Reappraisal of Manufacturing Techniques of Architectural Members Placed at Gates of Dholavira from its Quarry

Devendra Kumar Gupta[1] **and Priyank Gupta**[2]

1. Department of Ancient Indian History, Culture and Archaeology, Gurukul Kangri Vishwavidyalaya (Deemed to be University), Jagjeetpur, Haridwar, Uttarakhand – 249404, India *(Email: profdevendraguptagkv@gmail.com)*
2. Archaeological Survey of India, Dharohar Bhawan, 24 Tilak Marg, New Delhi, Delhi – 110 001, India *(Email: archaeo.priyank@gmail.com)*

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Abstract: *Dholavira is one among the five largest Harappan cities in the subcontinent and yet stands apart. It played a very crucial role in the production of limestone pillar members of various shapes that distributed to distant sites like Harappa and Mohenjodaro. This paper attempts to analyse the techniques that were used to manufacture the architectural members which form a composite pillar that are placed at the gates of castle of Dholavira. At the same time by analysing the previous research we tried to trace the quarry site which was the main source of raw material through which architectural members were made.*

Keywords: Dholavira, Limestone, Quarry, Pillar, Ringstones, Gates, Manufacturing Techniques

Introduction

Dholavira (23° 53' N long. 70°13' E lat.) was discovered in 1960s by Jagat Pati Joshi and subsequently excavated from 1989-90 to 2004-05 for 13 field sessions under the supervision of R. S. Bisht. This ancient site is located at Khadir island at Bhachau Taluka in Kachchh District of Gujarat (Figure1). The thirteen seasons of excavations at this full-grown city space have brought to light the successive settlements that revealed seven significant cultural stages of a model city which is remarkable for its exquisite town planning, monumental structures, aesthetic architecture, efficient water harvesting system and a variety of funerary architecture.

This urbanisation that made its humble beginning in stage I and went on progressing through stages II and III. In stage IV, decaying was started. Stage V and VI underwent through a transformation and finally in stage VII it become totally unurbanised. The city of Dholavira in its fullest form was precisely proportionate and follows a resolute set of principles of planning and architecture with mathematical precision (Chakrabarti

and Lal 2014). Kenoyer et al. (1991) did experimental work on creating stone beads in Khambat while Randall Law did a tiresome work of identifying raw material sources of stones and metals that Harappans were exploiting to make various architectural member as well as ornaments. Perforation of beads of Dholavira was extensively studied by V. N. Prabhakar. Through this article, we try to analyse the functionality of ringstones, its manufacturing process as well as its distribution to other far off Harappan metropolitan cities.

