Lakheen-Jo-Daro, an Indus Civilization Settlement at Sukkur in Upper Sindh (Pakistan): A Scrap Copper Hoard and Human Figurine from a Dated Context

Paolo Biagi and Massimo Vidale

ABSTRACT

The Bronze Age settlement of Lakheen-Jo-Daro is located in the northern outskirts of the city of Sukkur, ca. 2.5 km north of the present course of the Indus, where the river narrows to flow across the northernmost limestone fringes of the Rohri Hills. The site was accidentally discovered in 1985, though the first trial trenches were opened in 1994. During the cleaning of the profile of one of the trenches excavated in 1996, one copper anthropomorphic figurine was found very close to a small charcoal lens that was radiocarbon dated to 3960 ± 140 B.P. (GrN-23123). The result attributes the deposit to a period of development of the Mature Indus Civilization. Other finds from the same trench consist of important, unique specimens among which are a group of white "steatite" micro-beads and a probable small hoard of copper items that are the main subject of this article. Keywords: Pakistan, Upper Sindh, Indus Civilization.

INTRODUCTION

This article presents and discusses some results of a test trench excavated in 1996 at the site of Lakheen-Jo-Daro, a Bronze Age Mature Indus Civilization site discovered in Sukkur, Upper Sindh, Pakistan in 1985 (Fig. 1). The evidence includes a group of minor scrap copper items and one of the few human copper figurines ever found in early urban Indus sites. All objects probably belonged to the floor of a copper processing facility. The figurine was probably unfinished. We assume that hoarded copper scraps might also have been found in other Indus contexts in the past, but because of their unimpressive and fragmentary aspect, such finds did not receive proper attention. The discovery we publish at present is therefore as unique as it is relevant.

Indus or Harappan copper-based metallurgy has been the subject of important reviews and summary studies (Agrawal 1984, 2000; Chakrabarti and Lahiri 1996; Hegde 1991; Hoffman 2018; Hoffman and Miller 2009; Kenoyer and Miller 1999;

Paolo Biagi (ORCID: 0000-0002-5948-296X) is Senior Researcher at the Department of Asian and North African Studies at Ca' Foscari, University of Venice. Massimo Vidale (ORCID: 0000-0002-0543-6511) is Associate Professor of Bronze Age Archaeology of Central Asia, Iran and the Indus Valley at the University of Padua.

Asian Perspectives, Vol. 61, No. 1

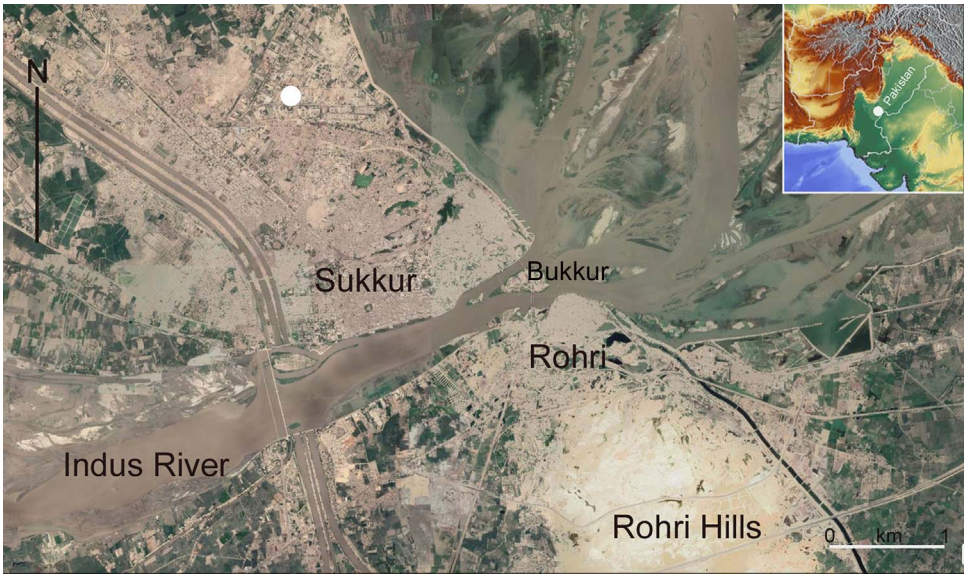

Fig. 1. Location of the Indus site of Lakheen-Jo-Daro (white dot) within the riverine landscape around Sukkur and Rohri (inset) (created by P. Biagi, base maps from Google Earth 01/20/2021, Image Landsat/Copernicus, 2021 Maxar Technologies).

Lahiri 1995; Miller 1994; Tripathi 2018; Yule 1985*a*, 1985*b*).[1] The resulting image speaks to an extremely wide and geologically variable copper procurement network presumably extending from Balochistan (and possibly eastern Iran) to Afghanistan and on to the Aravalli belt of Rajasthan, east of the Indus plains, and on the opposite side of the Arabian Sea, to the important Omani sources of copper ores. It also suggests that highly skilled technical knowledge of secondary transformation processes spread abundantly in the main urban hubs.

A peculiar aspect of the use and circulation of metal wealth in Indus centers is the burial of large, valuable hoards of utensils, tools, and unfinished items below the floors of private dwellings. This has been abundantly reported in the excavation reports of Mohenjo-Daro (Mackay 1938:121–133; Marshall 1931: plates 135–144), Harappa (Vats 1940:121–125), and Chanhu-Daro (Mackay 1943: plates 62–76) (see also Rissman 1988; Vikrama and Pradhan 2018). Much less known is how minor amounts of copper, in the forms of processing waste, tiny broken objects, or exhausted ornaments and tools, were gathered and preliminarily modified and prepared for recycling, a presumably common and economically relevant practice in Indus workshops (Hoffman and Miller 2009).

After a review of what is currently known about the large Indus site of Lakheen-Jo-Daro, this article focuses on the archaeological context of Trench C, which was excavated in 1996 and radiocarbon-dated by means of an *Acacia* sp. charcoal sample. A small group of scrap items and the copper figurine found in this context are then individually described in detail, including information on the conservation and preliminary chemical evidence on the alloys of part of the objects. Finally, we briefly discuss the implications of the finds in the broader picture of Indus copper metallurgy.

LAKHEEN-JO-DARO SITE

Sukkur and its surrounding region plays quite an important role in the archaeology of Sindh, mainly because of the discovery of Bronze Age tell sequences, among which for Sindh is that of Kot Diji. These sequences have greatly contributed to improving our knowledge of the origin of the Indus Civilization (Khan 2002), the presence of the most impressive groups of Indus chert mining areas so far known in the Indian subcontinent (Biagi et al. 2018), and Palaeolithic sites of different ages among which are Acheulian workshops (Biagi and Cremaschi 1988). Sukkur is of unique historical importance because here the ancient capital of Hellenistic Musicanus, known as Aror or Alór (Kalichbeg Fredunbeg 1900:44; Lambrick 1996:83–87), the Buddhist city of Seeraj-ji-Takri (Biagi et al. 2002), and other monuments from the same period (Biagi and Cremaschi 1990:37) are located here. Despite the importance of these monuments, many of them were destroyed in the 1990s due to illegal industrial activities (Biagi 2007).

The Indus site of Lakheen-Jo-Daro was absolutely unknown to scientists and historians before the 1970s (Blanford 1880:101; Memon 2000:188–210; Panhwar 1964:49), despite the many changes in the area involved with the relocation of the city during and after British occupation (Hughes 1876:832). Archaeological interest in the site is related to discoveries made by two geologists, Helmut De Terra and Thomas Thomson Paterson, at the top of the north-westernmost fringes of the Rohri Hills during their visit to Sukkur in 1937. Even though these geologists could not define a precise chronology of the knapped stone assemblages found there, they subdivided them according to three distinct types of patina; the "fresh and unpatinated" Group C type characterizes the Indus lithic industries of the region (Paterson 1939:334). Thanks to the discovery of groups of Indus chert manufacturing areas on top of the limestone terraces facing the city of Rohri, along the southern end of the western bank of the river, their importance started to attract the attention of archaeologists (Allchin 1976, 1979). Within the general framework of such an interesting and complex landscape, the discovery of a large Bronze Age settlement at Sukkur has greatly contributed to our knowledge of the archaeology of the territory.

The geology of Sukkur and its related territory was accurately described in the late 1800s in a seminal volume on the geology of western Sindh (Blanford 1880:102–106). Sukkur is one of the key strategic points of the lower course of the Indus River, where Bukkur Island (Wilhelmy 1966:273), on top of which is located an ancient fort, makes crossing the river easier. Studies put forward mainly between the 1960s and the 1990s (Flam 1987, 1993; Wilhelmy 1966) describe the Indus as a "notably vagrant river of enormous magnitude, exhibiting extraordinary wanderings and mutations of its course in response to natural and human induced environmental changes" (Flam 1999:39). From a geoarchaeological point of view, we know that thick deposits of Indus alluvium accumulated along the western piedmont of the Rohri Hills (Jorgensen et al. 1993; Pithawalla 1976:96). They buried many archaeological sites. Only a few of them are barely visible today, as are traces of dead river branches whose chronology is at present unknown (Fig. 2).

We know that the river's regime affected the location and life of the settlements scattered along most of its course during, before, and after the Bronze Age (Giosan et al. 2012). The Indus settlement of Lakheen-Jo-Daro, variously spelled Lakhueen-Jo-

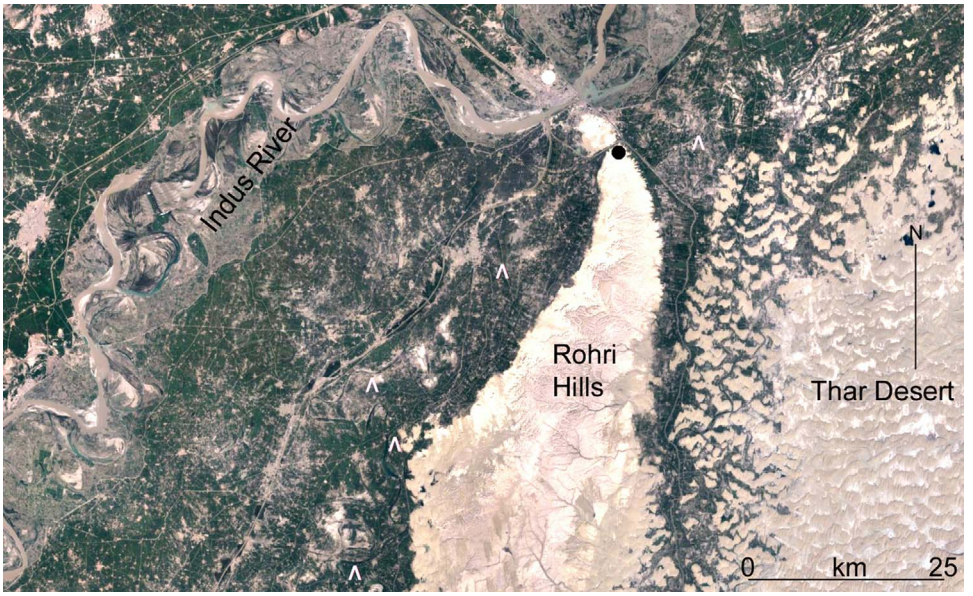

Fig. 2. The landscape surrounding Lakheen-Jo-Daro (white dot), including location of Aror (black dot) and the most visible fossil river branches (^) buried in the Indus alluvial plain (created by P. Biagi, base map from Google Earth, 01/20/2021, Image Landsat/Copernicus, 2021 Maxar Technologies).

