

Carinated and knobbed copper vessels from the Narhan Culture, India

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Abstract

Agiabir is a new site in eastern Uttar Pradesh of India in the Narhan series of cultures, excavated by Banaras Hindu University. A cache of ten large copper objects, two iron swords and an iron lamp stand were discovered in the excavation of 2000-2001. Archaeologically these objects are dated to be of circa 4th to 5th century BC. Two of these copper objects from Agiabir and one from Narhan have been analysed. All these have been obtained from Period III of the Narhan Culture, associated with NBP Ware.

Introduction

In 1984, discoveries at the small village of Narhan (26°19' N, 83°24' E), situated at the left bank of the river Ghaghara, in the Gola tehsil of district Gorakhpur, Uttar Pradesh, led to the identification of a new culture in the archaeological map of India (Singh 1994) (Fig. 1). During the subsequent two decades



Fig. 1. Map of Eastern India, showing Chalcolithic and NBP sites.

almost two dozen ancient settlements of this culture were discovered in the surrounding districts. Amongst these, the most recent one is from Agiabir (25°13' 52" N, 82°38' 41" E). The site is located in district Mirzapur, Uttar Pradesh on the left bank of the sacred river Ganga. The site was discovered in 1998-99 by the first author (Singh 1999), and the Banaras Hindu University conducted three sessions of excavations (Singh and Singh 1999-2000, 2001 and 2002).

The Chalcolithic culture of the Middle Ganga Valley is characterised by the use of copper and lithic artefacts associated with Black-and-Red Ware. The pots were fired in an inverted position, so that after firing the interior and a portion of the top exterior turn black under reducing condition, whereas the remainder of the exterior turns red, being exposed to the oxidizing furnace atmosphere. The Narhan culture is basically a pre-iron Phase Chalcolithic culture with the principal ceramic assemblages of white painted Black-and-Red Ware. The Period I of the Narhan culture is similar to period IIB of the Ferro-chalcolithic culture of Pandurajar Dhibi of West Bengal (De & Chattopadhyay 1989). The Chalcolithic culture of both these sites is significant due to the presence of iron. Period II is Pre-NBP with presence of iron. Period III is associated with NBP Ware.

In Period III of Narhan culture, the major pottery assemblage is the Northern Black Polished (NBP) Ware. NBP is made of well-levigated clay on a fast wheel. Thickness of the ware is generally uniform, and it was well-fired. Typologically, NBP can be classified into several categories, such as bowls with straight sides, bowls with convex sides, handis with sharp carination, and dishes with closing featureless rims. NBP is a deluxe pottery, and it is represented by many shades, including golden, pink, silvery, and steel blue. Red Ware is also known in this period and in some of those assemblages, the presence of closing featureless rims with rounded base, known as carinated handis (cooking pots), were noted. This shape in pottery is further adopted in large copper vessels.

The copper objects recovered from these cultural sites were studied to reveal the alloying pattern, manufacturing techniques, and their correlations with other sites. The copper objects from Narhan, Period I, includes one ring and one fishhook, Period II included two hairpins or so-called antimony rods, a nail-parer, four bangles, one fishhook, and indeterminate copper objects. Period III, on the other hand, originated one carinated copper vessel and a bead. Analytical studies have been made of some of these objects elsewhere (Singh, Merkel & Singh 1996-97).

The copper objects from Period I's first excavation season at Agiabir comprised a single item, namely a fishhook. Period II was free from copper, though about thirty iron objects were recorded. In the first season of excavation, ten specimens of copper, including wire, hairpins, bangles and a few objects of indeterminate use were recovered from Period III (NBP). The excavation of 2000-2001 has obtained a cache of copper and iron objects in a room, buried in layer (12), on the top of layer (13) from trench YE-6 III, at a depth of 6.60 m below datum (Singh & Singh 2001). These objects were recovered from Period III and can be chronologically dated to the middle phase of NBP (Fig. 2).



Fig. 2. Cache of Period III copper and iron objects in situ excavated at Agiabir, including carinated bowls, a mirror, knobbed vessels, copper objects and an iron lamp stand.

