A Study on the Stylistic and Technological Aspects of Indus Seals with a Focus on an Example from Bhirrana

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Abstract*: This paper discusses the stylistic and technological aspects of an Indus seal collected from Bhirrana in the Fatehabad district, Haryana, India. This seal is distinct from typical Indus seals in that it has a depiction of an unicorn facing right with an angular profile, especially on its body. This type of seal has been known from a handful of sites in the Greater Indus valley, but it is uncertain whether it represents either spatial or chronological variation in the Indus seals. However this seal type seems to be very important in the developments of the Indus seals, as it occurs in a non-negligible number along with the typical type that is more abundantly and more widely known. This paper attempts to understand the stylistic and technological distinctiveness of the seal from Bhirrana in order to clearly differentiate this seal type from other Indus seals.*

Keywords: Indus Seals, Bhirrana, Haryana, Stylistic Feature, Technology, SEM, Inscription

Introduction: Aims of this Paper

This paper examines an Indus seal collected by a local villager at the site of Bhirrana in terms of its stylistic and technological features (Figures 1 and 2). The seal has been already published by Manmohan Kumar and Vivek Dangi (Manmohan Kumar and Dangi 2007), but the authors had a chance to obtain a silicone impression from this seal after the primary publication. Therefore, the seal is re-examined in detail not only from a stylistic point of view but also with observations using the Scanning Electron Microscope (SEM) in order to see the technological features of this seal. Especially, the observations with SEM can enable us to examine the surface condition of carved surfaces that are difficult to observe with unaided methods. Using the images obtained

from SEM examination, we aim at a better understanding of the carving technology of this Indus seal, and Indus seal carving traditions in general.

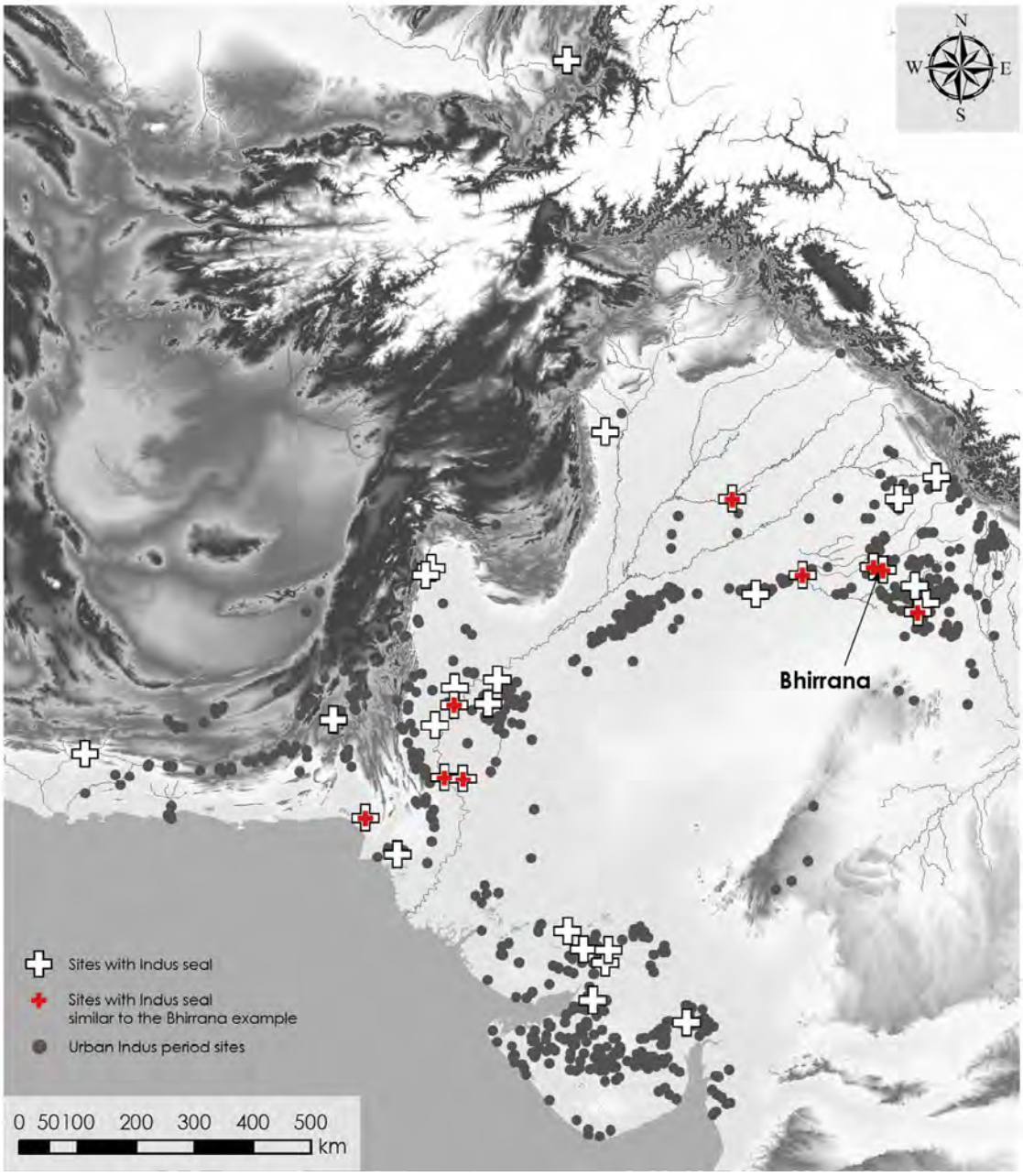

Figure 1: Distribution of the Indus seals (Criss-cross marks indicate the site with Indus seals)

Most earlier studies on Indus seals have been made based primarily on their stylistic features (Rissman 1989; Franke-Vogt 1991; Ameri 2012; Jamison 2011). This situation owes to a fact that most of Indus seals known to date were obtained from excavations in the 1920s and 1930s that were not done with strict stratigraphic control. To date few systematic attempts have been made to correlate stylistic variation in Indus seals with changes over time based on stratigraphic excavations. Kenoyer and Meadow (2010)

have developed a seal chronology at Harappa that documents changes in carving styles over time at the site.It is yet to be determined if this applies to seals from other sites and regions, but the seal chronology from Harappa can be used to model and test changes in seal carving styles over time. In addition, rigorous researches on the decipherment of Indus scripts (Mahadevan 1977; Parpola 1994; Farmer et al. 2004) have also been affected by the limited stratigraphic information and the limited understanding on the chronological changes of styles in seals.