Daro, Lakhian-Jo-Daro, Lakhan-Jo-Daro, or Lakhianjodaro by different authors, is located in a unique, strategic zone of Upper Sindh, where the present course of the Indus suddenly and dramatically narrows to flow across the north-westernmost mesas of the Rohri Hills between the cities of Rohri in the south and Sukkur in the north (Lambrick 1986:19; Wilhelmy 1966: fig. 2) (Fig. 1, Fig. 3). This Indus settlement was built at an altitude of ca. 65 m on a low limestone terrace that is not affected by summer monsoon floods (Kazi 2014) (Fig. 3 inset).

The site is located within the current Sindh Industrial & Trading Estate (SITE) of the city of Sukkur, ca. 2.5 km north of the northern right bank of the Indus River (Fig. 3). The site was discovered accidentally in 1985 while "development work in the SITE area was in progress" (ul-Haq and Ali 2001:29):

> The archaeological mounds originally covered nearly 50 hectares of the SITE area, which has now been cut, levelled, and demarcation for industrial plots and further divided by the metalled road network. The mounds have suffered extensively due to digging of the trenches for water and sewerage conduits and gas pipeline. . . . The surviving remains of this settlement can now be discerned as isolated swells, designated as mounds A, B, C, and D. (ul-Haq and Ali 2001:29)

If the estimate of 50 ha is not too distant from the real extension covered by the Bronze Age town, it adds an important mid-sized center to the local settlement network, ca. 85 km north of the Mohenjo-Daro metropolis (Jansen 1991; Shaikh and Ashfaque 1981). This is confirmed by discoveries made during the 2006 excavations when complex residential structures, among which are burnt and mud brick walls,

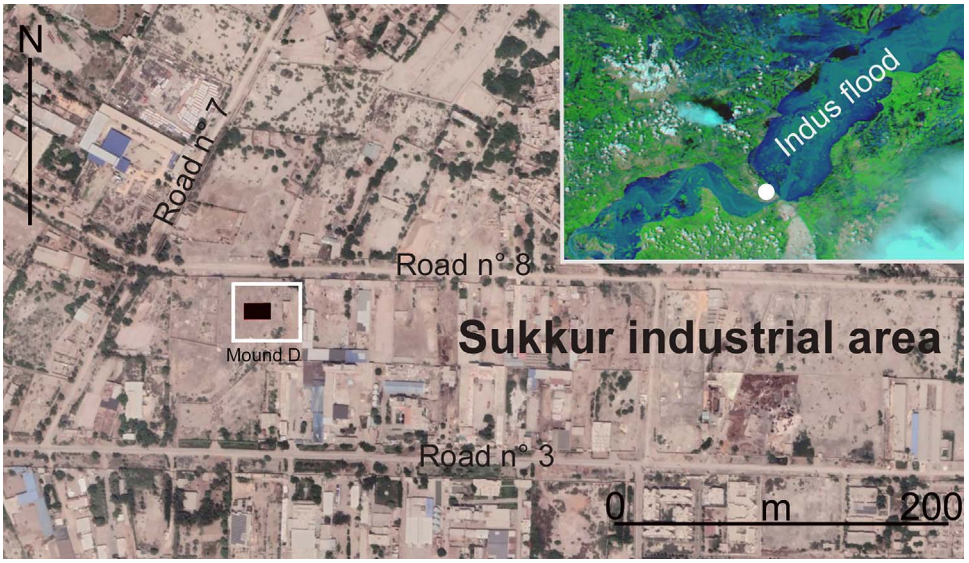

Fig. 3. SITE area of Sukkur, showing approximate location of Lakheen-Jo-Daro Mound D, Trench C (27°43′44″N–68°50′55″E) (black rectangle); Lakheen-Jo-Daro site (white dot) seen on peninsula-like geomorphologic feature during maximum extension of monsoon flood of summer 2010 (inset upper right) (created by P. Biagi, main base map from Google Earth 01/20/2021 Image Landsat/Copernicus, 2021 Maxar Technologies, inset base map from Maps for Free, Imagery 2021, CNES/Maxar Technologies).

rooms, doors, platforms, roads, and the remains of a drainage system, were brought to light (Shaikh et al. 2004–2005:60, fig. 27; 96, plate 92).

A somewhat accurate map of the Bronze Age settlement was published in the 2000s showing the distribution of different mounds first recognized in the 1980s (Shaikh et al. 2004–2005: fig. 4). A few data regarding the material culture assemblages collected from the site's surface, and some information on mound D, was published by M. M. Kazi in 1989. Kazi reported that mound D, located in plots D9–D11 close to Road No. 8, had been leveled by a tractor, and that before that event a burnt brick well had been visible in the southern part of an artificial hillock, which was later destroyed by local inhabitants (Kazi 1989:90). Pleas to stop the ongoing destruction of such an important site would seem mandatory, but probably not very effective.

Following the partial destruction of the archaeological area due to industrial works (still underway in the 2010s) (Lashari 2014), the first excavations of the site were carried out in January 1994. During this fieldwork season, a few trenches were opened in three different mounds (A, B, and C). Some of the finds, among which are ceramic potsherds, chert and marine shell artifacts, were published in a scientific journal and the authors suggested they could be culturally attributed to the Mature Indus period because of their typological characteristics (ul-Haq and Ali 2001:33). Despite its location very close to the northernmost fringes of the Rohri Hills terraces, which are rich in Indus Civilization chert workshops (Allchin 1979), the early excavations carried out at Lakheen-Jo-Daro did not yield any clear evidence of chert manufacturing,

storing, or knapping workshops. Consequently, the excavations did not contribute to interpreting the distribution and trade models of this important knappable stone resource (see ul-Haq and Ali 2001:33). An exception to this general picture was the later discovery of substantial evidence of steatite beads and micro-beads manufacturing made during rescue excavations carried out in 2017 (Mallah 2017:57–58, 65, figs. 71 72 74). The involvement of local craftsmen in the transformation of different varieties of steatite is also confirmed by the recovery of some unfinished Mature Indus stamp seals (Mallah 2017:67–72).

FINDS FROM TRENCH C, MOUND D

In November 1996, the Department of Archaeology of the Shah Abdul Latif University, Khairpur, opened three parallel trenches, each about 3 m long by 1.5 m wide, along the western slope of Mound D. The central Trench C was excavated by Ghulam Mustafa Shar of the same university. Unfortunately, we do not have a detailed report of the methods employed to conduct the work or of the precise location and description of most of the finds because the excavator published only a group of important, unique items brought to light from Trench C (Shar 2000–2001). In January 1997, Italian members of the Joint Italo-Pakistani Rohri Hills Project were invited to visit Lakheen-Jo-Daro.[2] The aim of the visit was to take samples for radiocarbon dating and soil thin section analysis from Trench C, from which many interesting copper items, a group of paste micro-beads, some semiprecious stone beads, and a few marine shell items had been retrieved two months earlier (Fig. 4 bottom). Note that the Trench C ceramics had not been systematically documented at the times the authors visited Khairpur, but what was published in other reports dealing with roughly contemporary contexts at Lakheen-Jo-Daro apparently pointed to the mid-third millennium B.C. (Mallah 2017; Shaikh and Ashfaque 1981; ul-Haq and Ali 2001).

A distribution map of some of the most important finds yielded by Trench C is provided in Figure 5c. During the cleaning of one of the profiles, a small anthropomorphic copper figurine (Fig. 5a) was accidentally discovered at the same depth of a charcoal lens ca. 25 cm to the left (west) of it (Fig. 5b). Their recovery locations suggest that all the items schematically shown in the distribution map can be considered contemporaneous. This fact is supported also by the horizontal trend of the overimposed anthropogenic levels that characterize the sequence of this part of the site (Fig. 4 top).

The ca. 3 cm thick *Acacia* charcoal lens was discovered at a depth of 30 cm, inside which two potsherds were found in a horizontal position during the cleaning of the northern profile of the trench (Fig. 5b). The charcoal bits were later sent for dating to the Groningen University Centre for Isotope Research (GrN-23123: 3960 ± 140 B.P.; 2881–2133 cal. B.C. 2σ [94.2%]: $\delta^{13}C$ −25.59). Although the standard deviation of the result is high, nevertheless the ordinary radiocarbon date attributes this part of the sequence to the Mature Indus Civilization, confirming the suggestion of the first excavators, which was based on the recovery of typical potsherds and other ceramic artifacts. The new radiocarbon result is important because it improves the very poor number of Bronze Age radiocarbon dates available from such an important region (Biagi et al. 2021; Shaffer 1991). It also contributes to the assessment of the absolute chronology of the local Bronze Age from which only three more or less comparable

Fig. 4. Lakheen-Jo-Daro Trench C: (top photo) sampling charcoal and soil samples from upper part of sequence of northern front; (bottom photo) location of Trench C along western slope of Mound D (January 1997) (photographs by P. Biagi).

results have been obtained. These include dates from layer 4 of the Kot Diji sequence (P-195: 3925 ± 134 B.P., from charcoal [Khan 2002:63]) and Rohri Hills chert mines RH-862 (GrA-3235: 3880 ± 70 B.P. from *Zyziphus nummularia* charcoal) and RH-59 (GrM-21237: 3999 ± 24 B.P. from a *Zootecus chione* land snail), though despite its good stratigraphic position, the latter result is disputable because of the material employed for dating (Biagi and Nisbet, 2021).[3]