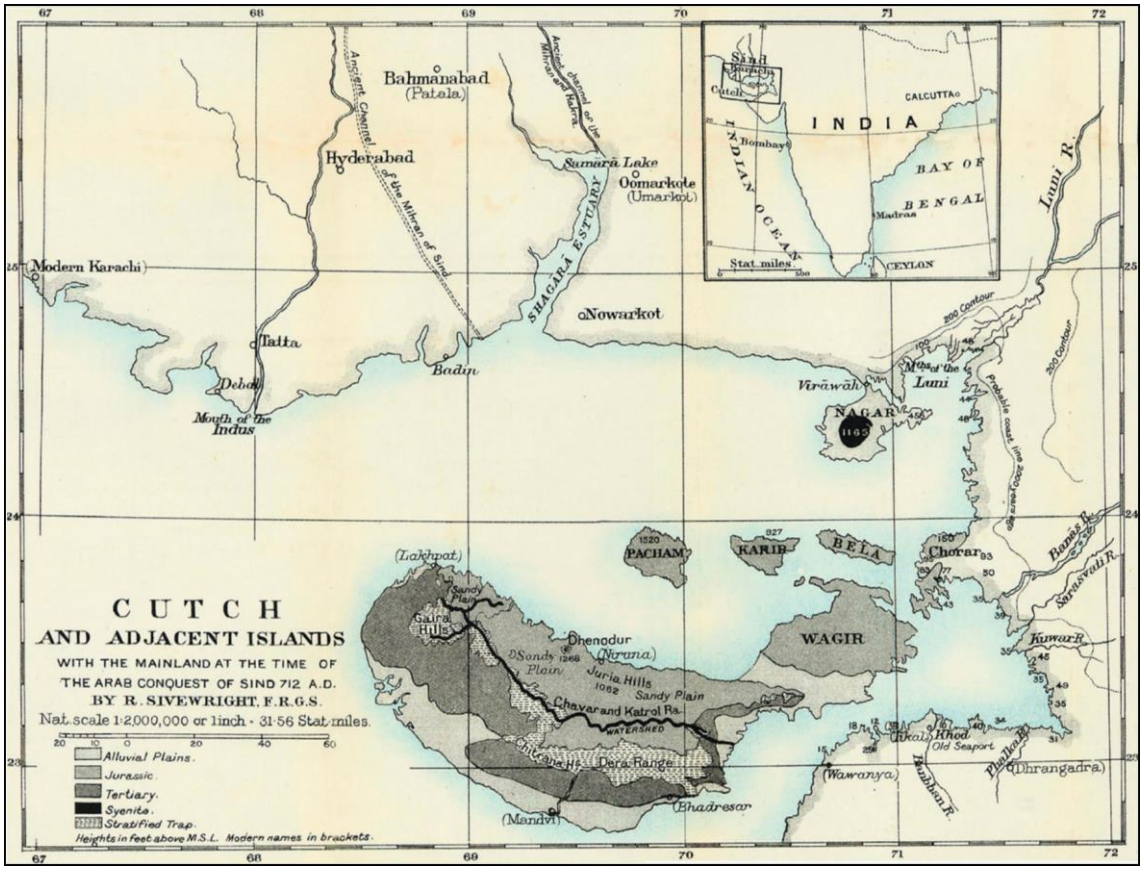

Figure 1: Kachchh and Adjacent Islands (after Sivewright 1907)

Establishment of Functionality of the Limestone Ringstones

Before stating the manufacturing process of the ringstones found from Dholavira here we try to give a brief history of the discovery and identification of these stones. In 1863 for the first time Sir Alexander Cunningham visited the site of Harappa. At the mound, near the eastern part of the shrine of Nao-Gaja Peer, three ring stone type objects were found which were placed beside the tomb of Nao-Gaja. According to the believe of local people those ring stones were the thumb rings of gigantic Nao-Gaja. (Figures 2a & 2b) Cunningham give the detail measurement of those ringstones. The largest ring stone is a black stone with 2 feet 9 inches in diameter, identified as gem of the ring. The other two are each 2 feet 1inch high, 10 inches in diameter with hole through the middle. In local language these are called *nal*. They are made of yellow ochreous limestone and are very peculiar in shape (Cunningham 1875).

Figure 2a: Plan of Harappa by Sir Alexander Cunningham

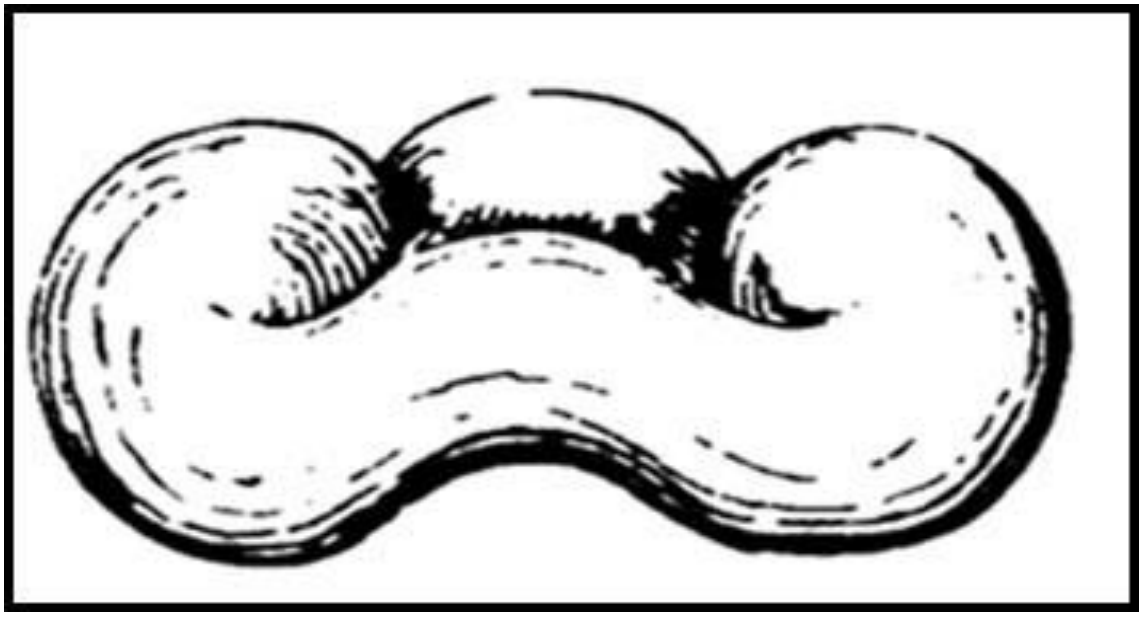

Figure 2b: Depiction of Ringstone by Cunningham

Thereafter, Marshall also stated about the undulating ringstone that found from Mohenjodaro in his excavation report. He mentioned these as "*yoni*" stones or to be used as 'stone money' (Figure 3) (Marshall 1931). On the other hand, Maula speculates these ringstones as astronomical "calendar stones" in 1984 (Maula 1984). On the contrary, Caspers and Nieskens mentioned these limestone rings as the ceremonial stones which must be associated with cultic tree-worship (Randall 2011). Although, in 1938 itself, Mackay had suggested that the ringstones found at Mohenjodaro were elements of composite columns made of stone and wood (Mackay 1938: 597).

