Studies on Gandhara Mirrors: The Specimen from Shaikhan Dheri

Pranab K. Chattopadhyay and Zakirullah Jan

Abstract

Shaikhan Dheri, the ancient Pushkalavati (modern Charsadda), one of the earliest cities of ancient Gandhara, was excavated by A. H. Dani, who along with other important cultural artifacts, discovered a metal mirror, in typical Gandhara style, highlighting skillful metallurgical art of the time. This paper highlights the initiation of mirrors at Anatolia from ore-minerals which later on transformed into metal in due course of time. The earliest evidence of metal is known from Mehrgarh, Baluchistan from its Neolithic context. There is every possibility for the beginning of mirror from that site or region. Introduction of mirrors in South Asia originated in Harappan sites most likely from South Baluchistan. From Harappan sites of Pakistan and India the use of mirror was popularized in mature Harappan Phase, (2600-1900 BCE).

Keywords: Gandhara mirrors, Shaikhan Dheri, Pushkalavati, Taxila, copper-bronze

Introduction

Humans have learnt the use of mirror in the Neolithic period or perhaps earlier. It is said that the earliest evidence of mirrors is equated with the polished ore-minerals such as obsidian, from Anatolia around 6000 BCE. Obsidian is a form of volcanic glass. This site is located at modern Turkey. Excavations at Çatalhöyük unearthed funerary gift mirrors, a very rare finding in the ancient settlement. The transformation of mirror from obsidian to metal was also noted when human learnt making and shaping of metal objects. One of the earliest discoveries of metallic mirror was from Armenia where earliest evidence of this object has been traced in the necropolis of Sisian, belonging to the Middle Bronze Age (Avetisian et al. 2000).

Introduction of mirrors in South Asia originated in Harappan sites most likely from South Baluchistan of Pakistan from Kulli culture. The earliest evidence of metal is known from Mehrgarh from its Neolithic context. There is every possibility for the beginning of mirror from that site. From Harappan sites of Pakistan and India the use of mirror was popularized in mature *Harappan Phase,* 2600-1900 BCE. Several Harappan sites yielded metallic mirrors- examples may be cited for Harappa, Mohenjo Daro, Kalibangan, Lothal and others. In the Gomal Plain region, in northwest Pakistan, a fragmentary copper bronze Harappan mirror was discovered at Gandi Umar Khan (Jan 2008 and Jan et al. 2011).

Introducing Taxila or Takṣaśilā and Gandhara

The Ancient Indo-Pakistani site of Taxila or Takṣaśilā (33.7463º N, 72.8397º E) is better known as the capital of Gandhara *mahajanpada*. The area of the Gandhara region includes north west portion of Afghanistan, and north east portion of Pakistan and several areas of Pakistan including Rawalpindi. The ancient site Takṣaśilā is situated in Rawalpindi District of Punjab. The excavation conducted here revealed antiquities of various categories. There is C^{14} dates *c.* 2550-2288 BCE for the earliest settlement at Taxila (in the Hathial area). The remains of Taxila noticed first identified with those by Sir Alexander Cunningham who visited there in 1863-64 and 1872-73. From 1913 to 1934, on behalf of Archaeological Survey of India, Sir John Marshall extensively excavated the regions at Sirkap and Bhir Mound (Marshall 1951). The capital in this site was established first at Bhir Mound, and then shifted to Sirkap. In 1944-45 Sir Mortimer Wheeler conducted small scale excavations in those city sites. Numerous Buddhist establishments were discovered in the region in recent past.

Subsequently Gandhara mirrors were discovered at Taxila and Shaikhan Dheri. From Barikot of Swat, Italian archaeologist has revealed a Gandhara type mirror (Colliva, 2019). From Afghanistan, Gandhara mirrors were also discovered recently from Mes Aynak (34º24'0" N, 69º22'0"E) by the Institute of Archaeology, Kabul.

The studies on the Gandhara mirrors would be completed when we would intensively study the mirrors associated with the graves of the Greater regions of Gandhara. Dani had equated Gandhara to be the land of Pashtuns and he argued that the term literally be translated as Pashtunkhwa or Pakhtunkhwa (Dani 2007:10). As considered by him, Gandhara consisted of several river valleys including the regions of Chitral, Hazara divisions and others.

The earlier information of mirror we knew from the publication of excavation at Gankorineotek (Chitral), Ihsan Ali has discovered this site. Abdul Hamid has shared this to the present authors. The site contemplated the presence of Gandhara Grave sites and recovered grave goods having great similarities with those found from Timargarha Graves (Dani 1967:36).

