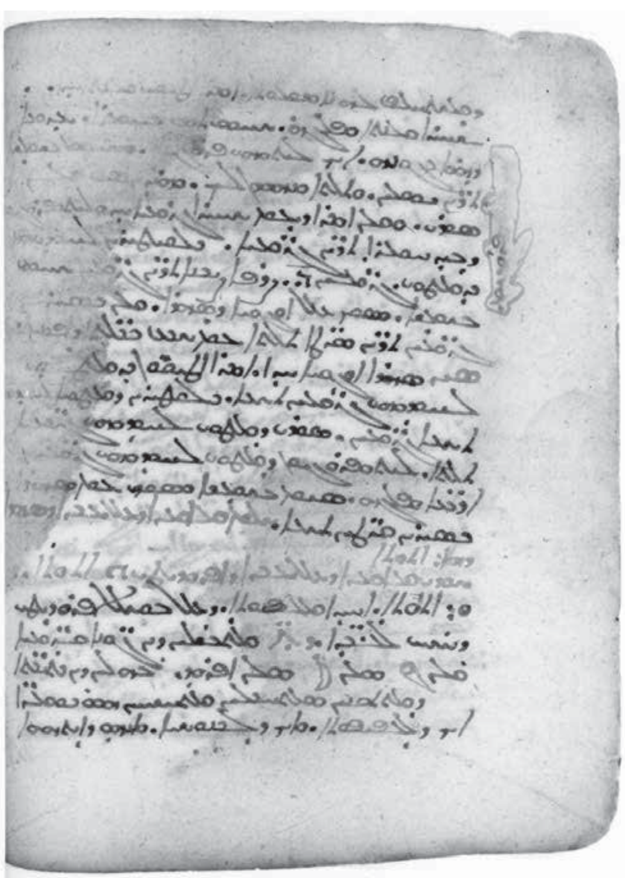


Fig. 16. The Cambridge manuscript Mm 6,29, in the Library of the Cambridge University, a 10th century CE translation into medieval Syriac. The third line from the bottom shows on the right the symbols employed by alchemists: the sun with one ray, i.e. gold, and the half moon, i.e. silver. (Photo Courtesy of E. Hunter)

Alchemists going East

How did Zosimos' recipes arrive in Syria? How were his texts preserved after the fall of the Roman Empire? And how might they then have made it into East Asia? Syria had been a Greek province, deeply influenced by Hellenistic culture, and it played an important role of mediator between the two worlds. It was mainly through this region that Greek and Roman science arrived later in the hands of Islamic scholars.

As the Cambridge manuscript suggests, Syriac Christians must have played an important role in the transmission of the texts. The early spread of Christianity across Asia is connected with the complex history of the Church of the East and a variety of Christian sects. Central to this story is what we commonly (if erroneously) term "Nestorianism," associated with Nestorius, who was for a time the Archbishop of Constantinople in the 5th century before being deposed for allegedly heretical views on the nature of the Trinity, exiled first to Antioch and from there to Panoplis in Egypt, coincidentally also the home town of Zosimos. His followers eventually were forced to seek asylum in Sasanian Persia, where Christianity had earlier spread but also had suffered persecution (Meyerhof 1930; Gottschalk 1965). From the schools of Nisibis, today's Nusaybin in Turkey, and later from Gundeshapur, one of the culturally most important towns in Persia (Khuzestan), they begun their missionary journeys to Asia. Their arrival in China in the 7th century was commemorated in Tang Dynasty Changan (Xi'an) in a very famous stele erected in 781. Its text shows in interesting ways how they attempted to adapt the Christian message to take into account traditional Chinese sensibilities. We can assume that the Syriac clerics had contacts with local scholars, and apparently in particular with Taoist monks (cf. also Wallis Budge 1928).