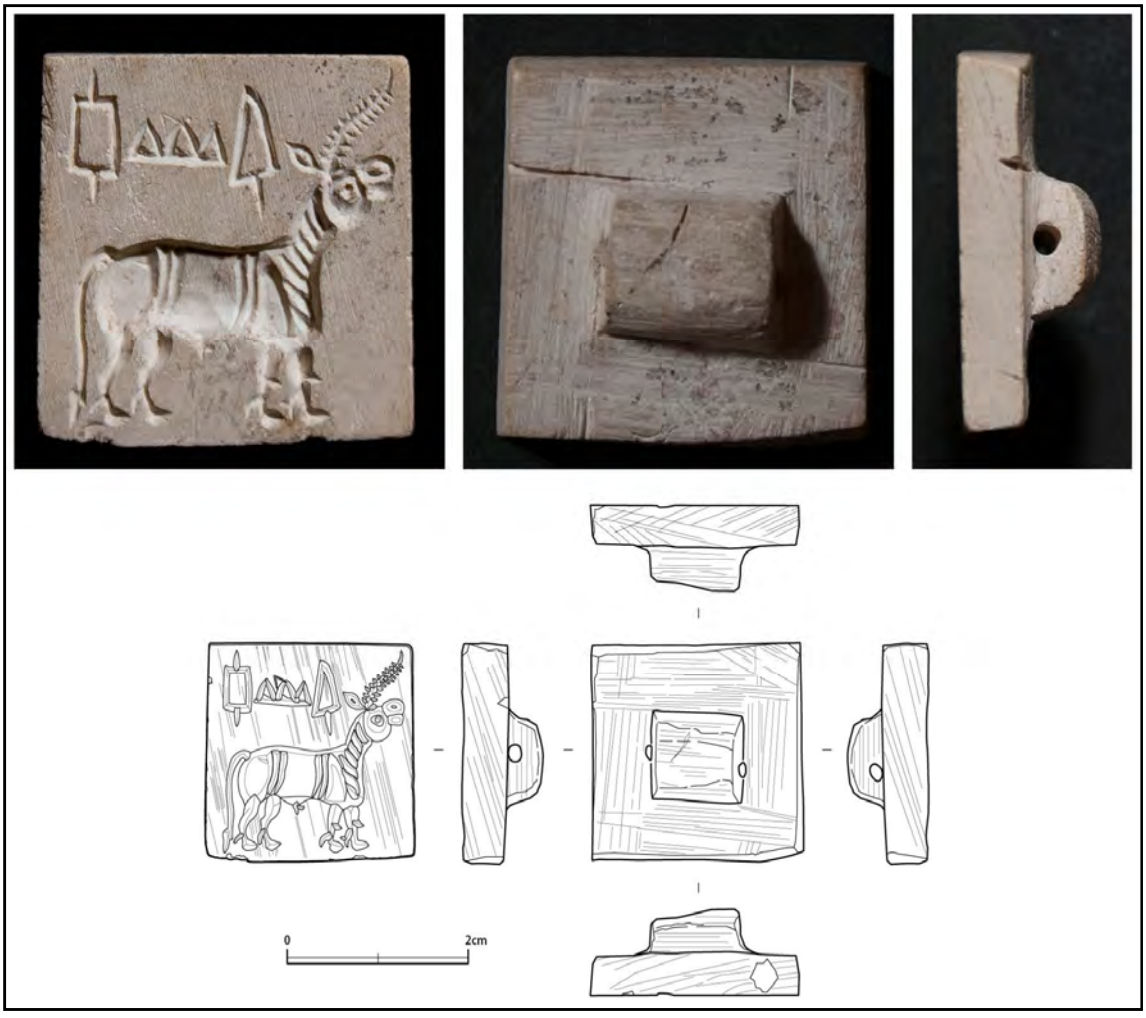

Figure 2: Seal from Bhirrana - surface collection

(Note that the image below right is produced by 3D scanning of the silicone impression to show the depth of carved areas. The blue colour is the flat surface and the yellow-orange colour exhibits the carved area, in which the orange coklour indicates the deepest areas. The image is reversed in direction in accordance to the original seal.)

The stylistic variations of seals that have been identified by several scholars should be examined in terms of their chronological and spatial distributions in order to see what the stylistic variations represent. Although this paper aims at better understanding stylistic and technological traits of one seal from one site to examine how stylistic

features are related to technological aspects on seals, the ultimate goal of this study is to reveal the chronological and spatial variations of Indus seals.

Background of the Sample Discussed

The site of Bhirrana having an area of about 3.8 hectares in size is located along the main stream of the Ghaggar River in the Fatehabad district, Haryana, India (N29.555162, E75.547992). It has been extensively excavated for three seasons from 2003-04 to 2005-06 by the Excavation Branch I, the Archaeological Survey of India. The excavations revealed two cultural period occupations belonging respectively to the Pre-Urban or the pre-/Early Harappan period and the Urban Indus period or Mature Harappan period. Although the full report of the excavations has not been published, the preliminary reports exhibit the importance of the site in the developments of the urban settlement from an incipient village (Rao et al. 2004, 2005, 2006). In the vicinity of the site, several important sites like Banawali and Kunal are situated.

The seal reported in this paper (Figure 2) is a surface collection by a person of the Bhirrana village. Although Manmohan Kumar and V. Dangi reported this seal in 2008 with a help of the collector (Manmohan Kumar and Dangi 2007), the authors of this paper again contacted the owner of this seal and were given a chance to make 2.1. silicone impression of this seal for the SEM observation.

The excavations by the ASI also yielded three seals akin to this one in the Urban Indus levels (Figure 3). They depict goat, buffalo, and three-headed composite animal, all of which exhibit an animal facing right with a distinctive style of carving as we discuss in the later section of this paper. The similar type of seals has also been known in a fair number from several sites in the Ghaggar region, although a few sites in other regions have also yielded this type of seal; Harappa in Punjab, Mohenjodaro in Sindh, and Balakot in southern Balochistan. As this type of seal is conspicuously distinct from the typical Indus seal with an animal facing left, it can be surmised that this type of seal may represent either spatial or chronological variation in the entire Indus seal assemblage. Although it is difficult to discuss the significance of this type of seal in the present state of research, the full understanding of the morphological, iconographical and technological features of this type of seal should be the first step to evaluate the importance of this seal type in the developments of the Indus urban society.