The cache comprised ten large copper objects. These include two cooking vessels (*handa*), a globular vessel, two bowls, two carinated handis, a copper knobbed vessel and a mirror. All these objects are complete and kept upside down, and found in a highly corroded state with thick bluish-green corrosion. An analytical study of two carinated handis of Agiabir and Narhan

(Sp. Nos. 1 & 2) (Fig. 3) and the knobbed vessel from Agiabir (Sp. No. 3) (Fig. 4) are presented here. A thin core of about 0.8 mm uncorroded metal was detected in the first two specimens. A metallic core was also detected in the third one, but it was rather thin. The dimensions and measurements of the vessels are recorded in Table 1.

TABLE 1

Sp. No.	Site	Diameter of the mouth (cm)	Diameter of the body (cm)	Thickness of the rim/ body (cm)	Height (cm)
1.	Agiabir	19.0	30.8	0.28	9.1
2.	Narhan	23.5	37.0	0.30	12.9
3.	Agiabir	27.6	33.6	0.57	3.2

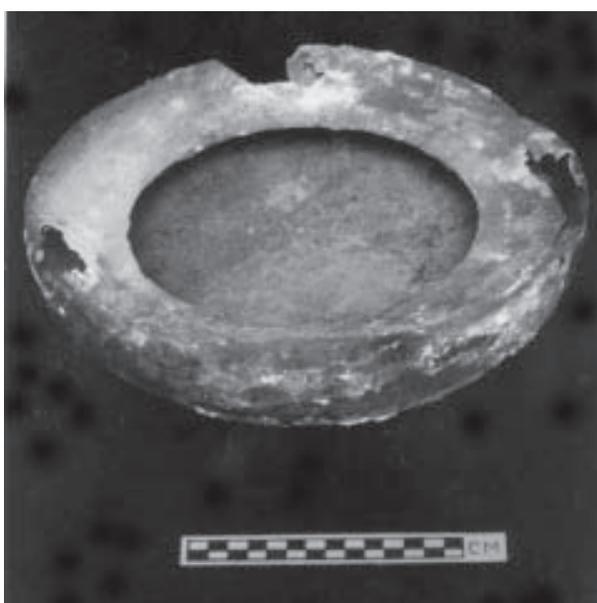


Fig. 3. Carinated handi from Agiabir, Period III (NBP), circa 4th to 5th century BC.

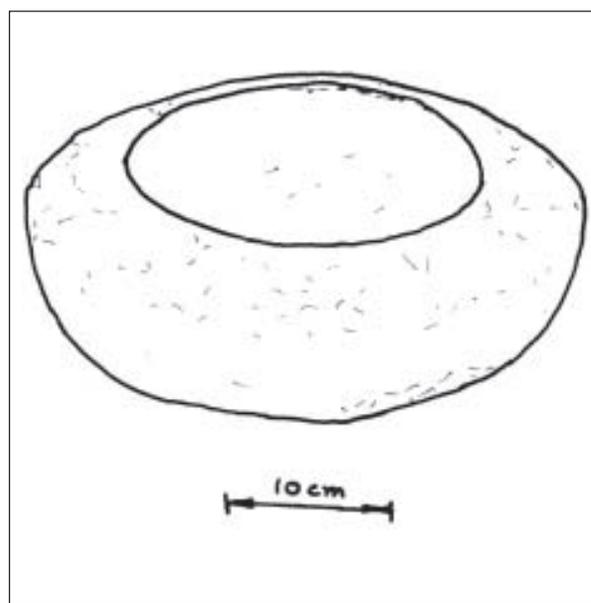


Fig. 4. Sketch of carinated handi from Narhan, Period III.

Analytical procedures

Initially the surfaces of the three specimens were inspected through a microscope. The carinated bowl from Agiabir (Sp. No. 1) was clean at its internal surface but was found to have soot marks at its outer surface as well as a coating of clay and ash. One may observe in villages still today the use of clay at the outer surface of the cooking pots. This clay layer protects the vessel from the soot produced in the fire of woods. The application of this protective clay layer indicates the use of the same tradition over thousands of years. The outer surfaces of all these three objects were found fully converted into malachite [CuCO₃.Cu(OH)₂] and other complex corrosion products, a common feature on copper-based objects (Chase 1979).

The chemical analyses of the three specimens are made to identify the constituents and alloying, if any, with the help of an Atomic Absorption Spectrophotometer, Perkin Elmer 238.