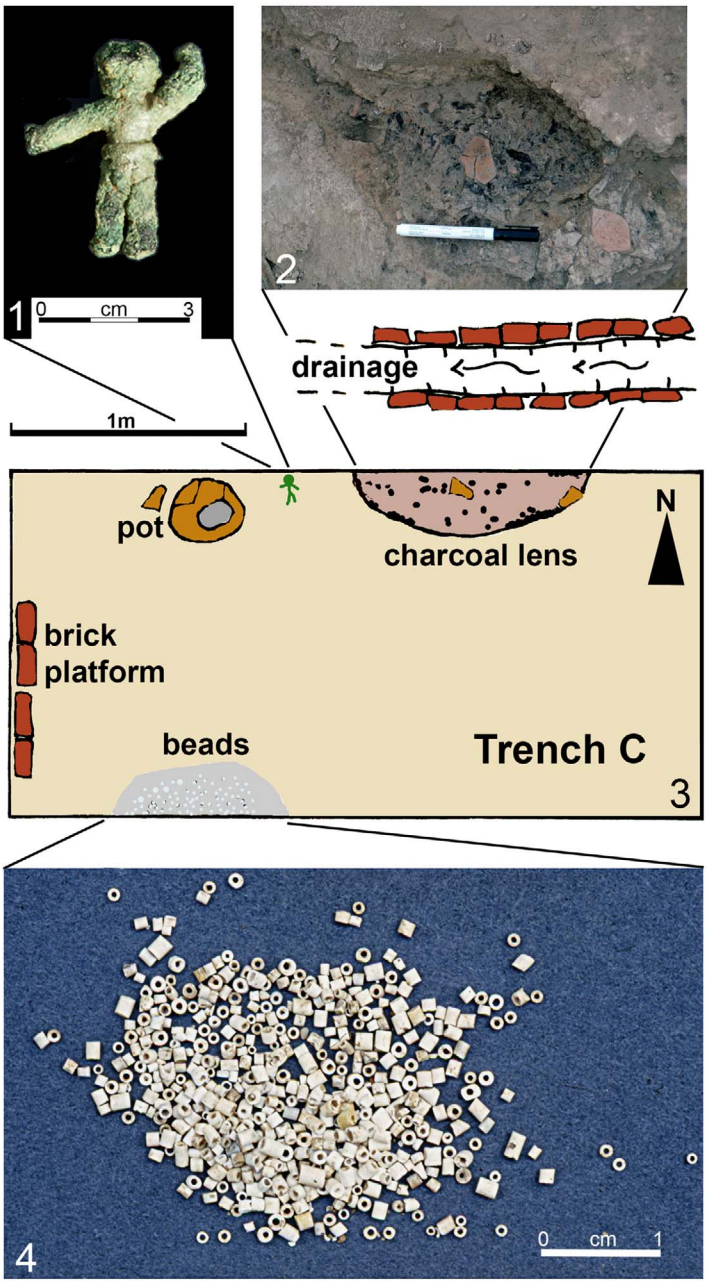

Fig. 5. Important finds retrieved from Mound D, Trench C at Lakheen-Jo-Daro: (1) figurine; (2) charcoal lens; (3) distribution of finds in Trench C; (4) paste micro-beads (photographs by M. Vidale; distribution map by E. Starnini).

CONSERVATION AND TREATMENT OF THE COPPER OBJECTS

At the end of October 1999, one of the current authors (Massimo Vidale) and restorer Cristina Passeri were employed with cleaning and conserving a group of small metal objects found by Shar in Trench C. The conservation of these objects was conducted in a room at the Shah Abdul Latif University, Khairpur where Passeri set up a small temporary lab furnished with a micromotor milling cutter, soft and hard brushes, chisels and lancets, glass fiber sticks, materials for chemical cleaning (EDTA, ionic exchange resins), basic chemicals such as alcohol, BTA, paraloid B72, and various types of adhesives.[4] Chemical cleaning was performed with applications of disodic EDTA and/or catodic resins. After cleaning, the objects were soaked for 30 m in BTA, in a 2% alcoholic solution, to inhibit further corrosion, and finally protected with paraloid B72 in a 3% solution.

Most copper objects were in very bad condition and some required urgent intervention. In general, they were covered with a thick layer of corrosion products, mainly copper chlorides mixed with silty sediment, with minor traces of oxides and carbonates. All the copper sheets described below had been mineralized and affected by layered corrosion processes, with the metallic core almost entirely changed into copper chloride. The surfaces of the copper sheets were partially cleaned in an effort to find technical features, decorations, or inscriptions.

Sediments and corrosion products forming solid, powdery lumps also coated groups of artifacts, concealing their original forms. These lumps were carefully excavated so that the artifacts could be individually cleaned. Unfortunately, in the pre-digital era of photography, we could not obtain satisfactory pictures of the lumps before treatment, and high resolution images of the cleaned objects are not available to us. Thus, documentation is based upon drawings made more than 20 years ago in the course of restoration.

Subsequent XRD tests carried out in Italy on the corrosion products detached while cleaning the copper items revealed strong peaks of paratacamite (copper chloride), followed by peaks of quartz, gypsum, and traces of micas from local sediments. The co-occurrence of chlorides and sulphates fully explains the unsatisfactory preservation of the copper objects.

Author Vidale describes all the copper objects and fragments recovered from Trench C below.

COPPER FIGURINE

Coming from a good stratigraphic context with an associated ordinary radiocarbon date from charcoals of the mid-third millennium cal. B.C. (GrN-23123), the anthropomorphic figurine shown in Figure 6 is one of the few artifacts of this type ever found in the Indus repertories. It is 4.4 cm high, 4.00 cm wide (from hand to hand), and about 0.7 cm thick (at the waist above the belt). At 1.25 cm long, the head is disproportionate to the total height of the body. The right arm is 0.58 cm thick, while the left one is 0.55 cm thick. The left leg is 0.7 cm thick at the knee, while at the same point on the right leg measures 0.6 cm. Both the legs and arms end in slightly projecting cylinder-like extremities rather than in natural-looking feet and hands.

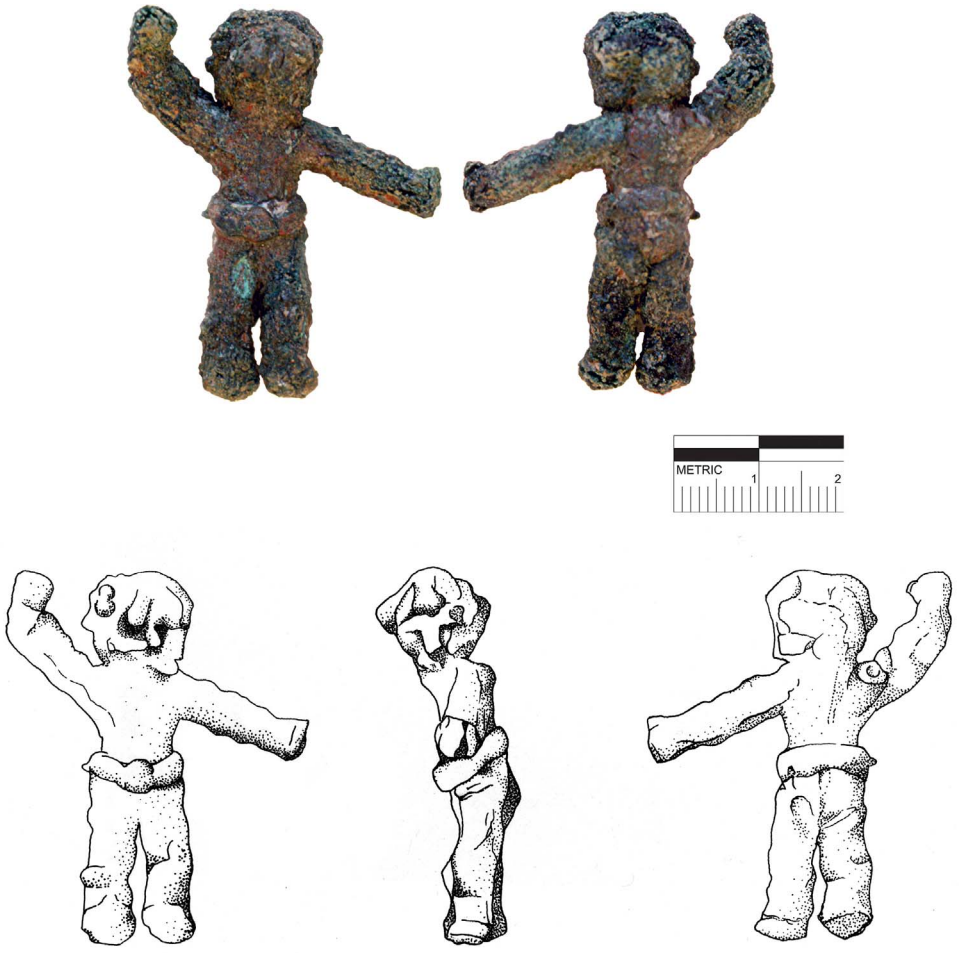

Fig. 6. Different views of copper anthropomorphic figurine found in Lakheen-Jo-Daro Mound D, Trench C (drawings and photographs by M. Vidale).

Damage in the form of cracks on the top of the head, right upper arm, and lower legs might have been caused by the exposure of the figurine to an accidental firing (or corrosion). The figurine was X-rayed in a medical shop in Khairpur Mirs (70–80 kV, 12 s). The X-ray plates (not illustrated) showed that a strong spongy corrosion was active at the extremities of the figurine, particularly on top of the upraised right arm, the right foot, and the head. The corroded sub-surface layer here may reach a thickness of 0.2–3 mm; it is a stable patina and should not be removed.

Several details suggest that the figurine was cast with a lost-wax process and was meant to be finished through a secondary finishing process that never occurred. First, the remnants of the filling of a casting canal - perhaps the only one used in this casting - are visible on the rear of the left shoulder. The canal was cut, but its residue was not filed down. Its setting and angle indicate that the figurine was probably cast in its standing position. Secondly, it is reasonable to assume that a secondary hot-forging process would have provided the figurine with hands and feet. Such forging would probably

have also lengthened the legs and the right arm, bringing the overall proportion between the head and total body length closer to a more reasonable ratio of 1/5 to 1/6, which would be more compatible with the elongated bodies of the few other known bronze Indus human figurines (Yule 1985*a*: tables 1, 2, 3, 6). Most copper human figurines feature a hair bun at the rear of the head, so it is also possible that the head looks larger and thicker than usual because this feature was badly cast or the bun was meant to be emphasized in subsequent forging.

The face is schematically suggested by a straight, flat nose and by the horizontal eye sockets. When one looks at the figurine from the front, the impression is that the image looks at the observer, but it actually looks to the left outstretched arm, as if aiming at a target. The person might wear a cap or some kind of head-dress, as suggested by some irregular folds. The folds are slightly deformed by corrosion, however, particularly on the temples and the front, so what they signify remains quite uncertain.

The figure is naked except for a belt enhanced by a round buckle or bead in low relief, a decorative element not uncommon in female terracotta figurines (Clark 2009, 2018). Despite the lack of genitalia, it is likely a male image.[5] The left arm is outstretched downward in front of the figurine, while the right one is lifted up to the height of the head, as though ready to strike. One notices the ill-proportioned length of the forearm, when compared with the rest. The body is slightly curved, with the left leg bent and projecting onward, while the right one, at rear, seems to balance the body's weight. Although the legs seem short and somehow clumsy, on the whole the posture is naturalistic and well-rendered; it very effectively suggests the bodily tension of a person in the act of throwing a spear.