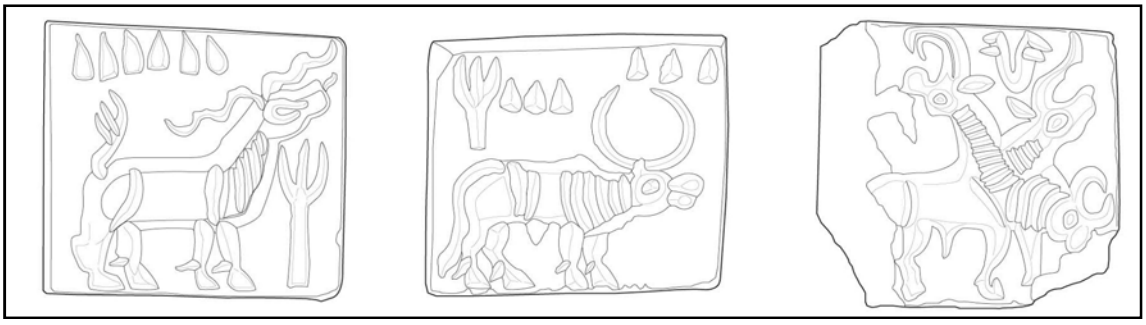

Figure 3: Seals from the excavations at Bhirrana (Drawn from Rao et al. 2005)

Figure 4: Indus seals from Farmana similar to the seal from Bhirrana
(after Konasukawa et al. 2011)

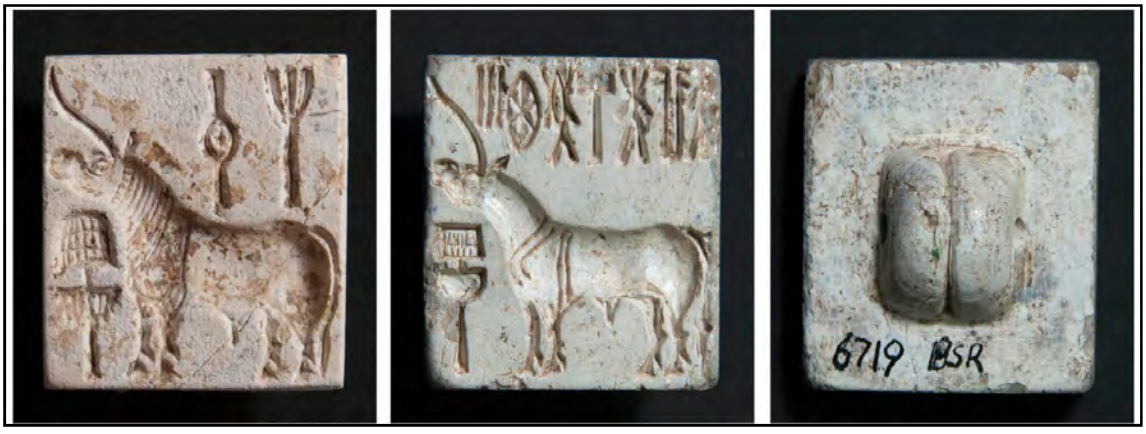

Figure 5: Examples of typical Indus seal with an animal facing left

(Left: seal from Farmana (after Konasukawa et al. 2011); **middle and right: seal from Bagasra** (Courtesy: Department of Archaeology and Ancient History, the Maharaja Sayajirao University of Baroda)

Methods of Study

The methods used in the study included basic descriptive statistics, formal stylistic analysis, and examinations using SEM. The three methods are complementary and provide a systematic way to understand the relationships among morphology, style, and technical features of the seal. Measurement including maximum dimensions of the seal, carved boss on the reverse face, and various elements of the unicorn and inscriptions were taken. The unicorn motif was broken into discrete elements (Figure 6) and measurements of maximum length and width were recorded and analyzed in order to gain a better perspective on the proportions and for comparative purposes, which will be discussed below. Unaided observations regarding the seals' color, surface treatment, and state of preservation were also conducted. Examinations of the morphology and orientation of the unicorn motif and inscriptions were also undertaken to assist in the stylistic analysis.

No.	Portion	Measurement (mm)
1	Body length	13.5
2	Body width	5
3	Neck length	2.7
4	Neck width	2.6
5	Head width	3.3
6	Head length 1	4.9
7	Head length 2	2.8
8	Muzzle width	1.5
9	Muzzle length	2.2
10	Mouth width	1
11	Mouth length	1.6
12	Eye length	1.5
13	Eye width	1.6
14	Ear length	2.7
15	Ear width	1.3
16	Horn length	6.9
17	Foreleg 1 length	4.3
18	Foreleg 1 width	1.6

No.	Portion	Measurement (mm)
19	Foreleg 2 length	4.6
20	Foreleg 2 width	1.4
21	Pizzle length	1.2
22	Pizzle width	0.7
23	Hindleg 1 length	5.5
24	Hindleg 1 width	1.5
25	HindLeg 2 length	5.8
26	Hindleg 2 width	1.5
27	Tail length	10.3
28	Sign length	7.7
29	Sign width	3.1
30	Sign length	6
31	Sign width	2.6
32	Sign length	7.5
33	Sign width	3
34	Boss width	10.9
35	Boss thickness	8.6
36	Boss height	4.3

Figure 6: Measurements

Formal stylistic analysis was conducted using methods outlined elsewhere (Jamison 2011) and consisted of studying the carving styles used to engrave eleven elements of the unicorn. Distinctions are based primarily on morphology, but characteristics of carving strokes and other decorative features present on various elements of the unicorn are also considered. This is part of a larger comparative study of Indus unicorn seal variation to try and identify patterns that represent distinct carving styles associated with the artisans and workshops that produced them. Comparative analyses of the seal from Bhirrana with published materials from other sites has revealed evidence of shared carving styles that may represent temporal or social affiliations that require further testing, using the methods employed in this study. Taken together, this research program provides a useful tool to evaluate spatial and temporal variation in Indus seals.

Summarizing the procedure of the observation by SEM, the object to be examined should be conductive. If the object is made of metals, it is conductive, but if the object is of stone or any other non-conductive materials, the object should be coated with

conductive materials. The actual artefact cannot be coated, so it is necessary to prepare an impression which can accurately copy the morphological features on the surface of an artefact including various working traces. In the case of seals, a silicone can be applied to prepare an impression. The silicone used for this study is JM silicone produced by Nisshin co., which is widely used in dentistry.

This silicone impression is to be sputter-coated by conductive materials. Gold powder was used in this study. The silicone impression has not only positive copy of carved iconography but also various traces made in production process like striations on the surface of the seal, which can be useful for examining carving techniques. The SEM machine used in this study is NIKON Quanta600, by which observations from various angles can be made on the silicone impression.

The SEM machine can use a wide range of magnifications starting from 20x up to more than 1000x, and the magnifications between 20x and 300x can provide various information on the seal production technology. The overall formal and technological features can be observed with magnifications between 20x and 100x, but if more detailed examination is needed, the magnification of 300x can be recommended. For instance, copper/bronze, bone or stone tools can be assumed for carving seals and experimental studies have shown that the surface condition of carved face made with each tool can be distinctive from each other. For identifying the tool types, the examination with higher magnifications like 300x should be used.

Observations of an Indus Seal from Bhirrana

Unaided observation

The seal from Bhirrana measures 22.5 mm in width, 21.5 mm in length and 9 mm in thickness. The surface of the seal is white in colour, due to heating at a high temperature more than 900 °C. On the obverse side, an unicorn facing right and three Indus scripts above the former are carved and on the back side, a semi-cylindrical boss with a lateral hole is equipped.