Another of the Christian sects in the East was the Jacobites, the Monophysites of Syria, who translated the manuscript belonging to the Cambridge library. Declared heretics in 518, fifty Monophysite bishops were excommunicated at the Synod of Constantinople. They sought refuge in Syria where they founded schools in Qennešrē, in Syria, and in Rēš ʻAinā in Mesopotamia. In their academies they translated a large number of alchemistic texts into Syriac (Sherwood Taylor 1953, p. 71), their religious and ecclesiastical language. Alchemy belonged at the time to science, just like mathematics, geography, astronomy and medicine, and was part of the teaching in the academies. The most important personality among Jacobite scholars was the poet and commentator Jacob of Edessa, who translated many Greek works and died in 708 AD. Jacobites were sent very early as missionaries to Yarkand, in Xinjiang (Roux 1997, p. 217), and from there they seem to have come into contact with Chinese scholars too, in particular Taoist monks.

There were as well rather early contacts and exchanges between Islamic alchemy and the Chinese "art of yellow and white," as alchemy was called in China, referring to the transformation of base metals into gold and silver. For example, the idea of a life elixir that had much earlier been known and developed in China appeared in the 9th century CE in the Islamic texts too (Sherwood Taylor 1953, pp. 71-75).

Alchemy had come from the schools of the Christian East into the Islamic world. In the Arabic texts the names of the early alchemists are quoted with great respect, and the writings were literally translated, trying to keep the original text without changing its structure and meaning. In the Arabic texts the technical terms derive from the Greek words, mixed together with some Persian and even Assyrian ones, taken from the writings of the ancient Sabians from Harran (Holmyard 1957, pp. 66-68). The work of Zosimos had a great influence n the Arabic alchemistic tradition. He was known as Zusimus, Risamus, Rusim, Arsimun and other variations of his name, and his texts circulated among scholars and were also translated into Arabic (El Khadem 1996).

Such evidence is, of course, fragmentary and leaves open the question of precisely what the routes and chronology of transmission of the knowledge of patinated alloys may have been. That there was such knowledge in many countries of Asia and at different dates is certain though, as the following discussion will demonstrate.

India and Tibet

A material called *jambunada,* a kind of native metal from the Himalayas is mentioned in the *Ramayana*, the Indian epic poem dated to the 4th century BCE, but reflecting older traditions. In this epos the material *jambunada* (or *jambunada suvarna*, i.e. "the gold of the Jambu river") is considered a precious kind of gold with the purplish colour of a plum, and it is used to pay the priests performing the important horse ceremony, the Ashvamedha of Vedic tradition (Tod 1892/1978, p. 66). The Greek sophist Philostratos wrote a "Life of Apollonios of Tyana" in the 3rd century CE. Apollonios was a wandering philosopher from Cappadocia, in Asia Minor who allegedly lived in Asia Minor and Greece, but traveled to many countries and up to India. Here he noticed "black copper coins" (perhaps *jambunada*?), and in a temple at Taxila saw copper-based tablets representing the life and deeds of Alexander and Poros (a mythological hero), on which the figures were made of brass, silver, gold and black copper, and the weapons of iron (Philostratos, *Apoll., 2,7;20*).

In India there is also an alchemistic, or magic, alloy called *asta dhatu*, consisting, after an ancient tradition, of copper, tin, lead, antimony, zinc, iron gold and silver or, in some texts, of gold, silver, copper, zinc, lead, tin, iron and mercury. This alloy was mentioned by several scholars working on northern Indian bronze statues; however, apparently, no example made of this kind of alloy has yet been scientifically identified (Lo Bue 1981, p. 33).

A possible trace of the earlier existence of a black patinated alloy in India can be found, allegedly since the 15th century, in the Islamic region of Deccan, at Hyderabad and in Bidar (Karnataka), but also in centers such as Murshidabad, Purnia and Lucknow, where *bidri*, a black-patinated and silver inlaid alloy, made of 90-92% of zinc and small amounts of copper and lead still is manufactured today. The objects are cast and must be carefully cleaned of the casting skin before patination, then the cross-hatched keying for the inlays is engraved and finally the object is inlaid with silver [Fig. 17, next page], more rarely with brass or gold. After hammering the inlays and polishing the surface, the items are ready for patination. The traditional method uses the soil taken from around the mud-brick walls of the fort of Bidar (hence the name of *bidri*), which is very rich in various salts, because the walls have been used as a latrine for a long time. In modern times a solution containing one part of potassium nitrate, 4 parts of ammonium

