Some Important Aspects of Technology and Craft Production in the Indus Civilization with Specific Reference to Gujarat

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This paper will briefly review the archaeological record of some of the aspects of the craft production in the Indus Tradition from the point of technology, as reflected in manufacturing cycles, possible workshops / activity areas, stock piling and dumping areas so far identified in the available archaeological record of Gujarat. The data presented here is mostly derived from three recently excavated Indus sites by the Department of Archeology and Ancient History, Maharaja Sayajirao University of Baroda in combination with the data obtained through ethnoarchaeological studies carried on the stone bead making at Khambhat, Gujarat by Jonathan Mark Kenoyer, Massimo Vidale and myself. With the adaption of rigorous excavations with emphasis on the recovery methods along with ethnoarchaeological studies a lot of fresh useful information regarding the various Indus crafts is beginning to get revealed. The study of the crafts and especially Indus Civilization crafts is growing field of investigation, though some South Asian archeologists still prefer to them as 'miscellaneous small finds'. This fresh data thus obtained is the highlights of this paper.

Keywords: Indus Civilization, Technology, Craft Production, Gujarat, Shell working, Beads, Faience.

In this paper, I will be discussing some important aspects of the current research on craft production in the Harappan phase of the Indus Tradition that corresponds (*c.* 2600 to 1900 BC) to the Integration Era (as defined in Kenoyer 1991a). The proto-urban communities of the Indus basin and surrounding regions appear to have organized into several regional city-states, which over the course of seven centuries, appear to have attained some form of political unification. From approximately 2600 to 1900 BC, we observe the growth of the first urban centers of South Asia. The development of large cities and towns affected parallel and impressive development of the Industrial sector. An important aspect of this process of integration was the invention and adaptation of specific styles in material culture, namely, in public and domestic architecture, ceramics (including pottery and refined personal ornaments such as faience and stoneware bangles), metallurgy, steatite, stone and shell ornaments.

In Harappan studies, archaeologists have been more successful in identifying and reconstructing major aspects of production than, for example, religion, or administrative practices. During the last three to four decades ethnoarchaeological researches on craft production have made significant advances, especially in the context of Harappan studies. A discussion of specific crafts below will demonstrate how ethnoarchaeological studies in combination with analytical studies have contributed to more reliable interpretations of resources and craft activity areas and has demonstrated how they are helping in developing more meaningful research questions of urbanism and the character of the Indus socio-religious and political systems. However, it is not possible to go into detail about technological and organizational aspects of various industries, but I will confine myself to certain selected crafts like stone bead making, shell working and faience making, with specific reference to the recent data recovered from the Harappan sites of Gujarat.

Roots of bead making traditions

The roots of the tradition of bead making can be traced to hunting and gathering communities of the Upper Palaeolithic into the foraging Era of the Mesolithic and Microlithic cultures of South Asia. Flaking tradition for shaping beads and the production of stone drills have their origin in the blade technologies of the Upper Palaeolithic and Mesolithic/Microlithic periods. Beads made from ostrich eggshell have been found at numerous sites in peninsular India dating to Upper Paleolithic Period (Kumar 1997) and over one hundred beads, some of which were incised with criss-cross lines, have been discovered at the site of Patne, Maharashtra dating to around 24,000 BC (Sali 1989).

So far there is no evidence for the production of sawn steatite or soft stone beads during the Mesolithic or Microlithic periods, but given the appearance of a well-developed steatite disc bead industry around 7000 BC it is highly likely that ostrich eggshell disc beads were replaced by shell or stone disc beads during the Mesolithic period. The only types of beads or pendents from this time period were made with antler in the form of ring shaped ornaments sawn with stone blades (Sharma *et al.* 1980).

The earliest stone bead perforated with specialized stone tools drills can be dated to second half of the 7th millennium BC of the Early Food Production stage

at the site of Mehrgarh, Baluchistan. The site revealed some complete calcite beads along with large numbers of unfinished beads and many fragments of calcite and several stone dills used in the perforation in association with structure MR. 3S, level 4.

One of the earliest bead workshop areas we know from the protohistory of south Asia is a disc-bead manufacturing area excavated at Mehrgarh belonging to the end of Period II dated to 5th millennium BC (Jarrige *et al.* 1995: Vidale 1995; Vanzetti and Vidale 1994, Barthelemy de Saizieu and Bouquillon 1994). According to J.-F. Jarrige, this early evidence, together with the late Neolithic or early Chalcolithic talc bead making area of the site may represent a prototype of small craft activity area and workshops identified as diffuse units in the later urban sites of the Indus basin (Jarrige *et al.* 1995: 66, 280).

Massimo Vidale studied the beads from this area and presented reconstruction of the manufacturing sequence of the talc disc beads on the basis of the study of the beads for their manufacturing traces by carrying out microscopic observations, experimental replicas and SEM observations of both archaeological and experimental samples. He informs us that steatite beads were manufactured aside shell disc beads that were probably strung together in contrasting patterns. The manufacturing sequence of talc disc beads included the shaping of rod – like blanks having polygonal sections, slicing these rods into polygonal blanks, their bi-polar perforation with chert drills made out of thin bladelets. The perforated discs were later probably strung on a fibre and ground into fine-grained abrasive stone. The XRD analyses of samples identified this rock composed by talc and calcite (Vidale 1995, 2000). A good talc darkens from 200^0 to 700^0 C, and becomes white approximately at 700° to 1000° C, when it changes into enstatite and cristobalite. From the pyrotechnological point of view lesser percentages of artificially whitened beads have been reported from this workshop. Some of the white talc beads had also been colored red with a coating of ochre. Six cakes of ochre have also been found nearby (Jarrige *et al.* 1995: 248). In Mehrgarh Period III (about 4500-3800 BC) the situation is completely different. Nearly 93% of the total amount recovered beads are in talc and all of them are white, suggesting a strong diffusion in the firing techniques. The typology of the beads is more varied, but their size seems to be more standardized. The beads seems to have cut from pre-formed cylindrical blanks (Vidale 2000: 62).

Later, in the first half of the 4th millennium BC, at Mehrgrah, there are some activity areas or dumps rich in bead making debitage of lapis lazuli, carnelian, calcite and turquoise, and including several tapered cylindrical drills in an unidentified green stone. The surface distribution of these materials might recall the pattern referred to by Jarrige as a loose scatter of limited amounts of flakes and semi-finished pieces reflecting a rare episode of stone manufacturing and little administrative control onto the bead makers.

The lapis lazuli debitage, collected from surface of the site labelled as MR.2 at Mehrgarh and the basic sequence of bead manufacture was reconstructed by Tosi and Vidale (1990) that included the separation of square-sectioned blocklets or rough-outs, aided by grooving-and-splitting technique (previously observed at Shahr-i Soktha, Tepe Hissar and recently, Altyn-depe in Turkmenistan), stages of grinding, drilling and polishing. Most of the common shapes are simple cylindrical and small discs. Some beads having unusual elaborate shapes are also recorded, this type of complex bead did not have great future in the later taste of Bronze Age societies.

A relatively small number of hard agate or carnelian beads have been recovered from the early periods, but they appear to have been short biconical shapes that can be perorated by pecking or chipping rather than drilling. Very little hard stone bead manufacturing waste has been found from Mehrgarh during early periods and it is thought most of the beads came from distant workshops rather than being made at the site itself.

During the following Chalcolithic or Early Harappan period, beginning around 4200-3500 BC (Period III) at Mehrgarh, there is evidence for use of hard stone drills made of jasper, banded agate and carnelian and the production of longer bead shapes in jasper, banded and tabular shapes of the earlier periods continued to be produced, the more common forms are lenticular barrel, short bicone and long bicone forms. During this period the practice of heating and whitening steatite beads begins to harden and turn them white (Vidale 1989). The practice of heating and whitening bead begun during this period and continued throughout all subsequent periods. The raw materials, techniques of manufacture and even bead styles of this earlier period, clearly formed the basis for later development in the Early Harappan and Harappan phases (Jarrige 1988). It is also possible that the additional heating was undertaken after beads was finished and for carnelian, this was often done to produce red-orange color.

Early Harappan stone bead making

Excavations at Harappa in the Early Harappan, Ravi Phase (*c.* 3500-2800 BC) and subsequent Kot Diji Phase (*c.* 2800-2600 BC) provide an interesting contrast to the data from Mehrgrah. Unlike Mehrgrah, which began its history by importing finished beads, the Ravi levels at Harappa have evidence of for local manufacture of both soft and hard stone beads (Kenoyer 2005). This indicates