One of the most unique aspects of this seal is the absence of a standard or offering stand in front or below the animal's head. Most unicorn seals depict this feature; its absence on this one is conspicuous. The ear and horn are engraved with carving styles and proportions seen on many other unicorn seals, though the hatched lines on the horn are not as common as plain forms. Both elements have sharp edges and appear to have been engraved with single carving strokes, suggesting a high level of skill by the artisans who created them. The unicorn has an upturned head with a broad circular eye, common among published unicorn seals. It appears that the eye may have been drilled, which is also noted on many other carved Indus seals. Prominent snouts and mouths delineated by carving strokes, both clearly visible on this seal, are less common, but do appear on many other examples. The rounded head is also common, but the sharp edges and lack of evidence of cracking or other surface damage is indicative of carving skill and effective tools.

The outline of the body is sharp and represented by steep slopes. The base of the engraved surface on the body is flat, as are the edges. The two pairs of vertical incised lines on the body are stylistically distinct; they are not common on most unicorn seals. Both sets are roughly parallel and evenly spaced, with the broadest part of the incision at the top. All four incised lines taper at the base of the body, which suggests the carving strokes ended there. The seven incised lines on the neck taper at both edges, and have broad, deep engraved surfaces, but all appear to have been created with single carving stokes. That they do not impact the edges of the body indicates they were carved afterwards. The front and rear flanks appear to be engraved deeper than the central part, but the engraved surface is flat and smooth throughout. A pizzle is minimally represented by a shallow depression and short carving stroke in triangular form, with an additional short stroke on its frontal side.

Among the most distinctive features of the seal are the legs. All four are engraved with prominent legs and dewclaws, and both front ones depict fetlocks. These features themselves are not uncommon on unicorn (and other) intaglio Indus seals, but the orientation and angular carving styles are distinct. The animal's tail is represented by a long, single curvilinear stroke that emanates from the top of the rear flank, also common on most unicorn seals. The triangular base of the tail, engraved multiple carving strokes, is angular, with sharp, well-defined edges. Most unicorn seals have more rounded and smoothened tail tips, and in this sense it is distinct on this one. Taken together, all of these features highlight the distinctive carving styles used to craft the seal.

There are three inscribed characters of the Indus script. All three have parallels on other Indus seals (Parpola 1994). They are irregular in orientation, but have sharp edges with tapered ends. This is distinct from most other inscriptions on Indus seals, but it is unclear whether this is due to chronology, regional carving style, tools used to engrave the characters, or some combination of all factors. The carving strokes used to engrave the inscribed characters are distinct from most of the unicorn, they are not as broad and have v-shaped profiles that can be seen under SEM. It is also possible to reconstruct the carving sequence of the inscriptions, and identify potential errors in engraving, which is discussed in the next section.

Compared to more typical Indus seals with unicorn motifs (for comparison, two seals from Farmana (Figure 4) and Bagasra (Figure 5) are illustrated), this specimen from Bhirrana is distinctive in terms of its style. The right-facing unicorn, body represented by steeply carved outline and flat bottom, and absence of offering stand can be pointed out for its uniqueness. The patterns of incised lines on the body are also uncommon. Broadly similar types of seals have been found at a number of other Indus sites, but more specimens have been found so far at the sites in the Ghaggar plains than other regions. The present state of our knowledge on Indus seals does not allow us to conclude that this type is unique to the Ghaggar plains, but the distinctiveness of this one should be paid much more attention to better understand stylistic developments

and variability both spatially and chronologically. In this regard, it is also noteworthy that this type of seal may be an early type of the Indus seals based on the evidence from Harappa and Farmana, although this requires more studies to conclude. The results of the stylistic analysis have also identified parallels with a seal from Mohenjo-daro.

The seal from Mohenjo-daro (M-977, CISI II) is fragmentary, and has not been subject to the same level of analyses as the one from Bhirrana under discussion in this paper. Nonetheless, there are a number of clear stylistic parallels worth further discussion here. Both seals depict right-facing unicorns engraved with distinct angular carving styles. It is not clear whether the seal from Mohenjo-daro was engraved with a standard, but even if it was originally present, other similarities remain. These are clearly visible in the styles of eyes, necks, legs and hooves, and pizzles. Though the ears and horns are not decorated in the same manner, there are parallels in their placements and orientations. Both unicorns also depict comparable patterns of incised lines on their necks and rear flanks. It is not possible to confirm with SEM, but the image of the seal from Mohenjo-daro indicates that it also has engraved edges with steep slopes and flat bottoms, especially on the body. The carving styles of the inscriptions are also comparable, particularly the angular carving styles and tapered ends of strokes.

Beyond the similarities already mentioned, the seal from Mohenjo-daro is also noteworthy because it is one of only a few from the site that depicts a right-facing unicorn. The fact that it demonstrates links with this seal from Bhirrana is also significant, because these two sites are separated by considerable distance and currently represent the best potential evidence for seal connections between a Ghaggar-Hakra site and one from Sindh. As the seal from Bhirrana has already been extensively studied, including the use of scanning electron microscope, the potential relationship between these two seals can be further investigated by conducting similar research on the seal from Mohenjo-daro. In fact, the methodology used to study the seal from Bhirrana can be used to study seals from across the Indus Civilization, and provide new insights into temporal and spatial variation. Such studies are useful to understand how seal production was organized and varied.SEM is a powerful tool to examine how individual seals were carved.

Observation Using Scanning Electron microscope (SEM)

The observations with SEM are done dividing the entire carving into head, neck, body, tail, legs and inscriptions.

Head

The head portion (Figure 7) consists of a head, a snout, a mouth, an ear and a horn. In terms of the order of carving among them, the SEM image confirms an order starting from the head through the snout to the mouth. It is also clear that the horn was carved

after the head. Although the order of carving out the ear is not clear as it has no overlap with other parts, it is likely that the ear was carved after the head.