Fig. 17. Small bidri *box from the Indian state of Karnataka, inlaid with silver.* Bidri *consists of 90-92% of Zn and small amounts of Cu and Pb and is patinated in a solution with one part of potassium nitrate, 4 parts of ammonium chloride and one part of sodium chloride. Imported black patinated, inlaid objects of Corinthian type might have suggested the idea for* bidri. *(Photo by author)*

chloride and one part of sodium chloride dissolved in hot water is used for the patination of *bidri* (Stronge 1985, 1993; Craddock 2005; La Niece 2015). The studies carried out by La Niece (2015, p. 188) have shown that the main components of the black patina are simonkolleite ($Zn_5(OH)_8Cl_2$), zincite (ZnO), both normally white, and cuprite (Cu_2O), normally red. The reason for the black color seems to be the patina structure. As it is the case with the Corinthian alloy, it seems that the black *bidri* patina, when damaged, can be restored by holding the object in the hands (La Niece 2015, p. 188). Interestingly, although the material is different from that of the ancient black patinated alloys, the treatment, some properties and the look of *bidri*-ware are very similar to those of copper-based patinated alloys containing gold. This suggests that *bidri* might be a local, cheaper imitation of the ancient *shakudō*-type alloys. The local popular tradition claims that this technique came from Arabia or Persia in the 14th century CE. However, zinc was not used in those areas, and certainly there is no *bidri*. The style of the earliest known objects and their decoration seem however to be Iranian, and this confers some credibility to the local legends and to the hypothesis that black patinated and inlaid objects of Corinthian type coming from Persia (where the Nestorian academy was) might have suggested the idea for *bidri*.

There are several indications of such an alloy in Tibet. In the 10th century CE some texts mention a rather mysterious alloy, produced there at least until the 18th century CE. Padma-Bkar-Po, a Tibetan artist and scholar who lived in the 16th century, wrote about *zi-khym*, an alloy used for inlays on statues. A further name for the same alloy seems to be *dzne-ksim*, described by Jigs-mad-gling-pa (1792–1798) as a dark and very precious alloy of copper, silver and *baitong* (the Chinese copper-nickel-zinc alloy) (Dagyab 1977, Ch. 21; Craddock 1981, p. 25).

As reported by Lo Bue (1981, p. 41), the larger-than-life statue of the Jo-bo of Lhasa, Śakyamuni, perhaps the most famous statue in Tibet representing the young Buddha, allegedly consists of an alloy of gold, silver, zinc, iron and copper, and was reputedly brought to Lhasa by Wen Cheng, the Chinese wife of King Srong-btsan-sgam-po (Songtsen Gampo) in the second quarter of the 7th century CE. This famous statue does not look black or inlaid, and no analytical data on the composition exist. However, from the documentation collected by Tucci (1945), it seems that the original statue was destroyed in 1717 by the Dzungars and that the image now visible in the temple was produced much later.

Black copper in China

In the first millennium CE, Chinese Buddhist sutras contain references to materials called *chi jin* 赤金 (scarlet gold), *zi jin* 紫金 (purple gold) and *zi mo jin* 紫磨金 (purple sheen gold) (Needham 1974, pp. 257–66). They state that these metals were originally found as native metal, i.e., as naturally occurring alloys, but that, after the sources were exhausted, the alloys were produced artificially. The encyclopedia *Liu tie* (六帖, Six Slips) dated around 800 CE mantains that the country Po-Lu (Bolur or Hunza Nagar, southeast of the Pamir, now northern Pakistan) was rich in *zi jin*, and it was suggested that the purple gold may have been *jambunada suvarna*. From the many records it is quite clear that this rather mysterious alloy had been in continuous use for many centuries. Needham tentatively identified *zi mo jin* with *shakudō* (Needham 1974, p. 264).