Copper/copper-bronze Mirrors were as revealed in second field sessions constitute the second largest group of findings at Gankorineotek (71º 48′ 377" E, 35º 54′136"N), (Ali Ihsan, Ibrahim Shah, Abdul Hamid and Ashfaq Ahmad 2010). A total of eight mirrors of various sizes were found during the excavations. The smallest one (GTC 005) measures 3.5 cm in diameter recovered from the balk between H I/1 and H II/I while the largest measuring 6 cm in diameter found from grave no 100. These mirrors were used for the purpose of decoration and having short handle as compared to those from the Northern Areas of Pakistan and almost all the handles have hole in the centre.

To recapitulate the brief history of this site, excavations conducted here in past and the Gandhara mirrors obtained in Taxila, now preserved in Museums of Pakistan and India. One of the most important museums of the sub-continent is Taxila Museum which initiated in 1918 and finished on 1928.

Gandhara is well known in ancient Indian literatures. One may recall that from the *Ramayana* it is known that the city (Taxila) was founded by Bharata who placed his son Taksha as its ruler. From the Mahabharata it is mentioned that one of the successors of Pandava, – Janamejaya, ruler of Hastinapur, performed the Snake-sacrifice at Takṣaśilā. In Buddhist literatures, *Jataka,* it was mentioned that Taxila was the capital of Gandhara and it was a great centre of learning where princes to common folk participated in learning. In historical times the area known as the province Gandhara of north western region, was annexed by Darius I, the Achaemenid ruler in c 518 BCE. Taxila also came under the foreign domination by Persians for about a century and a half. Taxila city was the capital of Gandhara satrapy. During 486-465 BCE Taxila was a part of Achaemenid Empire.

The Persian capital Persepolis was captured and destructed by the Macedonian ruler Alexander in 330 BCE. Taxila was ruled that time by Ambhi (mentioned in Greek sources as Omphis) who surrendered to Alexander in 326 BCE, posted in Taxila. The contemporary ruler Puru (Porus in Greek sources) ruled the land east of the Jhelum opposed the movement of Alexander. Later Chandragupta Maurya captured the Northwest at 325 BCE. Thus, the Greek rule in Taxila was short-lived. Aśoka, the grandson of Chandragupta, was made as governor of Taxila by his father Bindusara. The Taxila region was thus annexed under Mauryas. The rock edicts of Aśoka were discovered at Mansehra, which is close to Taxila. In a recent publication on Aśokan edict, Hultzsch (1991: 71-84) has mentioned the presence of a major rock edict in the north of Mansehra village. It was engraved on three boulders. The weak successors of Aśoka could not hold Taxila for long time. The last Mauryan ruler Brhadhratha was assassinated by Pushyamitra Sunga in 185 BCE and Sunga dynasty started. In northern Afghanistan region - Bactria was in the possession of Indo-Greek rulers who

built new capital at Sirkap. Menander (125 BCE) ruled from Sakala (Sialkot). Taxila was one of the capitals of Indo-Greek and continued to grow with foreign successors. In 20 BCE Gandophares captured Taxila and founded Indo-Parthian rule.

Indo-Greek rulers were overthrown by a nomadic tribe of central Asia, the Scythian (Śakas) in 1st century BCE for a short period and the Parthians from eastern Iran. The region is further captured by the Kushan tribes of Central Asia, under Kujula Kadphises in 76 CE. Kanishka 1 come to the throne in 78 CE, Taxila was one of the capitals of Kushans. In 460-470 CE Huns captured the region and destructed the Buddhist monasteries and stupas. Kanishka founded the third city, at Sirsukh.

Chronologically, Bhir Mound site of Taxila was dated to 5th century BCE. Indo-Greeks built new capital for themselves, now known as Sirkap in 2nd century BCE. Third city was identified as Sirsukh which was the shifted capital under the Kushanas. Bhir Mound and Sirkap is separated by a stream namely *Tamra Nalla*. Another remains has been incorporated in the ruins (Marshall 1951: 82-84) of lower city of Sirkap that includes an interesting group of buildings at a spot called 'Mahal' situated in a high ground in a dip between the rocky ridges at the western end of the Hathiāl spur. The word Mahal signifies a royal residence, and it has perpetuated a genuine tradition for the elevated but sheltered position which the building occupies. With its sunny aspects and fine commodities view to the west, would have been admirably suited for a royal winter residence and buildings are planned on a scale comparable to that of the lower city. According to the excavator, Mahal residence was in occupation of 1st century CE as confirmed from the masonry.

The most important feature of this site was the discoveries of 60 metallic vessels along with other antiquities; those were revealed from the hidden recesses between the small rooms. The objects included beakers, bowls, saucers, ladles and mirrors.

