STONE BEADS IN OMAN DURING THE 3RD TO 2ND MILLENNIA BCE: NEW APPROACHES TO THE STUDY OF TRADE AND TECHNOLOGY

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This paper focuses primarily on ancient stone beads found in Oman at sites dating to the 3rd to 2nd millennium BCE, generally dated to the Umm an-Nar and Wadi Suq periods. Archaeological collections were documented to determine the range of variation in the finished objects and if there is evidence for local production of carnelian and other hard-stone beads. A comparative analysis with published materials from other regions was also undertaken to document the bead types in Oman that might have been obtained through trade networks that linked this region to Mesopotamia, Iran, the Indus Valley region, Afghanistan, Egypt, and Anatolia. The overall outcome of this study is a more comprehensive understanding of the types of interactions that were carried out between communities in Oman and adjacent regions during the prehistoric period.

INTRODUCTION

Archaeological studies of early civilizations in the Old World have identified core areas and numerous interlinked regions that were the setting for early developments of technology, trade, and eventually, urban society. Four main core areas – Mesopotamia, Egypt, the Indus Valley, and China – have been the focus of intense archaeological research, but new studies are beginning to show that the peripheral regions also played an important role in the development of early urban civilizations (Azzara and Cattani 2018; Cleuziou 1992; Potts 1990). Since the early 1960s, archaeological investigation at sites on the Arabian Peninsula and the Makran Coast have demonstrated that there were numerous land and maritime routes that linked cities of the Indus Valley to trading posts and urban centers in eastern Arabia, Iran, and Mesopotamia (Figure 1) (Dales 1962, 1971, 1976; During-Caspers 1971; Edens 1993; Frenez 2011; Højlund 1989; Lamberg-Karlovsky 1979, 2009; Laursen 2010). In ancient Mesopotamian texts (Sumerian and Akkadian), several major regions to the east were specifically mentioned as being important trading partners: Elam (western Iran; Potts 1999), Aratta (eastern Iran/Afghanistan; Moorey 1994), Marhashi (southeastern Iran; Potts 2004), Dilmun (modern Bahrain; Potts 1983), Magan (eastern Arabia and the Makran Coast of Iran and Pakistan; Moorey 1994), and Meluhha (the Indus Valley of Pakistan and western India; Moorey 1994; Sollberger 1970). The main stimulus for long-distance interaction may have been the needs of elite consumers in the major urban centers in Mesopotamia and the Indus Valley, but communities in the intervening regions also benefitted from this trade and played a significant role in shaping the interactions.

The study of technology and the trade in raw materials and finished commodities provides important information about these communities since we have no textual documentation for the earliest periods and only limited references from Mesopotamia beginning in the mid-3rd millennium BCE. The Southeastern Arabian Peninsula, which includes the present-day Sultanate of Oman (Oman) and the United Arab Emirates (UAE), is strategically positioned along the major maritime trade network that linked the Indus Valley with Mesopotamia. Excavations at coastal as well as inland sites in Oman and the UAE have provided considerable evidence for the presence of Indus artifacts as well as Indus-style goods, but it is possible that trade between these regions may have begun much earlier than the mid-3rd millennium BCE (Kenoyer 2008).

In this paper we present the preliminary results of a long-term and multifaceted study of the role of craft specialists and traders who were present in ancient Magan during the 5th-1st millennia BCE (Table 1), with a specific focus on beads found at sites in modern Oman, and their relationship with the Indus Valley or Meluhha. This study expands on the important research begun by earlier scholars by using new methods of analysis for artifacts that were excavated in the past, and by studying new sets of data from more recent excavations. The study of stone beads includes the microscopic examination of bead drill holes using scanning electron microscopy (SEM) to gain a more precise understanding of bead production.