An alloy that is almost identical to *ḥmty km*, Corinthian copper and *shakudō*, except for the different patination treatment and the way the inlays are produced, was identified by H. Bruce Collier (1940, 1977), a Canadian scientist who worked in Yunnan between the First and the Second World Wars. This is the alloy *wu tong* 乌铜, “black or crow copper,” consisting of copper containing around 1% of gold, and artificially patinated by handling the inlaid objects with perspiring hands. It is important to note the similarity of this process with the repatination suggested for damaged *bidri*-ware. The decoration in contrasting color on the black surface is not a normal inlay, i.e. wire or thin metal sheet hammered into a keying cut on the surface of the black patinated material, but a different method. The motifs were chased or engraved on the surface, then a debased silver alloy of the type employed as a hard solder for silver, with 50-80 % Ag, 15-40% Cu, 4-8% Zn

Fig. 18. Closed shops in the street of Shiping where wu tong *ware was sold. (Photo by author)*

Fig. 19. A narrow street in the village of Yuejiawan, near Shiping. Here the family Yue had a well-known wu tong *workshop. (Photo by author)*

and some Pb, was inserted in the keying. The object was then heated above 820° C, so that the debased silver alloy melted into the keying and could, after cooling, be filed flat to remove the silvery metal in excess and obtain a smooth surface (Craddock 1996). The *wu tong* items are composite objects, with only thin sheets of the artificially patinated copper with 1% of gold — the actual *wu tong* – brazed with the same alloy used for the inlays on thicker sheets of brass, obviously to reduce the amount of the more expensive alloy. Strips of silver (in the better quality pieces), or of cupro-nickel, were used to finish the edges, keep the sheets in place and render the objects more stable.

This material was studied by Mang Zidan 忙子丹 and Han Rubin 韩汝玢 (1989), who personally told the author that the origin of *wu tong* might be as early as the Ming period (1368–1644). In their paper they report the information given in the *Records of Yunnan Province* 1939, stating that especially fine *wu tong* was produced in the town of Shípíng 石屏 in Yunnan [Fig. 18]. The most common objects were vases, boxes and inkwells, decorated with floral motives or writing. The *Record of Shiping Town* 1938 stated that the old production centre was the village of Yuejiawan 岳家湾 [Fig. 19], not far from Shípíng, where polychrome objects were produced. Allegedly since the 17th century, in Yuejiawan there was a well-known workshop, that also took apprentices and instructed them in this particular metalcraft. The name of the village — "The village of the family Yue"— comes from Yue 岳, the name of famous metalworkers and a family of artisans and artists who possessed the secret recipe for the production of this special alloy. Apparently the artisans in this area were not interested in the different nuances that could be obtained by varying the composition of the alloy, but only used copper with 1% of gold, to obtain a deep black color without bluish or purplish shades (Han Rubin, personal communication). Nevertheless, the Chinese Encyclopedic Dictionary 辭源續編 /*Ci yuan xu bian* (Fang et al. 1932) under the entry *wu jin* 乌金, dark gold or crow-gold, states: "Take copper 100 parts and add gold 1 part. Melt to produce a purple-black colour."

The known *wu tong* objects studied by Collier (1940; 1977), Mang and Han (1989), Wayman and Craddock (1993) and van Bellegem et al. 2007 all seem to have been manufactured at the earliest in the 19th century, with the only exception being small box in the collections of the British Museum, roughly dated to the early 18th century and possibly produced for the European market (Wayman and Craddock 1993, p. 133).