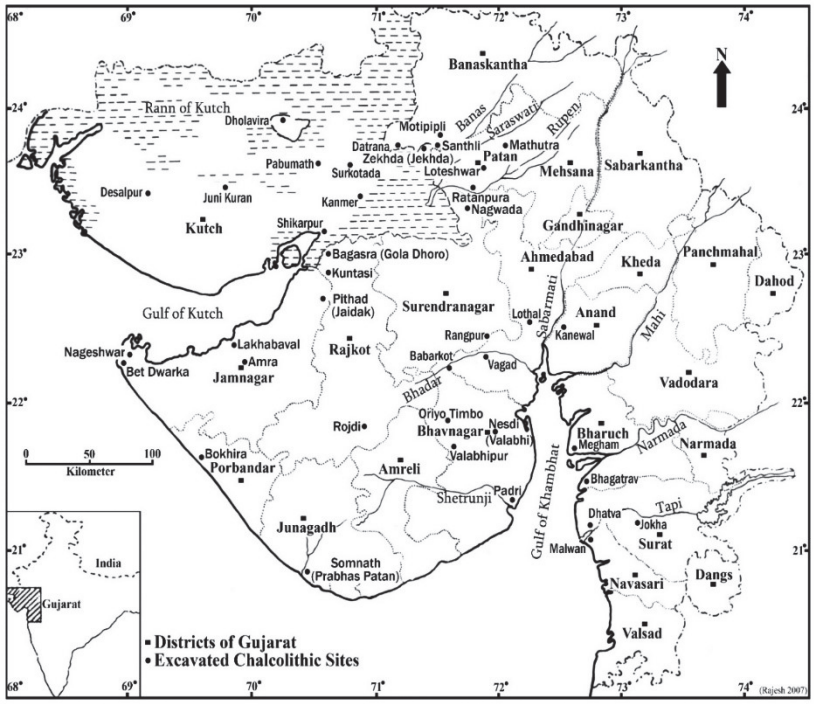

Figure 1. Map of Gujarat indicating important Chalcolithic and Harappan sites (courtesy Rajesh S.V).

that bead makers were among the first settlers at the site and may have contributed significantly to the economic growth and wealth of the inhabitants. All rock used to make beads, grinding stones and stone tools at Harappa were brought from the distance resource areas. Lapis lazuli was brought from over 800km to the north in Badakhshan, Afghanistan; amazonite and carnelian from Gujarat, some 800km to the south; steatite from Hazara some 500km to the north, chert drills came from 100 to 300km to the north or west (Law 2005, 2006). The most common shapes of beads were small discs, but short bicones, long bicones and a wide variety of other shapes are common in terracotta. The tiny steatite beads were probably drilled with copper tools, short carnelian beads were perforated by pecking, and longer beads of carnelian, jasper and amazonite were drilled with tapered cylindrical drills made of jasper and chert.

During the following Kot Diji phase at Harappa, there are increasing varieties of agate, sandstone, carnelian, limestone and possibly even obsidian being used for making beads (Kenoyer 2008: 11). This dramatic increase in the variety of raw materials is also noted at the site of Nausharo, Baluchistan (Barthélemy de Saizieu and Bouquillon 1994).

In Gujarat however, the earliest evidence of beads comes from the site of Loteshwar in north Gujarat (Figure 1). The chalcolithic deposit of Loteshwar Period II is about 10 to 30cm thick. In addition, the chalcolithic deposits there are many pits that penetrate into the Microlithic levels to natural sediment. These pits vary in dimensions, ranging between 50 to 200cm in diameter and 50 to 200cm in depth. They contain potsherds, animal bones, a few ornaments in the form of shell bangles, a carnelian and an amazonite bead, and hundreds of steatite microbeads. However, there are no indications of beads being produced at the site. Copper is represented at the site by a few undiagnostic pieces. However, it is interesting to note here that a cache of micro steatite beads stored in a pot were recovered from the site during one of the explorations conducted at the site. In addition, hand-pressed terracotta lumps ('*mushitak*') and terracotta perforated pottery discs and terracotta beads were recovered from the excavations. Besides, microliths are also found in these pits though it is not clear as yet to which period they belong given the chalcolithic pits were dug into Mesolithic levels. Two radiocarbon samples from two different pits of this period have yielded conventional radiocarbon dates with median probability of 3706 and 2993 cal. BC (PRL-1565 and PRL-1564, respectively) (Patel 2008: 123-134). The majority of pottery at Loteshwar belongs to Red ware and a very small percentage is represented by white painted Black and Red ware and Reserved Slip Ware. The Red ware is represented by three fabrics: Fine, Medium/ Gritty and Coarse. Pottery shows generic similarities with the Hakra and Ravi Phase pottery.

Another site that is in Gujarat associated with early bead manufacturing is Datrana in north Gujarat. The site is nearly 2km southwest of the present Datrana village and is situated on a large sand dune. There Period I is represented by Mesolithic/Mircolithic tools and Period II is represented chalcolithic pottery and copper implements. The site was a huge, perhaps seasonally occupied factory site for the production of blades from locally available raw material like chalcedony, carnelian

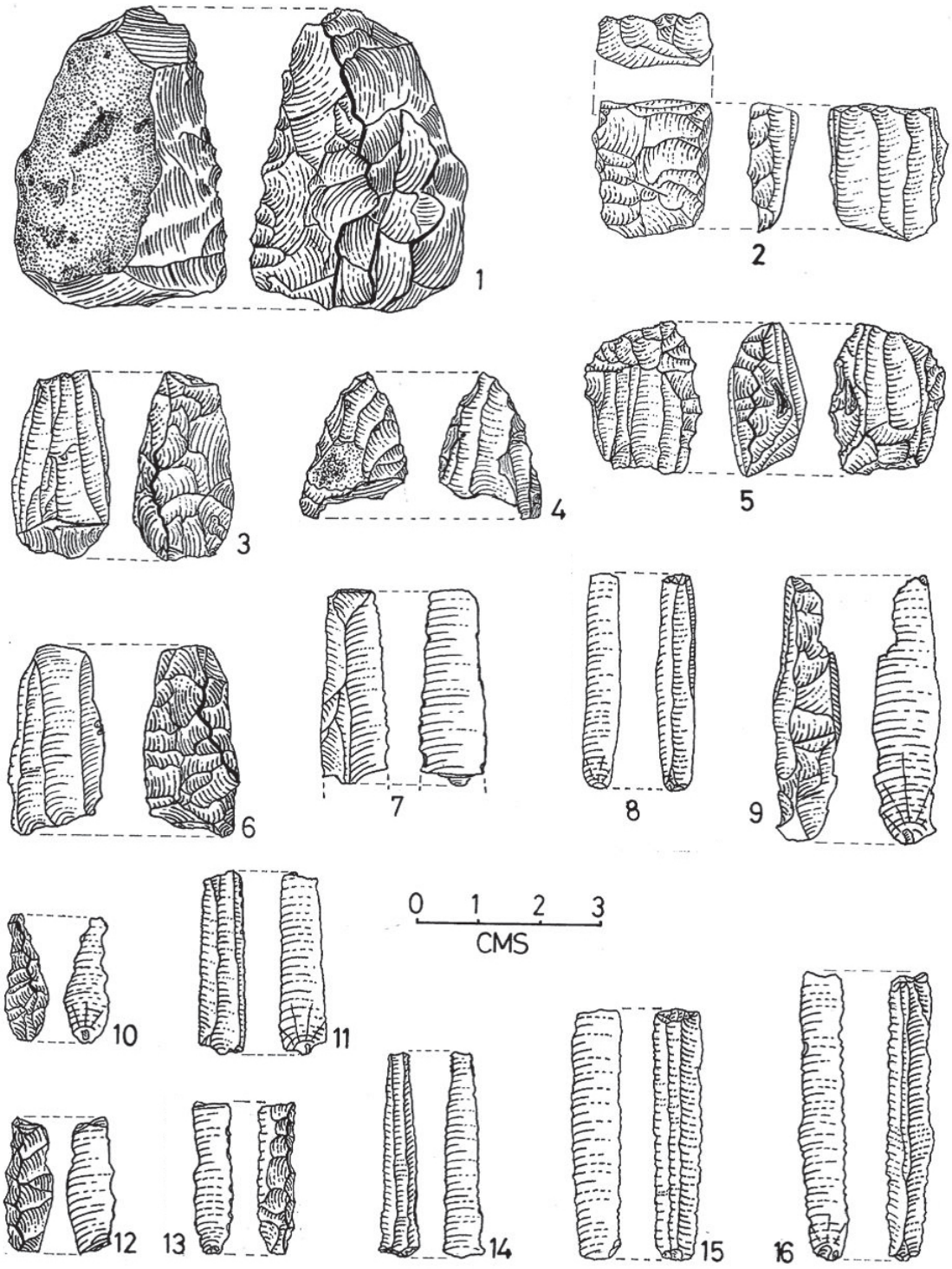

Figure 2. Datrana. 1-6) Cores; 7, 8, 11, 15, 16) Retouched blades; 9, 14) Blade blanks; 10, 12, 13) Crested ridge blades (courtesy Department of Archaeology and Ancient History, The Maharaja Sayajirao University of Baroda).

and jasper (Figure 2) during the chalcolithic period. The chalcolithic occupation at the site is characterized by several distant types of pottery showing similarities with the pottery reported from Loteshwar, Pre-Prabhas, burial pottery reported from Nagwada in North Gujarat (Ajithprasad 2002: 129–158). Unfortunately, we do not have any radiocarbon dates from the site as yet, but it seems to have been occupied from 2900 to 2600 BC.

As mentioned above, this settlement seems to have developed as a huge factory site solely associated with the manufacture of long blades using the crested ridge

Figure 3. Datrana. Carnelian bead rough-outs and small disc beads perforated by pecking along (photograph by K. K. Bhan).