We are tempted to mention that collection also include a fine handled jug of Hellenistic pattern, a perfume holder of polished agate and a conical Assyrian in front of the scorpion-god. Marshall further mentioned the inscription on one of the copper ladles suggested that it was brought to Taxila from the monastery of Kasyapyas at Bedali, 97 km north of the city, by monks fleeing before the advancing armies of Kushanas (Marshall 1951: 80).

It is known that a number of Harappan and Gandhara mirrors and other antiquities are available in different museums in India and Pakistan. We have information of several mirrors in the several pockets of this site in excavation or chance finds, but the detail information is not available in published forms. Several mirrors of Taxila Museum of Pakistan have been published (Nasir and Chattopadhyay 2020). One unique mirror with ivory handle of Taxila origin is available in the collection of National Museum of Pakistan in Karachi along with several specimens brought from this museum. In India there are only four mirrors – one at the National Museum, New Delhi and three specimens at Indian Museum, Kolkata. We have also observed a specimen of National Museum of Pakistan in Karachi (Chattopadhyay and Sen 2019, Chatterjee and Chattopadhyay 2019). That object of Karachi has been found with accession no 2043 SK/33-143/10; including that specimen and seven mirrors of Taxila Museum we have total information of twelve such specimens.

Location of the current Mirror

One mirror specimen was recovered from Shaikhan Dheri Excavation (1963 and 1964 sessions) conducted by Ahmad Hasan Dani (1965-66). The mirror specimen is presently located in the Sir Sahibzada Abdul Qayyum (SSAQ) Museum of Archaeology and Ethnology, University of Peshawar. Shaikhan Dheri (34.178°N 71.743°E) is lying one kilometer north from Bala Hissar on the other side of Sambor River, the branch

of River Jinde. The site is located about 20 km away from Peshawar towards east, currently located in district Charsadda (ancient Puskalavati).

This ancient city of Puskalavati was established in the second century BCE until the second century CE, occupied by Greek, Sakas, Parthian and Kushans. The present specimen is contemporary or may be earlier to Taxila. Puskalavati/ Pushkalavati (Sanskrit: पुष्कलावती, IAST: Puṣkalāvatī) means Lotus City in Sanskrit. According to the Ramayana, it was named Pushkalavati because it was founded by Pushkala, the son of Bharat (and hence nephew of Rama). The present name of this city is Charsadda. In fact, the objective of Shaikhan Dheri excavation of Prof. Dani was to search the second city of Puskalavati.

Information and Classifications of Gandhara Mirrors

From the information of Gandhara mirrors we shall begin with the excavation of Taxila by Marshall (1975:584-85). He had selected three specimens - nos. 208, 209 and 211 from his collection. His published specimens and subsequent known specimens indicate wide variation in dimensions. The well finished complete Gandhara specimen may be explained visually through Figs. 4 and 5. The former is visual one and the latter is its engineering drawing.

From excavations of Taxila, several Gandhara mirrors were recovered. Those are preserved in this subcontinent in a few museums. In India only four mirrors have been identified in Indian Museum, Kolkata and National Museum in New Delhi (Chattopadhyay and Sen 2017, 2019). Seven mirrors are preserved in Taxila Museum (Abdul and Chattopadhyay 2020). One specimen originally belonged to Taxila Museum was transferred to the National Museum of Karachi. All those Pakistani specimens were attached with ivory handles. Mirror handles are missing in Indian specimens, only tang remained there.

Manufacturing Techniques of Gandhara Mirrors

For in-depth study we should consider first the alloying pattern - whether Gandhara mirrors were manufactured from pure copper, or some other elements were used by the smiths intentionally or unknowingly entered into the metal from the ores or fluxes used during the melting process. Pure copper was not used by Gandhara smiths. That was due to the high melting point of copper as 1084.57 ^{o}C. Even without knowing the use of pyrometer, Gandhara smiths knew that that addition of tin (Sn) to copper (Cu) would make casting easier and change the colour of the metal. They learnt by practising only; formation of low tin below 10% Sn, they obtained Sn bronze alloy, which modern metallurgists call it in α phase (FCC). That was a single-phase alloy, both as cast and wrought - i.e, can be finished by forging easily. Melting temperature decreases less than 800 ^{o}C.

Smiths further discovered that if Sn is added more than 10 to 20% the product can be casted at lower temperature but product faces difficulties for forging. Above 20% Sn the alloy is in β phases (BCC) which is an electron compound (Cu_5Sn). This alloy we call it now as high tin bronze or *kansh.* Pure copper is red in colour whereas tin and zinc are white in colour. Copper tin alloy is harder than copper and its colour is golden.

