Stylistic and Technological Examination of Indus Steatite Seals from Farmana

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Abstract: *Inscribed steatite seals are diagnostic materials of the Indus Civilization (2600-1900 BCE) often used to identify and define the Harappan character of a site. Traditionally described and interpreted as highly standardized and uniform, recent research has highlighted diachronic variation in carving styles and production techniques, within and among different sites and regions. This study builds upon and contributes to growing awareness of diversity in Indus seals through analyses of two seals from the site of Farmana. Using novel, complimentary research methods that focus on carving styles and technological aspects of production, it has been possible to examine and uncover patterns in manufacturing techniques and methods that have important implications for understanding chronological aspects of Indus seal production and use. These studies are supplemented with formal stylistic and metric analyses that provide insights into the carving styles of the people who made them, which reflect shared and idiosyncratic templates, choices, and skills. Multi-faceted approaches to the study of Indus seals are useful to learn more about the organization of this important craft industry, which in turn helps further our knowledge of how the Indus Civilization was integrated and functioned. In the absence of deciphered written records, such studies are necessary to advance our knowledge of one of the world's earliest and most unique urban cultures.*

Keywords: Indus Civilization, Farmana, Bhirrana, Steatite Square Seal, Styles, Carving Technologies, Ghaggar-Hakra Region

Introduction

This article discusses the stylistic and technological variation in steatite square seals of the Indus Civilization based on the examination of two seals from Farmana in Haryana, India. These seals are composed of a flat square body, on which iconographic elements and inscriptions were engraved, and a boss drilled with a hole, which was most probably used for passing a cord through to hold them. This type of seal, which has been regarded as one of the most diagnostic artefacts of the Indus Civilization, is known for having variations, especially in its iconographic elements and carving styles (Rissman 1989; Franke-Vogt 1991, 1992; Ameri 2013; Jamison 2013, 2017, 2018a, 2018b,

2018c). However, since recognition of this variation is mostly based on broad stylistic classification and comparisons of iconography, and the diachronic changes on the styles of seals have not successfully been revealed, their meanings are yet to be clarified.

As any iconographic elements were engraved on the surface of steatite, it seems likely that iconographic and stylistic differences were closely connected to technological variations. If it can be assumed that seals were produced not in a single workshop at one site but in multiple workshops at different sites in the different parts of the Indus region, it may be that carving technologies reflects tempo-spatial variability more than iconographic elements; therefore, examinations of carving technologies can give us indispensable clues to understand the variations of seals better. While the authors examined one seal from Bhirrana based on its stylistic elements and carving technology (Uesugi et al. 2016), further examinations must be made on more samples to reveal the relationship between stylistic and technological features and the tempo-spatial variations of Indus steatite seals.

This article examines two seals from Farmana, which have iconographic and stylistic features similar to the one from Bhirrana, to compare these three seals to show how we can perceive and interpret variation in Indus seals.

Previous Studies on Variation in Indus Steatite Square Seals

Since seals are diagnostic of the Indus material culture, there have been many earlier studies focusing on them. Many of these have been descriptive in nature (Kenoyer 1998a, 1998b; Mackay 1931, 1938, 1943; Rao 1985; Vats 1940) or focused on the script (Mahadevan 1977; Parpola 1994; Rao 2018). Collectively, these studies also helped develop the framework for classifying and defining Indus seals and inscriptions, which were further elaborated upon and refined with the creation of the Corpus of Indus Seals and Inscriptions (CISI), a multi-volume catalogue that is the best source of information on inscribed materials from the Indus (Joshi and Parpola 1987; Parpola et al. 2010, 2019; Shah and Parpola 1991).

More recently, scholars have turned their attention to the context, function and use of Indus seals and writing, including investigations of diachronic variation in carving styles and production methods. Paul Rissman (1989) and Ute Franke (1991, 1992) were pioneers in this work. Their research resulted in the identification of patterned variation in unicorn seal carving styles and techniques that were linked with diachronic differences and regional diversity. The methods of formal stylistic analysis developed and used were influential on our own research on stylistic variability in Indus seals, and their interpretations remain valuable and relevant today.

The work of J. Mark Kenoyer has also contributed significantly to our understanding of variability in seal production and use. Based on stratigraphic excavations at the site of Harappa, Kenoyer has developed a chronological framework used to identify and

define changes in the carving styles of seals and uses of the Indus script over time at the site (Kenoyer 2006; Kenoyer and Meadow 2010, Table 1). Other publications by Kenoyer (2009, 2013, 2020) have explored variability in Indus seals, the iconography often engraved on them, and most recently, the origins and development of the writing system. Collectively, this research has positively impacted recent and current studies (including our own) on Indus seals and writing and highlighted the necessity of detailed, problem-oriented investigations to learn more about variation and its relationship to seal production and use.