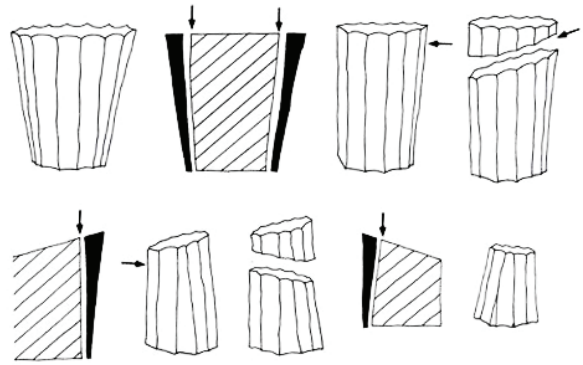

Figure 4. Diagram showing the process of production of core rejuvenation pieces (drawing by K. K. Bhan).

technique on locally available chalcedony, jasper, agate and carnelian. The stone craftsperson appears have produced a few small circular carnelian beads (Figure 3), by recycling the platform rejuvenation pieces, since they get produced in large quantities when the angle between the striking platform and the sides of the blade core approaches a right angle, it becomes more difficult to strike off new blades and if the core is reasonably large at this stage, a new platform is produced by flaking away the original one at an angle and these core rejuvenation platforms are often a common feature of the waste on the site where blades have been made and are at times used in making small beads (Figure 4). The recovery of a few finished and unfinished tapered cylindrical drill bits in the assemblage is quite interesting (Figure 5: 10-16). These drill bits appear to have been used in perforating the stone beads in combination with the pecking.

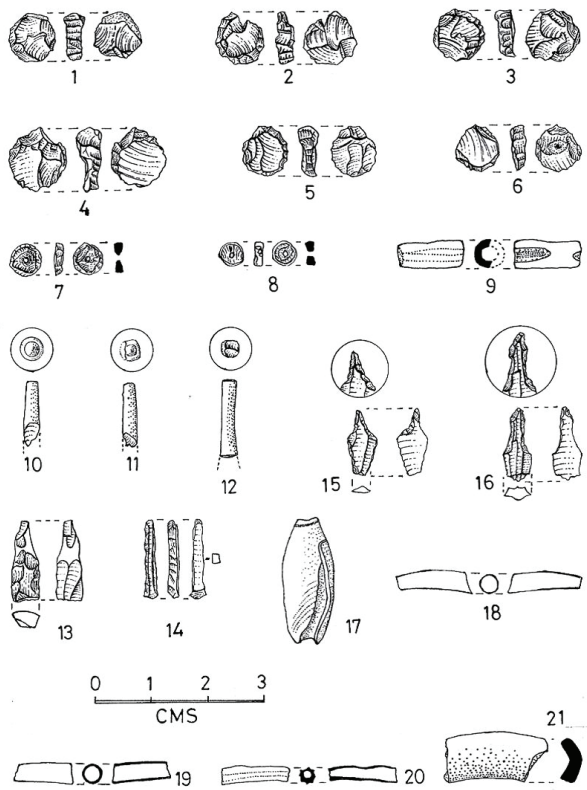

Figure 5. Datrana. 1-5) Carnelian bead rough-outs; 7-8) Carnelian disc beads; 9) beads broken during perforation; 10-12) utilized drills in chalcedony; 13-16) drill bits (courtesy Department of Archaeology and Ancient History, The Maharaja Sayajirao University of Baroda).

Harappan stone bead making

In recent times, agate bead technology has been the focus of new archaeological, ethnoarchaeological and experimental research. At Harappa American excavations are gathering large collection of bead making indicators, comparable with those of Mohenjo-daro and Chanhu-daro, and a possible 'activity area' for bead making and drilling has been identified in craft quarters on the extremity of Mound ET (Kenoyer 1997: 262–280). Besides, a large number of Indus Tradition sites have been discovered at Lewan in Bannu, N.W.F.P, Pakistan (Allchin *et al.* 1986: 81–87), Gazi Shah in Sindh Kohistan (Falm 1992; 1993: 131-158), Dholavira (Bisht 1990: 71–82), Shikarpur in Kutch, Gola Dhora (Bagasra) (Bhan 2014: 43–62; Bhan *et al.* 2004:153–158, 2005) and Nagwada (Bhan 2013; Hedge *et al.* 1988: 55–65) in North Gujarat. Limited amounts of unfinished and finished beads of semiprecious stones are often reported from Indus sites. For example, the excavations at Surkotada (Joshi 1990: 310–337) revealed 1050 beads in various materials, 11 agate specimens were unfinished. Such low figures might result from the episodic work of part time specialists living outside the cities. Another site, which had been associated with manufacture and trade of agate is Lothal in Gujarat. At Lothal (Rao 1979: 118–120) the excavator unearthed within a pottery jar with hundreds of finished and unfinished agate beads. For

different reasons (mainly because of the architectural context of the finds) the so-called 'bead factory' of Lothal cannot be considered as an actual manufacturing site.

One of the most important discoveries associated with the stone bead making in Gujarat is the recovery of stockpiles of raw material neatly kept in a series of clay lined bins (Figure 6) close to the eastern inner fortification wall at Gola Dhoro (Bagasra) in Saurashtra. Absence of stone bead making indicators around the stockpiling area suggests that the area was not actually used for bead manufacturing. A preliminary observation of the material indicates that the raw material was segregated on the basis of the type of raw material. Most of the bins contained red-green-white variegated jasper weighing in total nearly 170.29kg. One of the bins contained 27.84kg of smaller chunks of white banded black agate. The absence of manufacturing waste of red-green-white variegated jasper from the site perhaps indicates that this material was not meant to be used at the site but was stockpiled in order to be shipped to somewhere else for the manufacture of beads. While on the other hand white banded black agate seems to have been extensively used at the site for the manufacture of beads. Similar stock-piling areas segregated on the basis of raw materials also has been observed in Khambhat (Figure 7).

The presence of a few good quality shells of *Turbinella pyrum* and a broken stone dish perhaps also suggest that this area belonged to merchants dealing primarily with the supply of stone raw material to the bead makers of the settlement as well as other Harappan bead making workshops. We already have started mapping the resource areas of these stones, it appears the stone material especially (red-green-white) jasper was brought to the site approximately 70km south of the site in Saurashatra.

Robust evidence of bead making comes from the southern side outside of the fortification (Figure 8). The excavations revealed an activity area associated with bead making and this area is represented by beads, bead rough outs, and bead blanks in white banded black agate, micro debitage and tapered cylindrical drills (Figure 9) made on chert and jasper and constructed cylindrical drills made on a rare form of the metromorphic rock to which Kenoyer and Vidale (1992: 495–518) refer to as 'ernestite'. The analysis of the beads, drills and micro-debitage of this activity area is being carried out at present and we are hopeful to throw considreable light on this activity area in the future.

The site also revealed the manufacturing of beads in other materials as well. The recovery of a few famous long bicone carnelian beads from the site is very interesting but they don't seem to have been locally

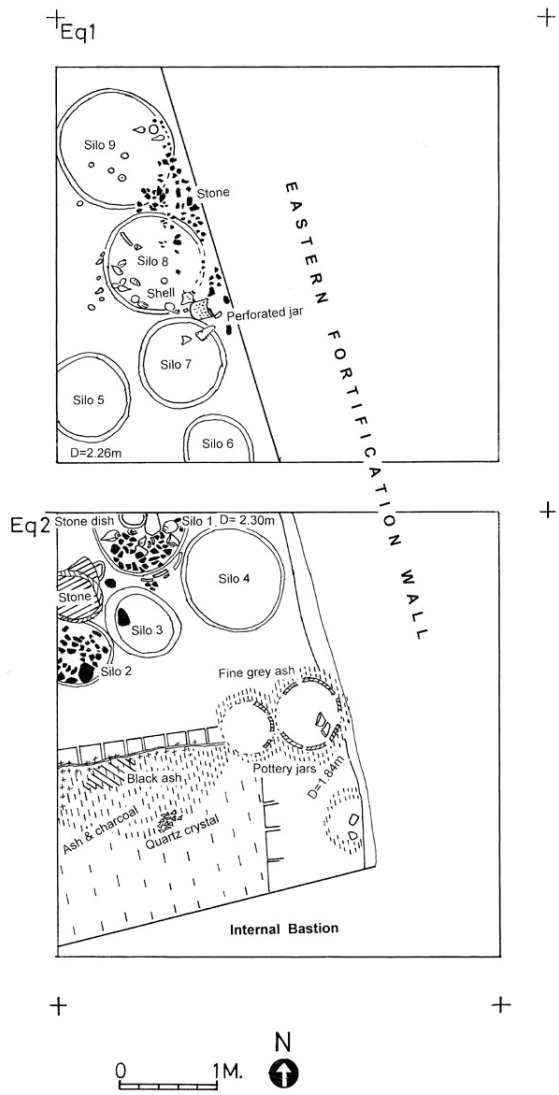

Figure 6. Gola Dhoro (Bagasra). Plan of raw material stock-piling area and faience activity area (courtesy Department of Archaeology and Ancient History, The Maharaja Sayajirao University of Baroda).

Figure 7. Khambhat. Present day stone stock piling area (photograph by K. K. Bhan).