Analysis of objects

The first analyses of the copper objects from Narhan had thrown new light on the inception of copper technology in this site (Singh, Merkel & Singh 1996-97). Analyses of a fishhook and

a bangle from Period I and a bead of Period III clearly indicated that there is no evidence of using pure copper for manufacturing artefacts, whereas use of alloy was recorded as low tin bronzes with the addition of tin from 3.81 to 9.86 wt%. In the contemporary copper bronzes of Bihar and West Bengal similar observations were recorded by Emission Spectrograph analysis, where evidences of tin were found around 10 wt% (Chattopadhyay 1992). The results are shown in Table 2.

TABLE 2

No	Site	Cu	Sn	Ag	Pb	Fe	Zn
1.	Agiabir	98.50	<0.1	0.02	<0.1	<0.1	<0.1
2.	Narhan	99.02	<0.1	0.005	<0.1	<0.1	<0.1
3.	Agiabir	35.83	17.98	0.02	<0.1	<0.1	<0.1

The specimens Numbers 1 and 2 from the above table clearly indicated that there is no evidence of alloying in the two carinated vessels from Agiabir and Narhan. The specimen Number 3, the knobbed vessel of Agiabir, was specifically searched more



Fig. 5.
Knobbed
vessel from
Agiabir,
Period III.

precisely for copper, tin, lead and zinc. The oxidized contents, *i.e.* the presence of non-metallic constituents, discouraged the analysis to 100 wt%. The ratio of metallic constituents of the object clearly identifies it as high tin bronze. Chase (1979) provides an explanation for the increase in tin as due to selective copper dissolution from the corrosion products. The silver content in these three specimens indicates the presence of it in copper ores.

Metallography

(Sp. No. 1): A sample was taken from the copper vessel of Agiabir and mounted on ebonite. The sample was polished and

observed through a metallurgical microscope. The specimen was found to have a pitted surface, due to corrosion. Subsequently it was etched with ferric chloride and ammonium hydroxide solutions. Fine twins were revealed in the microstructure. A few intergranular grey crystals have been observed, which may be Cu-Cu₂O or PbS inclusions.

(Sp. No. 2): Similar observations were made with a specimen from the copper vessel of Narhan. In this specimen corrosion pits were observed in the polished mount but in lesser amounts than the previous sample. However, after subsequent polishing it was almost minimized. After etching, the microstructure revealed twins.

(Sp. No. 3): A fragment of the knobbed vessel with a thickness of 2 mm was polished across its cross-section, and solid core was revealed, with a heavily-corroded outside surface. Subsequently it was etched with ferric chloride and ammonium hydroxide and was observed through a metallographic microscope to reveal its manufacturing technique. The microstructure was quite different from specimens 1 and 2. There was no evidence of dendritic cast structure or twins. Thus the use of casting alone or annealing after mechanical working could not be established.

SEM-EDX Analysis

For more precise and in-depth analysis, detailed identification of inclusions, matrix, and the remaining non-corroded core, all three specimens were further scanned and checked with SEM-EDX, with Leica S440 scanning electron microscope at Pal. Div. II of Geological Survey of India. In addition, the distribution of tin in the knobbed vessel of Agiabir was analysed. The observations clearly indicated its oxidized state. The semi-quantitative average values of the specimens (in atomic percent) are shown in Table 3. Two different types of inclusions have been observed during scanning in the carinated vessels.

Observations

(Sp. No. 1 and 2): The above studies clearly indicate that the inclusions noticed in the two carinated objects from the two sites are of two types. Bright inclusions in the structure are lead sulphide, perhaps indicating contamination of galena with the cop-

TABLE 3

No	Site/ Item	Cu	Sn	Pb	Fe	S	O	Sb
1.	ABR Carnt Vessel Matrix	95.16	0.21	-	0.59	-	4.04	-
2.	ABR Carnt Vessel Inclusion-bright	32.10	-	57.04	-	10.85	-	-
3.	NRN Carnt Vessel Matrix	99.62	-	0.03	0.35	-	-	-
4.	NRN Carnt Vessel Matrix	99.37	0.30	-	0.29	-	-	-
5.	NRN Carnt Vessel Inclusion -bright	46.34	0.15	15.37	4.92	33.21	-	0.01
6.	ABR Knobbed Vessel matrix	16.76	18.63	-	0.82	-	60.70	1.48
7.	ABR Knobbed Vessel matrix	5.62	20.21	-	0.89	-	71.42	-
8.	ABR Knobbed Vessel matrix	7.48	19.57	-	0.83	-	70.70	-

per ore. The grey inclusions are similar to chalcopyrite, as indicated by the presence of sulfur and copper in them (Figs. 6, 7 & 8). It is quite probable that sulphide ores, i.e. chalcopyrite, were used to smelt the copper.