Our basic objective is to evaluate the excavated mirror of Shaikhan Dheri. At the initial stage we are not using any destructive methodology. We are utilising the results of predecessors, starting from the excavator-archaeologist and his associated archaeochemists/ metallurgists what they found.

From the excavated finds of Taxila copper bronze objects were duly analyzed and interpreted by the pioneer archaeochemists, Mohammad Sana Ullah and M.A. Hamid included in the excavation report (Marshall 1975R: 564-606). The analyses divided in three categories. First category- a) soft copper- where tin

percentage is less than 0.74. Unalloyed copper was never cast in Taxila. The second category, b) includes high tin bronze without the presence of lead. Tin content in the 9 out of 11 bronze specimens are between 21.55 to 25.59%. We are aware the presence of one mirror specimen from Taxila that is preserved in National Museum, New Delhi. Marshall (1951) considers that its dating was 4th century BCE. A few mirrors were obtained from Sirkap: from strata III, IV and II. Regarding those mirrors, Marshall further commented, 'found only in the Śaka-Parthian city in Sirkap and were copied from Western prototypes'. They consist of a circular disk, 72 to 165 mm in diameter, furnished with a tang at the base which fitted into a bone, ivory or wooden handle. The face of the mirror is smooth and slightly convex. Back side was sometimes plain, but more frequently relieved with a broad wavy rim and a raised boss or *omphalos* (in Greek and Roman) in the centre. None of these mirrors are decorated. The mirror was attached with a bone or ivory handle one such object was found decorated with a female figure in relief (Marshall 1951: 135, ibid 43, plate 203 k).

The mirrors were probably cast using bivalve moulds where molten copper- bronze alloy was used. For better casting excess liquid metal were used for the reason that during solidification volume of the liquid metal decreases. The molten metal stored in the raised boss supplies metal to rim and other regions to fill up the space developed during cooling. If this decreased volume of molten metal and the raised volume are equal, then there might be no formation of *omphalos.* This was seen in Mirror No. 1, (7009, SK/15, 514) in (Nasir and Chattopadhyay 2020).

Description of Shaikhan Dheri Mirror

Dani had reported the presence of one copper mirror from that excavation. The specimen was obtained from Trench A' (4), (Dani, 1965-66: Pl. La). The specimen was recorded with its accession no. as 3. 4024 as copper flat circular mirror. The diameter of the mirror is 100.95 mm. The average thickness of the mirror is 5.8 mm. The mirror is made of two faces – one of which is almost flat, and the other has very much similar to Gandhara mirrors, as discussed earlier. This face is relieved with a broad rim. The backside of the mirror face is with a broad raised rim but unlike others no *omphalos* is present in this specimen. The mirror face is almost flat. Plate-1 (Pl. 1) is the front side of the mirror and Pl. 2 is the back side of the mirror which includes the rim.

The bottom of the face has a small projection on the edge with three iron rivets for holding the handle which is completely missing. Unlike other Gandhara mirrors' tang is thus totally absent. The bottom portion of mirror face is projected downwards; whose dimension is 5.6 mm in breadth and 2.2 mm in height. Above the projected portion there are three holes for iron rivets which were totally corroded. That portion is shown in enlargement in Pl. 3. Riveted holes are arranged in the form of a triangle.

The uniqueness of this mirror is the crescent shaped handle. The handle was made from a piece of metallic sheet whose average thickness is 5 mm only. The bredth of this crescent handle is 78.63 mm and its height is 94.78 mm. The Pl. 4 represents the engineering drawing of the mirror face and its crescent handle. It was designed in such a formthat the user can comfortably grip it through fingers. The width of the middle slott is 12.64 mm. The dimensions of the mirror face and the crescent handle is shown in Table-1.

Table- 1: Mirror face with handle of SSAQMAE, University of Peshawar (dimensions in mm).

Sl. No	Origin	Accession No	Front Pl. No.	Back Pl. No.	Height and Breadth of mirror	Max thick. mirror	Handle height	Handle breadth	Handle average thick	Drawing in Pl.
1	Shaikhan Dheri	3. 4024	1	2	100.95	5.8	94.78	78.63	5	3

Common type of Gandhara Mirror

The most common type of Gandhara mirror can be explained easily through Pls. 5 and 6. That would explain the mirror face of front, rim and *omphalos* at back, and tang at bottom. Engineering drawing of the specimen could be visualized. This specimen is preserved in the Indian Museum, Kolkata (Accession No. 9933/ A9304).