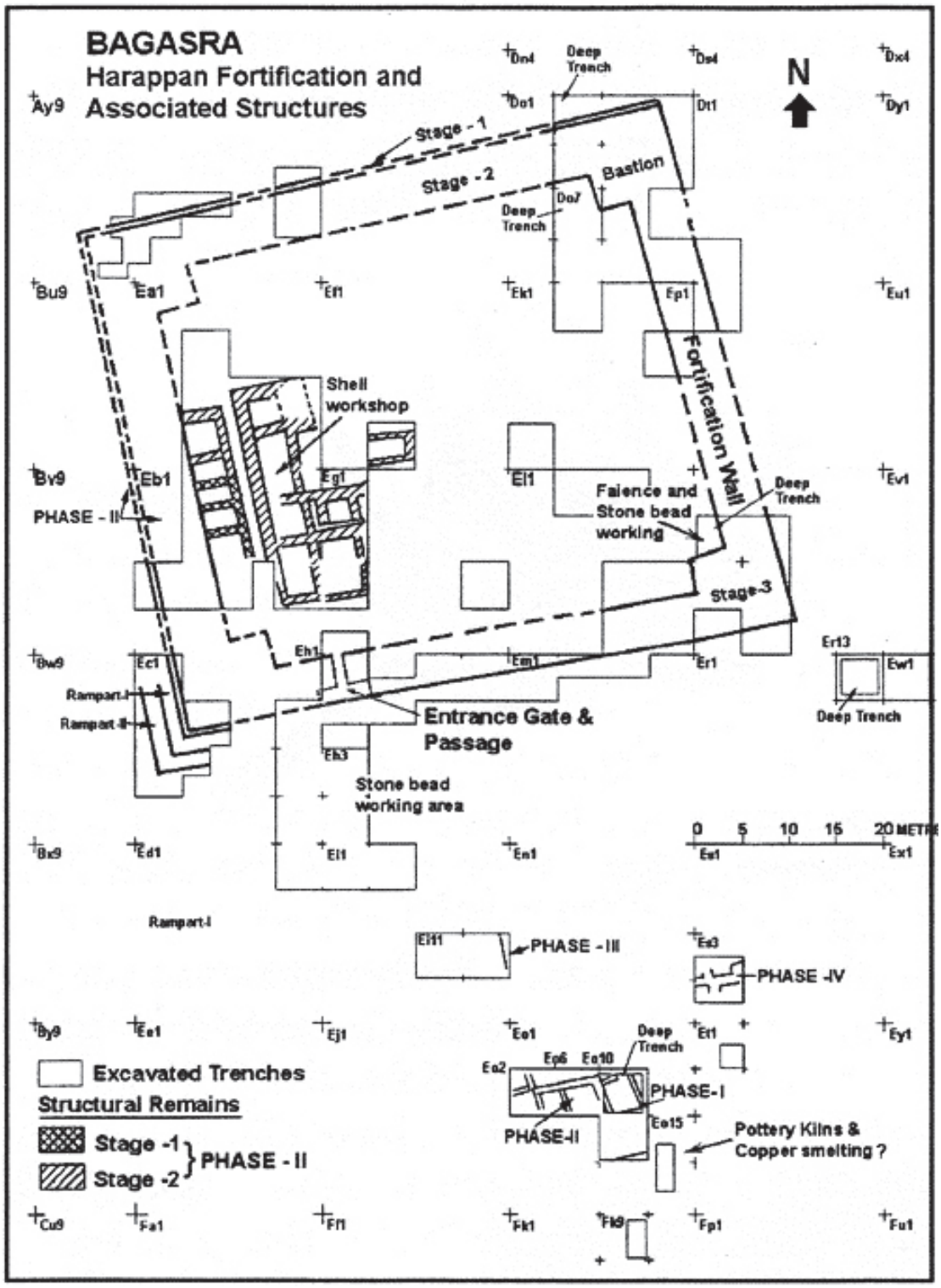

Figure 8. Gola Dhoro (Bagasra). Fortified settlement with craft activity areas within and outside fortification (courtesy Department of Archaeology and Ancient History, The Maharaja Sayajirao University of Baroda).

Figure 9. Gola Dhoro (Bagasra). Beads, bead blanks and tapered cylindrical drills (photograph by K. K. Bhan).

Figure 10. Nagawda. Constructed cylindrical drills and drill rough-out (photograph by K. K. Bhan).

manufactureed. Studies of some of the broken long bi-cones from the site revealed that they have been reworked to be used once they broke, suggesting economic value of such luxurious goods. One of the important interstings find from the site was the recovery of a bead with copper/silver wire intact in its perforation. It appears that this was one of the method of stringing beads during Harappan times.

It is intesting to note that the settlement of Gola Dhoro appears to be small industrial settlement of the Harappan Period assocaited not only with stone bead manufature, but also with faience bead making and shell bangle manufacture. The discovery of shell workshops inside the fortification is very interesting in this regard and is dicussed in detail later.

Another important Harappan site revealing the interesting craft indicators of bead making is from Nagawda in North Gujarat (Bhan 2014: 43–62; Hegde *et al.* 1988: 55–65). The site revealed beads in various stages of production, lithic micro-debitage, tapered cylindrical tapered drills made on chert, jasper and carnelian and constricted cylindrical 'ernestite' drills and drill rough-outs for drilling hard stone beads (Figure 10). Besides, manufactruing beads in carnelian, jasper, and banded agate (Figure 11), one of the most important materials that has been worked differently at the settlement of Nagwada was amazonite.

Softer stones like amazonite and lapis lazuli don't withstand flaking, these materials shatter on chipping. Therefore, the craftspeople of the Indus seem to have worked them differently. The manufacturing sequence of the amazonite beads includes separation of square-section blocklets or rough-outs by grooving and splitting techniques using a fine copper wire saw, followed by grinding, bi-polar perforation and polishing. This stone appears to have been drilled using tapered cylindrical

Figure 11. Nagwada. Carnelian, agate, jasper and amzonite beads (photograph by K. K. Bhan).

drills made on jasper, chert and carnelian, since these materials are comparatively softer stones.

Shikarpur, another important fortified site in Kutch that has revealed impressive indicators of bead making. Finished beads (Figure 12) and beads in various stages of production, micro debitage, cylindrical, 'ernestite' drill heads and one of the drills recovered from this site seems to have been used from both sides.

The recovery of amazonite beads and bead rough-outs have also revealed that like Nagwada, at Shikarpur the craftsperson manufactured amazonite beads by cut and splitting techniques. The serpentine bead rough-out recovered from Shikarpur (Figure 13) has retained clear evidence of sawing from both sides and snapping in the middle by percussion. Besides a few finished carnelian long bi-cones beads have been reported from Shikarpur, but there are no indications of these being produced at the site. The lithic material is being analysed and we expect very interesting results from this study. One

Figure 12. Shikarpur. Carnelian, jasper, chalcedony beads (photograph by K. K. Bhan).

Figure 14. Shikarpur. Raw 'ernestite' fragments (photograph by K. K. Bhan).

Figure 13. Shikarpur. Sawn and snapped serpentine bead rough-out (photograph by K. K. Bhan).

Figure 15. Dholavira. Bloodstone bead blank (courtesy R. S. Bisht).

of the important and interesting evidences related to bead manufacturing at the site is the recovery of large amounts of raw 'ernestite' lumps that are strewn throughout the site (Figure 14). Perhaps none of the so far reported Harappan sites have revealed such a large amount of ernestite. Finding large amounts of 'ernestite' from this site may perhaps indicate it was easily available to the inhabitants of Shikarpur and perhaps the raw material source might have been closer to the site. Locating the resource area of ernestite should be undertaken around this important site.

Other important sites that have revealed bead making indicators are Dholavira and Kanmer in Kutch, though we need to await the full publication on the bead material. However, it appears that Dholavira was at least geared in the production of long – bicones in bloodstone (Figure 15) that was one of the items of long distance trade. The distribution of bead making activities at almost all sites discussed above suggest small scale entrepreneurs workshops making small to medium sized beads in variety of raw materials. There is no evidence for maintenance of the area and wide variety of flakes scattered across the site. Overall this reflects a short-term production area by entrepreneurs.

In order better understand the most important aspects of the Harappan bead technology, it is mandatory to go back to the evidence gathered by Mackay (1943) at Chanhu-daro. Besides, recent re-study of Mackay's collection in the Boston Museum of Fine Arts and British Museum by Kenoyer and Bhan has significantly broadened our understanding of bead technologies. Mackay, at the relatively small site of Chanhu-daro was able to reconstruct manufacturing sequences of different types of carnelian beads including the beautiful long barrel specimens well known from Harappan hoards, which were later traded with Early Dynastic Mesopotamia (Chakrabarti 1982: 265–267; Inzian 1993). Interestingly, no evidence of production of these luxury beads have reported from any Harappan bead manufacturing centers of Gujarat. Therefore, Chanhu-daro appears at present to be only the center where such specialized luxury items were produced.

The long beads produced at Chanhu-daro required the performance of difficult and probably expensive manufacturing techniques, partially similar to those nowadays applied to Khambhat for the manufacture of *chasi*-long faceted beads. Such sequences involved chipping of windows in large carnelian nodules to access the particular quality of the stone; drying and heating of the agate nodule under sun in closely monitored storage areas, during summer, multiple cycles of firing in special terracotta containers and kilns to remove the residual moisture to improve chipping qualities and turn agate into red orange; sawing with copper/bronze saws in order to conserve the preserve the precious raw material and maintain the length of the bead; primary stage of chipping and/or pressure flaking; hand grinding on various grinding stones and polishing; multiple stages of drilling process with specialized tools and finally heating and polishing. The reconstructed sequence should have been basically similar to that observed in contemporary Khambhat, where long faceted carnelian beads are still produced for long trade.

A possible kiln used for firing carnelian nodules was found by Mackay (1943) in a room of large building housing various types of crafts in the center of the main mound at Chanhu-daro (Vidale 2000: fig. 16). It resembles the shape of kilns nowadays used at Khambhat (Figure 16) for the same purpose, with tanks and cells for setting the terracotta vessels containing the agate nodules (Kenoyer *et al.* 1994). The hypothetical Indus version from Chanhu-daro would be particularly sophisticated, having flue ducts below the tanks for better circulation of heat below the vessels. Such a kiln is still a unique discovery in Indus archaeology. Rao (1979) claimed to have identified at Lothal pottery vessels used for firing beads, but such items were never published, and it is unlikely that this interpretation is actually correct.