Other recent studies by Marta Ameri (2013, 2018) have identified regional variation in the distribution, orientation, and carving styles of different iconographic themes present on Indus seals. Based on these data, she argues for the presence of regionally distinct social groups, communities and cultural practices associated with making and using Indus seals. Ayumu Konasukawa (2013) has conducted detailed analyses of seals from the Ghaggar-Hakra region and noted differences in technological and stylistic properties when compared to similar materials from sites in the Punjab and Sindh. Additional work by Adam Green (2010, 2016, 2018) has investigated the operational sequences and carving choices used to create Indus seals, contextualizing both within the social relationships and practices of the artisans who crafted them. All of these studies underscore the diverse approaches to investigation on Indus seals and the multiple questions about Indus material culture that can be addressed by studying them.

Our work on Indus seals has also been influenced by and benefitted from these studies. The most comprehensive of this research has focused on the organization of Indus unicorn seal production and use, and its relationship to larger issues of socio-political organization and integration. Using experimental and ethnoarchaeological approaches to seal production, it has been possible to model sources of variation in carving styles and techniques (Jamison 2012, 2013, 2017, 2018a). These have been tested against archaeological data using formal methods of stylistic and metric analyses, resulting in the identification of stylistically distinct groups of unicorn seals that were likely made by different artisans and workshops. The analysis of the distribution of these groups suggests that unicorn seal production and use were likely decentralised throughout the entire Indus cultural sphere yet played an important role in integrating people and places over an expansive and diverse region (Jamison 2016, 2017, 2018b).

The methodology developed and used in these works has since been further applied to collections of seals from individual sites and those engraved with other animal motifs (Ameri and Jamison, in press; Jamison 2018c; Jamison et al. 2017; Uesugi et al. 2016). Collectively, this previous research can be categorised into two types based on the evidence examined: 1) iconographic elements and 2) production technologies. The former can be further classified into two types; those focusing on the associations of iconographic and metric attributes to find diachronic variations and different workshops, and others dealing with different types of iconography to see overall

patterns and regional variation in Indus seals. While the systematic examination of production technologies has not been done on a large scale yet, identifying different raw materials, tools, operational sequences, and carving practices are the main goals to investigate technological variation.

Table 1: Chronology of Seal and Inscription Carving Styles at Harappa
(after Kenoyer 2006; personal communication)

Period	*Chronology*	*Iconographic Carving Style*	*Inscription Carving Style*	*Inscription Orientation*
3A	2600-2450 BCE	Angular, Bold	Angular	Linear
3B	2450-2200 BCE	Round, Natural	Curved	Irregular
3C	2200-1900 BCE	Round, Natural	Bold, Rigid	Linear

Studies on iconographic elements attempt to identify stylistic groups, each of which share associations of attributes and metric values, and research on carving technologies focuses more on individual seals. This difference seems to derive from the viewpoint that most studies are based on, but a multi-directional approach including examinations of stylistic and technological aspects of seals is needed to reveal similarities and differences to identify and define regional styles, diachronic changes, and the products of different artisans and workshops. The current study attempts to do this through an investigation of two seals from Farmana.

Broad Stylistic Classification of Steatite Indus Seals

This section exhibits broad classification of steatite Indus seals that depict animal motifs to clarify the importance of the seals from Farmana and some related problems to understand the diversity of the Indus seals better.

While, as overviewed in the precious section, there are different viewpoints and classifications in examining Indus seals, a broad twofold classification is adopted here to highlight a significant stylistic difference between them; the Stylistic group 1 depicts an animal facing right, and the Stylistic group 2, the one facing left (Figure 1). Among Indus seals known to date, the Stylistic group 2 is overwhelmingly dominant counting 1,612 including unfinished ones, while the Stylistic group 1 is limited in number (63 in number). While some have already discussed these two broad groups (Kenoyer 2008; Ameri 2013; Konasukawa 2013; Konasukawa and Koiso 2018; Uesugi et al. 2016), it is important to reiterate that Stylistic group 1 dominates in the Ghaggar Valley (Figure 2) (Ameri 2013). As well as the seals FRN-1 and 4, the one from Bhirrana, which is located in the Ghaggar Valley, examined in our previous article (Uesugi et al. 2016) also belongs to Stylistic group 1.

The specimens of Stylistic group 1 differ from that of the Stylistic group 2, not only in the direction of the animal depicted, but also in the object associated with the animal and the shape of the boss on the reverse side. While a standard is placed in front of the animal in the case of unicorn seals and a trough in the case of bisons and tigers in the Stylistic group 2, an Indus sign, such as an arrow, a tree, etc. is represented in the case

of the specimens of Stylistic group 1, regardless of the variety of the animals depicted. With respect to the boss type, the specimens of Stylistic group 1 have a semi-cylindrical boss, while the ones of the Stylistic group 2 commonly have a double grooved boss.