Pl. 5 indicates the mirror face that was seen with pits formed due to corrosion. This is shown in LHS of the figure. The back side is shown in the middle of that figure, showing *omphalos* at the centre and rim at the boarder of it. Tang is slightly V- shaped. At R.H.S. mirror is shown from the side holding the tang. Pl. 6 reveals the engineering drawing of the specimen.

Marshall (1951) has given the analyses of a mirror from Taxila which was made of high tin bronze with 25% Sn. Since forging of high tin bronze was not known to the Taxila smiths. We presume that it was made by casting the ingot first, until and unless metallography was done one could not identify whether forging was done as the mirror blank; definitely the surface or the mirror face was made by polishing with sand and smooth river clay. Two mirrors were analysed which indicated high tin bronze, a bell from the same site also indicated high tin bronze (Table-2).

Table-2: Chemical Analyses of Gandhara Mirrors (Analysis conducted by Sana Ullaha)

Site (Level)	Accession No	Time Period	Cu	Major elements Other than Cu (Wt%)						
				Ag	As	Sn	Zn	Sb	Fe	Ni
Taxila, Sirkap	SK'33-143/10	1st c. CE	74.61	0.87	0.11	22.0	--	1.23	0.71	0.47
Taxila, Sirkap	SK'14-1385	1st c. BCE	74.28	Trace	0.04	24.85	--	0.12	0.71	--
Taxila Bell	SK'30-216	2nd c. BCE	74.80	--	0.10	24.14	--	0.20	0.55	0.21

From these analyses one may find that Gandhara smiths knew the use of high tin bronze or *kansha* for making mirror and other utensils were between 21.55 to 25.59% tin. We can now interpret this with the help of the researches incorporated in Pl. 7. https:// www. researchgate.net/figure/ The-Cu-Sn-phase-diagram-adapted-from-Saunders-and-Miodownik -40_fig 49_ 321875056.

Melting point of Cu is 1084.87 ºC and Sn is 231.9681 ºC. The composition of average Harappan mirrors and other Cu-bronze artefact is around 4% Sn and from the above diagram the solidification of that alloy begins at 1100 ºC. Whereas average High Tin Bronze of Gandhara is about 25% Sn, that means solidification begins around 830 ºC. The temperature difference between Solidus and Liquidus with respect to percentage of Sn in

Cu-Sn Phase Diagram tends to 0 ºC temperature range is minimum at 25.5% Sn, (Pl.8) that was achieved by Gandhara artisans (Chattopadhyay 2013). One may find the difference of solidification of alloy between average Harappan and average Gandhara mirror making as shown in that Cu-Sn Phase diagram.

Conclusion

Like other cultural artifacts, the mirrors of the early historic period are equally important to unveil not only the use of technology but also to understand the socio-economic aspects of the ancient societies. The skill in ancient metallurgy and metal casting also reached to its zenith in the early historic period in south Asia like stone sculpting, bead making, ceramic production. Due to recycling of the metal, such objects are usually found less in numbers from sites but are always of good quality. Even without knowing the use of pyrometer, Gandhara smiths knew that that addition of tin (Sn) to copper (Cu) would make casting easier and also change the colour of the metal. They learnt by practicing only.

Acknowledgement

The authors would like to thank the SSAQ Museum of Archaeology and Ethnology, University of Peshawar and the Taxila Museum, Taxila for giving us access to study the mirrors housed in their collections.

References

Abdul, N. and P.K. Chattopadhyay, (2020), Gandhara Mirrors Preserved in Taxila Museum, Pakistan, *Pratnatattva* Vol.26: 19-28, Research Journal of the Department of Archaeology, Jahangirnagar University, Savar, Dhaka.

Ali, I., I. Shah, A. Hameed and A. Ahmad 2010. Gankorineotek (Chitral) Excavations, Second Field Season (2008), *Pakistan Heritage*, Vol. 2: 209-237, Manshera: Research Journal of the Department of Archaeology, Hazara University, Manshera.

Archaeological Survey of India, *Annual Report* 1902-03 (R. 2002), 115, The Prehistoric site at Âdittanallûr, New Delhi: Archaeological Survey of India..

Avetisyan, P., Badalyan, R. Gevrkyan, A. and Khnkikyan, (2000). The 1998 Excavation Campaign at the Middle Bronze Age Necropolis of SisanArmemia; in *Estratto da, Studi Micenei Ed Egio-Anatolia*, Roma: CNR Istituto per GLI StudiMcnei (ed) Egio-Anatolici. pp.161-173.

Colliva, L. (2019). Barikot, Swat (1984-1992). Taxonomic Study of the Copper Alloy Objects, *Journal of Asian Civilizations,* Vol. 42, 2, 1-76.