Chipping might have been performed with both hard and soft hammers; the exact technique is not known, but it might have included indirect percussion techniques, similar to those presently used at Khambhat (Figure 17). As shown by the marks on agate debris at Chanhu-daro, Mohenjo-daro, Gola Dhoro, Shikarpur, and Nagawda, sawing of carnelian and other stones was done with thin copper or bronze saws. By sawing the nodules into two parts, craftspeople obtained a continuous, regular platform for ensuring chipping/pressure flaking stages and it helped to maintain the length of the bead, which otherwise would have been reduced by the frequent removal of platform rejuvenation that become necessary as the sides reach 90° to the striking platform. The stones used in grinding the beads into coarse blanks were in various quartzite; they are easily identified because they bear deep parallel groves where the blanks were pushed back and forth.

Figure 16. Khambhat. Kilns (courtsey J. M. Kenoyer)

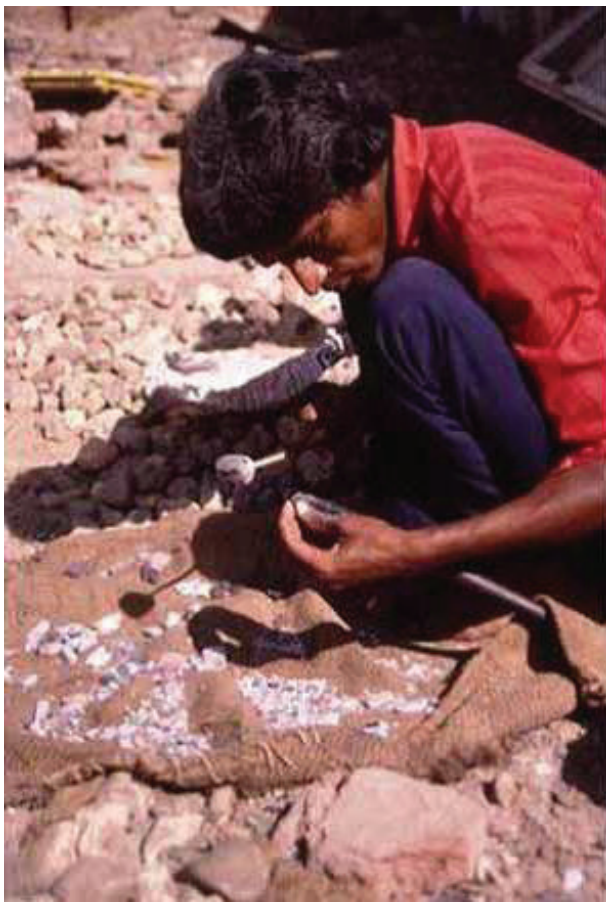

Figure 17. Khambhat. Inverse indirect percussion technique used to make beads (photograph by K. K. Bhan).

The drills probably used for long carnelian beads at Chanhu-daro are a specific Indus type, that Kenoyer and Vidale (1992) have labeled as 'constricted cylindrical' in order to distinguish them from common 'tapered cylindrical drills' of the Regionalization Era of the Indus Valley and earlier 3rd millennium cultural complexes

of South Asia. Polishing is nowadays done with wheel of metal and hard wood, but other techniques involving abrasive are possible alternatives.

As a comparison with carnelian – working evidence at Chanhu-daro, substantial evidence of bead making using a wide variety of semiprecious stones was also brought to light with Aachen-IsMEO survey of the workshop areas of Mohenjo-daro (Vidale 1984). In the Moneer South-east area at Mohenjo-daro it was possible for Masimo Vidale to map on the surface and collect thousands of flakes of semiprecious stones, defective bead roughouts, broken drills, both used and unfinished, the debitage left by the manufacture of drills, grinding stones for smoothing the beads, and unfinished cubic weight in chert from Rohri Hills. Some of the fragments show the use of copper / bronze saws for cutting agate and hard metamorphic rocks.

A detailed reconstruction of the manufacturing techniques at this site is presented by Vidale (1984). Quantitative analysis indicated that the varieties of semiprecious stones were exploited at the site included chalcedony, i.e. agate in various colors, mainly varieties of red, followed by translucent apple-green stone of grossular, then followed by jasper, bloodstone, rock crystal, and a few flakes of lapis lazuli, but no steatite chip was found in the bead makers' dumps (Vidale 2000: 48).

Similarly, a variety of raw materials were found being utilized at most of the recently excavated Harappan sites of Gujarat. The analysis of the bead manufacturing debris from Nagwada, Shikarpur and Gola Dhoro is at present under progress. The list of the semiprecious stones used in manufacture of beads by the Moneer area craftspeople at Mohenjo-daro and other mentioned Harappan sites is indeed varied. The most important technological feature of agate working at these sites is very careful exploration of distinctive types of raw materials. Instead of the beautiful, massive and translucent carnelian used at Chanhu-daro for making long beads, the bead makers at these sites used opaque, white - to- red agate whose red color was most probably enhanced by firing. The fibrous agate is distinguished by inner diaclastic planes that run orthogonally to the direction of the stone's radial fibers. Vidale is of the opinion that bead roughouts were expediently detached by percussion exploiting the stone's diaclastic or fault lines. In this way were detached squared blocklets of multi-layered agate created, which could be ground made into attractive beads with eye-patterns (Vidale 2000: 48, fig. 21). The manufacture of amulets and beads in grossular appears to be equally skillful and specialized.

At these sites large numbers of 'constricted' short drills made on 'ernestite' were evidently manufactured by the bead makers, together with small 'tapered' chalcedony, jasper and chert drills made out of retouched bladelets, similar to drills used in Eastern Iranian and Central Asian sites to drill softer materials like lapis lazuli, turquoise, amazonite and shell.

Important aspects of Indus drilling technology have been defined by Kenoyer and Vidale (1992) with various analytical techniques. Silicon impressions of the inner holes of long carnelian beads were taken and studied with a Scanning Electron Microscope (SEM), a technique well known from previous studies on bead making. In some cases, for perforating long bi-cones three drills of different diameters were used for drilling the same bead, the thickest in the beginning of the drilling process, the thinnest at the end. Additional evidence on these highly specialized techniques was provided by ethnoarchaeological and experiments carried out at Khambhat.

The 'ernestite' rock was found in angular blocks at Mohenjo-daro, Chanhu-daro, Nagawda and Harappa. These blocks were grooved with parallel cuts and split in bars, which were finally ground and polished; the upper part was ground into a carefully faceted shaft, probably to grant a good centering with the haft. The point was shaped into distinctive constricted shape. Another feature of drill is a peculiar circular depression at the tip, whose nature, at the beginning was not fully understood (see Vidale 2000: 51, fig. 17.1).

A possible organizational pattern emerges from the available evidence. Now, we have relatively detailed information from four sites with intensive manufacturing evidence - Chanhu-daro, Moneer South-east Area of Mohenjo-daro, Nagwada and Gola Dhoro, Shikarpur in Gujarat. All the sites show efficient and very specialized techniques for transformation of semiprecious stones into beads. At Chanhu-daro one witnesses the application of standardized techniques for the production of large amounts of valuable beads of rare, high-quality transparent carnelian, and refined chemical treatments were applied to obtain artificial patterns on the beads' surface. The study of silicon impression from the holes of the long beads from Chanhu-daro revealed similarities to those found in the Ur graves; suggesting direct trade or the presence of in the Mesopotamia cities of craft enclaves using same techniques and materials used in the subcontinent (Kenoyer 1997). In contrast, at Nagwada, Gola Dhoro and in the Moneer site at Mohenjo-daro, different techniques and materials were used, on much more limited scales, for producing smaller beads with a wide range of raw materials, and in some cases surfaces with white-orange or white-black contrasting patterns were sought for and obtained through a careful exploitation of the stone's natural bands. In another paper (Kenoyer *et al.* 1994) we have hypothesized, on the base of

preliminary comparisons with ethnoarchaeological evidence from Khambhat, that Chanhu-daro perhaps represents centralized production controlled by state institutions or important merchants connected with political *élites*, versus more flexible, independent forms of production represented by Nagwada, Gola Dhoro, Shikarpur and the Moneer site at Mohenjo-daro. Only the extension of research to other bead making areas will allow a proper testing of this important hypothesis.

Shell working

Shell working for the personal ornaments is well attested for several prehistoric contexts in the subcontinent. The finds of Neolithic graves of Mehrgarh show that marine shells were widely worked and traded across the Indus basin and Baluchistan at least since Neolithic times. At Mehrgarh, between the 7th and the 6th millennium BC, marine shells such as *Spondylus*, *Cardium*, *Dentalium*, *Pinctada*, *Conus* and other species appear to have been base materials for ornaments such as beads, pendants, and bangles, manufactured with simple sequences of chipping, grinding, drilling and polishing using chert tools and grinding stones (Vidale 2000: 67, fig. 27). Furthermore, the Neolithic graves of this site contain the earliest specimens of thick bangles cut out of the conch shell, *Turbinella pyrum* (Kenoyer 1998: fig. 2.10). This early trade of luxury commodities probably involved, since the Neolithic, regular trans-oceanic shipping from the coast of Oman to the bays of shores of the Makrani coast, activities which in time became systematic and economically more and more relevant, reaching an apex in the last two centuries of the 3rd millennium BC (Vidale 2000: 67).