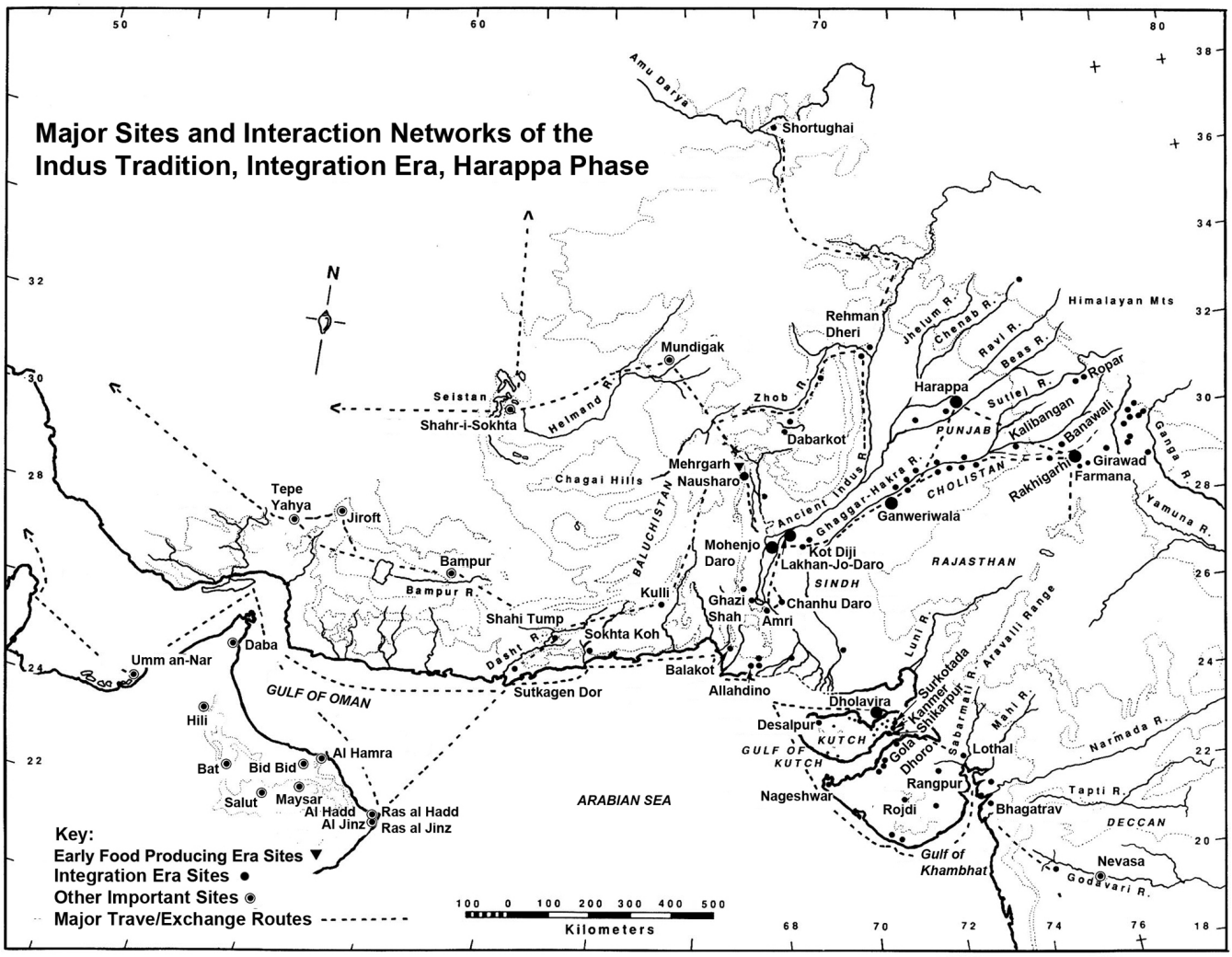

Figure 1. Major sites in Oman and the Indus (all images by the authors unless otherwise indicated).

Stone beads from archaeological excavations (Table 2) were studied at various locations of the Ministry of Heritage and Culture's Department of Excavations and Archaeological Studies, Oman, at the Faisal Bin Ali Museum Storage Lab for the National Museum, and at the Office of the Adviser to His Majesty the Sultan for Cultural Affairs (Diwan) (*see* acknowledgements below).

This paper focuses on the stone beads of the mid-3rd to late 2nd millennium BCE from the sites of Bat (Schmidt and Döpper 2014), Salut (Frenez et al. 2016), and a collection of beads from Bid Bid in order to better understand the possible development of local bead production and the trade connections that linked Oman to surrounding regions. In addition, some beads from later periods will be presented to show the major differences in bead types and drilling technology over time. These collections provide an excellent overview of the types of information that are available through the study of the beads from sites in Oman and will provide a framework for future work in this region.

Methodology of Stone Bead Analysis

Each of the beads under study was measured using a digital caliper to record the length, width, and internal hole diameter (Figure 2). The external surfaces of the beads, and particularly their ends, were examined using a 10x hand lens in order to document the raw material and to study the shape, external manufacture, and use indicators. In addition, specific features of surface modification were documented using a digital microscope (Dinolite ™) that can be linked through a USB port directly to a computer. These details of manufacture are critical for differentiating beads that look

Table 1. General Chronology (Kenoyer 2014; Moorey 1994; Weeks 2014).

Indus Tradition	Oman/UAE	Mesopotamia
Localization Era		
	Iron Age II: 1000-600 BC	
	Iron Age I: 1300-1100 BC	
Late Harappa Phase: 1900-1300 BCE	Wadi Suq Period: 2000-1300 BCE	Isin-Larsa Dynasties: 2000-1600 BCE
Integration Era		
Harappa Phase: 2600-1900 BCE	Umm an-Nar Period: 2700-2000 BCE	Ur III Period: 2100-2000 BCE
		Akkadian Period: 2350-2100 BCE
		Early Dynastic Period: 3000-2350 BCE
Regionalization Era		
Early Harappa Phase: 5000-2600 BCE	Hafit Period: 3200-2700 BCE	Jemdet Nasr Period: 3500-3000 BCE
		Uruk Period: 4000-3500 BCE
Early Food Producing Era		
Mehrgarh Phase: circa + 7000-5000 BCE	Foraging-Agro/Pastoral: 6000-3200 BCE	Ubaid Period: 5500-4000 BCE

the same but may have been made in different workshops by different craftspeople (Kenoyer 2003). The wear on the ends and the exterior of the beads provides information about their actual use. If a freshly manufactured bead is deposited in a burial or lost, it has very sharp drill-hole edges and the surface shows traces of the final polish. If a bead has been worn on a string next to other beads or metal objects, the ends are worn, the edge of the drill hole is worn and polished, and the exterior of the bead can show various types of wear and abrasion. These details provide a general idea of the relative use life of a bead and if it was used for a short or long period of time prior to being buried or discarded.

Drill-hole impressions were studied using a 10x hand lens and also a standard binocular microscope to determine the nature of the technology and the specific patterns of production. For example, some beads are drilled only from one end and when the drill pops out at the other end, it leaves a conical flake scar. Other beads are drilled half way from one end and then turned around and drilled from the opposite end. If the driller is highly skilled, the drill holes usually meet perfectly at the center of the bead. In many cases, the drilling was not done very carefully so the holes do not meet properly. This causes sharp edges that can cut the suspension string. These special features of drilling are

Table 2. Oman Bead Collections Discussed in this Report.

Site	No. of Beads	Material	Major Periods	Project/Institution
Bid Bid	80	Carnelian, agate	4th millennium to Iron Age	National Museum
Bat RTF1	94	Carnelian, agate, shell, ostrich eggshell	Umm an-Nar to Iron Age	American Mission to Bat
Salut ST 1	3	Carnelian	Umm an-Nar	Italian Mission to Oman
Dhank	29	Carnelian, agate, etc.	Hafit and Umm an-Nar, not studied	SoBO Dhank, Temple University
Bat - German Project	1	Carnelian	Umm an-Nar	German Expedition to Bat, Tübingen University

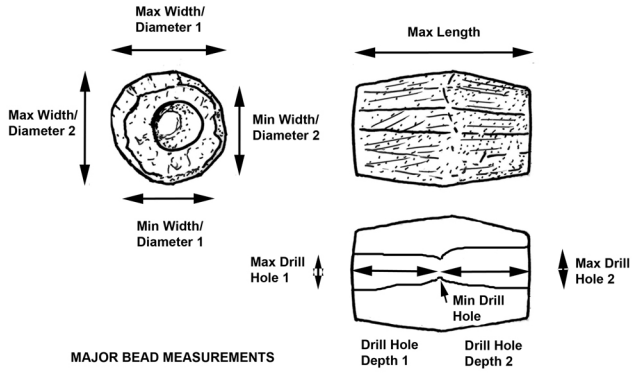

Figure 2. Major bead measurements.

indicative of different workshops and production traditions. Beads produced in major workshops of the Indus Valley region tend to have drill holes that are exceptionally well centered, while beads drilled in other regions tend to be quite irregular and are often not centered.