Chatterjee, Shoumita and P.K. Chattopadhyay (2019). Mauryan and Post-Mauryan Mirrors of North Indian Subcontinent: Re-evaluation, *Pratnatattva*, 25 143-150. Research Journal of the Department of Archaeology, Jahangirnagar University, Savar, Dhaka.

Chattopadhyay, P.K. and S. Sen (2017). Mirror from Taxila: Specimens Collection, *Icon Journal of Archaeology and Culture*, Vol.3, 1-4 and pp 229-231.

Chattopadhayay, P.K., and SatyakamSen *(*2019) Taxila Mirrors Preserved in India and Technology Transfer, *Indian Journal of History of Science*, Vol. 54.2, 135-143, Indian National Science Academy, New Delhi

Chattopadhyay, P.K. (2013) *Archaeometallurgical Investigation on Material Technology of High Tin Bronze Between the Early Historic and Pre-Industrial Periods of Bengal,* Unpublished PhD, thesis Metallurgical Engineering, Jadavpur University, Kolkata.

Dani, A.H. (1965-66) Shaikhan Dheri Excavation (1963 and 1964 sessions) *Ancient Pakistan* Vol. 2:17-214.

Dani, A.H. (2007), *History of Pakistan: Pakistan through Ages*, Lahore: Sang-e-Meel Publications.

Hultzsch, E. (1991) Inscriptions of Aśoka. *Corpus Inscriptionum Indicarum* 1: 71-84.

Jan, Z. (2008) *The Bronze Age Cultures of the Gomal Valley (An Analysis of Cultural Traits with Special Focus on Gandi Umar Khan),* unpublished PhD dissertation, University of Peshawar.

Jan, Z., I. Ali, M. A. Durrani, and M. N. Qazi (2011).The Mature Harappan Occupation at Gandi Omar Khan in the Gomal Plain, *Ancient Pakistan,* 22, 1-16 (2011).

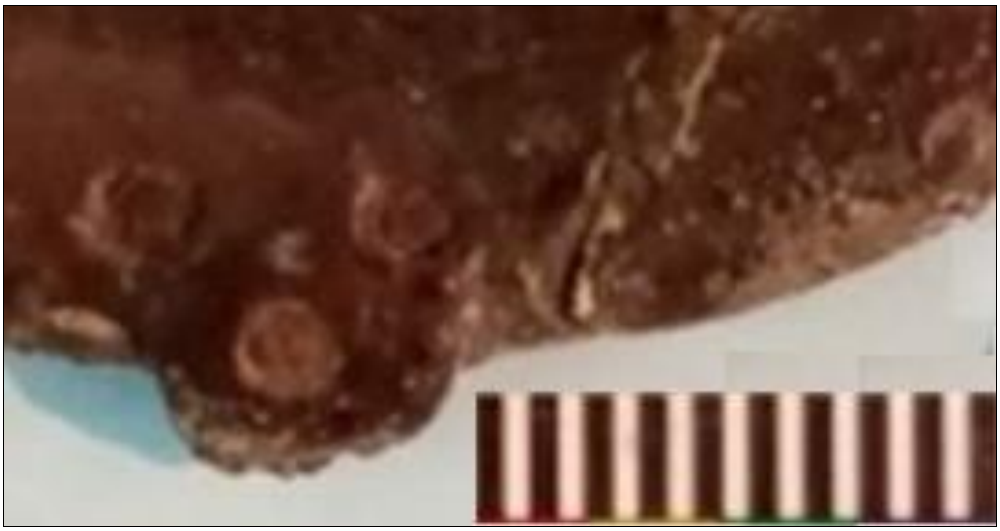
Marshall, J. (1951, R 1975) *Taxila, Minor Antiquities*, Vol. II, Cambridge: University Press; pp. 584-585, Reprint Delhi: Motilal Banarsidas and also Varanasi: Bhartya Publishing House.

https://www.researchgate.net/figure/The-Cu-Sn-phase-diagram-adapted-from-Saunders-and-Miodownik-40_fig49_321875056