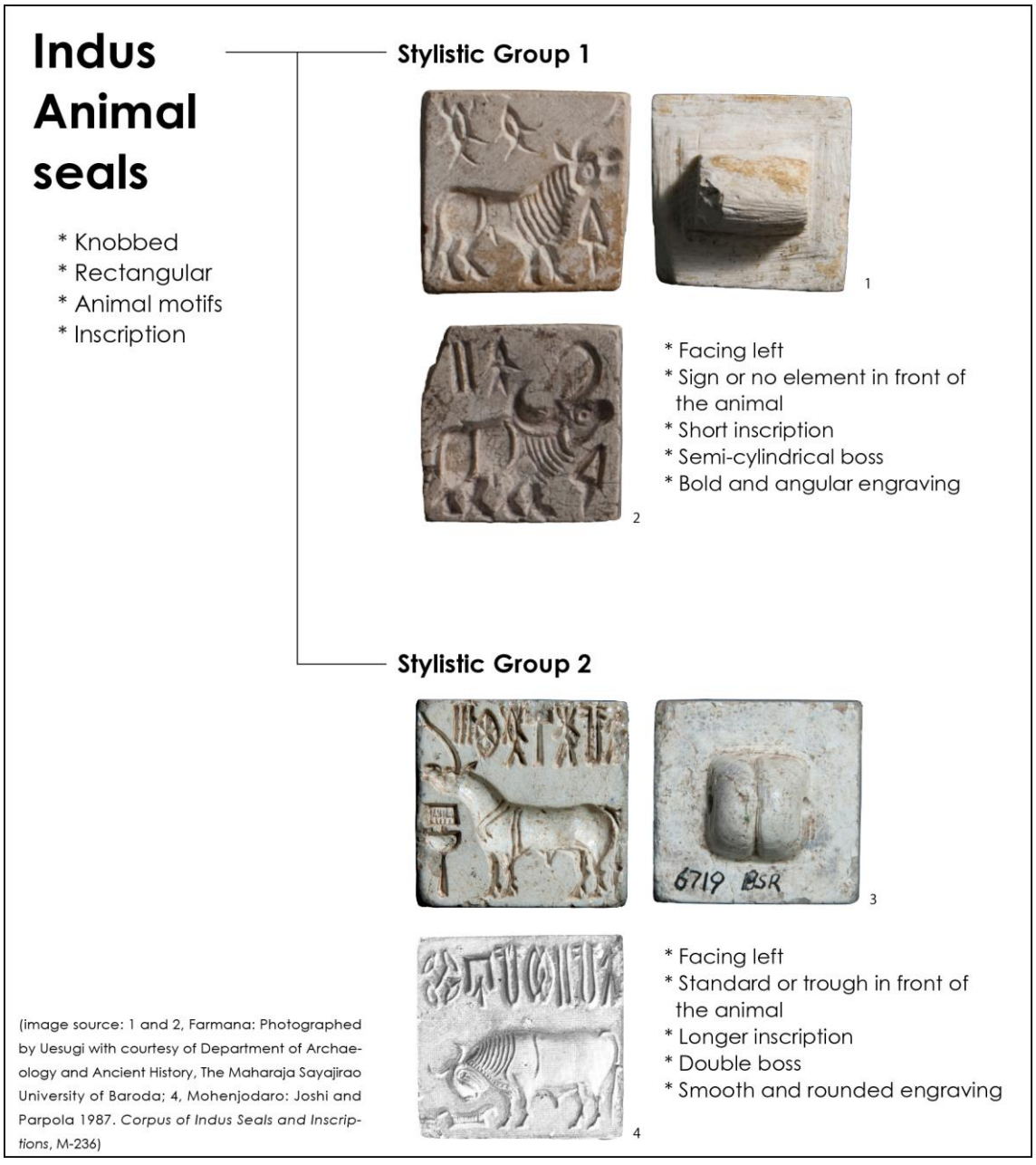

Figure 1: Broad classification of Indus seals

These differences distinguish the two stylistic groups. In addition to the differences mentioned above, the ones of Stylistic group 1 have a distinctive angular cross-section in the carved area. The example from Bhirrana that were examined by the authors using SEM demonstrates a close connection between the cross-section and the carving style and technique. In contrast, many of the Stylistic group 2 have a rounded cross-section that remarkably differs from that of the Stylistic group 1. Therefore, these two

stylistic groups can also be distinguished in terms of carving techniques that are best studied using an approach that focuses on production technologies instead of iconography.