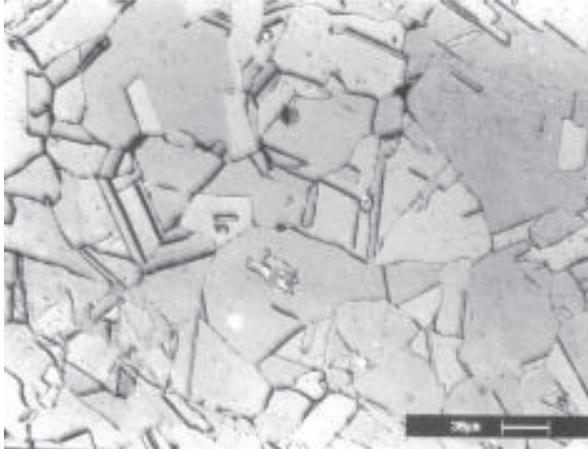


Fig 6. Microstructure of carinated copper handi of Agiabir, showing twinned copper grains, bright lead and grey chalcopyrite inclusions. Scale bar 30 μm SEM-EDX. Etched; ferric chloride and ammonium hydroxide.

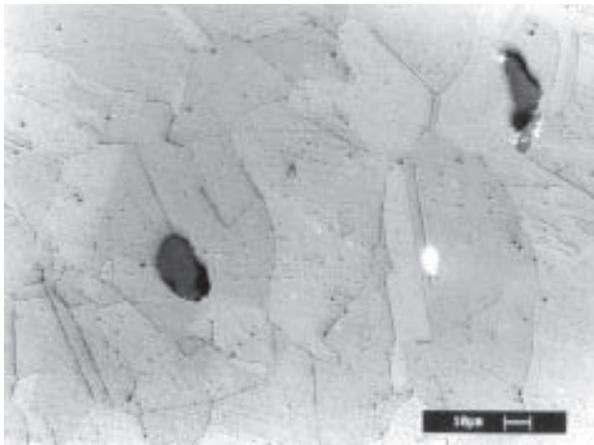


Fig. 7. Microstructure of carinated copper handi from Agiabir, showing twinned bright lead and grey chalcopyrite inclusions. Scale bar 10 μm SEM-EDX. Etched; ferric chloride and ammonium hydroxide.

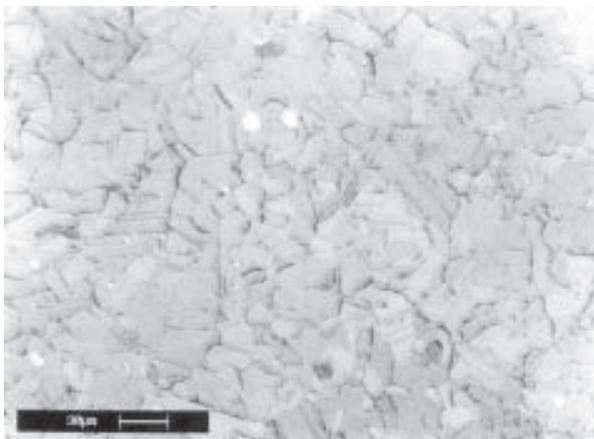


Fig. 8. Microstructure of carinated copper handi from Narhan, showing twinned copper grains, bright lead and grey chalcopyrite inclusions. Scale bar 30 μm SEM-EDX. Etched; ferric chloride and ammonium hydroxide.

(Sp. No. 3): The knobbed vessel, though highly corroded, exhibits unaltered microstructures. The vessel consists of around 19.5 percent tin, and definitely has been accepted as high-tin bronze. The microstructure as revealed through SEM-EDX indicates that quenching was performed. The structure (Figs. 9 & 10) clearly indicates that quenching was closest to pure β phase. In one region of its structure martensite was found with random dislocations and stacking faults.