Selected drill-hole impressions were studied under the higher-power SEM at the Department of Animal Sciences Microscopy Laboratories of the University of Wisconsin to document the nature of the drilled surfaces to confirm the type of drilling. Due to limited time, only a few samples have been studied at this level and further reports will include more details regarding the SEM study.

Bead Drilling

The type of drill used to perforate a bead also provides important information on the details of the manufacturing process (Figure 3). Most of the hard-stone beads in the collections were made from microcrystalline silicates, such as carnelian and jasper. The only drill that can perforate this type of stone is one made from a harder silicate stone (e.g., chert or ernestite) (Figure 4) (Kenoyer and Vidale 1992), or from corundum/emery (hardness 9 on Mohs scale) or diamond (hardness 10) (Kenoyer 2003). The type of drill used to perforate a stone can be determined based on the nature of the abraded surface of the drill hole. The most effective way to determine this information is to take an impression of the hole using fine-quality vinyl polysiloxane dental impression material (3M Express, light body, regular set) and then studying the impression using high-power magnification (Kenoyer 1997, 2017a). Two or more sets of impressions are made of each bead drill hole. The first impression usually has traces of sand and dust on it so the second or third impression is used for the high-magnification study using SEM (Kenoyer 2017b).

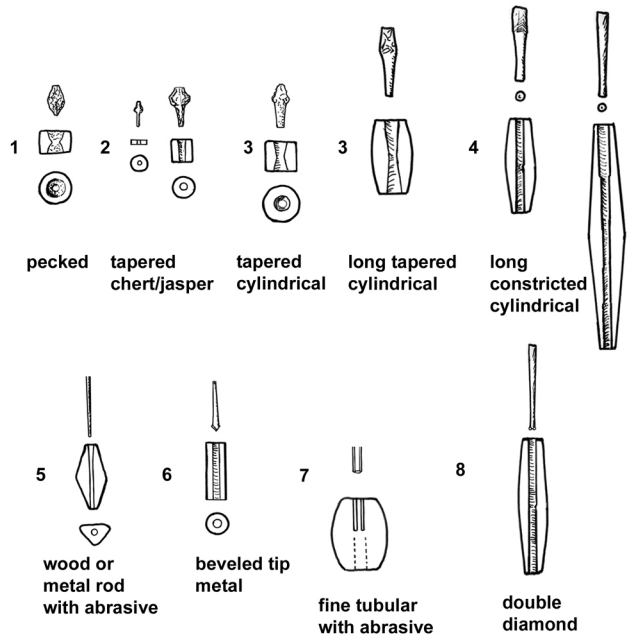

Figure 3. Major bead drill types and drill-hole sections.

Figure 4. Indus ernestite drills and long biconical carnelian beads from Chanhudaro (courtesy of the Museum of Fine Arts, Boston).

OMAN STONE-BEAD TECHNOLOGY

Beads from Bid Bid

Over the course of many years, a large quantity of ancient beads was collected from the area of the modern town of Bid Bid (Figure 1), southeast of Muscat. The collection was donated to the Ministry of Heritage and Culture's Department of Excavations and Archaeological Studies in 2012 and is currently in the holdings of the Oman National Museum. The beads were not recovered during proper archaeological excavations, but appear to have been collected from disturbed sites and tombs dating from one or more chronological periods. After an initial sorting of the larger collection, a smaller sample of 80 stone beads was selected for further study at the Faisal Bin Ali

Museum Storage Lab in Muscat. Although the beads were not recovered in a primary archaeological context, they represent a wide variety of bead styles and manufacturing techniques, and provide an excellent collection for study that can be linked to beads from excavated sites. The value of this collection is that it covers a long period of the history of Oman and can help to demonstrate the many links between Oman and other regions throughout its long history.

Preliminary analysis of the drill-hole impressions and the general shapes of the beads suggests that they come from many different time periods and represent production from many different regions of West Asia, South Asia, and possibly Arabia itself. Some of the beads were made using soft stone such as steatite. This type of raw material can be shaped with stone or metal tools and is easily perforated to create beads or pendants. In contrast to the soft steatite ornaments, hard-stone beads such as carnelian require specialized technologies to produce, beginning with chipping and grinding, then drilling, and finally polishing. While chipping, grinding, and polishing are generally the same for all carnelian and agate beads, the technology associated with perforation or drilling is quite distinct. By determining the nature of drilling, it is possible to determine some aspects of the chronology, as well as the types of workshops in which a bead was produced.

Some of the beads were made using a pecking technique (Figure 3, 1) that is known from very early Neolithic times, circa 6000 BCE in Mesopotamia (Chevalier, Inizan, and Tixier 1982), and from slightly later times in Arabia, Egypt, and the Indus Valley regions (Kenoyer 2003). These may be beads that have been passed down for thousands of years and used by many different people before their final burial. Other beads have been drilled using a constricted cylindrical ernestite drill (Kenoyer and Vidale 1992), a technology that was only found in the Indus Valley region and dates to around 2600-1900 BCE (Figure 4). This means that some of the beads were brought to Oman from the Indus Valley region. Other beads have been drilled using a solid or tubular metal drill with some form of abrasive. Based on Kenoyer's current studies of Indus beads, drilling with abrasives is documented at sites in the Indus Valley such as Harappa and Dholavira between 2500-1900 BC, but the type of abrasive is not known.