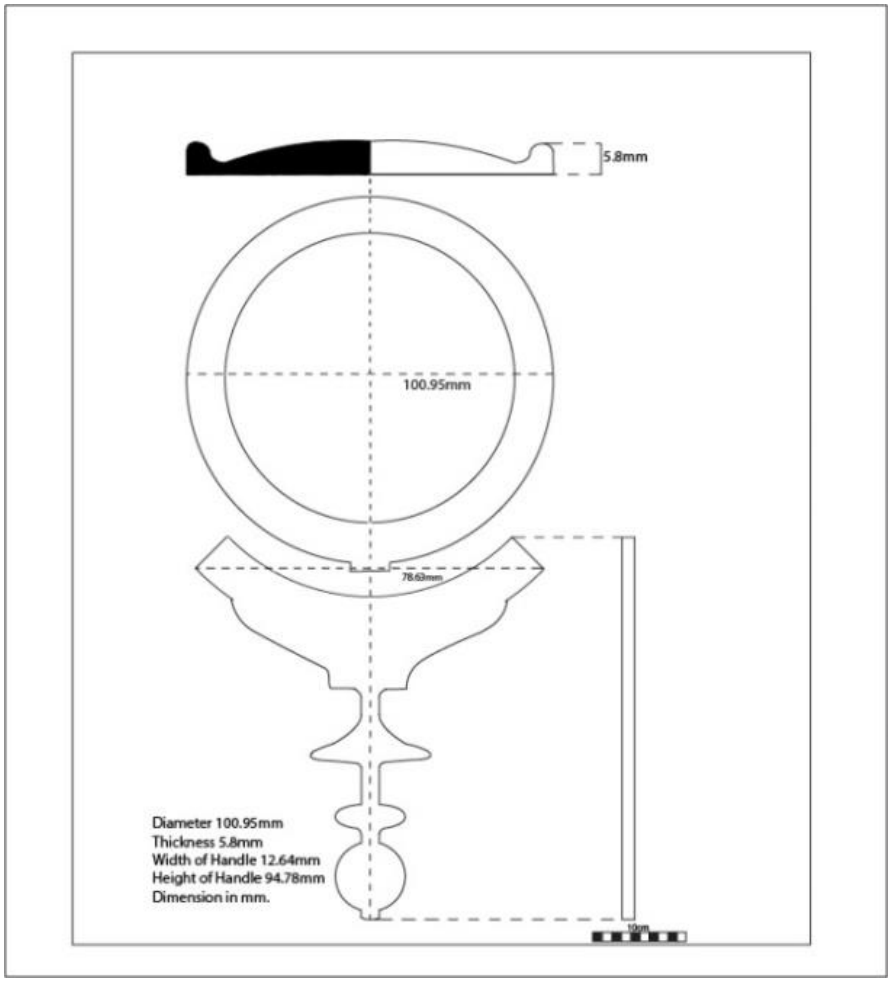
Plates

Pl. 1: Front side of the mirror face in SSAQMAE .

Pl.. 2: Back side of the mirror in SSAQMAE



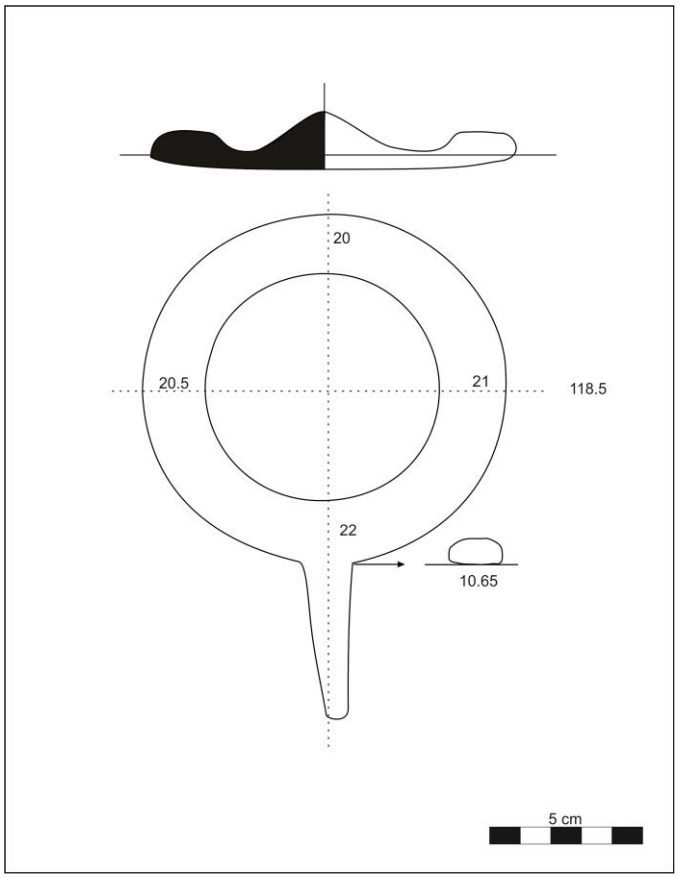
Pl. 3: Enlarged View showing rivet holes.