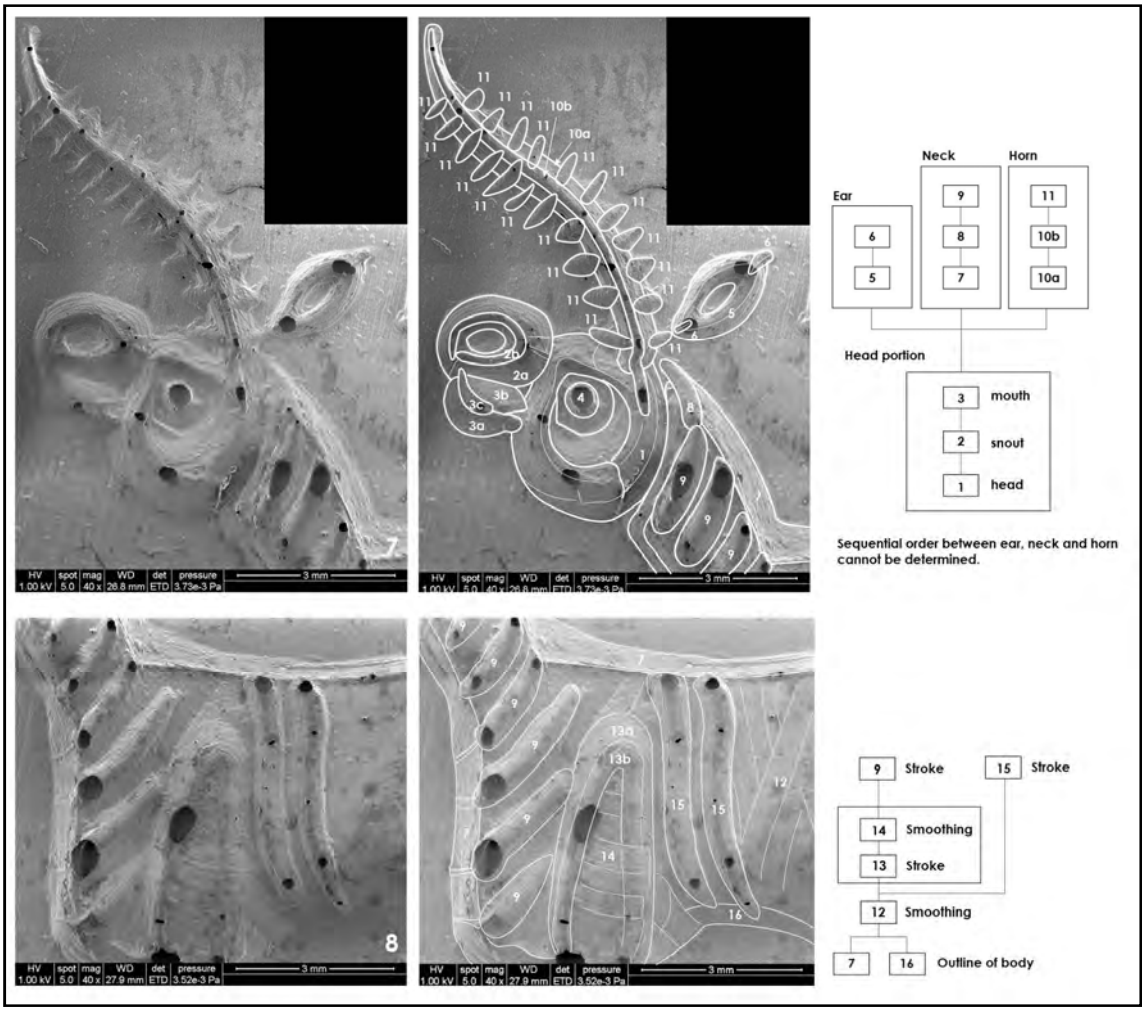

Figure 7: SEM Images

The head shows a roughly circular profile, but its upper frontal portion is slightly projecting. An end point of a carving stroke can be observed on the lower right of the head. This evidence clearly indicates that the circle for the head was made by moving a carving tool round, not using a tubular tool or drill. The discontinuous striations on the lower half of the head indicate that the circle was made by several strokes. The eye appears to have been made using a drill on a raised area inside the head.Thus it seems that at least two different tools were used to carve the head and the eye.

The snout is also represented by an ovoid circle. Similarly this circle was made by carving an oval stroke as the end point can be observed on its lower left. Two strokes can be observed for it (nos. 2a and 2b); an outline (no. 2a) and thin stroke on the bottom of the former (no. 2b).The striations visible on the impression of the snout and lower part of the head are similar suggesting that they may have been carved with the same tool.

The mouth is indicated by an oval hollow, but at least three strokes can be identified (nos. 3a - 3c). Two strokes (nos. 3a and 3b) make the outline and a thin stroke (no. 3c) is added on to the bottom of the former.

The ear consists of two strokes, an outline (no. 5) and short strokes (no. 6) on both ends of the former.

The horn is made of a curvilinear stroke (no. 10) and short strokes for hatches (no. 11). The curvilinear line is comprised by two strokes (nos. 10a and 10b). No. 10a represents a wider stroke for the outline of the horn and no. 10b is a thin stroke on the bottom of the former. Both strokes overlap the circle of the head, but no. 10b cuts more deeply on to the circle of the head.

The short strokes (no. 11) were all carved after no. 10. The ones on the lower part of the horn are wider and the ones on the upper part become thinner. Although it is not clear whether different tools were used for carving these wider and thinner strokes or not, it is highly likely that these differences were intentionally made as the horn itself becomes thinner towards its upper end. Most of the short strokes are accompanied with minute breakages on both sides indicating that the strokes were made with one motion. It is also clear that these shorter strokes do not overlap with the strokes used to engrave the horn, and they are not symmetrical on either side of the main part of the horn.

Neck/Body/Tail

The neck, body and tail (Figure 8) were carved as a whole consisting of outlines, strokes and flat face. The outline of the body and neck (no. 7) has clear sloped edges. It shows steeper angles on their upper, frontal and back side, while it becomes more gentle on its lower side. In terms of the relationship between the outline and the smooth, flat face on the bottom of the body, it is evident that the final outline was cut after making the flat face on the bottom, as the striations on the surface of the outline and the ones on the flat face are discontinuous and the lower edge of the outline cuts into the flat face. In other words, after carving out a rough hollow, the bottom surface was smoothed for making a flat face and then the outline was cut to make more distinctive faces. On the flat surface of the bottom, very subtle striations can be observed vertically and diagonally (no. 12), indicating that a tool with a flat end was used scooping out the surface.

Two sets of two vertical strokes (nos. 15 and 17) divide the body portion into three parts. These strokes have wider upper ends tapering towards the lower ends. The striations observed on the carved surface are all continuous. These strokes are clearly posterior to the outline of the body as they cut on to the latter.

Among the three parts, the frontal and rear parts are carved more deeply than the central part. The SEM images clearly indicate that these deeper portions are made of strokes for their outlines and flat face on their bottom, which were made by the same

technique as the one observed on the central part of the body. Two strokes (nos. 13a and 13b) can be observed for the outline on the frontal part and two or three strokes (nos. 21 - 23) on the rear part. In both parts, the final stroke is made of thin line (nos. 13b and 23). The bottom surface inside the outlines in both cases is made flat and smooth moving a tool with a flat end vertically and laterally.