Drilling with abrasives is also known from prehistoric sites in the Mediterranean and Anatolian regions to the west, but comprehensive studies have not been conducted to understand the origin or distribution of this technique. It is possible that some of the beads from Bid Bid were made in the Indus Valley or in Anatolia (modern Turkey), or somewhere in Mesopotamia (modern Iraq, Kuwait, Syria) or Egypt. A few of the beads were made using a double-diamond drilling technique that is only known from ancient India starting around 1000-600 BC. These beads may have been brought to Oman directly from South Asia or indirectly through trade networks passing through Baluchistan, Iran, or Yemen. A selection of the beads will be discussed below according to their drilling technology and also their shape, as these features help to define the workshops and general cultural associations of the beads.

Carved Steatite Beads, Metal Drill

Two examples of carved steatite beads were examined to determine the nature of the drilling and carving techniques (Figure 5). Such beads with carved surfaces could have been used as seals and are often called button seals, but these examples do not have any evidence for such use. Made from a soft grey-colored steatite (hardness 1 on the Mohs scale), the beads have not been fired to harden the stone. They were perforated using what appears to be a metal drill with possibly a beveled cutting edge (Figure 3, 6). The carving on the surface of the beads appears to have been done with a sharp metal blade. The type of metal has not been determined, but it could have been copper, bronze, or iron, depending on the actual period during which these beads were made. The dot-in-circle motif is found on stone beads as well as seals and other decorative objects of the mid-3rd millennium BCE.

Figure 5. Carved steatite beads, Bid Bid collection.

This design was made with a special type of compass drill featuring two or three sharp points where one is slightly longer than the others. The drill turns on the longer point and engraves a perfect circle with the second point. Some drills have three points and are used to make dot-in-double-circle motifs. This decorative motif is widespread in the Indus Valley region as well as in many areas of the ancient world. Even today the motif is carved on stone vessels or wooden tools throughout the region. Shihuh craftsmen from the Musandam Peninsula of northern Oman carve the motif using a stone tool called a *ma'z*, and more recently an iron compass drill called a *zahrah* (Ziolkowski and Al-Sharqi 2006). Stylistic studies of the carved beads from Bid Bid

need to be undertaken to compare them with beads from sites with better chronological control, but an example recently discovered in Tomb 156 by the German Archaeological Project at Bat suggest that they may date to the Iron Age (Schmidt and Döpper 2014:11, Figure 8).

Short Barrel and Short Biconical Carnelian Beads, Pecked Drilling

The technology of pecking is generally associated with short cylindrical, barrel, or biconical stone beads. This technique has been documented at sites in Arabia, Egypt, Mesopotamia, the Indus Valley, and even China (Kenoyer, ongoing studies). All of the pecked beads in this collection are carnelian and have a short barrel or biconical shape. Three of the beads have a lot of wear on the narrowest part of the hole that is the result of wear from a string. These beads may have been passed down over many generations before they were buried.

The beads are pecked from both ends resulting in an inverted biconical hole (Figure 6). This type of drilling is common for short biconical and short barrel-shaped beads at sites throughout Oman and also is common in the Indus region at sites such as Mohenjo-daro, Chanhudaro, Dholavira, and Harappa (Figure 7). The pecking technology involves the use of a pointed stone tool that is struck against the bead and gradually fractures tiny conical points that eventually break off to create a wide hole with a narrow tip that can be clearly seen when examined using SEM (Figure 8). The bead was turned over and the same process was repeated from the opposite side. In some cases, the final percussion from the first side resulted in a large cone of percussion that broke through the bead, resulting in a pecked conical depression on one side and a single conical flake scar on the other. No examples of this type of hole were found in the sample from Bid Bid, but an example of this type of bead was discovered in recent excavations by the authors at the site of Ras al-Hadd, HD1 in 2018.

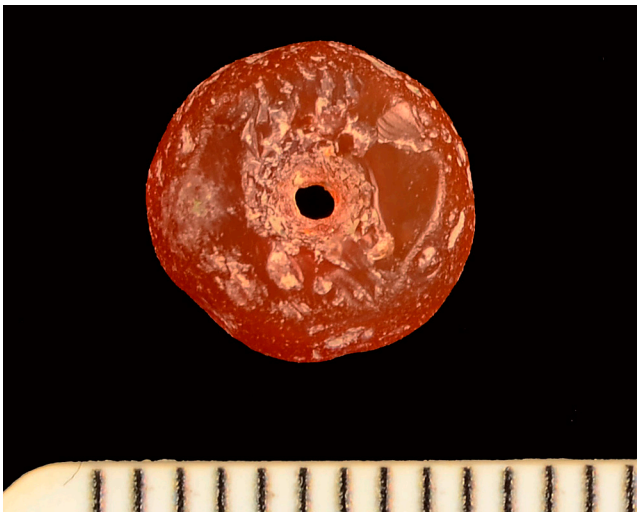

Figure 6. Carnelian bead with pecked perforation, Bid Bid.

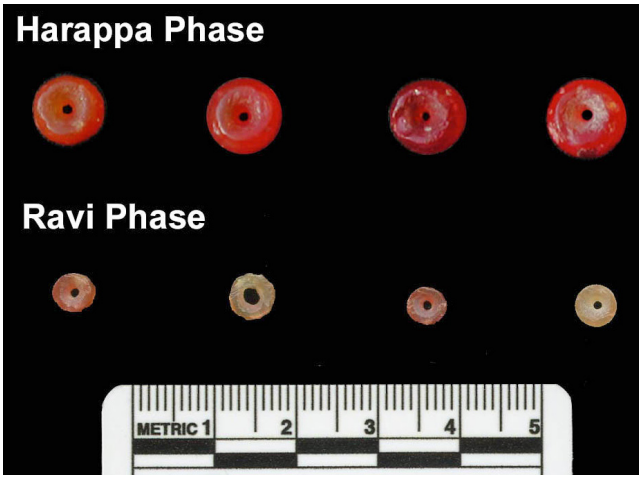

Figure 7. Carnelian beads with pecked perforation from Harappa.