Pl. 4: Engineering Drawing of the mirror, in SSAQMAE

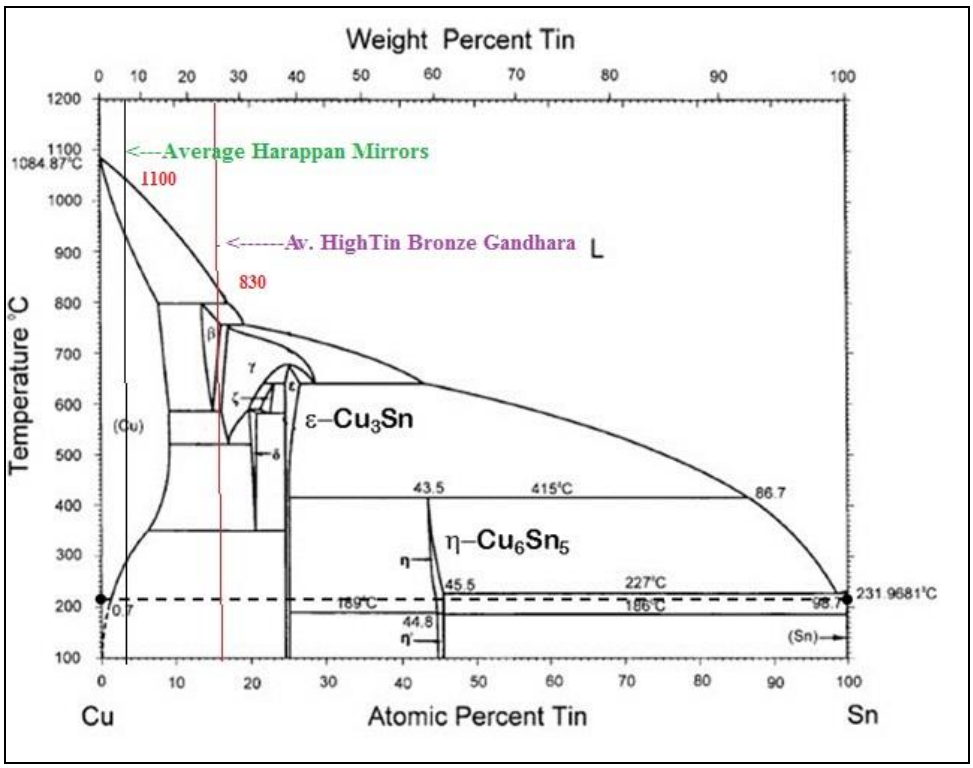
Pl. 5: Face, back side and side view of Indian Museum, Kolkata.

(Accession No. 9933/ A9304).

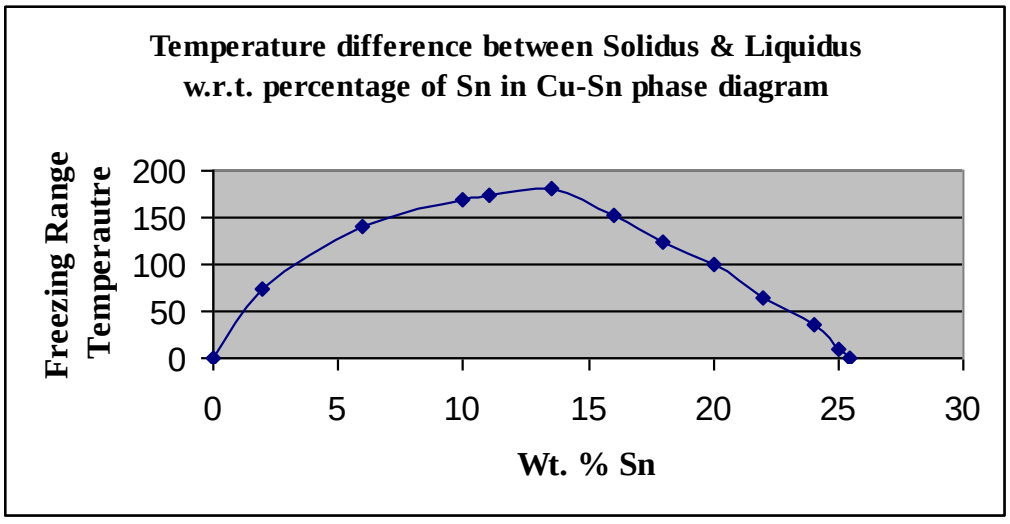


Pl. 6: Engineering Drawing, Indian Museum specimen

Kolkata



Pl. 7: Cu-Sn Phase Diagram adopted from Saunders-and-Miodownik-40



Pl. 8: Freezing Range for Cu-Sn Bronzes from 0 – 25.5 wt. %Sn.