As no manufacturing waste has been so far identified for Period I, we have to assume that the bulk of manufacturing was performed along the coasts, and only finished goods were traded inland. In particular the manufacture of disc beads from *Spondylus* shells and their distribution inland suggested by Kenoyer the possibility that such goods might have represented a form of standard medium of exchange between coastal and interior communities. In Period II, the pattern is somewhat similar, but there is possible evidence of manufacturing at the site, consisting of a few unfinished shell artifacts. A local tradition of shell working developed without interruption through 5th and 4th millennium BC. In this period, at Mehrgarh, *Turbinella pyrum* becomes the main raw material and there is positive evidence of its working at the site. Shell bangles with unusual grooved pattern appear only during this time span (Jarrige *et al.* 1995: 571). The major source for this early trade in *Turbinella* shell seems to be Makran coast. In 3rd millennium BC, shell ornaments appear more simplified and assume the plain canonical shapes characteristic of the Indus types in the second half of the millennium.

Shell working is the industry we have the clearest picture of urban segregation and about the sequential stages of manufacture of various types of objects during Harappan times. The study of shell, which is one of the most durable materials in the archaeological context, has helped us to reconstruct the trade networks within the Indus Valley and adjoining regions. Some shell species have a very isolated or limited distribution along the specific coastal regions and by determining the ancient source areas of these species; we have been able to gain a new perspective on the trade networks and exploitation of marine resources by prehistoric coastal populations (Kenoyer 1983, 1984c, 1985; Bhan and Kenoyer 1984; Bhan 1991; Bhan and Gowda 2003).

Although many different species of marine and fresh water mollusca have been reported from most of the major Harappan sites, the shell of only few marine species: *Turbinella pyrum*, *Chicoreus ramosus*, *Fasciolaria trapezium*, *Lambis truncata*, *Tivela damaoides*, etc. were actually used in the manufacture of shell objects such as bangles, inlays, ladles, rings, pendants, beads, figurines, etc. (natural shells that have simply have to be perforated for ornaments, e.g. dentallium shell, are not included in the present discussion).

Kenoyer's study on the shell industry of Indus Civilization has indicated that three areas were being exploited for the procurement of raw material (1983): the Karachi coast for *Turbinella pyrum* (hereafter *T. Pyrum*) and *Pugilina bucephala*; the Gulf of Kutch for *T. Pyrum* and *Pugilina bucephala* and *Chicoreus ramosus* (hereafter *C. ramosus*); and the Gulf of Oman *Lambis truncata sebae* and *Fasciolaria trapezium*. This later suggestion has been confirmed by the finds at Ras Al-Jinz, within what is probably a warehouse dating 25th–23rd centuries BC, of remains of hoarded unworked *Fasciolaria* shells (Cleuziou and Tosi 1985, 1987; Cleuziou *et al.* 1990). *Fasciolaria* shells are also found in Gulf of Kutch, they were not reported till recently from any of the Harappan sites of Gujarat. However, the recent recovery of a hoard of unworked *Fasciolaria* shell from the shell workshop area of Gola Dhoro perhaps suggests the raw shell of *Fasciolaria trapezium* might also have been obtained from the Gulf of Kutch. On the basis of the distribution of different species originating from these distinct source areas and the nature of shell manufacturing at specific sites, Kenoyer (1983) postulated a complex hierarchy sphere and system within the greater Indus Valley region.

Shell industries of the Harappan period also reflect the stratification in the trade of raw materials and the movement of finished objects, At Mohenjo-daro, Chanhu-daro, Harappa, Nagwada, Lothal, Rangpur etc. we see a wide variety of objects being primarily produced for markets within sites and nearby sites. On the other hand, small rural towns or coastal sites

like Allahdino, Balakot, Nageswar, and Gola Dhoro produced a limited range of artifacts. At Balakot the intensive production of *Tivela damaoides* bangles appear to have been specifically for local inhabitants (Kenoyer 1983: 255). Nageswar, however, seems to have been a specialized center in the production of bangles and ladles (Bhan and Kenoyer 1984) and Gola Dhoro (Bhan and Gowda 2003) for bangles manufactured primarily for trade to the regional and extra-regional markets. In contrast to specialization between sites the manufacturing technology was quite standardized.

After the brief outline of the most important species and their probable source areas, now we would shift to summarize the manufacturing techniques carefully reconstructed by Kenoyer (1983) for most of the important categories of shell products, namely ornaments (bangles) and utensils (ladles), etc. will be presented below.

Shell bangles were produced almost exclusively from *T. Pyrum*. The meat of this shell fish is edible and might have been important source of food for the coastal communities. We know that at least in some cases they were traded in unbroken condition, as an area was found at Mohenjo-daro where the shell was broken at the tip to remove the meat before further processing of the shell. The sequence of manufacture begins for preparing the shell for sawing by hollowing out interior and breaking the thick columella. A stone or metal hammer was used to perforate the apex and then metal pick was used to break the internal septa, Once the shell had been hollowed out in this manner, it was sawn at a diagonal to avoid the aperture and remove the irregular anterior portion. The remaining hollow spire was sawn in rough circlets. These circlets were ground on the interior using a cylindrical piece of sandstone or some other type of abrasive tool, while exterior was ground on a flat sandstone slab (Kenoyer 1983: fig. 3-6). The columella of *T. Pyrum* which comes as waste from the bangle manufacture is perfect raw material for the production wide array of small solid objects from rings, to beads and pendants.

The bangle manufacturing sequence ended when shell-cutters incised a 'V' shaped pattern at the location of the suture between the whorls. This design was traced either with chert and/or metal tool, and was evidently meant to turn the irregularities left by natural form of shell into a decorative pattern. The manufacture of *T. Pyrum* shell bangles reconstruction, involved the use of a kit of 6-7 tools. While hammers and /or pick were made of either bronze or stone. The recovery of a ceramic container (tool-kit), containing a bronze pick and flat sandstone grinding in the shell workshop of Gola Dhoro is very significant. According to Kenoyer, one of the specialized metal tools was relatively large and heavy saw, with long convex edge and an extremely thin blade, between 0.4 and 0.6mm, bi-directionally denticulated. It could cut to a minimum depth of 30mm as it was pushed back and forth. The blade of the saw must have been as hard as that of steel saw used by contemporary shell-cutters of Bengal. Another specialized copper/bronze tool used in this context was the tubular drill for manufacturing rings that we will see in detail later.

C. ramosus were also used for making bangles; the thick spines were cut by groove-snap technique and later ground to produce a smooth surface. Given the larger orifice of this shell, the columella and inner septa could be broken from such opening; after this shell could be sawn diagonally sliced with the same technique described for *T. Pyrum.* Bangle manufacturing from *C. ramosus* also leaves recognizable wasters in the form of sawn columella and unperforated apex portions (Kenoyer 1983: figs. 3-7). Although the difference in procedure does not affect the finished product, it highlights the ingenuity and technical skills of Harappan craftspeople. Differences in shell morphology, however, do affect the form of finished bangles, such that bangles made from *C. ramosus* are generally larger in diameter than average *T. pyrum* and are thin and twisted.

Pugilina bucephala was also occasionally used for making bangles; small amounts of *P. bucephala* was used at Nagwada and Gola Dhoro, in the last phase of the settlement. Like *C. ramosus* the spines were cut and ground smooth and later sequence is similar to the *T. pyrum* shell. At Nagwada, the columella thus produced as manufacturing waste has been seen recycled perhaps to produce small beads.

One of the distinctive utensils found at Harappan sites is the large shell ladle made from *C. ramosus*. Before the body of the shell could be cut, all the spines were completely sawn or partially sawn and later snapped. Then a diagonal cut was made from top to the main whorl extending around both sides of the shell and eventually reaching the narrow anterior end of the shell. A handle was formed by making longitudinal cuts from the anterior tip towards the main whorl. In this manner, the rough ladle was detached from the shell; a second similar ladle could be produced, leaving behind the apex, spine along with columella as distinctive manufacturing waste (Bhan and Gowda 2003: fig. 5).

Due to the small size of most inlay pieces, it is often impossible to determine the species of shell used in making a particular piece, but the study of shell waste fragments indicates that larger gastropods were used in the production of inlays. Waste fragments of *T. pyrum* and *C. ramosus* left from bangle manufacture were recycled to make various flat designs. However, Kenoyer (1983) has reported that *Fasciolaria trapezium* may have been solely used for the manufacture of inlay, where

only thick body whorl was sawn, chiseled and drilled to produce various geometric shapes (Kenoyer 1984: 104). Another species of shell used at Mohenjo-daro for the manufacture of solid plaques was *Lambis truncate sebae*. In this the outer lip was sawn into the desired design. The species has not been so far reported from coastal sites of Gujarat, though this species is found in the western coasts of the Indian subcontinent.

The solid massive columella produced as a manufacturing waste from of *T. Pyrum* bangle making was recycled to produce a wide range of objects. One such item extensively made at Nagwada was the simple and multiple grooved rings. The craft indicators of ring production at Nagwada are much higher than any so far known Harappan site. The study of the shell debitage from the site indicates the process of transformation of rings from recycling of the *T. pyrum* columella, through various manufacturing stages, this hypothetical reconstruction of the manufacture sequence was than tested with the experimental simulation carried out in an ethnographic situation at Khambhat (Bhan and Gowda 2003: 61).