The iconography of violence or aggression is scanty but not absent for the Indus Valley Civilization. For example, in a famous cylinder seal found at Kalibangan (India), two warriors rise long raised spears over a woman in front of a mythical composite creature (Joshi and Parpola 1987:311, K-65). Also, a miniature terracotta tablet found at Harappa depicts an individual spearing a water buffalo while pressing its head down with his foot in front of another figure in a yogic position (Kenoyer 1998:114, fig. 6.24). The copper figurine found at Lakheen-Jo-Daro is also comparable to a fragmentary one found at Chanhu-Daro which has been interpreted as a "male spear-thrower or dancer" (Kenoyer 1998:136, fig. 7.26): the facial traits are similarly rendered and the head seems covered by some kind of head-dress. It can also be compared more generically with a third copper figurine found at Harappa in which the raised right arm suggests a similar attacking posture (Yule 1985*a*: tables 1, 6). If all three statuettes represent the same character being shown in a recurring posture, they may be depicting an important person, perhaps an armed hero or deity; this might also explain the use of copper rather than a less prestigious material. Unfortunately, the weapon the person might have originally held have never been preserved, so we cannot confirm that the figurines represent a male person actually holding a spear, and dancing, for the moment, cannot be ruled out.

OTHER COPPER ALLOY OBJECTS

Tubes and Tube Fragments

The copper tubes and tube fragments described below are shown in Figure 7.

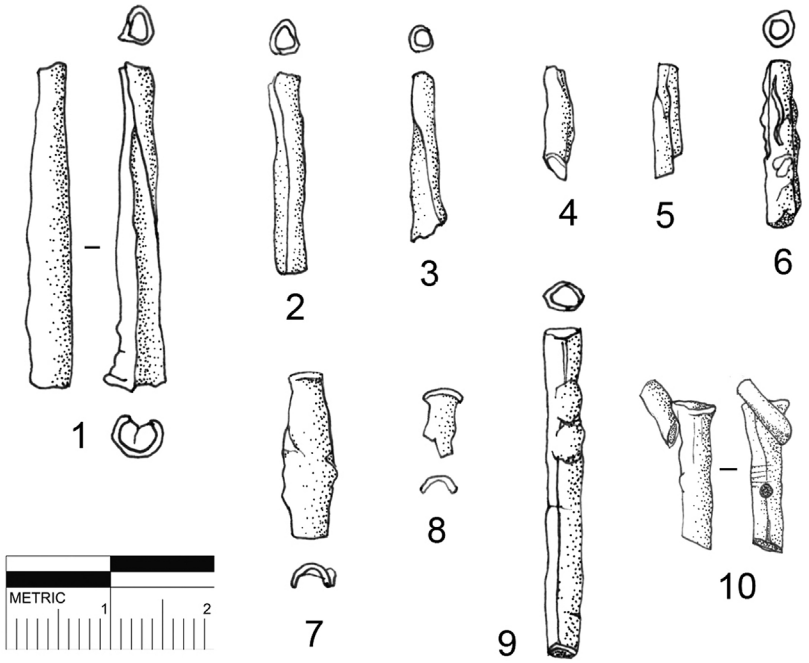

Fig. 7. Lakheen-Jo-Daro Mound D, Trench C copper hoard objects 1–10: micro-tubes and tube fragments (drawings by M. Vidale).

1. A complete tube, slightly tapering, made with a rolled copper sheet. The edges, in the present state of the object, do not overlap. It measures 3.18 cm in length. The largest end has diameters of 0.32–0.38 cm, while the opposed one measures 0.35–0.43 cm.
2. A well preserved, complete cylindrical tube, made by rolling a very thin rectangular copper sheet and superimposing it onto itself along the edge. It is 1.98 cm long; one extremity measures 0.31–0.36 cm, while the opposed end measures 0.29–0.32 cm.
3. Part of a broken tube. The surviving part is 1.58 cm long and has a more evident spirally end. While one of the ends is flat (0.42 cm), the other has a surviving diameter of 0.24–0.30 cm.
4. A median fragment of a very corroded tiny copper tube (1.11 × 0.29 cm). The edges join without overlapping.
5. Another median (?) fragment of a tiny tube (1.20 × 0.31 cm), possibly belonging to the same specimen as object 4.
6. This tube is 1.62 cm long. The minimum diameter is 0.20–0.23 cm on top, while the maximum diameter at the opposite end is 0.26–0.32 cm. The tube was made by rolling an extremely thin sheet onto itself at least 3 times. In spite of heavy corrosion, it looks almost complete.
7. A larger lump of oxides and sediments included not less than six tube fragments. The best preserved one, object 7, measured 1.56 (original length) × 0.49 (maximum diameter), and had a slightly convex profile. The other fragments in this group measured 0.65–1.00 cm in length and 0.65–0.70 cm in diameter.
8. Another tiny tube fragment from the same corroded mass as object 7 was 0.65 cm in length. The diameter is unknown, but the fragment retained a distinctive everted margin.
9. A (probably) complete cylindrical tube, rolled spirally, 3.18 cm long; the diameter was 0.28–0.36 cm at one extremity and 0.24–0.32 cm at the opposite end.
10. Two tiny tubes fragments were soldered together by corrosion. Tube 10 is broken, but the surviving part is 1.85 long. One end is intact, with a tapered flaring mouth. Here the edge has a diameter of 0.55 cm, while below the rim it measures 0.38 cm. The rolled sheet

joins with a partial overlap. A series of tiny, regular stripes or wear lines run across the join, apparently formed while the tube was finished by rotation, or perhaps while using it for an unknown function. A second tube, on top of the first, is a tiny median section, 0.94 in length by 0.25 in diameter.

Tablets, Bar-Like Objects, and Sheets

Figure 8 shows a variety of tablets, bar-like objects, and sheets.

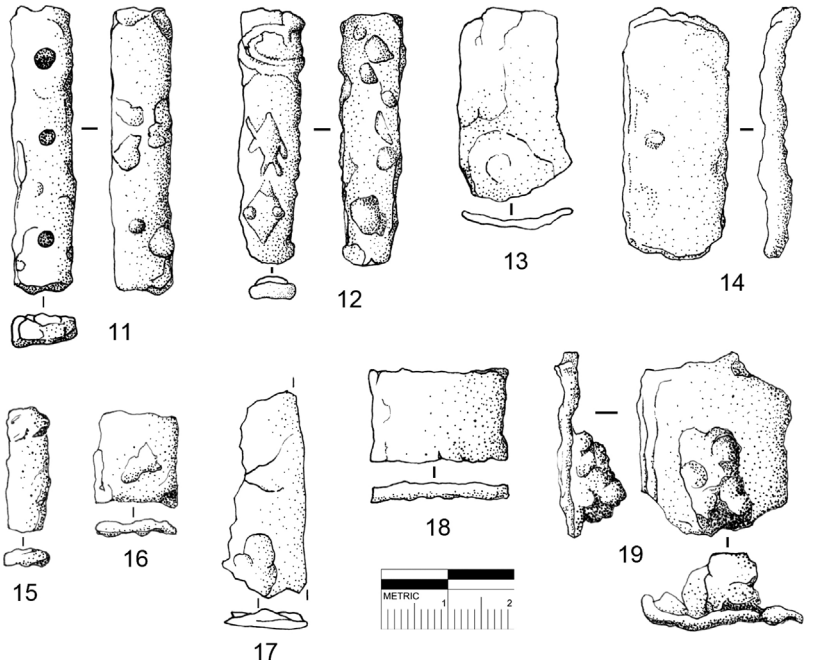

Fig. 8. Lakheen-Jo-Daro Mound D, Trench C copper hoard objects 11–19: sub-rectangular "tablets" and sheets (drawings by M. Vidale).

11. A long rectangular bar, 5.50 × 4.23 × 1.02 cm. Very corroded on surface, it probably retained a solid copper core. Cleaning revealed three holes at regular distances on one face, but not on the opposed one (maybe because of the corrosion). This peculiar form suggests that it might have been a spacer for a multiple-string necklace (similar to specimens illustrated in Marshall 1931:517–518, plate 147, nos. 1–20).
12. An elongated rectangular "tablet" (4.07 × 1.02 × 0.73 cm) bears on one side three Indus signs in relief. Only two of them are identifiable: a lozenge with round dots at the wider corner (apparently a variant of sign M-874/M-1126 seen in Parpola 1994:77–78, fig. 5.1 and discussed in Koskenniemi et al. 1973: xxii); and a variant of the fish sign (seen in Parpola 1994:71, fig. 5.1 and identified with sign 67 in Koskenniemi et al. 1973: xxvi).
13. A sub-rectangular sheet (2.83 × 1.55 × 0.27 cm), damaged at the edges, deeply corroded and completely mineralized. The section is slightly curved.
14. A rectangular tablet-like artifact measuring 3.86 × 1.69 × 0.34 cm. All surfaces are original and the object is unbroken. The profile of the sheet is slightly S-shaped; the short sides appear slightly rounded. A strong corrosion, with abundant flourishing of chlorides, prevents clear observation of the main surfaces.
15. A complete rectangular strip (1.88 × 0.77 × 0.33 cm).

16. A square sheet (1.46 × 12.9 × 0.16 cm). Its bent edges suggest that this sheet had been detached through a sequential bending and snapping process.
17. Fragment of the round edge of a thin sheet (3.07 × 1.32 × 0.18 cm), probably the cutting edge of a blade or (less likely) mirror.
18. A complete rectangular sheet or "tablet" (2.09 × 1.47 × 2.36). The short sides are slightly concave, and the inner corrosion is layered. Despite careful cleaning, the surface did not reveal any features.
19. A subrectangular sheet measuring 2.60 × 2.22 × 2.02 cm. On the rear one sees a heavily corroded mass. It was not possible to ascertain if this feature was originally soldered or mechanically joined to the sheet or it was attached to its surface by corrosion. According to Passeri, it could have been belonged to a tiny chain.

Folded Sheets

Figure 9 presents examples of folded sheets.