The production of *wu tong* seems to have stopped in rather recent times. The last famous artisan, Su Jincheng, begun to work for the family Yue in 1916, and at some point he moved to Kunming where he was active until 1960. In 1994 his grandson still lived in Shípíng and agreed to be interviewed in his house [Fig. 20]. At Kunming there is a workshop called Arts and Crafts Mill, where various differently colored copper-based objects are produced. Here some older frames for photos made of *wu tong* were on display in glass

Fig. 20. The grandson of the last famous wu tong *artisan Su Jincheng, in his home at Shiping, Yunnan, with his own grandson. Su Jincheng begun to work as an apprentice for the family Yue in Yuejiawan, near Shiping in 1916. (Photo by author)*

Fig. 21. Wu tong *frame, on display in the Arts and Crafts Mill, Kunming, with the photograph of a peacock made of "ice copper." (Photo by author)*

cases [Fig. 21], but they were not on sale. Other large pieces made of "ice-copper" or "mottled copper" had some black details, but they seemed to be stained, not inlaid. The items produced in this workshop were also sold in Beijing in various shops selling metalcraft.

From Yunnan, in southwest China, this technique seems to have reached the neighboring areas, for instance in Myanmar, where a very similar material, called *mylar* is found. Regrettably not much information on this material exists, and the known pieces are mostly dated to the beginning of the 20th century. Several boxes, employed as lime containers, were studied by van Bellegem et al. (2007), and these were very similar in manufacture and construction to the *wu tong* boxes. They had various components. The black patinated sheets were soldered on copper, and a silver brazing alloy was used for the inlays. However, a wider range of alloys, brass, copper, cupro-nickel, copper-arsenic, silver and a silver brazing alloy was employed to achieve polychromy effects. In the area of Chieng Mai in Thailand, not far from Myanmar, there is an alloy called *pan ca*, apparently a Hindi word, that is used for black patinated betel boxes and it is said to contain five metals (or alloys): silver, gold, brass, red-copper and red-gold (Craddock et al. 2009, p. 49).

At least since the 17th century in Korea, there are metal objects, mainly of cupro-nickel, inlaid with black copper, itself inlaid with silver and sometimes gold. However, these pieces do not seem to have ever been analysed (Craddock et al. 2009, p. 48). The Korean name of the black patinated copper seems to be *oh dong* or *ah dong* (Giumlia-Mair 2002). Korea seems to have been the *trait d'union* between China and Japan, particularly regarding the transmission of materials and technologies. However, absent any study of the Korean black patinated alloys, it is not possible to say anything about the role Korea may have played in the creation of *shakudō*.

Alchemy in Japan

When and how did alchemy arrive to Japan? Needham (1974, pp. 12-50) lists several cases of alchemical experimentations and concepts, reported in various texts dated to the 5th – 4th century BCE that represent the earliest documentations of attempts chemically to produce gold as a medicine to attain longevity and actual immortality. In short, they document the existence of alchemy in China. Legends say that alchemy was brought to Japan by the scholar, alchemist and magician Xu Fu 徐福 in the 3rd century BCE (Davis and Nakaseko 1937a,b). The Chinese scholar Xu Fu was the court magician of Emperor Qín Shi Huang 秦始皇 (259–210 BCE), who twice sent him off to discover the secret of immortality on the "three supernatural islands" where, "the immortals and the drug which prevents death can be found" on the Penglai 蓬萊 mountain [Fig. 22]. He sailed to the East, but the first time he came back without having found the mountain of the immortals. When the emperor sent him again on the quest for the wonderful drug, he prepared an expedition "with a fleet of decked ships," accompanied by archers, by a large number (varying in the different texts) of young men and women, and many labourers, and

Fig. 22. The Penglai Mountain. Xu Fu was sent by the Qín Emperor Shi Huang Ti (259–210 BCE) to find the supernatural mountain, where the immortals live. Painting by Yuan Jiang. Collection of the Palace Museum. Beijing.. (Photo: <https://upload.wikimedia.org/wikipedia/commons/d/d0/YuanJiang-Penglai_Island.jpg>)

sailed to the Japanese islands, but he never returned to the emperor (Needham 1974, pp. 122-23).