As specified above, many opinions and discussions took place about the functionality and occurrence of these ringstones there. During the excavations at Dholavira which started in 1989, same ringstone objects were found from the southern gateway of the citadel of Dholavira. From this place, complete ringstones have been found in position that strongly suggests that they were the bases of pillars (Bisht 1989). After this, many *in situ* specimens were documented from northern and eastern gates of the Castle. This discovery clearly denotes that Mackey's identification at Mohenjodaro was correct.

Finally, after Dholavira excavations, the functionality of these ringstone was established as pillars and pilasters (Figure 4) of gates which were placed at Harappan metropolitan cities like Harappa, Mohenjodaro and Dholavira.

In 2010, Vidale mentioned about the moulded terracotta tablets that he found from Mohenjo-Daro which is a small model of column-like objects that were made in parts and stacked one after another. This moulded terracotta tablets were identical to the flat-topped ringstones found from Indus site of Lakhanjodaro and Dholavira (Randall 2011). After establishing the functionality of limestone pillars here a brief description of architectural members found from gates of Dholavira is presented.

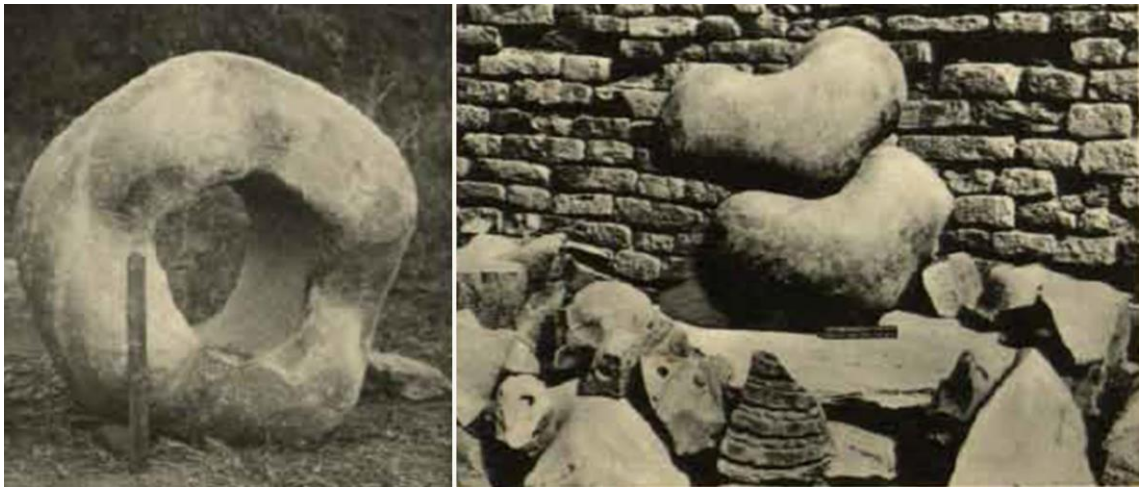

Figure 3: Wavy Ringstones Speculated as "Yoni" Stones or 'Stone Money' by Marshall (Marshall 1931)

Figure 4: Pillar elements of Dholavira (after Nomination Dossier of Dholavira: A Harappan City Uploaded on UNESCO Website)

Architectural Pillar Elements of Dholavira

A large number of architectural members were encountered from Dholavira excavations which were manufactured out of the locally available limestone. Among all these architectural elements, pillar elements have come into notice from the excavations. Some of them noticed in situ in their original position and condition.

These pillar elements mostly recovered from the North Gate and East Gate of Castle. The *in situ* pillar elements clearly indicate the nature of position adopted for each shape of the architectural element.

The various categories of stone objects were involved in making architectural members. The raw materials for making such objects were carefully selected by the Harappans after a long period of trial and error during the preceding phases of the Harappan Culture. Consequently, a sound knowledge of raw material sources from different areas surrounding the Indus and its adjoining river valleys enabled the Harappans to choose the right raw material for the suitable end product.

The evidence indicates the use of square blocks at the base followed by bi-concave element and finally truncated spherical element. These pillar elements could have been affixed together by wooden pegs as indicated by small and tenon holes in them. The evidence also indicates that, upon the truncated spherical pillar element, a wooden log could have stood supporting the roof of the chambers. These pillar elements, three in order of one above the other, rests on a basal slab which is a long rectangular stone piece (Figure 5). The position of these pillar elements on a firm footing clearly indicates that Dholavirians had the understanding of the implications of distribution of weight; hence they had made this extraordinary arrangement.