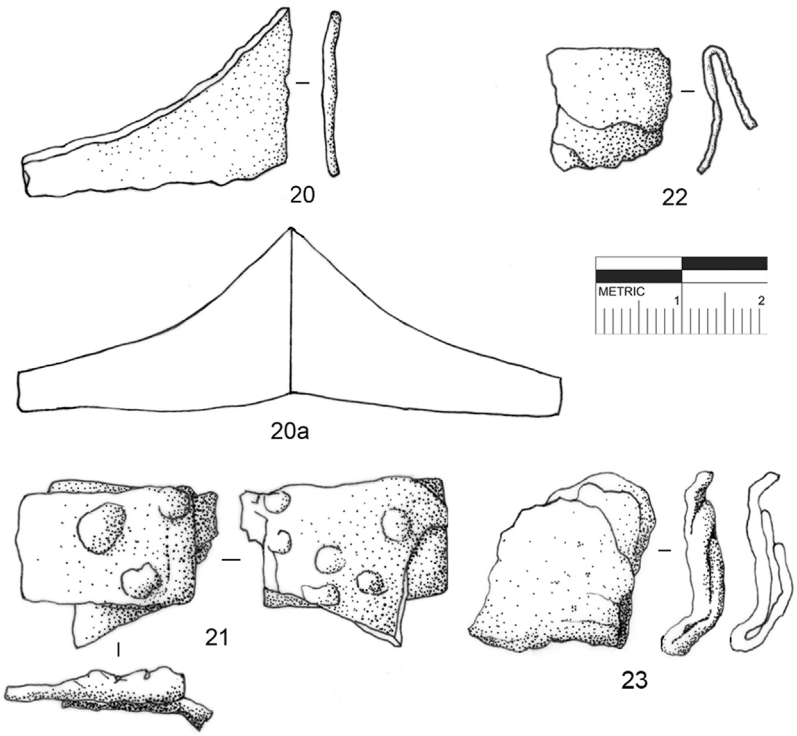

Fig. 9. Lakheen-Jo-Daro Mound D, Trench C copper hoard objects 20–23: hammered folded sheets (drawings by M. Vidale).

20. A subtriangular sheet (3.77 × 2.12 × 0.39 cm) made by two sheets with the same precisely matching form, folded one onto the other. The form of the original piece, before being beaten onto itself, is reconstructed in Fig. 9-20a. It is probably a residue of the cutting of a double bent sheet to manufacture two identical sheets with curved sides. Corrosion hides the details of the edges, which, in a different context, would suggest cutting by some kind of scissors. Though invisible on the surface, evidence of decorative elements were detected within the stable patina of copper carbonates after it was cleaned.

21. Two views of a sub-rectangular copper sheet beaten and folded onto itself, after which it measures 2.26 × 1.56 × 0.22 cm.
22. A fragmentary thin folded sheet. The pieces measure 1.40 × 13.2 × 0.15 cm.
23. Two or three copper sheets heavily hammered one onto the other to produce an S-shaped profile. The resulting object measures 2.03 × 1.70 × 0.5 cm. If the three folded parts belonged to a single original sheet, it would have measured about 5 × 1.5–2 cm.

Broken Objects Soldered by Corrosion

Figure 10 depicts broken objects that were soldered together by corrosion.

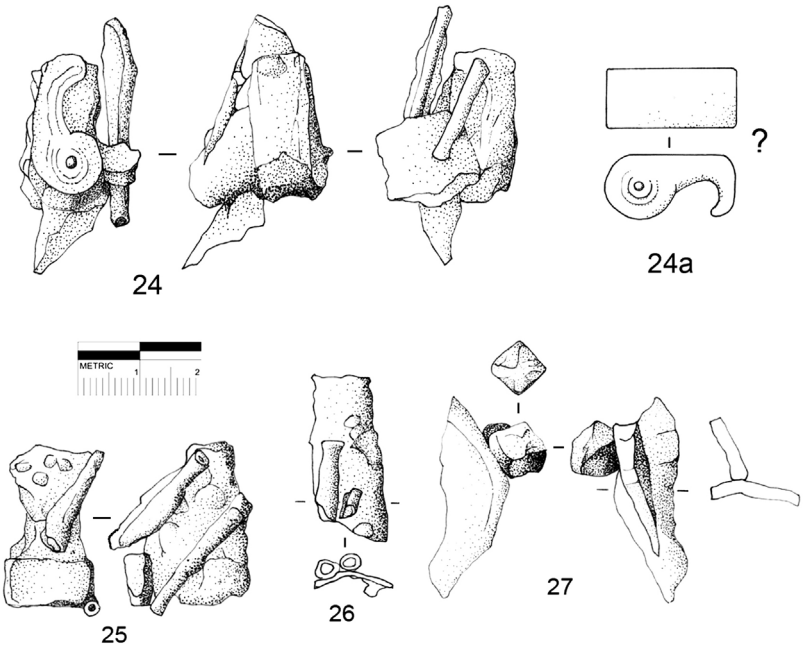

Fig. 10. Lakheen-Jo-Daro Mound D, Trench C copper hoard objects 24–27: lumps of objects soldered together by corrosion, including a possible hook (24a), tubes (25, 26), and a cube (27) (drawings by M. Vidale).

24. Before cleaning, the objects in this group appeared as a compact lump of copper oxides and tiny copper fragments. Careful cleaning brought to light not fewer than 5 different small clustered objects joined together by corrosion during burial.
The most prominent (2.20 × 1.00 × 1.05 cm) piece is a hook-like object (Fig. 10-24a), recognizable mainly from the side view. It has a thick cylindrical element, with a central projection surrounded by concentric lines and an attached lateral hook-like projection. It is uncertain if the object is a single artifact, but it does bear some similarity to a couple of hook-like copper "latches" or "catches for dentate wheels" found at Harappa by Vats (1940:56, 391, plate 122, nos. 28, 33). The strong corrosion does not help, and the reconstruction in our drawing is partly conjectural.
Attached to the possible hook, one sees a shapeless elongated copper sheet (3.05 × 1.04 × 0.26 cm) and a semi-cylindrical sheet measuring 1.25 × 1.48 × 0.30 cm. A tiny tube, broken at both ends, was also extracted from the powdery mass. One of the ends is slightly constricted. It is 1.65 cm long; the only measurable diameter is 0.3 cm.

A second less preserved copper tube was soldered to the rest, along with a flake of brown chert completely covered by corrosion products.

25. This was another lump or cluster of strongly corroded, small copper items or fragments, including tubes, sheet fragments, and other unidentified objects.

The main object, around which the others were attached by corrosion, looks like an irregular parallelepiped (2.66 × 1.50 × 1.15 cm), distinguished by its irregular and very porous surfaces.

It was joined to an elongated irregular sheet fragment in which corrosion had opened an inner cavity measuring 2.03 × 0.65 × 0.27 cm.

A complete small tablet-shaped object measuring 1.58 × 1.02 × 0.57 cm is in better condition.

There is also a very corroded tiny tube. It has a flattened extremity 2.41 cm long and 0.49 cm wide. The diameter of the other end is 0.27 cm and the inner diameter is 0.168 cm.

26. Fragments of two tubes were joined by corrosion onto the curved surface of a fragment of a cylinder-like artifact. The first tube fragment measures 1.31 × 0.28–0.35 cm; the diameter of the second is 0.29 cm.

27. Another group formed by the soldering in burial of three different small objects or fragments.

The largest (3.5 × 1.00 × 0.27 cm) piece is the broken edge of a flat curved object, apparently having a slightly raised edge.

The second object is a much smaller but complete cube-like item (0.94 × 0.83 × 0.62 cm), the purpose of which is unidentified. The lines of impact and compression visible on the surface of the cube indicate that it was hammered into its final shape on an anvil.

The third fragment (2 × 0.54 × 0.36 cm) is also unidentified, but is perhaps the point of a bar-shaped object having a flat rectangular section.

Other Copper Objects

Figure 11 presents other copper objects retrieved from Trench C.

28. A thick pin, or more probably a chisel-like tool (?), perhaps unfinished, measuring 8.30 × 0.90 cm. The section is round but becomes oval where the object gets thicker and has cracked; this suggests an incipient stage of forging.

29. A cylindrical object with expanded ends (1.99 × 0.40 cm), slightly bent. It could be a rivet or even a fragment of casting canal cut from a cast.

30. A broken tang of a knife or dagger (1.99 × 0.95 × 0.54 cm), having a square section.

31 and 32. After cleaning, we obtained two enigmatic, very corroded copper half-cylinders (Fig. 11-31, 32). Both bear incomplete conical holes. Although they appear very similar, the two pieces do not fit together. Both have slightly raised edges on both ends, showing that in the sense of the length (the axis of perforation) they are complete.

Object 31 is 1.47 in length, and 1.58 cm in maximum diameter. The cone-shaped hole measures 0.67 cm on top and 0.37 cm at the bottom. It could have been drilled after casting, but corrosion hides the relevant details. The outer surface shows two poorly preserved festoon-like features in relief. The pattern or motif is badly preserved and cannot be further commented upon.

Object 32 measures 1.36 cm in length, 1.47 cm in maximum diameter and is very similar to the first half-cylinder. Its incomplete central cone-shaped hole measures 0.40 cm on top and 0.29 cm at the bottom. The outer surface shows festoon-like features similar to those of 31, but here too the damage is extensive.

Broadly speaking, the outer features in relief remind us of inscribed cast copper tablets found at Harappa, but the cylinder-like shape and the central hole cannot be explained. The function of these enigmatic finds remains unknown and we do not know of other specimens of the same type.

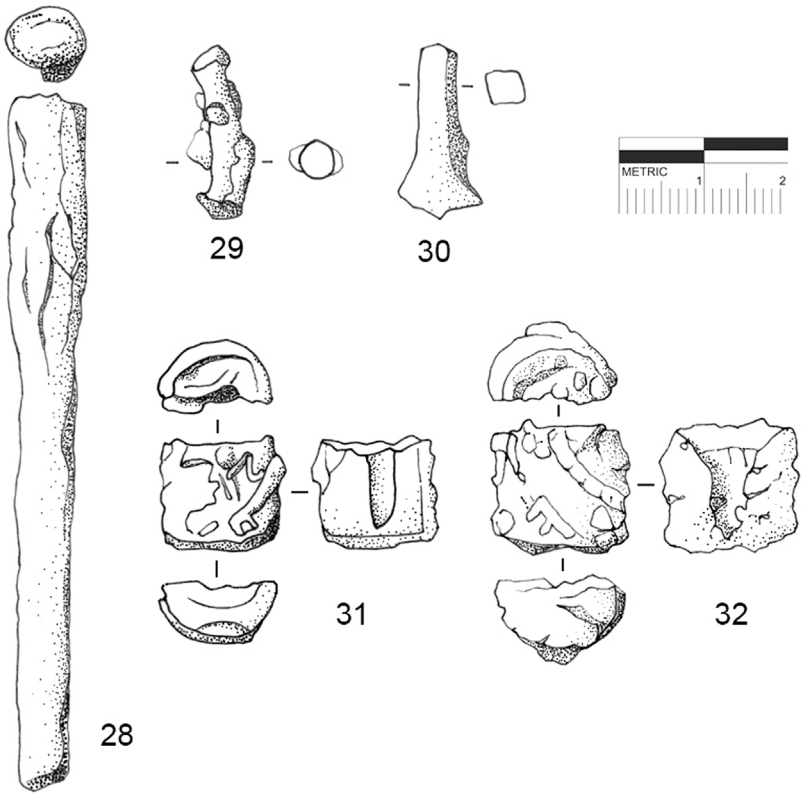

Fig. 11. Lakheen-Jo-Daro Mound D, Trench C copper hoard objects 28–32: pin or chisel (28); possible rivet or piece of casting canal (29); broken tang (30); two fragments of cylindrical (?) objects with spiral-like features in relief (31, 32) (drawings by M. Vidale).