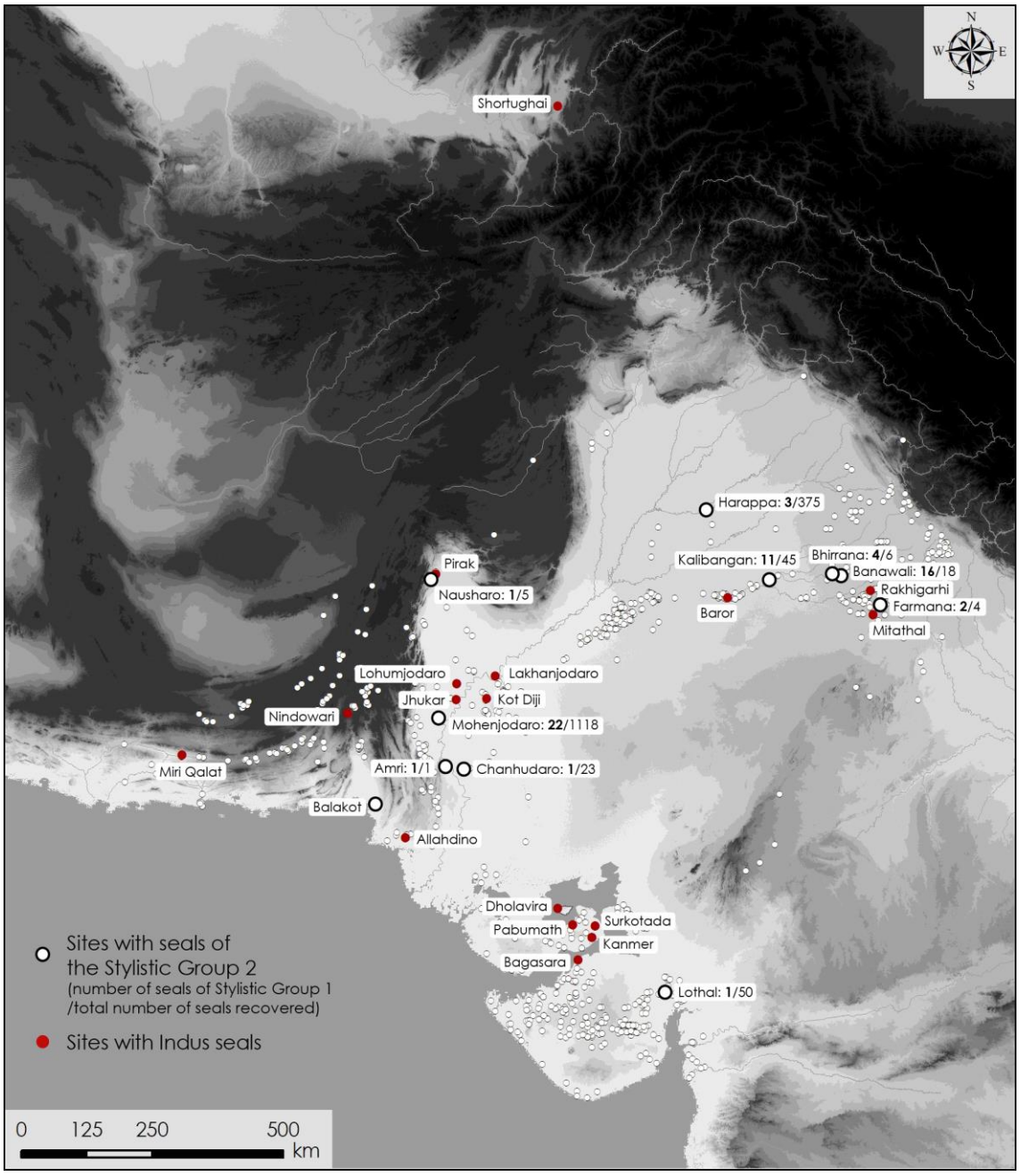

Figure 2: Distribution of Indus seals

In this respect, four seals from Farmana, two of which belong to Stylistic group 2 and the others of which are of Stylistic group 1, are important for better understanding the stylistic and technological differences between the two groups within one site in association with contextual evidence. This paper examines two seals of the Stylistic group 1, while the other two will be dealt with in a separate paper.