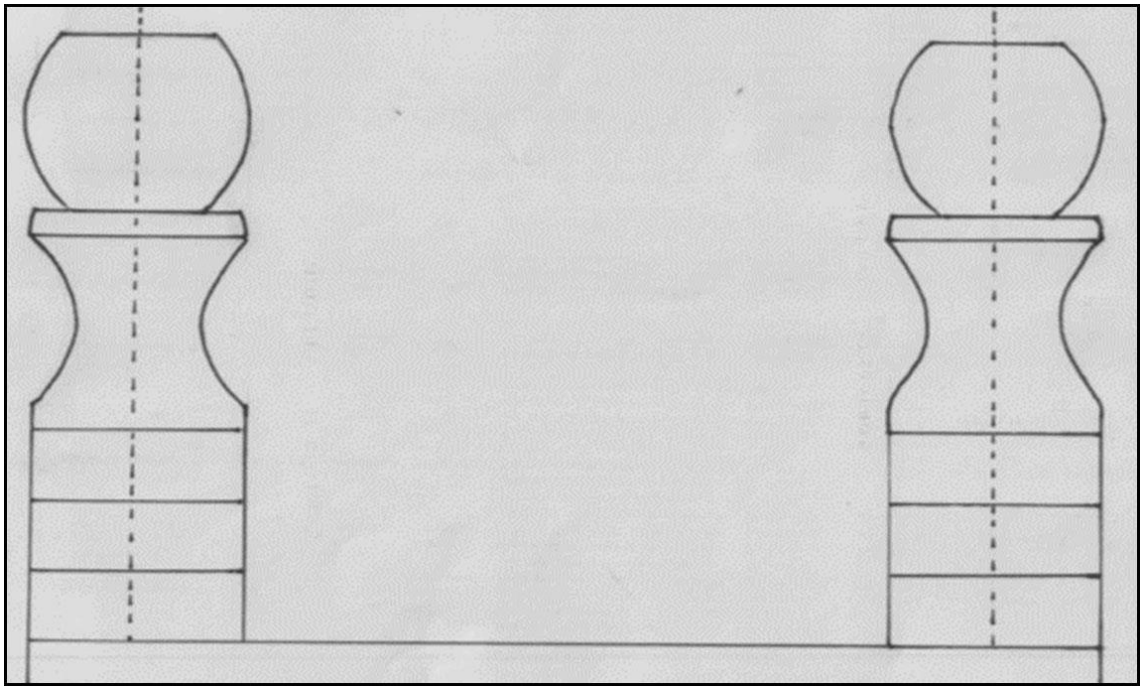

Figure 5: Conjectural View of Arrangements of Stone Blocks from Gates of Dholavira

Quarry and Its Selection

A quarry is a place where rocks, sand or minerals are extracted from the surface of the Earth. A quarry is a type of open pit mine from which rock or minerals are extracted. These are normally utilized for extracting building materials which have been used for

thousands of years. Ancient Egyptians built the Great pyramids with massive limestone from nearby quarries (https://www.national geographic.org/ encyclopedia/ quarry).

Unlike other Indus cities, stone is used in Dholavira not only for the gateway ringstones, but also for the city's walls, stairs, houses, drains, wells and other public works. Much of this stone seems to have come from a quarry located three kilometres directly north of the site (Figure 6).

Figure 6: General View of the Stone Architectural Members Placed at the Gates of Dholavira