PRELIMINARY CHEMICAL ANALYSIS OF THE COPPER ALLOYS

A series of tiny corroded flakes and powdery fragments that became detached during cleaning and could not be refitted back to the original artifacts were analyzed at the Istituto Centrale per il Restauro (ICR), Rome by means of Energy Dispersive X-Ray Fluorescence (EDXRF). The residues were too small and had no preserved metallic core, therefore were not suitable for quantitative or metallographic analysis. Copper objects 14 and 18 were analyzed twice, from two different points in the sample, in order to double-check the test. The qualitative elemental identifications reported in Table 1 certainly do not provide the reliable chemical composition of the alloys. The utility of EDXRF only relies on the presence-absence of main elements, with the understanding that corrosion and segregation processes may have deeply affected such preliminary analytical values.

Despite the partial analytical value of the test and the heterogeneity of the assemblage, the composition alloy seems to be quite consistent across the samples. Tin seems to be absent, but the copper is regularly alloyed with minor amounts of lead and arsenic. This is one of the most common alloying patterns of Indus copper-based metalworking (Hoffman 2018: table 2; Kenoyer and Miller 1999).

TABLE 1. RESULTS OF EDXRF TESTS OF CORRODED COPPER FRAGMENTS FROM ARTIFACTS FOUND IN LAKHEEN-JO-DARO MOUND D, TRENCH C

SAMPLE NUMBER	OBJECT NUMBER	TYPE	ELEMENT[a]			
			Cu	Pb	As	Ag
1	14	Rectangular tablet	+ +	+	(tr.)	–
2	14	Rectangular tablet	+ +	+	+	–
3	18	Rectangular tablet	+ +	(tr.)	–	–
4	18	Rectangular tablet	+ +	(tr.)	–	–
5	23	Sheet	+ +	+	+	(tr.)
6	20	Double cut sheet	+ +	+	(tr.)	–
7	4	Tube	+ +	(tr.)	–	–
8	–	Undetermined	+ +	+	+	–
9	–	Undetermined	+ +	+	+	–
10	–	Undetermined	+ +	+	+	–
11	–	Undetermined	+ +	+	(tr.)	–

[a] Key: ++ = main peak; + = secondary peak; (tr.) = traces; elements such as Fe, Sr, Rb, Ca that were present in the samples as soil contaminants not included.

FRAGMENTS OF A POSSIBLE IVORY SCALE

Together with the artifacts so far described, the excavation brought to light two fragments of what looks like a well-crafted ivory measuring rod; it has been burned and partially warped by fire, which turned it dark grey to black in color (Shar 2000–2001) (Fig. 12). Although the two fragments do not fit back together and were altered in different ways, they probably belonged to the same scale. They retain the original thickness (ca. 0.63 cm), but, having been casually broken, are not the same width or length. The size and proportions of the two fragments may have been altered by firing.

The intervals on the main surface, cut with a thin blade (ca. 0.20 mm thick) are well preserved and clearly measurable with the aid of a magnifying lens and digital caliper. From the median line of each preserved groove, the reliable distances were measured in cm (Table 2). Given the damage, these recorded values remain questionable, and more advanced digital approaches to the same measurements would be commendable. Nonetheless, the intervals appear rather uniform. With an average of 0.854 cm they precisely match the 0.17 cm intervals reported for the Lothal specimen, multiplied by 5. Rao (1979:626–627) describes the Lothal and related Indus scales as follows:

> The average distance of each division is 1.7 mm. It is noteworthy that 20 such divisions are approximately equal to the distance between two circles in the Mohenjo-daro scale, i.e. 33.46. The sixth and twenty first lines are marked longer than others and it is, therefore, highly probable that the scale was divided decimally. The first ten divisions give a distance of 17.5 mm and if the mean error is added, it comes to 17.7 mm. The unit of 177 mm is almost equal to the aigula referred to in the Arthashastra which Raju and Mainkar have equated to 17.86 mm.[6]

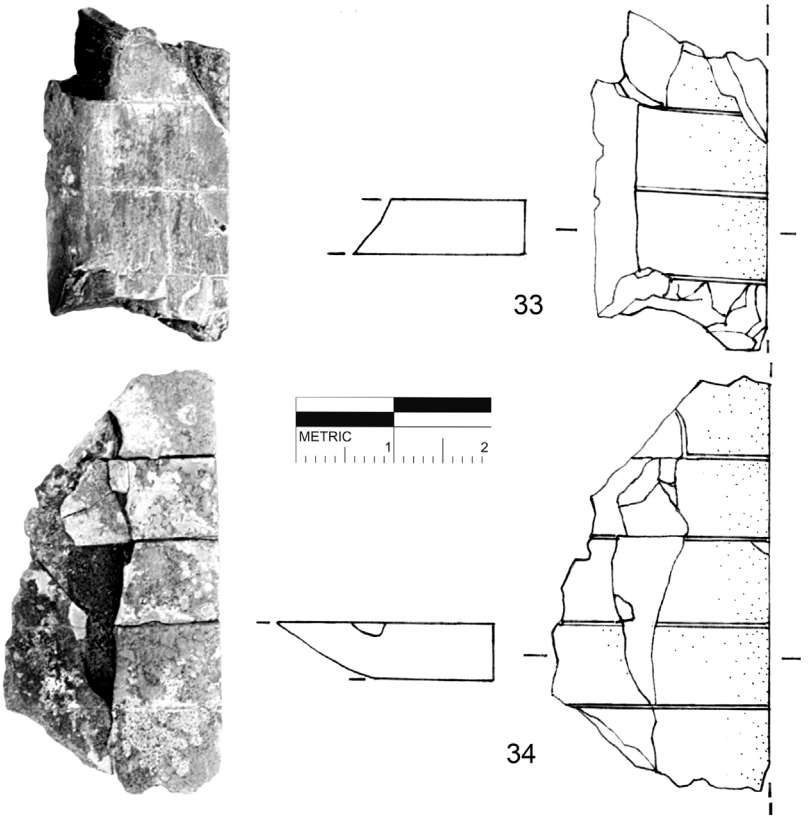

Fig. 12. Lakheen-Jo-Daro Mound D, Trench C objects 33–34: two fragments of ivory with parallel incisions on surface suggesting a possible scale (drawings and photographs by M. Vidale).

Table 2. Intervals between Lines Cut into Two Burnt Ivory Fragments Possibly Representing a Measuring Scale, Found in Lakheen-Jo-Daro Mound D, Trench C

object number	minimum (cm)	maximum (cm)	
33	0.855	0.858	
33	0.841	0.866	
34	0.857	0.857	
34	0.818	0.843	
34	0.856	0.862	
34	0.864	0.874	
34	0.853	0.853	
Average	**0.849**	**0.859**	**0.854**

The presence of a possible measuring tool in a specialized craft context at Lakheen-Jo-Daro adds to the picture of highly organized control of specific industries often linked to the Indus Civilization. However, how and how far such a standard scale would be used in a metallurgical workshop (as in this unique case) remains unexplained. In principle, length measurements might have been required for rods and

bars of regular volume or for the diameters of circular items such as pots, scale pans, or plano-convex ingots, or possibly even for crucibles.

A COMMENT ON THE ASSEMBLAGE

On the whole, the small collection of copper alloy objects seems to belong to a small scrap hoard. Presumably, the copper objects were originally gathered within a small bag-like container that was subsequently lost on the floor during a destructive event. After burial, the scraps within the bag were altered by corrosion adhering one to the other; this retained them in their relative positions brought on by the original loss event.

Some of the sheets had been folded, superimposed, and hammered onto themselves (objects 20–23 seen in Fig. 9). One of these artifacts is interpreted as the residue of the cutting of two superimposed sheets to obtain as many pieces as possible with the same geometrical shape (Fig. 9-20). Object 29 might be the filling of a casting canal ready to be re-melted (Fig. 11-29). Both object 28, a possible craft tool (Fig. 11-28) and the figurine (Fig. 6) appear unfinished. This evidence strongly suggest that Trench C excavated at Lakheen-jo-Daro cut through the floor of a metallurgical workshop where various scraps to be recycled were kept.

Leaving aside the figurine, this small assemblage was composed of sheets and sheet fragments (constituting a little more than a third of the total), roughly the same number of several tubes that had turned into small crumbles, and a few other heterogeneous artifacts. The tubes were the most common type of object. Some tubes had flattened extremities and were kept together with the sheets and the other artifacts.

However, such modifications do not necessarily imply that the tubes were kept there waiting to be re-melted. Ranging in size from about 1.60 to 3.20 cm, with diameters from 0.30 to 0.60 cm, the Lakheen-Jo-Daro tubes are slightly conical; the unbroken specimens always show a larger end, sometimes provided with a trumpet-like flaring edge, and a more restricted opposed end.

A series of similar tubular tools, comparable in size but provided with points or tiny tubular extremities, where they were also enfolded with copper rings or shorter tubes, were found at Chanhu-Daro in rooms and contexts containing large amounts of small "steatite" beads. These rooms were interpreted as belonging to a "bead factory" (Mackay 1943:186–187, plate 80, nos. 1–8, and plate 93, nos. 12–13). In the opinion of Mackay and W. Y. Young of the Museum of Fine Arts, Boston, such tubes might have been the terminals of a device forcing by extrusion a steatite powder paste ". . . in much the same way that confectioners today force frosting through tubes to ornament cakes" (Mackay 1943:187). Talc or steatite artificial pastes are normally recognized as base material for a wide variety of Indus beads.

Few scholars have made a similar interpretation of these tubular tools, with the exception of Indian colleagues who describe the use of a talc paste extrusion process for the manufacture of Indus micro-beads (Hegde 1982; Hegde et al. 1993). In the case of Lakheen-Jo-Daro, as at Chanhu-Daro (as far as we know, the only other site where groups of these presumed tools have been found), the tubes come from a possible workshop where large amounts of white microbeads have also been found; we noticed that at least one of the copper tubes bore fine parallel rotational wear traces compatible with the hypothesis of the insertion of the tube in a larger one (Fig. 8-14). However, the possibility that these tubes were used for the extrusion of steatite pastes so far

remains highly hypothetical. The tubes were checked and no residues of white powders were observed within them. A simpler hypothesis is that these tubes functioned as tubular drills on stone or other materials.