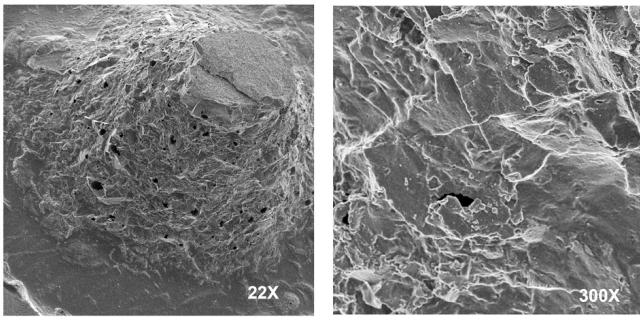

Figure 8. SEM image of pecked drill hole, DA 12772.1 Salut.

Biconical and Barrel-Shaped Beads

While many beads look the same on the outside, the drilling technique used for perforation can be quite different. The differences in drilling technology can sometimes be determined at low magnification, but the final identification should be done using SEM analysis. The Bid Bid beads in Figure 9 include those that were drilled using stone as well as abrasives. The use of stone drills results in a highly polished surface of the carnelian (Figure 10, a) since the stone drill is only slightly harder than the bead itself. Other beads were drilled using a solid metal drill with abrasive (Figure 10, b), or with a tubular metal drill with abrasive (Figure 10, c).

The collection also has examples of carnelian beads that have been drilled from one end with the closed end popping

Figure 9. Long barrel and biconical beads, Bid Bid collection; nos. 24, 25, and 26 have Indus-style stone drilling.

out due to pressure from drilling. Other beads have been drilled from both ends and meet in the center of the bead.

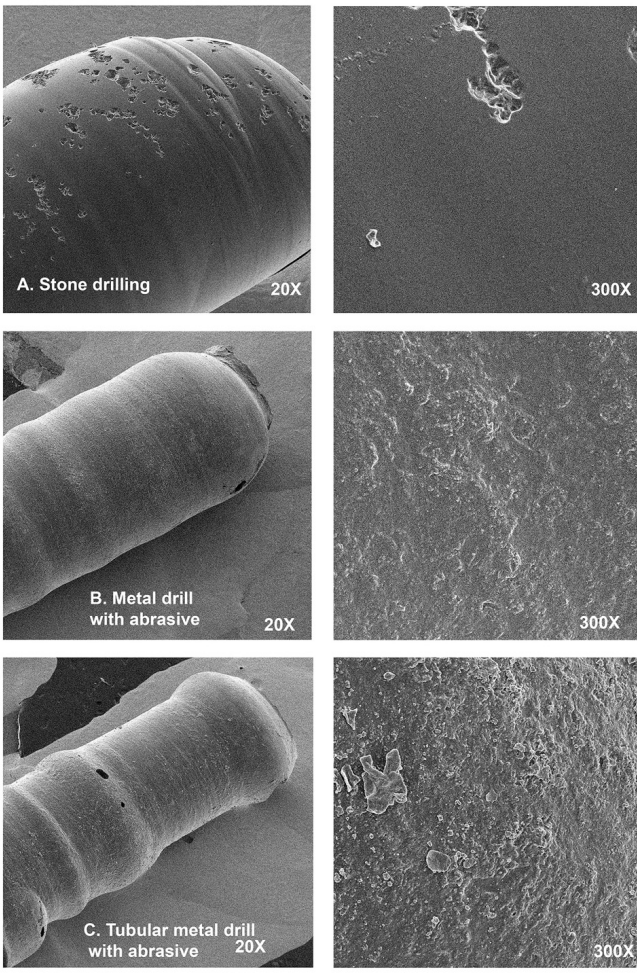

Figure 10. SEM image of Bid Bid bead perforation drilling.

Sometimes the drilling is done to equal depths from both ends and meets precisely in the center with careful alignment of the holes. In other instances, the drilling is primarily done from one end and a shorter drilling is done from the other to complete the hole. In some cases the same drill sizes are used for both ends, but in others two or more sizes are used. This creates stepping or distinct drilling striae. The patterns of drilling – from one or both ends, the numbers of steps, and the distance drilled between each change of drill – can help to determine the precise workshop in which the beads were produced. This study is still ongoing, but promises to help clarify distinctive workshop styles of carnelian bead production. Recent studies of carnelian beads from the Levant by Geoffrey Ludvik (2018) have demonstrated that it is possible to define distinctive workshop styles related to Indus bead production that was taking place either in Mesopotamia or the Indus Valley region.

Long Barrel and Biconical Beads, Constricted Cylindrical Stone Drill – Indus Style

The use of constricted cylindrical stone drills (Figure 3, 4) made from the hard stone called ernestite is a technology that is directly linked to the Indus civilization (Figure 4) (Kenoyer and Vidale 1992; Prabhakar et al. 2012). The bead shapes associated with Indus-style drilling are also typical of beads produced in the Indus workshops (Kenoyer 1998, 2005, 2017a). The Bid Bid collection contains seven beads that appear to have been made using Indus shapes and drilling techniques, and three are illustrated in Figure 9 (nos. 24-26). This size and shape of bead is commonly found at Indus sites and appears to have been an important trade item that reached even into the interior of Oman at sites such as Salut, Bat, and Hili (in the UAE). Ongoing studies are being carried out to quantify the precise shapes and drilling techniques used for this type of bead to determine if they were all made in similar workshops or if they were made at many different locations. The technique of perforation and the distinctive shapes suggest that the craftspeople that were making them were from the Indus region or were trained in Indus workshops. It is also possible that some of these beads may have been made in workshops in Oman using raw materials from the Indus or other sources. So far, however, no conclusive evidence for local production has been reported.