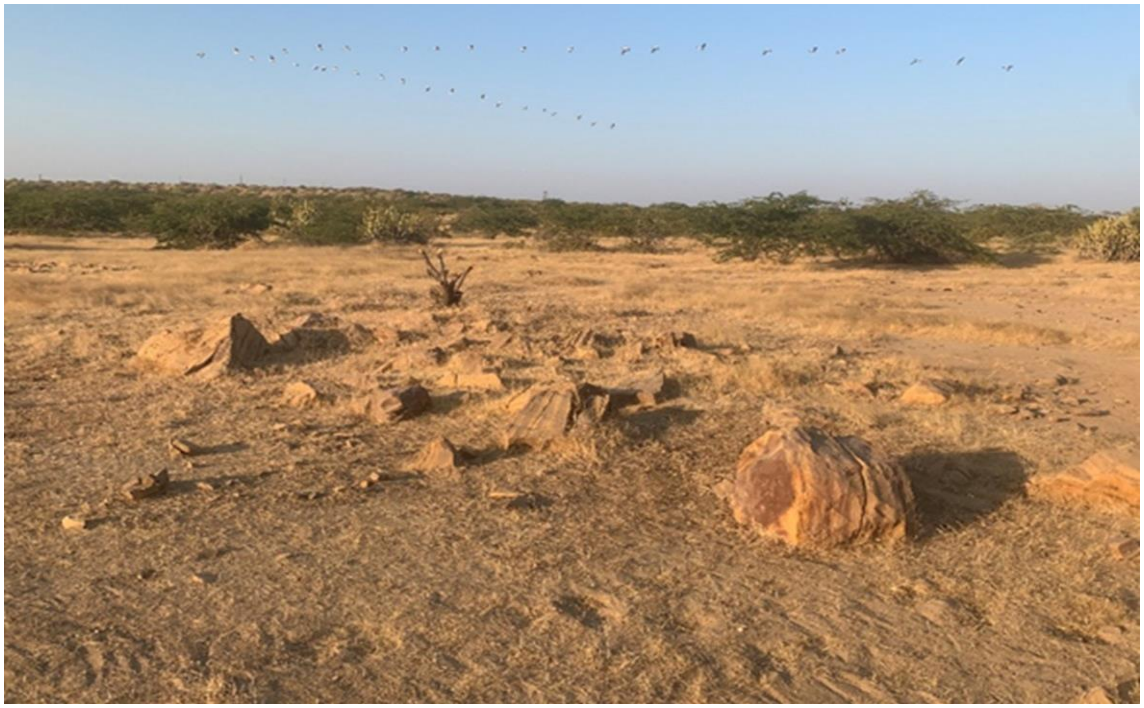

Figure 7: General View of the Limestone Quarry Site near Dholavira

Figure 8: Ringstone 'Blanks'

Figure 9: Quarrying Activities by the Inhabitants of Dholavira

Evidence of quarrying limestone (Figure 7) from at least three locations is noticed to the northeast and northwest of the Harappan settlement at Dholavira. The materials which were manufactured from limestone include various kinds of pillar elements, pilasters, door sills, special kind of architectural elements, covering stones for drains and in one case drain mouth, weights, bowls etc. One of the quarry fields is locally known as Baral pat, meaning burnt ground, in the local dialect. Among the other stone quarries, Pachchham is identified as an important quarry and Limdiwali Tari quarry is also located nearby and it has sandy textured reddish-brown banded sand stone (Bisht 2015).

The stone quarry site was explored about two km in the direction of north-east from Dholavira towards the Machhi post. Here, more than six unfinished stone architectural members were noticed and scattered in different locations within a radius of 500 mts. To understand the quarry process, a 2x2 m. trial trench was taken by the excavator at the stone quarry site near Macchi post. From these excavation many stone flakes and

chips were noticed. Some of the stone flakes were also scattered on the surface. Most significantly, many ringstone 'blanks' were found that were discarded during the rough-out process (Figure 8). Several of these roughed out and discarded slabs have been found within the kilometre long quarrying area. Dholavira has revealed many architectural members of yellow and banded limestone in different size and shape at east gate, north gate of castle, bailey and lower town. These are similar to the architectural members noticed at the quarry site. It was also noticed that some quarries were discarded because of inherent defects such as crystallization or some cracks or pocket. This activity clearly denotes that Harappan artisans gained a sound knowledge of raw material sources that enabled them to choose the right raw material for the suitable and sustainable end product.

The presence of numerous chipped stones spread over a large area indicates large-scale quarrying activities by the inhabitants of Dholavira. The prominent find at the quarry includes a large bi-convex unfinished pillar member which was abandoned due to the presence of faulty veins of quartz crystals inside the limestone formation. There are numerous other evidences of removal of long slabs of stones.(Figure 9) Unfinished pillar members could have been carried from the same site by the late Harappans for probable use near the east gate. Another interesting feature of the site is the presence of large-scale chipping of stones, except this no other evidence of Harappan presence is noticed. The stones could have been chipped using the primitive stone knapping technique and no evidence of use of copper chisels is noticed. The chipping of these limestone blocks could have been carried out by gabbro nodules. From this evidence we cannot identify the fact whether the final finishing and polishing of this pillar elements and architectural features were carried out at the site or at the city itself. Though the absence of other Harappan cultural materials and utility objects, it indicates that the artisans carried their food and water in leather bags for the day (Bisht 2015: 83).

After analysing geological samples of Dholavira and Harappa through INAA and inductively-coupled plasma mass spectro metry (ICP-MS) (Law and Burton 2006), Law explained that most of the limestone were taken from Pachchham formation that is located near the site of Dholavira for making architectural members. This analysis clarifies the fact that Pachchham formation in Kachchh region is the potential geologic formation which is the most probable source of the sandy limestone artefacts found at the Dholavira. (Figure 10) Along this, Jaisalmer formation is the second potential source of Limestone but it is very unlikely that the Harappans exploited those quarries as no Indus settlement within 100 Kilometres of the Thar Desert has yet been reported which could have established any Harappan connection with the Jaisalmer Limestone quarry.