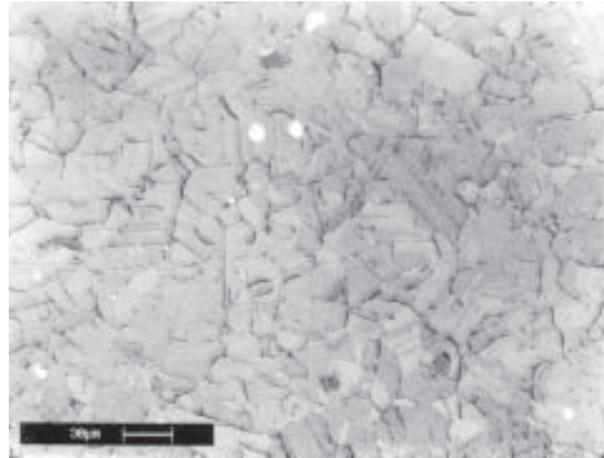


Fig. 9. Microstructure of knobbed vessel from Agiabir. Martensite indicates that quenching was closest to pure β phase. Scale bar 30 μm SEM-EDX. Etched; ferric chloride and ammonium hydroxide.

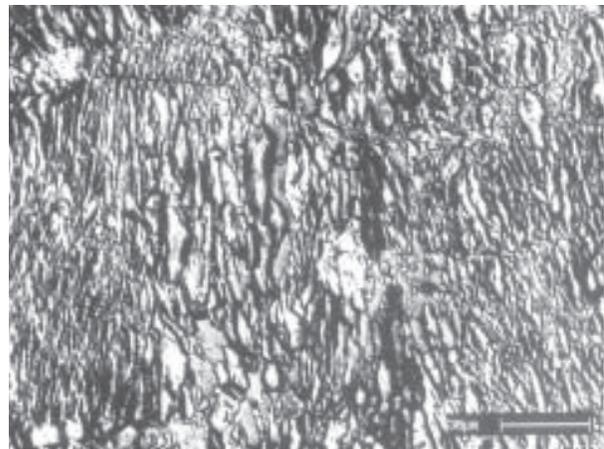


Fig. 10. Microstructure of knobbed vessel from Agiabir. Martensite in another region shows random dislocations and stacking faults. Scale bar 20 μm SEM-EDX. Etched; ferric chloride and ammonium hydroxide.

The specimen, analysed in the present context, has a different composition and structure. To reveal the manufacturing of the knobbed vessel the traditional bronze making techniques were studied through ethnoarchaeological context. The basic practices in Kerala and also in West Bengal are similar in nature (Srinivasan 1998; Srinivasan & Glover 1998; Chattopadhyay 2002b). Tin is added to liquid copper in a crucible to give the desired ratio. After melting the liquid is poured into sand moulds and an ingot is made. After reheating it was hammered into a vessel by alternate heating and forging. There is every possibility of traditional continuity in the present day practices of high tin bronze making.

Finishing processes, perhaps, made by hammering with wo-oden mallets and subsequently heating and quenching was carried out. The non-existence of as-cast dendrites and twins on the one hand, and on the other hand the internal structure of martensite, clearly indicates the quenching after hot working.

Conclusions

The presence of high tin bronzes has not yet been detected in a Chalcolithic context in eastern India. It may be tentatively concluded that the use of high tin bronze began in the early historic period. The mirror from Chandraketurgarh highlights the stages of the metal craft of the early historic period in Eastern India (Chattopadhyay 2002a). The copper and bronze objects of Agi-abir, on the other hand, highlight the stage of copper and bronze metallurgy during the 5th to 6th century BC. Detailed studies of high tin bronze vessels and mirrors have been made elsewhere (Srinivasan 1998; Srinivasan & Glover 1998).

The shape and microstructures of the two vessels revealed that they were manufactured by forging, i.e. cold working from the original cast. The grains break into smaller sizes and after reheating, i.e. annealing, twinned grains are formed. In manufacturing vessels of this shape the methods of sinking and raising are applied. In sinking, the vessels are hammered from the internal surface by placing them over a wooden groove, whereas raising is a process of working by placing them over a dome headed stake and hammering from the outside surface. In most cases, both sinking and raising are applied simultaneously. Based on the identical shape, composition, similar cultural context and contemporaneity of the two carinated vessels, the present authors presume that both were manufactured at the same location. The analysis of two carinated vessels also establishes the use of copper, in purer form without any alloying, also a new finding in Eastern India during the 5th to 4th century BC.

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