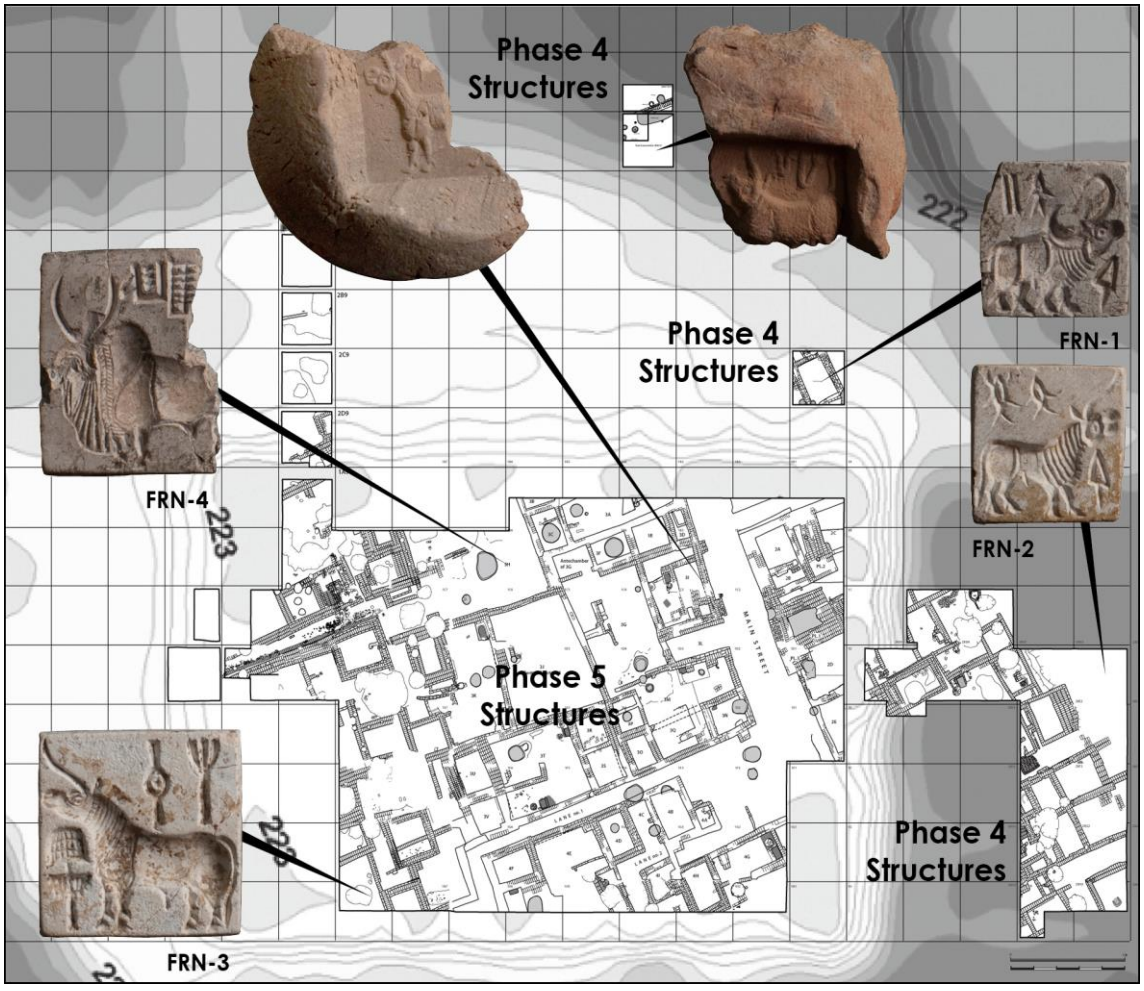

Figure 3: Contextual distribution of Indus seals at the settlement of Farmana

Archaeological Contexts of Steatite Seals from Farmana

Four steatite square seals were recovered from the settlement site of Farmana (Figure 3). Two of them (FRN-3 and 4) belong to Stylistic group 2, which represent a unicorn and a humped bull respectively, and the others (FRN-1 and 2; Figure 4) to Stylistic group 1, one depicting a buffalo and the other a unicorn.

The occupational deposits at this site were divided into five structural phases based on the stratigraphic relationships between mud brick structures and their related deposits. C14 determinations of charcoal samples from stratified contexts date the lowest Structural phase 1 to around 2500 - 2400 calBC and the uppermost Structural phase 5 to around 2300 calBC (Paleo-Labo AMS Dating Group 2011). These dates indicate that the occupations at Farmana roughly corresponds to Harappa Periods 3A and 3B (2600-2200 BC, Kenoyer and Meadow 2010). This chronological association can be confirmed by the ceramic evidence; the stylistic features of Harappan painted pottery from these phases at Farmana indicate that the entire occupation levels belong to the first to second phases of G. Quivron's sequence (Quivron 2000) (the early phase of Uesugi's terminology) (Uesugi 2017).