Large Scale Utilisation of Limestone at Dholavira

After identifying the functionality, we need to find the reason for the profuse use of limestone. The reason limestone was used to create large items probably because it was

more durable and aesthetically pleasing to them. It may be noted that the limestone formation is sedimentary in nature, geologically, it is of Middle/Upper Jurassic period. This massive rock predominantly composed of calcium carbonate which was used to create objects larger than are typically found at Harappa. It tends to break with a conchoidal fracture (Figure 11) and is softer than sandstone, quartzite or igneous rocks such as granite or diorite. Thus, objects like ringstones are more easily roughed out and carved from limestone. Some of those objects are "ringstones" and other big pieces of carved rock that probably had some architectural or ritualistic symbolic purpose. Not only for making pillars, Dholavira settlers also acquired large piece of limestone for sewer drain covers and grindstone. Limestone is a highly variable rock both compositionally and visually. It is, in addition, widely available in most of the geologic formations surrounding the Indus Basin. Banded limestone is another rock that was transported from its source in Gujarat to Harappan sites deep within the Indus Valley.

Figure 10: Pachchham Formation in Kachchh Region

Techniques of Making Architectural Members

On the basis of evidence the following steps of manufacturing were observed:

Step 1 - Selection of area (Figure 12): At first artisan chose a raised formation and then carved out a desired shape depending on the size of the formations. First they marked the length and width to get the size of what was to be made. Then the outer area was excavated by using block on block technique with the aid of gabbro pebbles from the nearby Bhajara bet, which are igneous and much harder. Many similar pebbles have

also been found at the site for manufacturing purposes. They remove almost 1 m. deep outer area for manufacturing the pillar (Bisht 2015: 81).

Figure 11: Conchoidal Fracture of Limestone

Step 2 - Removing of Outer Flake (Figures 13a & 13b): After removing the outer flake the block was detached from the parent rock using wooden logs. It is noticed that banded limestone can be detached easily following the line of sedimentation by applying pressure technique on the bands. They had taken advantage of composition of rock in the quarry (Bisht 2015: 82-83).

Step 3 - Shaping the Stone Blocks (Figures 14a & 14b): The block was then processed and shaped by the block on block technique. The striking evidence has been noticed on a semi-finished architectural element and scattered flakes of same stone are also found from surrounding (Bisht 2015: 83).

Step 4 - Finishing of Architectural Members (Figures 15a & 15b): The discovery of semi-finished architectural members and discarded members from quarry site from Dholavira clearly indicate that these were brought to the habitation area and the final finishing was carried out by flaking out small chips, rubbing and polishing to get desired shape and size (Bisht 2015: 82-83).

Figure 12: Selection of Quarry Area

Long Distance Distribution of Architectural Members

After the production of these limestone architectural members, it was distributed in many Harappan metropolitan cities. Transporting these heavy pieces of stone (sometimes as heavy as 135 kgs.) would have certainly been a difficult and costly

undertaking. Large-sized “ringstones” (some weighing over 100 kg) made of limestone, however, are a category of artefact that seems to be exclusive to Indus Civilization cities (Dales 1984). The styles in which they were carved and types of limestone from which they were made from seem to differ somewhat from site to site. Limestones of Dholavira are composed of sandy-textured yellow and reddish-brown banded limestone with a flat tops and bases with small central holes and can have either concave or convex midsections. The "typical” ringstone at Harappa has an undulating (or wavy) top and base with a large central hole that is composed of a light yellow micritic (microcrystalline) limestone while ringstones of Mohenjodaro are composed of cream-colored micritic limestone with a flat top and base with a large central hole. Among the total stone objects, Harappa yielded only 5% heavy weight stone objects (more than one kilogram). Except grinding stones, nearly all remaining heavy weight artefacts are composed of limestone.

Figure 13a: Removing of Outer Flake to Make the Block Member

After due examination, Law opined that the limestone pillar members and other large stone architectural members of Harappa, which increases exponentially in concentration from Period 3C, has close resemblance with the limestone found from Pachchham formation of Kachchh, located near Dholavira. The presence of such heavy stone objects so far from their source bears testament to the advanced transportation capabilities of Harappans during the later part of the Mature Harappan Period (ca.

2100 to 1900 BCE). These similarities demonstrate that, including the advancements in the ability to transport stone in bulk sizes to long distances there other factors also influence the Harappan society to use limestone objects. This acquisition of expensive to transport large limestone objects from multiple sources, some as far away at Kachchh, represented a new way of living of Indus Civilization people through which they express prestige and power.