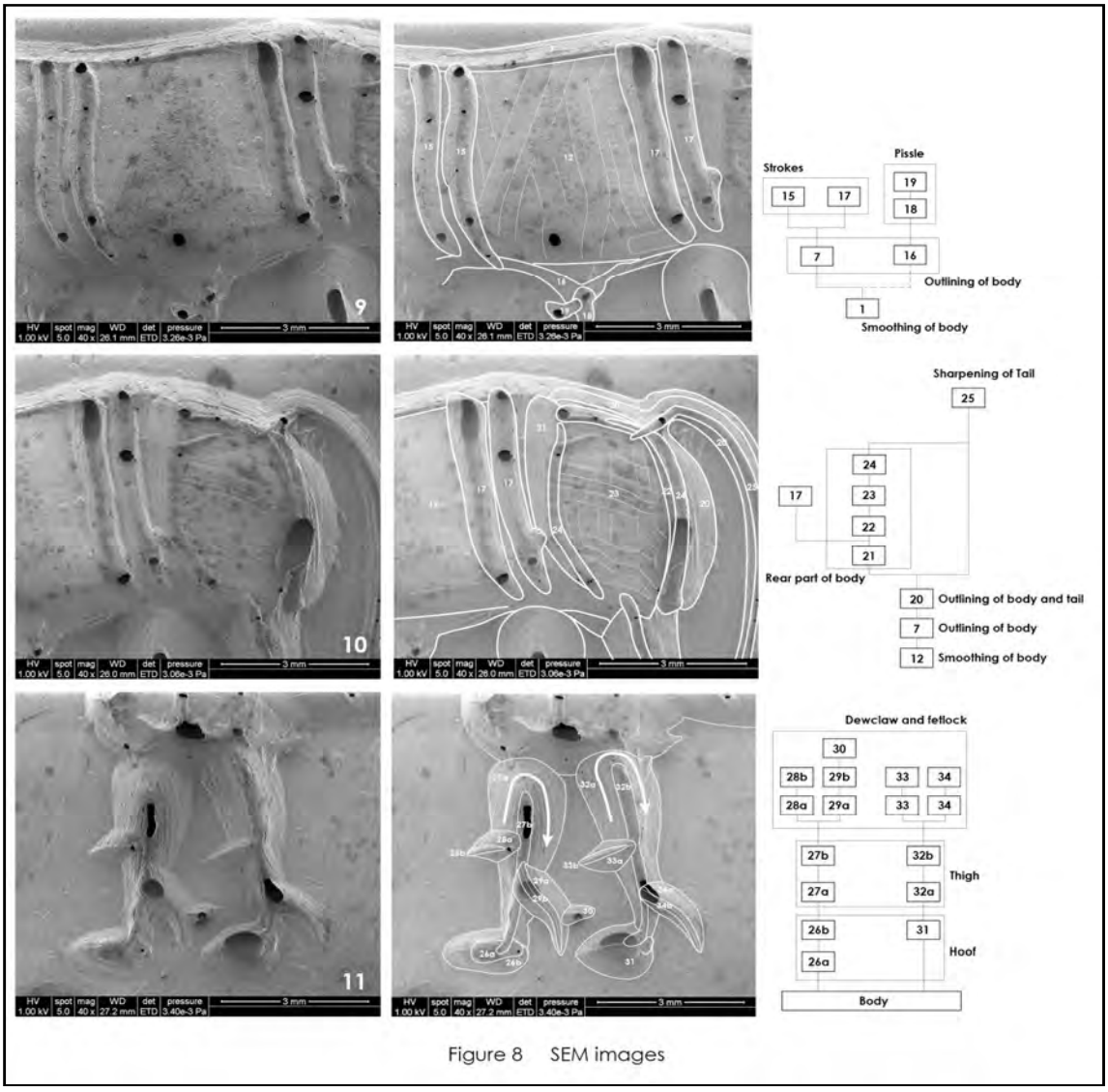

Figure 8: SEM Images

The strokes on the neck (no. 9) also cut on to the outline of the neck indicating their posterity to the outline. Their feature having a wider end tapering towards the other end is identical with the vertical strokes on the body.

Legs

The frontal legs are evidently posterior to the body. Both legs (Figures 8 and 9) are comprised by the same parts, with an order of carving from hoofs (nos. 26 and 31), through thighs (nos. 27 and 32), to the fetlocks (nos. 29 and 34) and projections on

knees (nos. 28 and 33). In respect to the hooves, the left hoof clearly consists of two strokes (nos. 26a and 26b), although the right hoof cannot be observed due to a large bubble on the impression. No. 26a, which is anterior to no. 26b as striations that are associated with no. 26b cut no. 26a, is oblong and no. 26b has a ridge on its centre. The central ridge can be observed on no. 31.

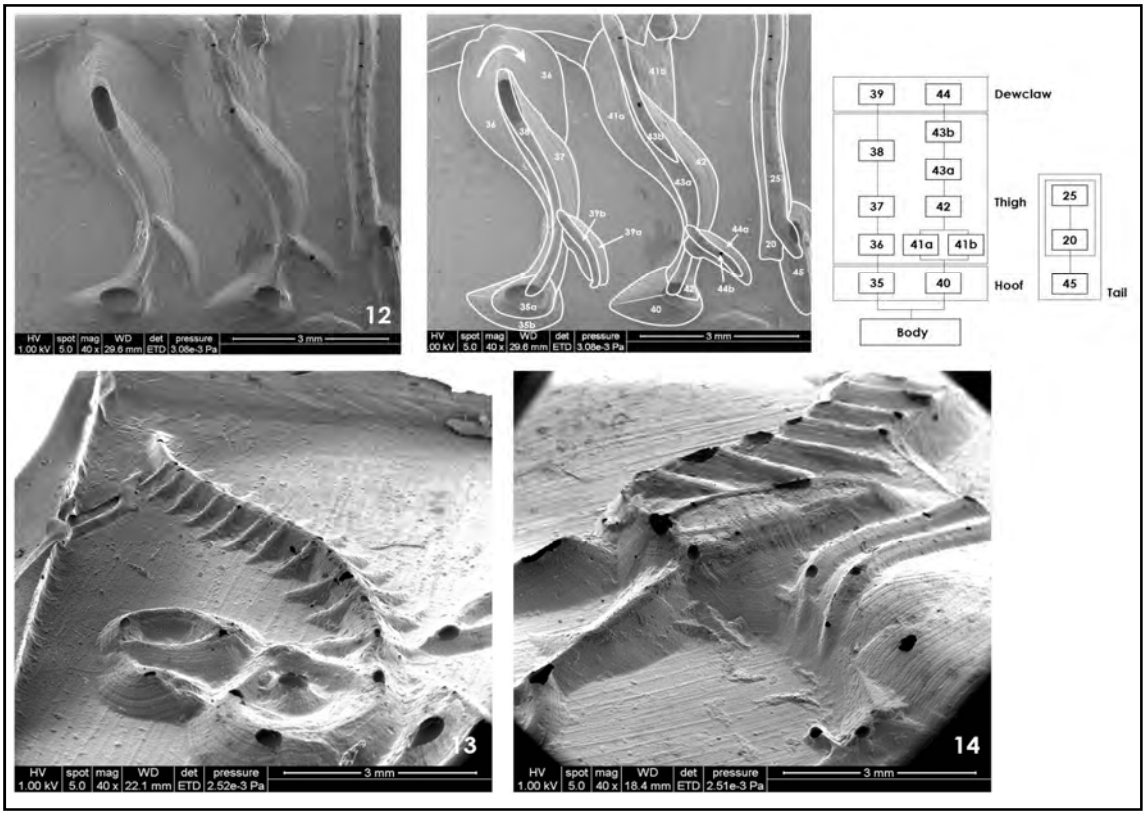

Figure 9: SEM Images

The thighs are composed of at least two strokes, wider outlines (nos. 27a and 32a) and thin strokes on the bottom of the former (nos. 27b and 32b). The latter strokes prominently overlap the hoofs. The fetlocks (nos. 29 and 34) and projections on knees (nos. 28 and 33) were carved in posterior to the thighs. They are shaped in tapering towards their external ends and thin strokes (nos. 28b, 29b, 33b and 34b) are also visible on the bottom of the strokes for outlines. The left fetlock has an additional stroke.