Salut ST1 – Carnelian Beads

One of the most important aspects of our study of stone beads has been to confirm the presence of carnelian beads that

appear to have been made in the Indus and traded to Oman. Three carnelian, long biconical bead fragments (Figure 11, a) were discovered in the excavations at the 3rd-millennium stone tower site at Salut ST1 (Frenez et al. 2016). These beads are technically long bicones, but in the classification developed for these types there are three sub-types: long biconical, very long biconical, and very, very long biconical (Kenoyer 2017a: Figure 6). The shape and finishing of the beads is identical to beads studied by Kenoyer from the site of Dholavira, Gujarat. The drill hole perforation is also identical to the perforation technique using constricted cylindrical drills and this has been confirmed using SEM (Figure 11, b).

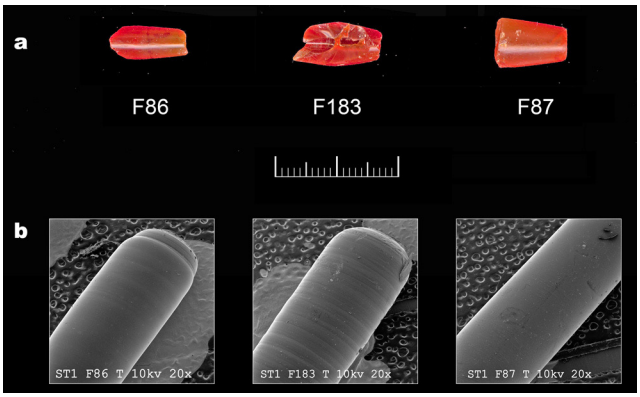

Figure 11. a) Carnelian beads from Salut ST1 and b) SEM images of drill hole impressions.

Bat – Carnelian Beads – German Archaeological Mission

Excavations by the German Archaeological Mission headed by Dr. Conrad Schmidt from the University of Tübingen have discovered one of the largest and most complete examples of a very, very long biconical Indus bead (7.7 cm) in Tomb 155 at Bat (Figure 12, a) (Schmidt and Döpper 2014). Impressions were made of the drill hole and, through SEM analysis, it is possible to confirm that this bead was drilled using Indus-style constricted ernestite drills (Figure 12, b). The production of very, very long biconical or barrel shaped carnelian beads is well documented in the Indus region at the site of Chanhudaro (Mackay 1943), as well as the sites of Mohenjo-daro, Harappa (Kenoyer 2005), and possibly at Dholavira (Prabhakar et al. 2012). In the Indus, these beads were generally worn as part of elaborate beaded belts that would have required around 42 beads to create (Figure 13). The production of these beads required high quality carnelian nodules of suitable length. Based on experimental reconstructions, a full belt of long carnelian beads may have taken more than a year to produce (Kenoyer 1998). The length of the bead and the quality of the carnelian suggest that the bead from Bat was made in the

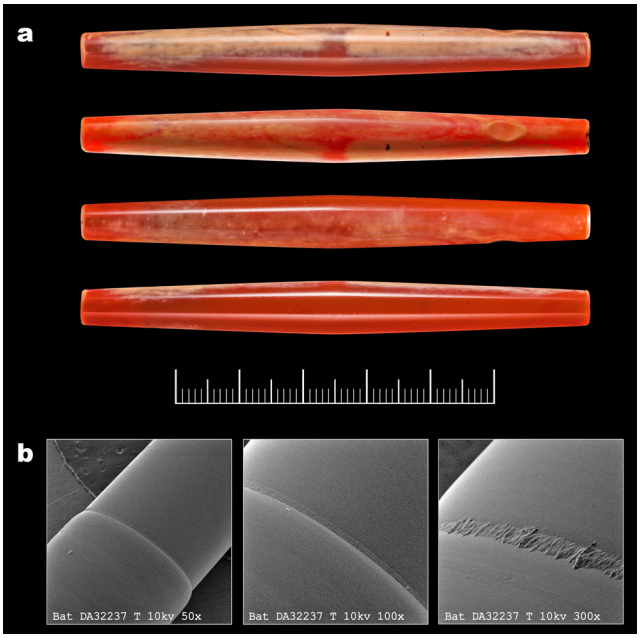

Figure 12. a) Long biconical carnelian bead, four views, Bat (photo: P. Koch, courtesy of Ministry of Heritage and Culture and Conrad Schmidt, German Archaeological Mission); b) SEM images of long biconical bead drilling from Bat.

Indus and traded to Oman. The fact that only single beads of this type have been found suggests that they were not part of belts but were probably worn around the neck or as part of a headdress as has been documented from the burials of Ur (Zettler and Horne 1998).

Bleached Carnelian Beads

Another distinctive bead type produced in the Indus region includes beads that have been decorated artificially with a white design. One of the beads in the Bid Bid collection (668-4) (Figure 14) is decorated with a white design that is referred to as bleaching (Kenoyer 2003), though earlier publications use the term etching (Beck 1933; De Waele and Haerinck 2006; Lessa and Vogt 1972). The bead has a common Indus bleached design of two circles or eyes on each side of the bead similar to that seen on beads from Harappa (Figure 15). The bead shape is a short lenticular ellipse and the drilling is done with an Indus-style drill that leaves a straight cylindrical drill hole with stepped drilling striae and highly polished surfaces (Figure 16).

In contrast to the above bead, two other bleached carnelian beads were drilled using an abrasive and probably a copper/bronze drill (668-3, 5) (Figure 17). The bleaching technology used to decorate the beads is usually associated with the Indus region and Indus technology in general, but

Figure 13. Belt of long biconical carnelian beads, and gold jewelry from Mohenjo-daro, Pakistan (courtesy of the Department of Archaeology and Museums, Government of Pakistan).

the drilling was done using what appears to be an emery abrasive from one end only and the closed end popped out (Figure 18). Abrasive drilling is found at sites in the Indus, but it is done with a softer abrasive such as quartz and is usually done by drilling from both ends. The practice of drilling from one end and popping out the stone at the other was sometimes practiced with stone drills in the Indus and is particularly associated with bleached carnelian beads. These two beads are the first examples of bleached beads that use a combination of Indus decorating and Indus shapes, but possibly using emery abrasive, which is a non-Indus-style drilling. They may have been made in Mesopotamia where other bleached carnelian beads with non-Indus designs have been found (Kenoyer 1997, 1998), or it is possible that they were made in a workshop in the region of Oman or the UAE.