CONCLUSIONS

Many settlements attributable to the Indus Civilization are known around Sukkur in Upper Sindh, though only a few of them have been recorded and excavated and even fewer have been dated. This lack of research interest in the region greatly contrasts with new research strategies put forward in neighboring regions of South Asia (e.g., Green et al. 2019). Fragmentary evidence nevertheless confirms once again that Lakheen-Jo-Daro was a very important Bronze Age settlement of the Upper Sindh and that it was deeply involved in craft production.

Despite the richness of the complex architectural and characteristic material culture remains, the wider trenches opened during the excavations at Lakheen-Jo-Daro over the last two decades have not yielded any other unusual finds (Mallah 2017; Shaikh et al. 2004–2005). The lucky discovery made in Trench C of a scrap hoard of copper items, a complete copper anthropomorphic figurine, and other important ornamental and functional artifacts within a radiocarbon-dated context fills in some gaps in our knowledge of Mature Indus technologies. As Hoffman and Miller (2009:248) remarked:

> Patterns of alloying are likely obscured..because the Indus metalsmiths used alloying for a variety of purposes—functional, aesthetic, ritual, and/or simply expedient..[and] by sampling and excavation problems, as well as the prevalence of Indus recycling, as seen in the numerous caches of metal objects and scraps recovered from all of the major sites.

The discovery at Lakheen-Jo-Daro demands renewed attention on the batches of scraps stored and prepared for re-melting at other old and new sites, and the need for proper chemical studies of their alloys, no matter how small or formally meaningless the objects might appear.

The finds also suggest a question about the sets of tiny copper tubes, similar to those found at Chanhu-Daro, and their hypothesized use in the steatite bead and microbead manufacturing industries. This aspect of the Trench C assemblage (Law 2018; Miller 2008) is even more relevant in light of the very abundant steatite disk bead waste recovered from the same site (Mallah 2017).

The discoveries made at Lakheen-Jo-Daro thus contribute to the study of some important aspects of the Indus Civilization in the region covered by the so-called Greater Indus Valley (Mughal 1973:39). Recent excavations at Lakheen-jo-Daro and Chanhu-Daro, both in the course of being published, will provide us with new important insights into craft development and socio-economic organization during the beginning of the Mature Indus period.

ACKNOWLEDGMENTS

This article was written thanks to a grant from the Italian Ministry of Foreign Affairs (MAECI). Many thanks are also due to Dennys Frenez for his comments and improvements to the text and to Cristina Passeri for information on the conservation of the copper objects.

NOTES

1. For the protohistoric development of Eurasian metallurgy in a wider framework, see the recent synthesis by Mille (2017).
2. During that time, the site was also visited by then Italian Ambassador to Pakistan, His Excellence Dr. E. G. de Maio, who took action to try to save the site from destruction.
3. The chronology of the Indus Civilization in the Indus Valley has not improved much over the last thirty years. Most of the available results are obsolete and disputable (Kenoyer 1991*a*:43, 1991*b*:337–338; Possehl 1989). The only exceptions are new radiocarbon dates obtained from mangrove and marine shell specimens selected from shell middens and other coastal sites discovered along the Arabian Sea coast of Lower Sindh and southeastern Las Bela (Biagi et al. 2018; Biagi et al. 2021) and a few sequences excavated in north India and the Gujarat (Sarkar et al. 2020; Sharma and Pokharia 2020).
4. Local students were informed about the basic principles of archaeological conservation at that occasion.
5. "The presence or absence of sex attributes on the figurines may also reflect the influence of other aspects of social difference such as life cycle, status, occupation, and ethnicity, as sex and gender may not have been the primary concern" (Clark 2003:321).
6. For a general discussion of systems of linear measurement used in Indus cities, see Danino (2014).

REFERENCES CITED

Agrawal, Dharmapal

1984 Metal technology of the Harappans, in *Frontiers of the Indus Civilization*: 163–167, ed. Braj Basi Lal and Swaraj Prakash Gupta. New Delhi: Books and Books.

2000 *Ancient Metal Technology and Archaeology of South Asia: (Pan Asian Perspective)*. New Delhi: Aryan Books International.

Allchin, Bridget

1976 Palaeolithic sites in the plains of Sind and their geographical implications. *Geographical Journal* 142(3):471–489.

1979 Stone blade industries of early settlements in Sind as indicators of geographical and socioeconomic change, in *South Asian Archaeology 1977*: 173–211, ed. Maurizio Taddei. Istituto Universitario Orientale Seminario di Studi Asiatici, Series Minor 6. Naples: Istituto Grafico Italiano.

Biagi, Paolo

2007 The archaeological sites of the Rohri Hills (Sindh, Pakistan): The way they are being destroyed. *Sindhological Studies* 23(1–2):5–26.

Biagi, Paolo, and Mauro Cremaschi

1988 The early Palaeolithic sites of the Rohri Hills (Sind-Pakistan) and their environmental significance. *World Archaeology* 19(3):421–433, DOI: 10.1080/00438243.1988.9980049.

1990 Geoarchaeological investigations on the Rohri Hills (Sind, Pakistan), in *South Asian Archaeology* 1987: 31–42, ed. Maurizio Taddei. Rome: Istituto Italiano per il Medio ed Estremo Oriente.

Biagi, Paolo, and Renato Nisbet

2021 Mining knappable stone resources during the Bronze Age: Some examples from the Caucasus (Georgia) and Sindh (Pakistan). *Journal of Lithic Studies* 8(2):1–26.

Biagi, Paolo, Renato Nisbet, and Tiziano Fantuzzi

2018 Mangroves: Environmental changes and human impact along the northern coast of the Arabian Sea (Pakistan) from the beginning of the Holocene to the present. *Archäologische Mitteilungen aus Iran und Turan* 46:1–32.

Biagi, Paolo, Renato Nisbet, Michela Spataro, and Elisabetta Starnini

2021 Archaeology at Ras Muari: Sonari, a Bronze Age fisher-gatherers settlement at the Hab River mouth (Karachi, Pakistan). *Antiquaries Journal* 101:16–66, DOI:10.1017/S0005381520000414.

Biagi, Paolo, Michela Spataro, and Renato Nisbet

2002 A Buddhist town at Seeraj in Upper Sindh (Khairpur, Pakistan): Historical, chronological, archaeometrical and archaeobotanical aspects. *Rivista di Archeologia* 26:16–29.

Blanford, William Thomas

1880 The geology of Western Sind, in *Memoirs of the Geological Survey of India*, vol. 17:1–210. Calcutta: Office of Superintendent of Government Printing.

Chakrabarti, Dilip Kumar, and Nayaniot Lahiri
1996 *Copper and its Alloys in India*. Delhi: Munshiram Manoharlal.

Clark, Sharri R.
2003 Representing the Indus body: Sex, gender, sexuality, and the anthropomorphic terracotta figurines from Harappa. *Asian Perspectives* 42(2):304–328.

2009 Material matters: Representation and materiality of the Harappan body. *Journal of Archaeological Method and Theory* 16:231–261.

2018 Revisiting the ornament styles of the Indus figurines: Evidence from Harappa, Pakistan, in *Walking with the Unicorn: Social Organization and Material Culture in Ancient South Asia*. Jonathan Mark Kenoyer Felicitation Volume: 120–148, ed. Dennys Frenez, Greg M. Jamison, Randall W. Law, MassimoVidale, and Richard H. Meadow. Oxford: Archaeopress.

Danino, Michel
2014 II.4.8., Metrology and linear measurements, in *History of Ancient India, vol. 2: Protohistoric Foundations*: 309–320, ed. Dilip K. Chakrabarti and Makkhan Lal. New Delhi: Aryan Books International.

Flam, Louis
1987 Recent explorations in Sind: Paleogeography, regional ecology, and prehistoric settlement patterns (ca. 4000–2000 B.C.), in *Studies in the Archaeology of India and Pakistan*: 65–80, ed. Jerome Jacobson. Warminster: Aris & Phillips.

1993 Fluvial geomorphology of the lower Indus Basin (Sindh, Pakistan) and the Indus Civilization, in *Himalaya to the Sea. Geology, Geomorphology, and the Quaternary*: 265–287, ed. John F. Shroder, Jr. London: Routledge.

1999 The prehistoric Indus system and the Indus Civilization in Sindh. *Man and Environment* 24(2):36–68.

Giosan, Liviu, Peter D. Clift, Mark G. Macklin, Dorian Q. Fuller, Stefan Constantinescu, Julie A. Durcanc, Thomas Steven, Geoff A. T. Duller, Ali R. Tabrez, Kavita Gangal, Ronojoy Adhikari, Anwar Alizai, Florin Filip, Sam VanLaningham, and James P. M. Syvitski
2012 Fluvial landscapes of the Harappan civilization. *PNAS* 109(26): E1688–E1694, DOI: 10.1073/pnas.1112743109/-/DCSupplemental.

Green, Adam S., Hector A. Orengo, Aftab Alam, Arnau Garcia-Molsosa, Lillian M. Green, Francesc Conesa, Amit Ranjan, Ravindra N. Singh, and Cameron A. Petrie
2019 Re-discovering ancient landscapes: Archaeological survey of mound features from historical maps in northwest India and implications for investigating the large-scale distribution of cultural heritage sites in South Asia. *Remote Sensing* 11(18):2089, DOI: 10.3390/rs11182089.

Hegde, Karunakara T. E.
1982 The art of the Harappan microbead. *Archaeology* 68:69–72.

1991 *An Introduction to Ancient Indian Metallurgy*. Bangalore: Geological Society of India.

Hegde, Karunakara T. E., Vishwanatha Karanth, and Southanou P. Sychanthavong
1993 On the composition and technology of Harappan micro-beads, in *Harappan Civilization*: 239–244, ed. Gregory L. Possehl. New Delhi: Oxford & IBH Publishers.

Hoffman, Brett C.
2018 Indus copper and bronze: Traditional perspectives and new interpretations, in *Walking with the Unicorn. Social Organization and Material Culture in Ancient South Asia*. Jonathan Mark Kenoyer Felicitation Volume: 251–264, ed. Dennys Frenez, Greg M. Jamison, Randall W. Law, Massimo Vidale, and Richard H. Meadow. Oxford: Archeopress.

Hoffman, Brett C., and Heather Margaret-Louise Miller
2009 Production and consumption of copper-base metals in the Indus Civilization. *Journal of World Prehistory* 22(3):237–264, DOI: 10.1007/s10963-009-9024-4.

Hughes A. W.
1876 *Gazetteer of the Province of Sind* (2nd ed.). London: George Bell and Sons.