The rear legs are also composed of the same parts as the ones on the frontal legs, except for the projections on knees. Their sequential order of carving is also the same as in the frontal legs. The features of carving are also identical with the frontal legs having two strokes on the hoof (nos. 35a and 35b), three to four strokes on the thighs (nos. 36 - 38 and 41, 42, 43a and 43b), and two strokes on the fetlocks (nos. 39a, 39b, 44a and 44b). One fact to be noticed is the sequential relationship between the body and legs; whereas the right leg is clearly posterior to the body, the left leg is partly posterior (no. 41a) and partly anterior (no. 41b). This indicates an additional work on the body after carving left legs.

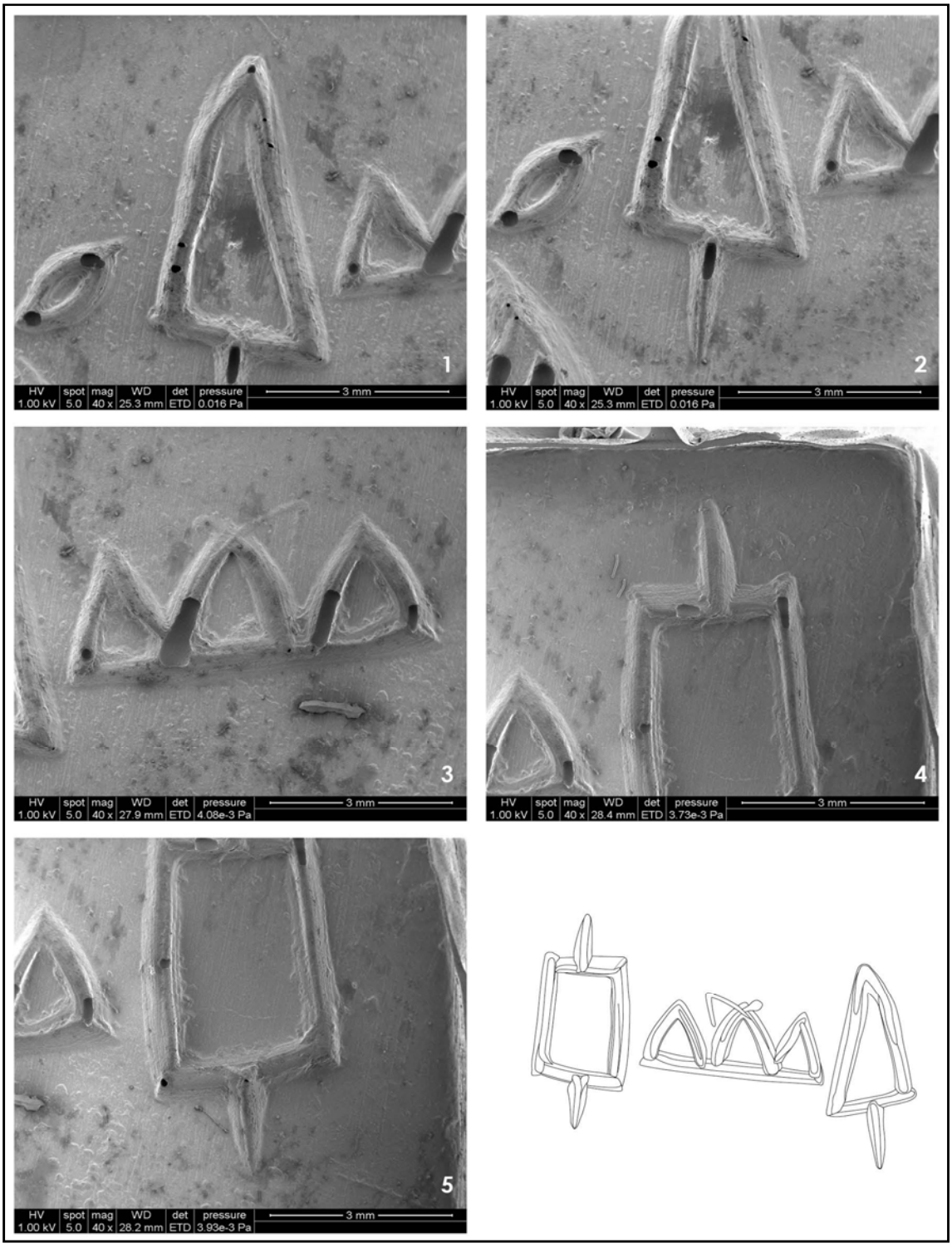

Figure 10: SEM Images

Inscription

Three signs are identified on this seal, an arrowhead-shape, three triangles and a rectangle with two vertical strokes (Figure 10). For the arrowhead-shape, the bottom stroke of the triangle was carved first and then the legs were made. An additional

stroke can be observed on the top of the triangle, which seems to have been carved to make the apex prominent. The vertical strokes on the lower part of this sign were finally added. Similarly the bottom line was carved and then legs were delineated on the three triangles for the three triangles. Each line is made of several strokes including thin ones on the bottom of lines. Additional strokes can be observed overlapping the central triangle, which were shallowly made after the carving of the triangle. For the sign of a rectangle with vertical strokes, the rectangle was carved first and then vertical strokes were made on both side of the former. Each line consists of several strokes in the same way as in other signs.