An ancient grave in the city of Shingū 新宮市, situated at the estuary of the Kumano River on the main island of Japan at the easternmost point of the Wakayama Prefecture, is considered one of the places of interest in the Yoshino-Kumano National Park (吉野熊野国立公園). The grave is allegedly that of the alchemist Xu Fu, known in Japan as Jofuku, Jofutsu or Joshi, still venerated today as a sage and wise man. Japanese people pray at his shrine for longevity and happiness. Xu Fu legends are found in many locations in Japan, and also in South Korea and in China. In Japan he is seen as a saintly man who brought knowledge to the country, and apparently he also had many followers who continued to teach his doctrine: next to his grave in Shingu a monument also honours the "seven disciples of Jofuku" and the park is called "Jofuku Memorial Park." Here a memorial festival is held every August. Apparently the Chinese legend of the naval expedition of Xu Fu must contain some grains of truth, if the memory and the beliefs in his science and his teachings survived in Japan for such a long time. However, the earliest mention of this legend in Japan is found in Kitabatake Chikafusa's *Jinnō Shōtōki* (The True Lineage of Emperors of Divine Descent), composed in 1339 (Davis and Nakaseko 1937a, p. 112).

The name *shakudō* is found in the texts of the Nara period (710–784), but up to now no actual objects dated to this time have been identified, and, as the word literally means "red copper," it might refer to an altogether different material. In Japanese, the black-patinated *shakudō* is sometimes called *karasu-kin*, the literal translation of which is "crow-gold" (Morimoto Yasunosuke, personal communication). This name strongly recalls the Chinese appellative *wu jin*, dark gold or crow-gold, described as purple-black alloy in the Chinese Encyclopedic Dictionary (Fang et al. 1932). One of the Japanese varieties is called *murasaki-kin*, which means purple gold, and contains over 10% and up to 25% of gold (Murakami 1993, p. 88).

The earliest examples of *shakudō* employed as decoration are the set of sword fittings (*mitokoromono*) attributed to Goto Yujo (1440–1512), founder of the most famous family of metal artisans Goto, however some scholars suggested that this material had became popular already in the late Kamakura period (1185–1333) (Harris 1993; Craddock et al. 2009, p. 45). The family Goto is said to have possessed and kept secret the recipe for *shakudō* for a long time, until this knowledge slowly spread to other artisan families, and finally, in the Edo period, treatises on this art were compiled (Oguchi 1983, p. 125). As in ancient Egypt and in Roman times, in Japan too there were cheaper imitations made of other alloys that sometimes were also employed as ingredient for cheaper versions of *shakudō*, with only very little gold.

Conclusions

This paper is a much shortened summary of the long and complex story of patinated alloys through three continents and four millennia, one which has omitted many facets of the larger study. Important questions concerning the possible transmission of the Egyptian technology to far away countries are still open and in need of more research. An entire forthcoming mongraph will serve as the basis for research in the Near East, with a particular focus on alchemy as it was known and practiced in the academies from which it then spread farther into Asia. The role of Persia still has to be investigated, and Chinese predecessors of *wu tong* are still to be recognized in museums and among finds from excavations. The reconstruction of the story of *wu tong* and its related alloys is important, and can illustrate the fundamental role of China in the diffusion of ideas and the transmission of technologies in Asia. The connection of this material with the world of alchemy is indisputable. In all probability, its history begun in the workshops attached to the temple of Ptah, under the control of the high priests and the pharaoh. The experiments that led to this discovery were certainly related to the imitation of gold or to the attempt at producing gold out of base metals.

For the moment there is no direct evidence of technology diffusion in the case of these special alloys, and it will certainly be difficult to prove or disprove this fascinating hypothesis. Nevertheless, the probability seems rather small that such an unusual alloy, which looks like unalloyed copper before patination, and needs a long surface treatment and a complex chemical process to be transformed in a beautifully colored metal, might have developed more than once in different places around the world.

About the author

Dr. Alessandra Giumlía-Mair was Professor by contract in Archaeometallurgy and Archaeometry at the Universities of Salzburg (Austria), Trieste and Udine (Italy), has lectured widely at many other academic institutions, and participated in international projects on objects and collections of major museums in Europe and the United States. She is Vice-President of the Standing Committee of the Bronze Congress, and Member of the Standing Committees of the International Conferences "Archaeometallurgy in Europe" and "Beginnings of the Use of Metals and Alloys (BUMA)" on Asian metallurgy. In 2000 she founded a laboratory "AGM Archeoanalisi," specializing in archaeometry analyses. E-mail: <giumlia@yahoo.it>.