Jansen, Michael
1991 Mohenjo-Daro—A city on the Indus, in *Forgotten Cities on the Indus. Early Civilization in Pakistan from the 8th to the 2nd Millennium BC*: 145–166, ed. Michael Jansen, Máire Mulloy, and Günter Urban. Mainz: Phillip von Zabern.

Jorgensen, David W., Michael D. Harvey, Stanley A. Schumm, and Louis Flam
1993 Morphology and dynamics of the Indus River: Implications for the Mohen Jo Daro site, in *Himalaya to the Sea. Geology, Geomorphology, and the Quaternary*: 288–326, ed. John F. Shroder. London and New York: Routledge.

Joshi, Jagat Pati, and Asko Parpola
1987 *Corpus of Indus seals and inscriptions: 1. Collections in India*. Annales Academiae Scientiaram Fennicae, Ser. B 239; Memoirs of the Archaeological Survey of India 86. Helsinki: Suomalainen Tiedeakatemia.

Kalichbeg Fredunbeg, Mirza (translator)
1900 *The Chachnamah: An Ancient History of Sind, Giving the Hindu Period down to the Arab Conquest*. Karachi: Commissioners Press.

Kazi, Asadullah
2014 A review of the assessment and mitigation of floods in Sindh, Pakistan. *Natural Hazards* 70:836–864, DOI: 10.1007/s11069-013-0850-4.

Kazi, Mohammed Mukhtiar
1989 Lakhueen-Jo-Daro. *Journal of Central Asia* 12(1):89–106.

Kenoyer, Jonathan Mark
1991*a* Urban process in the Indus tradition: A preliminary model from Harappa, in *Harappa Excavations* 1986–1990: 29–60, ed. Richard H. Meadow. Madison: Prehistory Press.

1991*b* The Indus Valley tradition of Pakistan and Western India. *Journal of World Prehistory* 5(4): 331–386.

1998 *Ancient Cities of the Indus Valley Civilization*. Karachi: Oxford University Press.

Kenoyer, Jonathan Mark, and Heather Margaret-Louise Miller
1999 Metal technologies of the Indus Valley tradition in Pakistan and Western India, in *The Archaeometallurgy of Asian Old World*: 107–153, ed. Vincent C. Pigott. University of Pennsylvania Museum Monograph 89. Philadelphia: University Museum Publications.

Khan, Fazal Ahmed
2002 *The Glory that was Kot Diji Culture of Pakistan: An Archaeological Outline*. Khairpur: Department of Archaeology, Shah Abdul Latif University.

Koskenniemi, Kimmo, Asko Parpola, and Simo Parpola
1973 *Materials for the Study of the Indus Script*. Annales Academiae Scientiaram Fennicae, Ser. B 185. Helsinki: Suomalainen Tiedeakatemia.

Lahiri, Nayaniot
1995 The alloying traditions of protohistoric and historic India: Some general trends and their ethnographic dimensions. *Puratattva* 24:64–73.

Lambrick, Hugh Trevor
1986 *Sind: A General Introduction*. History of Sind Series, vol. 1 (3rd ed.). Hyderabad-Jamshoro: Sindhi Adabi Board.

1996 *Sindh Before the Muslim Conquest*. History of Sind Series, vol. 2 (2nd ed.). Jamshoro: Sindhi Adabi Board.

Lashari, Ali
2014 Subject: Destruction of the archaeological site of Lakhianjodaro, Paper presented at 3rd Meeting of the Management Board for Antiquities and Physical Heritage of Sindh held on 23rd December 2014, Karachi.

Law, Randall
2018 The art of the Harappan Microbead – Revisited, in *Walking with the Unicorn: Social Organization and Material Culture in Ancient South Asia*. Jonathan Mark Kenoyer Felicitation Volume: 327–342, ed. Dennys Frenez, Greg M. Jamison, Randall W. Law, Massimo Vidale, and Richard H. Meadow. Oxford: Archeopress.

Mackay, Ernest John Henry
1938 *Further Excavations at Mohenjo-Daro* (2 vols.). Delhi: Government of India.

1943 *Chanhu-daro Excavations, 1935–36*. New Haven: American Oriental Society.

Mallah, Qasid Hussein
2017 *Lakhanjo-daro: Western Mound Salvage Excavation 2017*. Report submitted to the Director General, Culture, Tourism and Antiquities Department. Karachi: Culture, Tourism and Antiquities Department, Government of Sindh.

Marshall, Sir John
1931 *Mohenjo-daro and the Indus Civilization: Being an Official Account of Archaeological Excavations at Mohenjo-daro Carried out by the Government of India between the Years 1922 and 1927* (3 vols.). London: A. Probsthain.

Memon, Muhammad Siddique G.
2000 *Sukkur Then and Now*. Karachi: Oxford University Press.

Mille, Benoit
2017 D'une amulette en cuivre aux grandes statues de bronze: évolution des techniques de fonte à la cire perdue, de l'Indus à la Méditerranée, du 5e millénaire au 5e siècle av. J.-C. [From a copper amulet to large bronze statues: Evolution and technique of lost wax casting from the Indus to the Mediterranean from the 5th millennium to the 5th century B.C.]. Doctoral thesis in Prehistory, Université de Paris de Paris Nanterre and Université de Fribourg.

Miller, Heather Margaret-Louise
1994 Metal processing at Harappa and Mohenjodaro: Information from non-metal remains, in *South Asian Archaeology*, 1993: 497–510, ed. Asko Parpola and Petteri Koskikallio. Annales Academia Scientiarum Fenniacae Series B, vol. 271. Helsinki: Soumalainen Tiedeakatemia.

2008 The Indus Talc-Faience Complex: Types of materials, clues to production, in *South Asian Archaeology 1999: Proceedings of the Fifteenth International Conference of the European Association of South Asian Archaeologists, held at the Universiteit Leiden, 5–9 July, 1999*: 111–122, ed. Ellen M. Raven. Groningen: Egbert Forsten.

Mughal, Rafique Mohammad
1973 Present state of research on the Indus Valley Civilization. *Bulletin of the Society for Near Eastern Studies in Japan* 16(1):161–184, DOI: 10.5356/jorient.16.161.

Panhwar, Muhammed H.
1964 *Ground Water in Hyderabad & Khairpur Divisions*. Hyderabad: G. Shariff at Capital Press.

Parpola, Asko
1994 *Deciphering the Indus Script*. New Delhi: Replika Press.

Paterson, Thomas Thomson
1939 Stratigraphic and typological sequence of the Madras Paleolithic industries, in *The Ice Age in the Indian Subcontinent and Associated Human Cultures with Special Reference to Jammu, Kashmir, Ladakh, Sind, Lindar and Central & Peninsular India*: 327–336, ed. Helmut de Terra and Thomas Thomson Paterson. Washington: Carnegie Institute.

Pithawalla, Maneck B.
1976 *A Physical and Economic Geography of Sind (the Lower Indus Basin)*. Hyderabad: Sindhi Adabi Board.

Possehl, Gregory L.
1989 *Radiocarbon Dates for South Asian Archaeology*. Philadelphia: University Museum, University of Pennsylvania.

Rao, Shikaripur R.
1979 *Lothal: A Harappan Port Town (1955–62)* (2 vols.). Memoirs of the Archaeological Survey of India 78. New Delhi: Archaeological Survey of India.

Rissman, Paul
1988 Public displays and private values: A guide to buried wealth in Harappan archaeology. *World Archaeology* 20(2):209–228, DOI: 10.1080/00438243.1988.9980068.

Sarkar, Anindya, Arati Deshpande Mukherjee, Shubhra Sharma, F. Torsa Sengupta, M. K. Bera Ram, Subir Bera, Oindrila Biswas, M. G. Thakkare, G. Chauhan, M. G. Yadava, A. D. Shukla, and Navin Juyal
2020 New evidence of early Iron Age to Medieval settlements from the southern fringe of Thar Desert (western Great Rann of Kachchh), India: Implications to climate-culture co-evolution. *Archaeological Research in Asia* 21:100163, DOI: 10.1016/j.ara.2019.100163.

Shaffer, Jim G.
1991 The Indus Valley, Baluchistan, and Helmand drainage (Afghanistan), in *Chronologies in Old World Archaeology I*: 425–446, ed. Robert Ehrich. Chicago: University of Chicago Press.

Shaikh, Khurshid Hasan, and Syed M. Ashfaque
1981 *Moenjodaro: A 5,000-Year-old Legacy.* Geneva: UNESCO.

Shaikh, Nilofer, Ghulam Mojuhuddin Veesar, and Qasid Hussein Mallah
2004–2005 Excavations of Indus period site Lakhan-Jo-Daro 2006. *Ancient Sindh* 8:7–196.

Shar, Ghulam Mustafa
2000–2001 Discovery of an Indus scale at Lakhueen-Jo-Daro (Sukkur, Sindh, Pakistan) and implications in the study of the linear measurements of the Indus Civilization. *Ancient Sindh* 6:49–55.

Sharma, Shalini, and Anit K. Pokharia
2020 Dating adoption and intensification of food-crops: Insights from 4MSR (Binjor), an Indus (Harappan) site in northwestern India. *Radiocarbon* 62(5):1–21, DOI: 10.1017/RDC.2020.37.

Tripathi, Vibha
2018 Metals and metallurgy in Harappan civilization. *Indian Journal of History of Science* 53(3): 279–295, DOI:10.16943/ijhs/2018/v53i3/49460.

ul-Haq, Saleem, and Ali Syed Shakir
2001 Archaeological excavation at Lakhian-Jo-Daro first season 1994. *Museum Journal National Museum of Pakistan* 1–2:29–46.

Vats, Madho Sarup
1940 *Excavations at Harappa, Being an Account of Archæological Excavations at Harappā Carried out between the Years 1920–21 and 1933–34* (2 vols.). Calcutta: Government of India Press.

Vikrama, Bhuvan, and Arakhita Pradhan
2018 Copper vessels in the Indus Valley Civilization: A case study in the light of Harinagar Hoard. *Indian Journal of History of Science* 53(3):271–278.

Wilhelmy, Herbert
1966 Der "Wandernde" Strom: Studien zur Talgeschichte des Indus [The "Wandering" stream: Studies in the history of the Indus Valley]. *Erdkunde* 20:265–276, DOI: 10.3112/erdkunde.1966.04.03.

Yule, Paul
1985*a* *Figuren, Schmuckformen und Täfelchen der Harappa-Kultur* [Figures, Jewelry Forms and Tablets of the Harappan Culture]. Prähistorische Bronzefunde [Prehistoric Bronze Finds] 1(6). München: C.H. Beck.

1985*b* *The Bronze Age Metalwork of India*. Prähistorische Bronzefunde [Prehistoric Bronze Finds] 20(8). München: C.H. Beck.