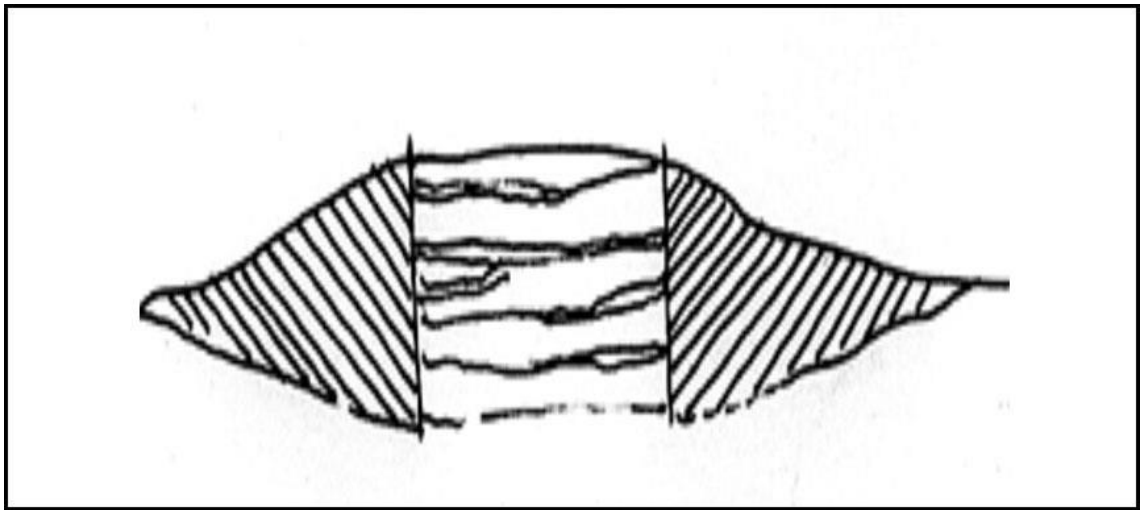

Figure 13b: Removing of Outer Flake to Make the Block (Courtesy: Bisht 2015)

Figure 14a: Shaping the Stone Blocks to Make the Pillar Member

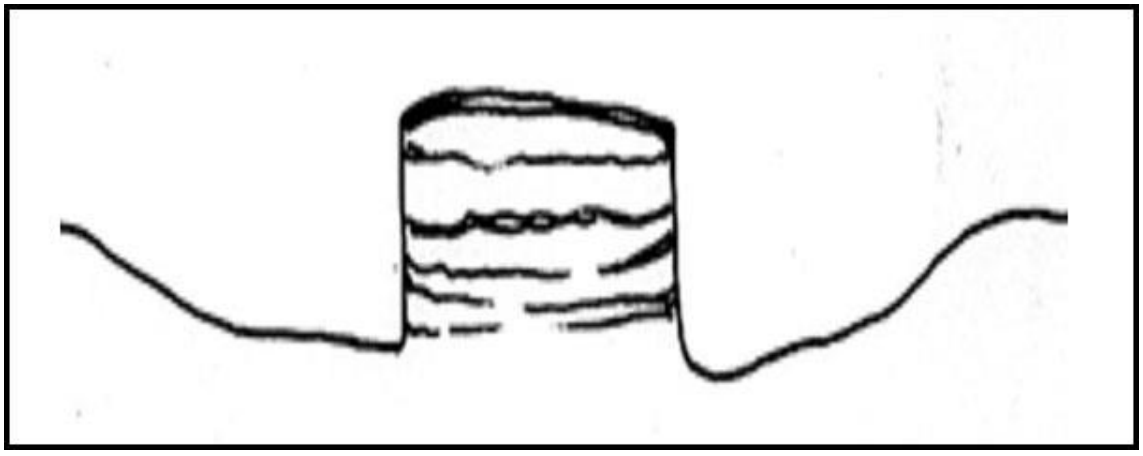

Figure 14b: Shaping the Stone Blocks to Make the Pillar Member (Courtesy: Bisht 2015)