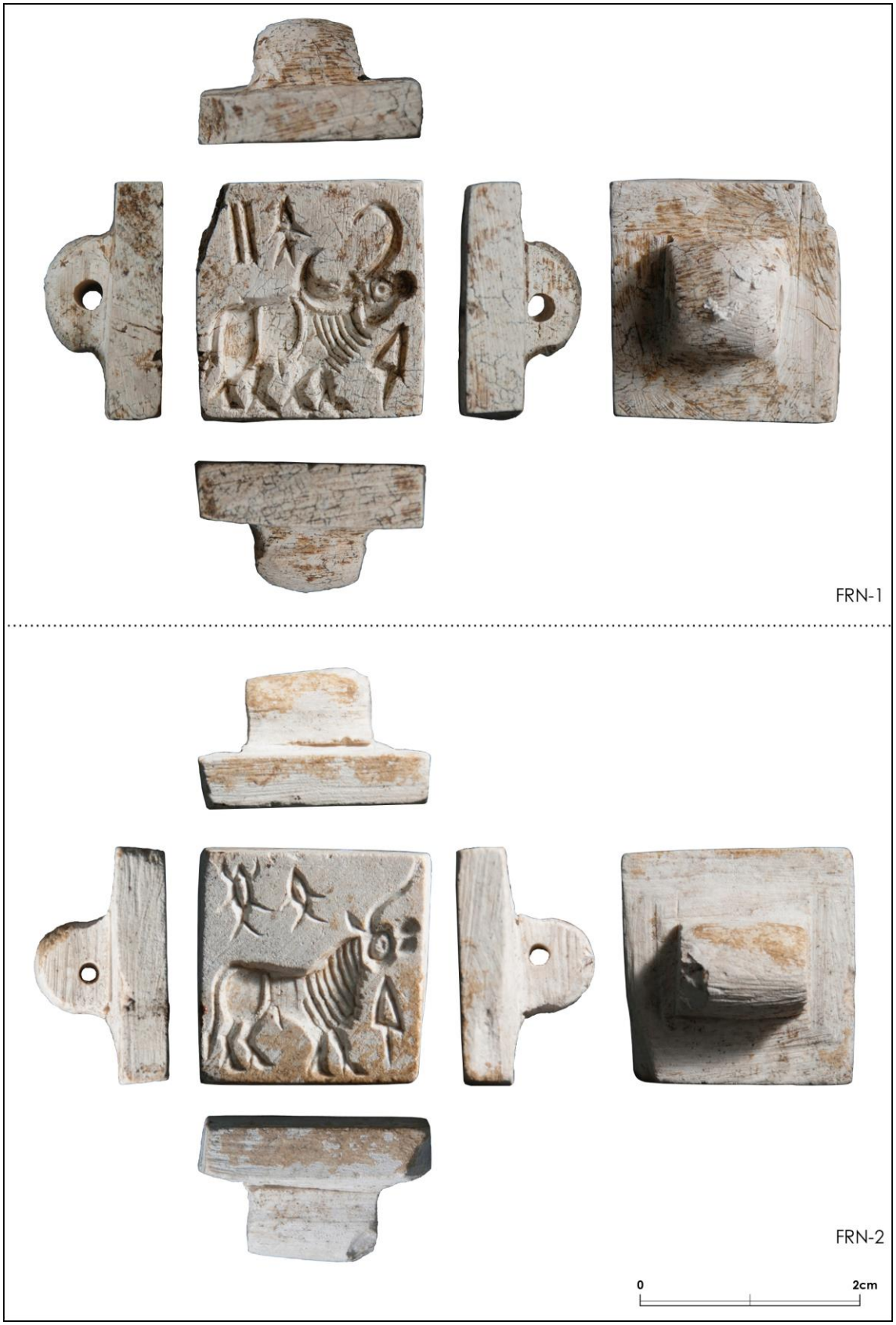

Figure 4: Seals of the Stylistic Group 1 from Farmana

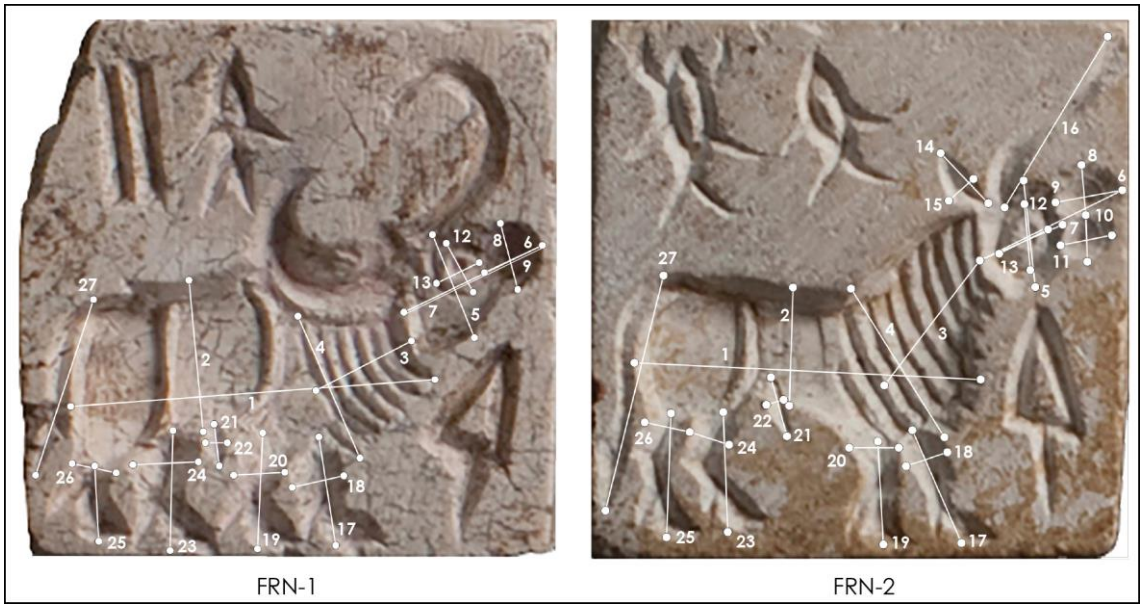

Figure 5: Method of measurements of attributes

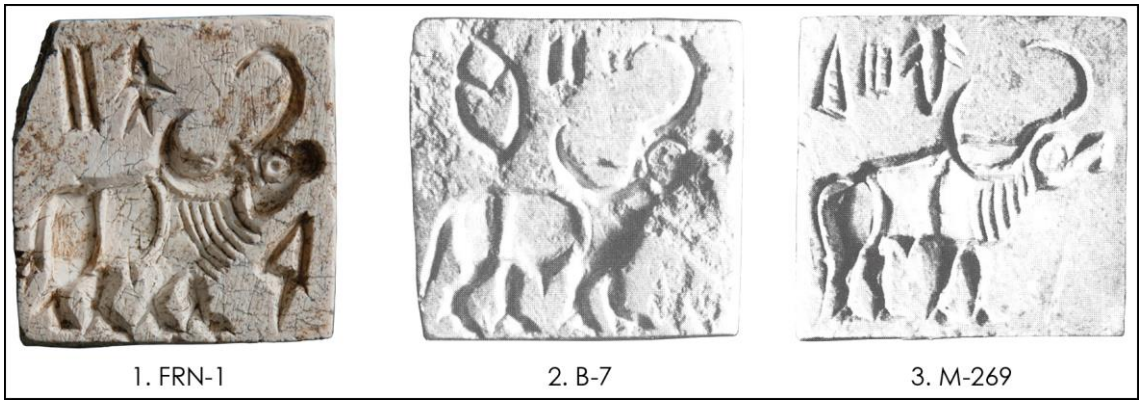

Figure 6: Buffalo seals from different sites (not to scale; produced using published images in the CISI 1)

In terms of these structural phases, FRN-1 and 2 of Stylistic group 1 were retrieved from the Structural phase 4, while the two of the Stylistic group 2 were from the Structural phase 5, suggesting that the two seals of Stylistic group 1 were discarded earlier than the other two of Stylistic group 2. In connection to the spatial contexts, FRN-1 was found in the interior space of a building; and FRN-2 was recovered in a space outside a building or a courtyard. However, it should be mentioned that since the seals were found in floor filling layers not in association with any specific remains such as a pit or a container, it is not clear whether their contexts were primary or secondary.

Stylistic Features of the Seals of Stylistic Group 1 from Farmana

FRN-1 (Buffalo): This seal is well-preserved and appears to have been made of fired and surface treated steatite. It depicts the Indus buffalo, which is distinguished from

similar forms (including the zebu bull and bison) primarily on the basis of the large, curved horns that are morphologically distinct. Methods used to examine this seal have been applied in earlier studies (Jamison 2017, 2018a; Uesugi et al. 2016) and consist of formal stylistic and metric analyses of animal iconography (Figure 5 and Tables 2 - 3). They are useful for comparative studies that help identify patterned variation in Indus seal carving styles and techniques that provide insights into how production was organised and varied diachronically. There are a few examples of this animal from other Indus sites (Joshi and Parpola 1987; Parpola et al. 2010; Shah and Parpola 1991), yet this seal is significant for a variety of reasons.