Figure 14. Bleached carnelian bead (front and back), Bid Bid.

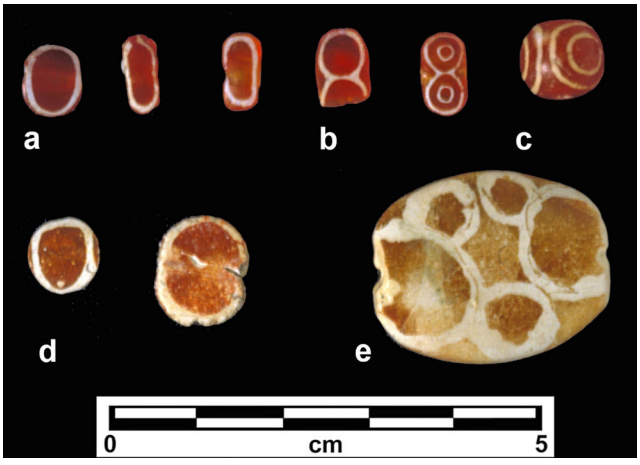

Figure 15. Bleached carnelian beads from Harappa, Pakistan.

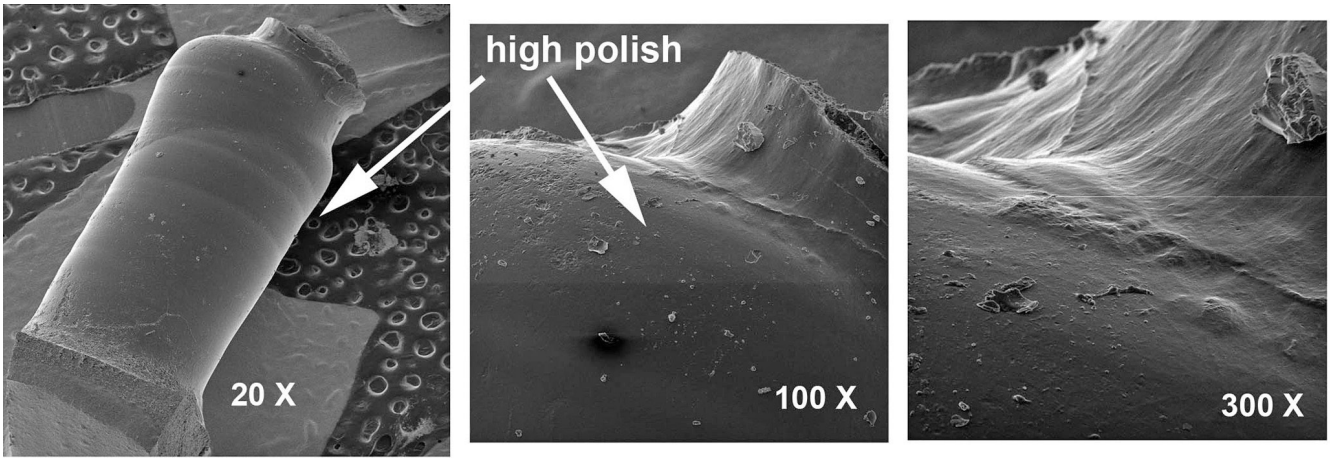

Figure 16. SEM images of Bead 668 4 showing Indus-style stone drilling.

Abrasive Drilling with Metal Drills

All but two of the remaining stone beads in the Bid Bid sample were drilled using an abrasive, possibly emery and a metal drill (Figures 3, 5 and 7; 10, b-c). The type of metal used cannot be determined, but it was probably copper or bronze for beads made during the earlier periods (before 1400 BCE) and iron or steel in later times. Further comparative analysis of the bead shapes and drill holes with samples from well-dated sites will be needed to sort out the periods of these other beads. The beads come in a wide variety of shapes and decorative styles, as well as raw materials. The drilling processes used to perforate the beads are highly varied and include straight cylindrical drill holes, often with flaring collars that would have been made using tubular drills (Figures 3, 7; 10, c). The flaring collars are the result of problems in drilling when the drill tip spreads out from too much pressure. There are also tapered-cylindrical and long or short conical drill holes that were made using solid metal drills. These can also exhibit some collaring if there was too much pressure on the drill, but generally they do not produce as much flaring as tubular drills. Both tubular and solid drills involved drilling from one end and popping the other end out, as well as drilling from both ends. In some cases the drilling from both ends is well aligned, but in other cases they are not centered and barely come together. By looking closely at the raw-material quality, the bead shapes, and the variations in drilling details, it will be possible to identify different workshops and also periods of beadmaking.

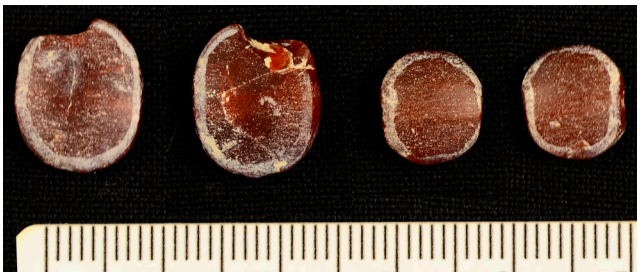

Figure 17. Bleached carnelian beads, Bid Bid collection.

Many of the other beads in this collection are similar to beads found in Mesopotamia, the Indus region, Afghanistan, Baluchistan, Iran, Egypt, and the more distant Mediterranean and Anatolia. Comparative studies of beads from these other regions will help to determine the trade networks that connected the region around Bid Bid and interior Oman to these distant regions.