The sequence of shell rings at Nagwada included the shaping of columella into squares /rectangular rod like elements, followed by rounding of columellas by grinding and slicing of the ring blanks. These ring blanks were drilled using copper tubular drill (Figure 18), leaving characteristic circular discs that are thinner on one side and thicker on the other, thus having trapezoidal sections, in case of the simple ring manufacture. While in case of the multiple grooved rings the ring blanks were thicker and were drilled using copper drill to produce a bipolar-bi-conical asymmetrical drill waste. Though these circular shell discs could have been used later as inlay or could have been later converted into small beads by perforating them by chert drills, but were not made intentionally for the purpose. The use of tubular drills on hard stone has not been reported from perhaps for any of the Harappan sites. It is during Megalithic Period at Kodumnal in South of India we see the use of tubular drill to produce stone rings in hard stone (Figure 19). Later, in Gujarat during the Early Historic period we also evidence of stone ring manufacture at Limbodra.

Indus settlements developed local communities that were intensively involved in the processing and trading of commodities to be exported to regional and extra-regional markets. This happened with the production and trade of sea shells. In the following paragraphs we will discuss coastal shell working sites of Gujarat in order to understand the collection, distribution and levels of production of shell.

Rao (1973: 236) interprets the presence of shell manufacturing at Lothal being indicative of a major

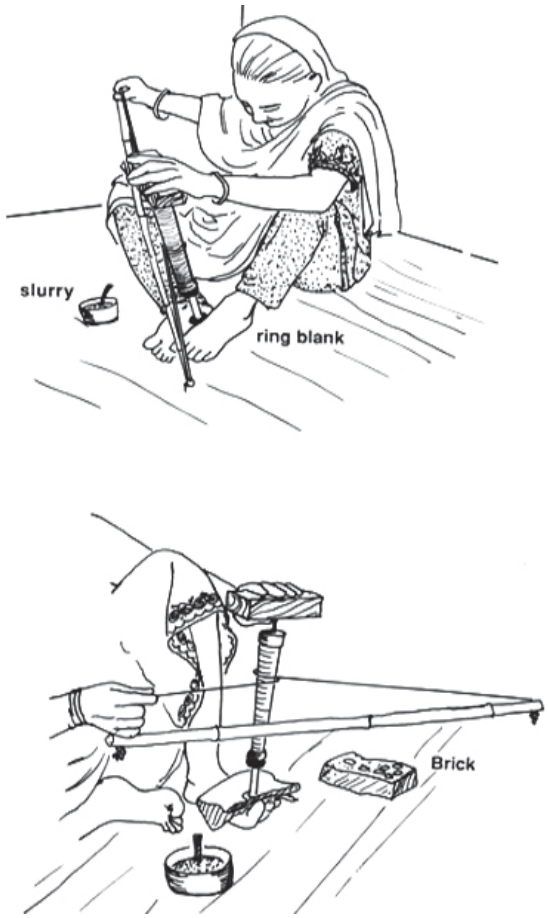

Figure 18. Khambhat. Tubular drilling (courtesy J. M. Kenoyer).

Figure 19. Kodumnal. Stone ring manufacture: 1) Ring roughout, 2) Ring and drilling waste, 3) Tubular drill sharpener, tubular drilling waste (courtesy K. Rajan).

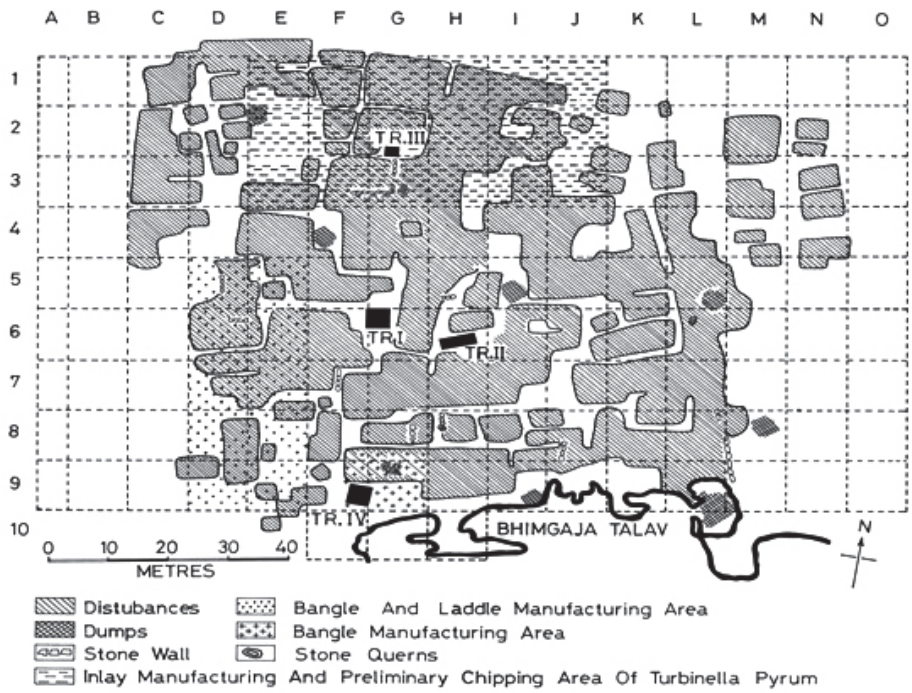

Figure 20. Nageshwar. Distribution of various shell craft indicators. (courtesy Department of Archaeology and Ancient History, The Maharaja Sayajirao University of Baroda)

industry aimed at export to hinterlands and to sites in Mesopotamia. On the basis of frequency of finished shell objects to wasters from Lothal and Rangpur, Kenoyer is of the opinion that Lothal was primarily catering to local demands (Kenoyer 1983: 283).

Nageshwar, situated on the southwestern tip of the Gulf of the Kutch provides an important perspective of the shell industry (Bhan and Kenoyer 1984; Bhan and Gowda 2003). The site is located on the southern shore of the Gulf. It is about 17km northeast of Dwarka. Systematic surface survey and limited excavation at the site revealed that Nageshwar was a major center for the production of shell bangles and ladles.

Shell bangles appear to have been made primarily from *T. pyrum* and less commonly from *C. ramosus.* Relatively, few finished bangles were recovered from the site (n=135). Vast quantities of shell wasters were found from the pits dug out by earthwork contractors, who were building the northwestern embankment on Bhimgaja Talav (a natural fresh water lake near the site). In one such pit there were 714 sawn columellas, 430 outer margins of lips and 11 apex portions of *T. pyrum* spread over 1m square. The cache of wasters from this single pile was more than what was reported from the entire excavation at Mohenjo-daro (n=110) (Kenoyer 1983: 241). These wasters may have been intended for reprocessing into other shell objects like rings and beads. Another, neatly kept pile of 413 columellas of T. pyrum was recovered from rammed floor level during excavations. Except one tubular drill waste and few finished beads there are no indications of reworking of the columella at the site, thereby suggesting that this material was carefully saved for transportation elsewhere for recycling them into rings and other shell items.

Besides, bangle manufacture from *T. pyrum* and *C. ramosus* another significant feature of the site was the production of ladles from *C. ramosus*. In the course of surface survey, a shell working location for the manufacture of ladles and bangles was located in D5-D9 and E5-E9 squares (Figure 20). In this area, a large number (n=89) of *C. ramosus* wasters discarded during ladle manufacture and sawn shell sections forming the blanks of Ladles were recovered. This area also revealed *C. ramosus* wasters discarded during the bangle manufacture and can be easily identified from unperforated sawn apexes (n=93) and nearly 54 columella portions. Not a single finished ladle was recovered from excavation and surface explorations. The absence of finished ladle and high frequency of bangle manufacturing and ladle waste of this species imply that these objects were being manufactured exclusively for trade to major urban centers in the eastern and nuclear region.

On the basis of the proximity of Nageshwar to sources of *T. Pyrum* and *C. ramosus* and based on the recovery of enormous quantities of waste, higher than that at any other Indus Valley site, it can be assumed that this site was geared towards the supply of good quality raw shell and finished goods in the form of bangles and ladles for regional and interregional markets. On the basis of the near absence of bore holes and undersized shells of *T. Pyrum* from this settlement suggests the shell cutters were perhaps themselves involved in the procurement

Figure 21. Gola Dhoro (Bagasra). Shell bangles and circlets (photograph by K. K. Bhan).

of shell and perhaps also suggests that the *T. pyrum* species was collected using boats for diving into deep waters, while *C. ramosus* seems to have been collected from rocky areas of the coral reefs during low tide or from shallow shores.

Gola Dhoro (Bagasra) is a small village on the southeastern shore of the Gulf of Kutch in Maliya taluka of Rajkot District of Saurashtra. One of the most important craft activities pursued with great vigor at the site was the production shell bangles from *T. pyrum*. One of the most fascinating discoveries associated with this craft was the recovery of a rectangular structure approximately 5.60X3.20 m with an adjoining chamber, situated on the northwestern periphery inside the fortification wall. Within this structure, three large unworked heaps of *T. pyrum* shell, resting against wall and thousands of unfinished shell circlets, perhaps kept on a wooden box containing 1933 complete and 3139 fragmentary circlets, and few finished shell bangles were recovered outside the box (Figure 21), a grinding stone and a few vessels perhaps to hold water that could have been used while grinding stage and a tool-box containing a copper chisel perhaps used to hollow the shell. The floor of the workshop was full of micro shell debitage indicating the shell cutting into circlets was carried out in this area. Unfortunately, no saw used for cutting the shell was recovered; however, recovery of three copper ingots from the unworked shell heap is very significant in the light of most of the times this precious raw material might have been often recycled.