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Notes

1. Cu = copper; Sn = tin; Pb = lead; Zn =zinc; Fe = iron; Ni = nickel; Au = gold; Ag = silver; As = arsenic; Sb = antimony.

Explanations of the analytical techniques referred to in this article may be found as follows:

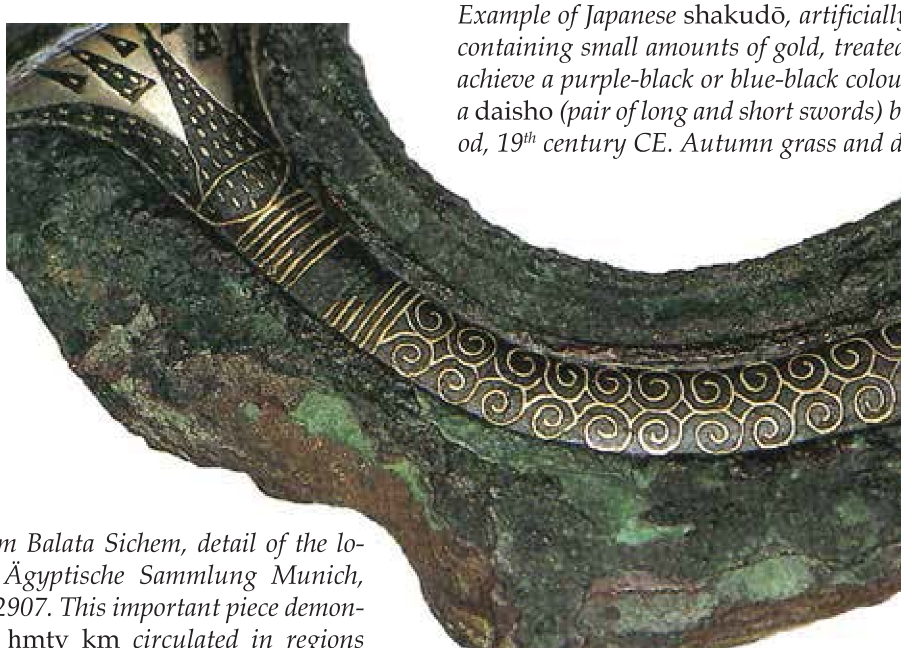
- **Inductively coupled plasma atomic emission spectrometry (ICP-AES)** <https://en.wikipedia.org/wiki/Inductively_coupled_plasma_atomic_emission_spectroscopy>;
- **X-ray crystallography (X-ray diffraction or XRD)** <http://encyclopedia.thefreedictionary.com/x-ray+diffraction>;
- **Atomic absorption spectroscopy (AAS)** <http://encyclopedia.thefreedictionary.com/Atomic+Absorption+Spectroscopy>;
- **X-ray fluorescence (XRF)** <http://encyclopedia.thefreedictionary.com/X-Ray+Fluorescence>.

2. The texts of Pausanias and of the other Classical authors may be found in the "Perseus Digital Library <http://www.perseus.tufts.edu/hopper/>, some including English translations. They will not be listed individually in the references to this article.

Plate VIII

Giumlia-Mair, "Technology Transfer," pp. 127, 129.

Example of Japanese shakudō, *artificially black patinated alloy containing small amounts of gold, treated in a chemical bath to achieve a purple-black or blue-black colour.* Tsuba *belonging to a* daisho *(pair of long and short swords) by Kazutomo, Edo period, 19th century CE. Autumn grass and deer. (Photo by author)*



Khepesh from Balata Sichem, detail of the lotus flower. Ägyptische Sammlung Munich, Inv. № ÄS 2907. This important piece demonstrates that ḥmty km *circulated in regions under Egyptian influence. (Photo by author)*