Figure 15a: Finishing of Architectural Members

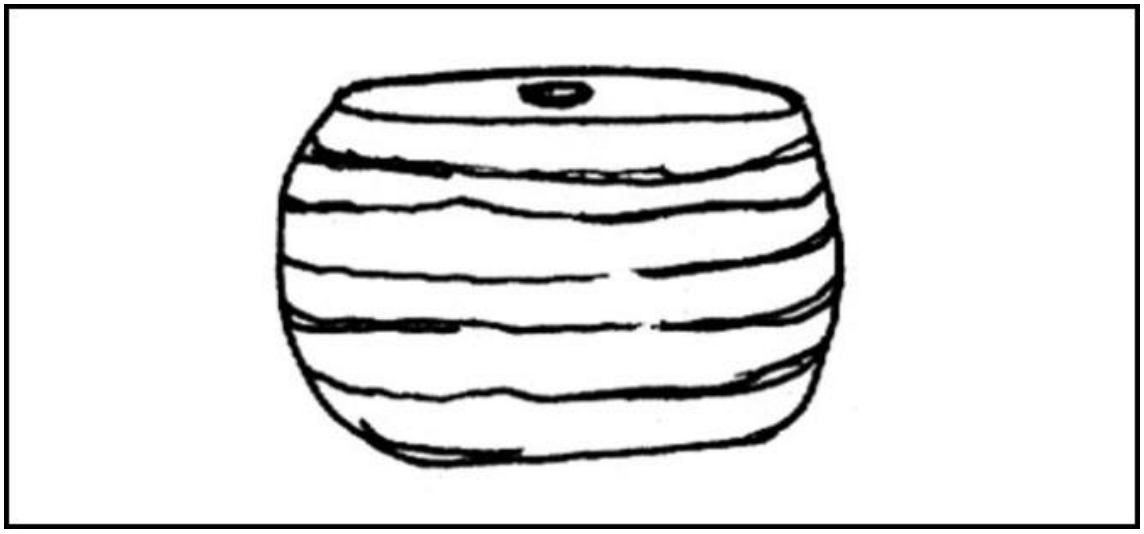

Figure 15b: Finishing of Architectural Members (Courtesy: Bisht 2015)

Dholavira lies appx. 800 kms north-northeast of Harappa as the crow flies. Taking into account the upstream movement, the journey via the Indus river system would have been considerably long and tiring. Therefore, the inland routes must be the more favorable mode of conveyance to transport such large limestone blocks from the quarry site of Dholavira to Harappa and in some cases even Mohenjodaro. To cover this long tiring journey, there would undoubtedly be resting points at regular intervals for traders which may also be mapped along the various probable routes to Harappa from Kachchh coast.

Conclusion

In concluding note we tried to analyse the typological and technological aspects of stone architectural members which made Dholavira very unique among all the metropolitan cities. The ornamentation of the city through stone pillars and other architectural objects clearly depends on i) the availability of raw materials for making the products and ii) the level of technological complexity or virtuosity needed to turn them into finished items (Kenoyer and Vidale 1992). Among all the phases, the fourth stage of Dholavira is identified as the classic phase of mature Harappan settlement. According to R.S. Bisht, the excavator of Dholavira, almost all the salient features of the city planning were scrupulously maintained along with the monumental structures such as gateways, fortification, drainage system during this occupational stage of the site (Chakrabarti and Lal 2014).

Dholavira was beautifully decorated with stone architectural members as the concentration of stone architectural members is higher as compared to the other major Harappan metropolises. One major reason for this is the availability of raw material in abundance near the settlement and resources to large scale brick manufacturing is absent unlike other sites like Harappa and Mohenjodaro. Contrary to Harappa and Mohenjodaro, we found the scarcity of suitable clay and wood for baking the brick in Dholavira.

Carnelian and agate nodules were transported from Kachchh since the early Harappan phase. From that one big nodule, many typical long barrel Harappan beads could be manufactured. At early period these beads were used as very prestigious elements. Gradually they also transported ringstones (100 kg or sometimes even greater than this) at late urban phase. From one such large nodule only one ringstone can be made. This phenomenon probably reflects a new development in the way Harappans (or at least certain Harappans) expressed social power through the consumption and display of stone. Harappan period 3C is coeval with the Stage V and Stage VI of Dholavira. Again, we can see that the artisans of Dholavira produced beautiful pillars and pilasters and other architectural members made of stone while in Harappa and Mohenjodaro decorated pillar and pilasters were found in later part of Indus civilisation (period 3C at Harappa). From this phenomenon many changes can be traced that took place in the society as well as this incidence indicate the paradigm shift in the technology and transportation system.

The creation of small, high-value personal ornaments that signalled the status of those wearing them was one of the principal means through which social and economic hierarchy in the Indus Civilization was marked and maintained (Kenoyer 2020). A ringstone weighing 100 kg would have required as much effort, energy and expense to bring to Harappa from Kachchh as would 100 kg of high quality carnelian nodules.

The difference is that with the nodules hundreds, perhaps thousands, of carnelian beads could have been created and dispersed while with a ringstone all of the effort-energy-expense was concentrated within a single item. Bulk stone objects of this kind thus would have probably been important symbols of wealth, prestige and power for Harappan people living at settlements located up on the alluvial plains. Their display may have also been a visible marker of a social or territorial relationship held with the distant region where the stone originated. Using such stones in the construction or adornment of religious spaces, private buildings or public areas such as gateways or streets would have been a powerful expression of a person's, a social group's or an organization's ability to expend energy, wealth or influence. This acquisition of large stone objects enhance our understanding of long-distance trade, inter-regional interaction and changing expressions of prestige and power at Harappa.

Scholars working on defining intra and inter-regional cultural trade route and quarrying sites of these stones has located the origin and transportation patterns of most of the found stones in Harappan civilization but these studies have mostly dealt with the semi precious stone raw material exploitation places and inter-linking of various sites but still there's a vast area of stone related studies which is in primitive stage as far as the non decorative stones artefacts are concerned.

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