Preliminary observations of these unworked shell piles revealed that one of them had hundreds of shells that were either undersized or worm-eaten. This indicates that the shell-cutters of Gola Dhoro, separated shells based on quality. However, unlike Nageshwar it appears that the shell cutters were perhaps not personally involved in the collection of shell. Kenoyer's ethnographic work on shell workers of Bengal (1983: 328) provides an excellent parallel to this situation. He reports that since large quantities of shell are shipped from South India, merchants mix defective worm-eaten and undersized shells with good quality ones, thus leaving distributors in Kolkata with defective shells. These are passed on to smaller producers. Tidal mud flats in the vicinity of Gola Dhoro may have been the source of some edible shells and smaller gastropods, but larger gastropods must have been sourced from the coral reefs of the Jamnagar coast, which is nearly 150km away. Thus, it appears that the shells of Gola Dhoro depended on other coastal sites for the procurement of raw materials that also contained a large quantity of defective shells.

Looking at the distribution of shell in coastal Gujarat it appears that the shell cutters of Nagwada also had no direct access to the raw shell (Bhan and Gowda 2003: 77). Though, *T. pyrum, P. bucephala* and *C. ramosus* were used occasionally for the manufacturing of bangles, *T. pyrum* appears to have reached the settlement in a semi-finished stage. Manufacturing wasters produced during preliminary chipping and subsequent hollowing of the shell is more or less negligible, thereby suggesting that these stages were carried out somewhere else. As mentioned earlier that the site was geared towards ring manufacture and it appears that columella portions of the shell were brought to the sites for the manufacture of rings perhaps from sites like Nageshwar, since we have evidence of stock piling of columellas carefully saved to be supplied to some other settlement for recycling.

The Harappan shell industry of Gujarat reflects three levels of distribution/production systems. Nageshwar and Gola Dhoro produced limited range artifacts. At Gola Dhoro, we see intensive production of bangles from *T. pyrum* and occasionally *P. bucephala*; and Nageshwar seems to have specialized in the production of bangles (from both *T. pyrum* and *C. ramosus*) and ladles. Both the settlements appear to have traded in raw material and finished goods to regional and extra regional markets.

On the other hand, sites such as Surkotada, Rangpur, Lothal and Nagwada, we see wide variety of objects being produced. At times there are indications of reprocessing of shell wasters. Most of the sites appear to have produced shell items for local markets and nearby sites. The distinct North Gujarat settlement, where small occurrences of shell working have been reported, represents the third level. This appears to be the activity of travelling shell cutters and/or traders, who visited these settlements along with their wares and producing shell items on the basis of specific local demand.

Faience technology

By 2600 BC, like Egypt and Mesopotamia, the Indus Civilization artisans also created a glassy or vitreous paste commonly referred as 'faience' (Vandiver 1982). It reached a high level of production and approaches the quality of early glass (MacCarthy and Vandiver 1990; Kenoyer 1994a, 1994b). While many techniques were similar, each cultural region developed its own style of ornaments and technologies for producing them.

A wide variety of faience ornaments including beads, bangles and jewelry have been retrieved from the major ancient sites of Mohenjo-daro, Harappa, Chanhu-daro, Dholavira and Gola Dhoro (Bhan *et al.* 2004, 2005; Dales and Kenoyer 1991b; Mackay 1938, 1943; Marshal 1931; Sonawane *et al.* 2003). Recent excavations at Harappa have revealed the faience beads from early levels dated to 3300 BC, but the production of elaborate faience ornaments, figures and vessels are more prevalent during Harappan Phase (Dales and Kenoyer 1991; Kenoyer 1991b).

The ancient artisans of the Indus Civilization appear to have almost exclusively utilized efflorescence, a technique wherein the color of the glaze is strongly bonded with the underlying body. Recent studies carried out by Kenoyer (1994a) have shown that efflorescence itself has variations and can be divided into two processes based on how quartz is prepared. In one process, the powdered quartz combined with both flux and colorant. In second process, the powdered quartz is partially melted with colorant to produce *frit* and then reground to very fine powder. This fine glassy powder, already colored, is mixed with additional flux to prepare faience paste. Adding fine ground quartz increases the volume, but also results in reduction of color homogeneity. Faience objects made by first process tend to have larger quartz grains (50 to 100 microns) and close examination reveals a speckled color distribution. Under low magnification (20X) its granular character is discernible in objects, where the glaze is eroded or where a broken edge reveals the objects interior core. This paste produced small tokens as well as wide variety of beads. A similar coarse-grained faience was commonly made in Egypt and Mesopotamia (Kenoyer 1994b).

Most faience objects – bangles, tiny beads, miniature vessels and animal figurines – were produced using the second process, resulting in a homogenous, compact structure with a high percentage of glassy matrix. No other region of the ancient world is known to have produced this type of glassy faience referred as compact faience (McCarthy and Vandiver 1990). It is made of extremely fine evenly colored glassy powder that has a percentage of glass and fine grains of unmelted quartz, with grain size less than thirty microns (very few had particles larger than 50 microns). When quartz is ground to this size, the texture resembles talcum powder.

The discovery of white rock quartz and quartzite fragments at Harappa and large lumps of quartz more recently from Gola Dhoro in Gujarat suggests that it may have been a major source of silica powder in making faience. A large number of tubular beads and a few bangles of faience were recovered from the site of Gola Dhoro. The evidence of local manufacture of faience at the site comes from the recovery of a large number of chunks of white rock quartz that served as the base material for the production of faience at the site. The site revealed two areas associated with silica production that are associated with intense burning and whitish powder and both the localities are confined within the fortified area of the settlement.

One such area measuring 3.5 x 2m is situated close to the eastern periphery of the fortification wall. Here a fine patch of ash contained a thick layer of whitish powder and small quartz pieces. The X-ray diffraction analyses (carried out by Randy Law) of the whitish powder samples indicated it as quartz powder. The recovery of large number of exceptionally heavy and large querns and pestles, kept upside down in a nearby area suggests that they might have been used in crushing the quartz to the prepare silica powder. Their presence in large numbers at one place perhaps suggests industrial rather than domestic use. Repeated firing and subsequent crushing of quartz to produce fine powder for the production of faience objects seems to have been carried out by the Harappan artisans of Gola Dhoro.

Other minerals found in Harappan faience included alumina, sodium and potassium, and since they are not found in large quantities, they must have been derived from the adhesives, flux or colorant that were mixed with the silica (McCarthy & Vandiver 1990). The sodium and potassium probably came from two types of flux that are still used for glazing and glass production in South Asia (Kenoyer 1994c). In traditional glazed tile technology and glass production in South Asia, the primary flux (Urdu *sajji* or *khar*) for melting silica is an alkaline ash derived from burning of desert plants generally referred as camel-thorn (*H. multiflorum, Salsola foetida, Suaeda fructicosa*) (Rye and Evans 1976). Experiments carried out by Kenoyer (1994c) with fine ground frit and *sajji* demonstrated that no additional adhesive or gums are necessary for forming difficult objects such as bangles or tiny vessels. Another type of flux used in glazing is naturally occurring sodium carbonate/ bicarbonate, commonly referred as (Urdu *reh*). Traces of calcium in some Harappan faience may be due to calcinated bones or calcium phosphate, also a

flux and probably a component of white faience, since *sajji* or *khar* creates a greenish-grey glaze.

Copper, iron or manganese is also found in minute traces in Harappan faience and although they help to lower the fusion point of silica, their primary function appears to have been for color. Most of the faience of the ancient world, including the Indus Tradition, was colored with copper minerals to produce blue-green glazes. However, Harappans developed special techniques to produce glaze of pure white (from calcium), deep azure (from copper), black (manganese), yellow, brown and red-brown (perhaps from iron minerals) and brilliant red (colorant unknown). These glazes were usually used with one or more colors and reflect an intimate knowledge of the temperatures needed to melt silica as well as the atmosphere (oxidizing or reduction) for obtaining specific colors (Kenoyer 1994c). However, we also failed in our attempt to produce faience at Nagwada, where large number of beads have turned back, instead of usual blue-green. XRD analysis carried out by Prof. Vishwas Gogate indicates quartz and calcite peeks and he is of the opinion that beads might have turned black due presence of calcite in that batch of raw material (Gogate, personal communication), however, it could have been also because of the condition of the kiln prevailing at the time of firing.

One of the important questions about faience technology is the type of adhesive used to hold the ground quartz together during forming process. In experiments conducted by Kenoyer (1994c), numerous adhesives which include honey, mustard oil, clay, gum of *shisham* tree (*Dalbergia latifolia*) and gum tragacanth were used. *Shisham* gum proved to be one of the best adhesives since it did not shrink. He is of the opinion that it is possible that Harappans used no adhesive at all because of the extremely fine powder that was used and combined with water and soapy alkaline mixture of *sajji* or natron, the fine quartz was malleable enough to from delicate shapes. Even during drying, the paste remained quite strong and it is possible to scrap and incise the surface with intricate designs.

The technique of making compact faience continued after Harappan Phase ended and set the foundation of the development of glass technology of later Early Historic period (*c.* 600 BC). The famous *meena-kari*, enamel on gold and silver, which is still practiced throughout the subcontinent, may have roots in the early experiments with glazed faience inlay in gold.

Conclusion

The study of various crafts is a growing field investigation in the archaeology of South Asia. Though some archaeologists still prefer to refer to them as 'miscellaneous small finds', most of the scholars agree that they provide a unique perspective on ancient trade, networks, technological and economic organization, wealth and social hierarchy, ritual symbols, as well as chronological changes. With the adaptation of rigorous excavation and recovery methods along with ethnoarchaeological studies a lot of useful information has been forthcoming from many recently excavated sites, though we still need to learn much more about the ancient crafts to see distinct patterns of continuity and change that provides a more comprehensive understanding of the role played by these crafts in human history.

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