Banded-Agate Beads, Double-Diamond Drilling

In order to highlight the difference between later historical drilling and the drilling seen in prehistoric beads, an example from a later period showing diamond drilling is presented. Two beads in the sample were made from a distinctive banded agate with the banding oriented perpendicular to the drill holes (Figure 19). Each bead was drilled twice in order to be used as a spacer bead for a necklace or ornament with two strands of beads. The lenticular rectangular form is very thin and has a fine polish; the ends show slight wear. The straight cylindrical drill section with clear drilling striae is diagnostic of diamond drilling using a double-diamond drill (Figures 3, 8; 20). This technique was developed exclusively in South Asia and used in peninsular India beginning as early as 1000-600 BCE. It is still carried out today in the region of Khambhat, Gujarat (Kenoyer, Vidale, and Bhan 1991). The drilling of these beads was done primarily from one end for both drill holes and then well-aligned but shorter drilling from the opposite side. This type of bead is well attested in sites

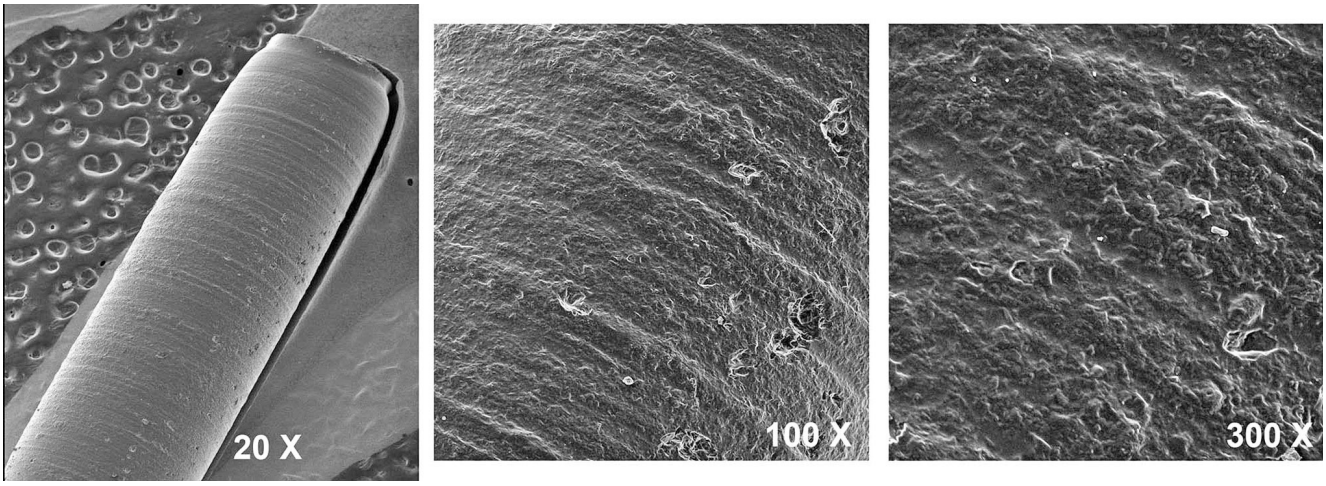

Figure 18. SEM images of Bead 668 3 showing abrasive drilling.

from the 3rd century BCE to 3rd century AD in what is now Pakistan, Afghanistan, and throughout most of the Indian subcontinent. The color of the stone appears to have been created by dying the agate to create the grey, black, and white banding. According to historical accounts, this was done by soaking the agate in a sugar solution and then heating the beads to carbonize or blacken the sugar (Newton 1849; Russell 2008).

Figure 19. Lenticular rectangular and barrel beads of banded agate, Bid Bid collection.

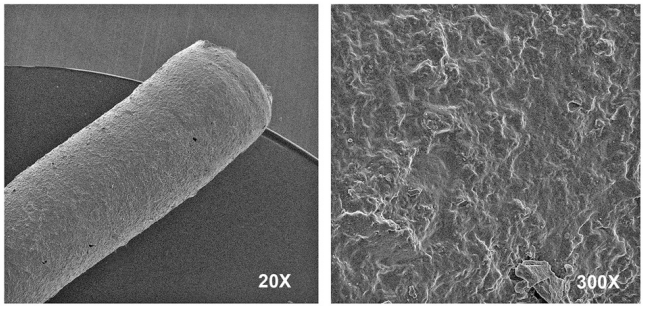

Figure 20. SEM images of diamond drilling, spherical carnelian bead, Samad (DA26612.3).

CONCLUSION

The samples of beads studied from Bid Bid, Bat, Salut, and other sites that are currently under analysis provide a wide range of stone-bead types and manufacturing techniques. These variations reflect the overall changes in bead-production styles and technologies over time and in different geographical regions of Arabia, North Africa, West Asia, and South Asia. The production of soft-stone beads and beads from shell is well attested in Oman from the 4th millennium BCE at sites such as Ras al-Hamra (Azzara and Cattani 2018) and Ras al-Hadd (HD-6) (Azzara and Cattani 2018; Panei, Rinaldi, and Tosi 2005), but there is very little evidence for the production of hard-stone beads such as carnelian from any sites in Oman. Except for the two carved steatite beads, all of the beads in the collections studied to date are made from hard stones that may have been manufactured in some distant region and brought to Oman through various trade networks. The beads from the Bid Bid collection appear to have been accumulated from many different archaeological contexts and may have come from disturbed tombs or settlement sites or from hoards of ornaments buried by ancient communities. They clearly demonstrate the long use life of beads since some of the beads may belong to the earliest Neolithic period (4000 BCE or earlier), while others date to the Bronze Age (3000-1900 BCE), the Iron Age (circa 1500 BCE), and later historical periods. The beads from Bat all come from tombs that can be assigned to specific periods. The long carnelian biconical bead can clearly be dated and linked to the Indus civilization and the beads from the RTF Site 1 excavations appear to be from the early Iron Age. These later beads also appear to include some curated beads that come from earlier times and SEM analysis of the drill holes will help to sort them out.

This overview of the bead analysis represents the first stage of a long-term study of all Indus-related crafts represented in Oman. The initial results from this study demonstrate it is possible to determine the distribution and local use patterns of Indus objects. It is also clear that many carnelian beads found in Oman come from other sources and that it is important to broaden our study of ancient trade networks to include areas such as Afghanistan, Iran, Yemen, Egypt, and Anatolia. When combined with the data being studied for pottery and copper, it will be possible to develop a new interpretive model for explaining the interactions between Oman and its neighbors in the prehistoric and early historic periods.

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