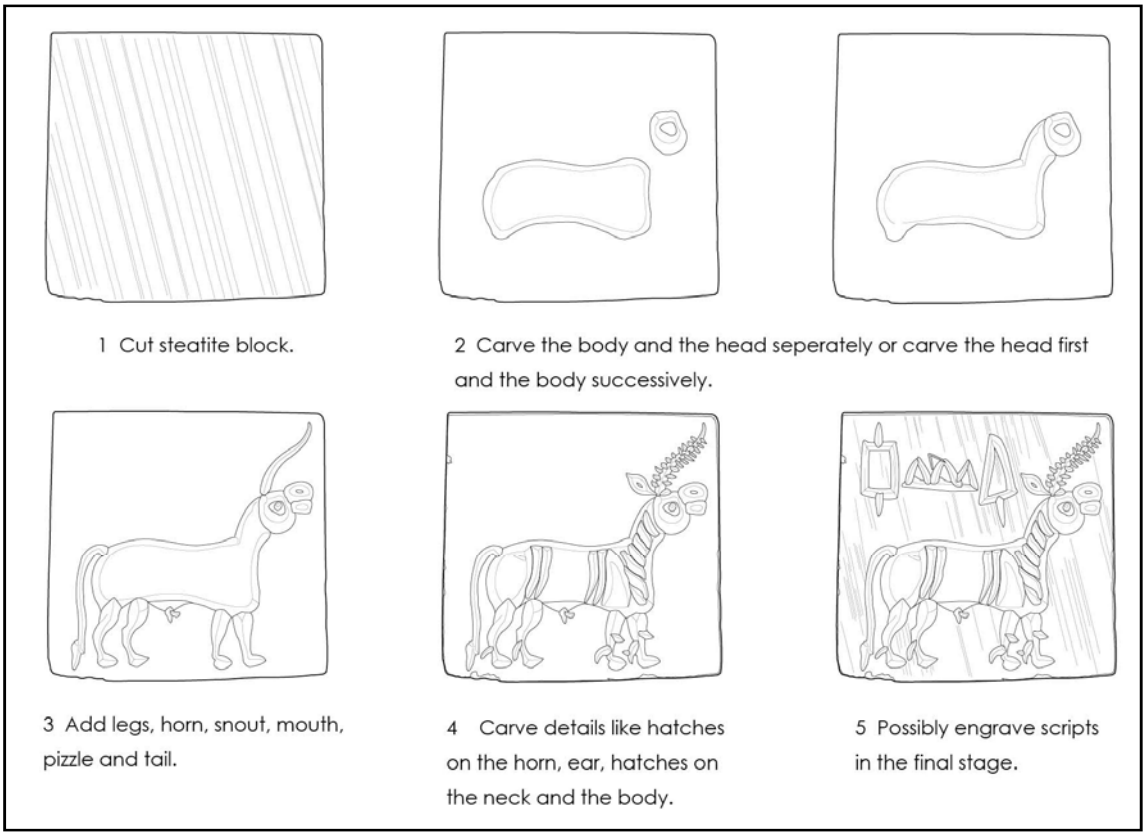

Figure 11: Sequential Order Carvings

Summary

Even though this is only one seal, we can learn a lot by studying it using these methods.

1) The stylistic analysis helps describe its various elements, and can be used to compare seals from different sites. In the absence of good stratigraphic control, this can help provide information on chronology and potentially different workshop or artisan carving styles. This can help us understand how production was organized.

2) SEM helps us understand technological aspects of production that are difficult to understand just by looking at the seal. We can identify different tools used to carve

the seals. This seal was carved with at least three different tools. SEM can also help us reconstruct the carving sequence (Figure 11).

This is just a start, we need a lot more data from different sites, regions, etc., to understand how seal production was organized and how stylistic and technological features of Indus seals changed through time and across space. However comparative examinations among seals using the same methods can reveal the distinctive and common features among seals. Then we can make better classifications of seals based not only on the stylistic features but also technological ones and can set out to discussing the production and distribution systems of seals during the Urban Indus period.

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References

Ameri, M. (2012) Regional Diversity in the Harappan World: The Evidence of the Seals. in S. Abraham, P. Gullapalli, T.P. Raczek and U.Z. Rizvi (eds.) *Connections and Complexity: New Approaches to the Archaeology of South Asia*. Left Coast Press, Walnut Creek. pp. 355-374.

CISI II = Shah, S.G.M. and A. Parpola (1991) *Corpus of Indus Seals and Inscriptions2: Collections in Pakistan*. SuomalainenTiedeakatemia, Helsinki.

Farmer, S., R. Sproat and M. Witzel (2004) The Collapse of the Indus-Script Thesis: The Myth of a Literate Harappan Civilizations. *Electronic Journal of Vedic Studies* 11(2): 19-57.

Franke-Vogt, A. (1991) The Glyptic Art of the Harappa Culture. *Forgotten Cities on the Indus: Early Civilization in Pakistan from the 8th to the 2nd Millennium BC*. Verlag Philipp von Zabern, Mainz. pp. 179-187.

Jamison, G.M. (2011) Regional Studies of Harappan Seal Production: A Case Study From Sites In Sindh. *Ancient Sindh* 11: 17-44.

Jamison, G.M. (2016) *The Organization of Indus Unicorn Seal Production: a comparative diachronic analysis of carving style, technology, and socio-political organization*. Unpublished PhD Thesis, Department of Anthropology, University of Wisconsin-Madison.

Kenoyer, J.M. and R.H. Meadow (2010) Inscribed Objects from Harappa Excavations 1986-2007. in A. Parpola, B.M. Pande and P. Koskikallio (eds.) *Corpus of Indus Seals and Inscriptions*, vol. 3. SuomalainenTiedeakatemia, Helsinki. pp. xliv-lviii.

Konasukawa, A., H. Endo and A. Uesugi (2011) Chapter 7: Minor Objects from the Settlement Area. in V. Shinde, T. Osada and Manmohan Kumar (eds.) *Excavations at Farmana, Rohtak District, Haryana, India 2006-2008*.Indus Project, Research Institute for Humanity and Nature, Kyoto. pp. 369-529.

Mahadevan, I. (1977) *The Indus Script, Texts, Concordance and Tables*. ASI, New Delhi.

Manmohan Kumar and V. Dangi (2007) A Harappan Seal from Bhirrana. in Manmohan Kumar (ed.) *Numismatic Studies* Vol. 8. Harman Publishing House, New Delhi. pp. 135-136.

Parpola, A. (1994) *Deciphering the Indus Script*. Cambridge University Press, Cambridge.

Rao, L.S., N.B. Sahu, PrabashSahu, U.A. Shastry and Samir Diwan (2003) Unearthing Harappan Settlement at Bhirrana. *Purātattva* 34: 20-24.

Rao, L.S., N.B. Sahu, U.A. Shastry, PrabashSahu and Samir Diwan (2005) Bhirrana Excavations 2005-06. *Purātattva* 36: 45-49.

Rao, L.S., Nandini, B. Sahu, PrabashSahu, Samir Diwan and U.A. Shastry (2004) New Light on the Excavation of Harappan Settlement at Bhirrana. *Purātattva* 35: 60-68.

Rissman, P.C. (1989) The Organization of Seal Production in the Harappan Civilization. in J.M. Kenoyer (ed.) *Old Problems and New Perspectives in the Archaeology of South Asia*. Department of Anthropology, University of Wisconsin, Madison. pp. 159-170.

Shinde, V, T. Osada and Manmohan Kumar eds. (2011) *Excavations at Farmana, District Rohtak, Haryana, India. 2006-2008*. Indus Project, Research Institute for Humanity and Nature, Kyoto.