Table 2: Metric properties of selected attributes of the buffalo on Seal FRN-1

No	*Attribute*	*Measurement (mm)*	*No*	*Attribute*	*Measurement (mm)*
1	Body Length	13.6	21	Pizzle Length	1.56
2	Body Width	5.65	22	Pizzle Width	0.82
3	Neck Length	4.00	17	Outer Foreleg Length	4.08
4	Neck Width	5.75	18	Outer Foreleg Width	1.96
6	Head Length	5.71	19	Inner Foreleg Length	4.31
5	Head Width	4.13	20	Inner Foreleg Width	1.90
12	Eye Diameter 1	2.07	23	Inner Rear Leg Length	4.46
13	Eye Diameter 2	1.77	24	Inner Rear Leg Width	2.44
8	Snout Length	2.54	25	Outer Rear Leg Length	2.80
9	Snout Width	2.38	26	Outer Rear Leg Width	1.67

Table 3: Ratios of Length/Width for selected attributes of the buffalos in Seals FRN-1, B-7, and M-269

Attribute/Seal	*FRN-3*	*B-7*	*M-269*
Body L/W	2.40:1	2.34:1	2.06:1
Neck L/W	0.70:1	0.90:1	0.76:1
Head L/W	1.38:1	1.44:1	1.47:1
Eye L/W	1.17:1	0.88:1	0.99:1
Snout L/W	1.07:1	0.73:1	0.61:1
Pizzle L/W	1.91:1	1.84:1	1.03:1

The first is that it is one of only a few seals with this motif that depicts a right-facing animal in the obverse. We calculate a total of 15 (possibly 17) published inscribed Indus seals with the buffalo motif, of which only four or five have right-facing animals (Figure 6). That half of these are from sites in the Ghaggar-Hakra region is not a coincidence and correlates with earlier studies, discussed here and elsewhere, highlighting the important role that the region played in the origins and development of Indus seals and writing (Ameri 2013; Jamison 2018a; Konasukawa 2013; Uesugi et al. 2016). Second, the seal represents an early phase of the Urban period (Harappa Period

3A) carving style with parallels at only a few sites. This interpretation is supported by absolute dates from Farmana and comparative analyses with seals from Harappa. Though not a focus of this study, current research on inscriptions by Konasukawa (2020) reinforces the notion that this seal belongs to the early phase of the Urban period based on the few inscribed characters that are present. Our analysis also supports earlier research (Jamison 2018c) and demonstrates connections in the carving styles of right-facing buffalo seals that provide insights into the organization of seal production during the early part of Indus integration.

Seal #FRN-1 is nearly intact and depicts the full buffalo icon, a short inscription above it, and an engraved character in front of it (Figure 4: above). The function of the latter is unclear and not present on most buffalo seals, in which usually a small trough or manger is present in front of or (more commonly) below the animal's head. It is clearly and deeply engraved in a bold, angular carving style that is characteristic of Period 3A (2600-2450 BCE) at Harappa (Jamison 2017; Kenoyer 2006; Kenoyer and Meadow 2010). The bases of the most prominent portions of the engraved surfaces, visible in the body, neck, legs, and lower part of the face, are flat and smooth, and the edges are steep and angled. These characteristics are visible in both the photographs and the scanning electron microscope (SEM) images presented in the next section of this paper. Earlier research (Jamison 2013, 2017; Uesugi et al. 2016) suggests that multiple tools with different tips and edges are useful for creating smooth, flat engraved surfaces with steep edges and angles, especially in basal sections of carved surfaces.

Analyses of other compositional elements of the buffalo also provide insights into carving styles and techniques. The horns, hooves, pizzle (penis), and incised lines on the body are broad and deep with angular edges, which stand in contrast to the flat, smoothened bases of the engraved surfaces of the body, neck, legs, and face. There are six parallel, curvilinear incised lines below the left horn, present on the neck and front flank of the animal's body that are deeply engraved but less broad than those on the animal's body, suggesting the use of different tools and/or operational sequences to create them. One of the most distinctive features of this seal is the eye, characterised by a deeply engraved eyeball and an incised circle that encloses it. The former appears to have been drilled, the latter was likely carved with a different tool. As with most buffalo seals, this one does not depict a clearly identifiable ear. This provides evidence of variability in the carving styles and techniques used to create the buffalo on the seal.

Some of this is functional and likely represents the tools and methods used to engrave various attributes of the animal's anatomy. The buffalo icon is comprised of discrete elements that vary in their morphology and proportions, and it is clear that the artisans who made them used different tools for different carving tasks. Evidence of carving sequences and strokes used to create them are best studied under SEM and discussed in the next section of this paper. However, this functional interpretation does not fully explain this seal or account for the stylistic and technological variation present among all buffalo seals, in spite of their small numbers in the corpus of published Indus seals.

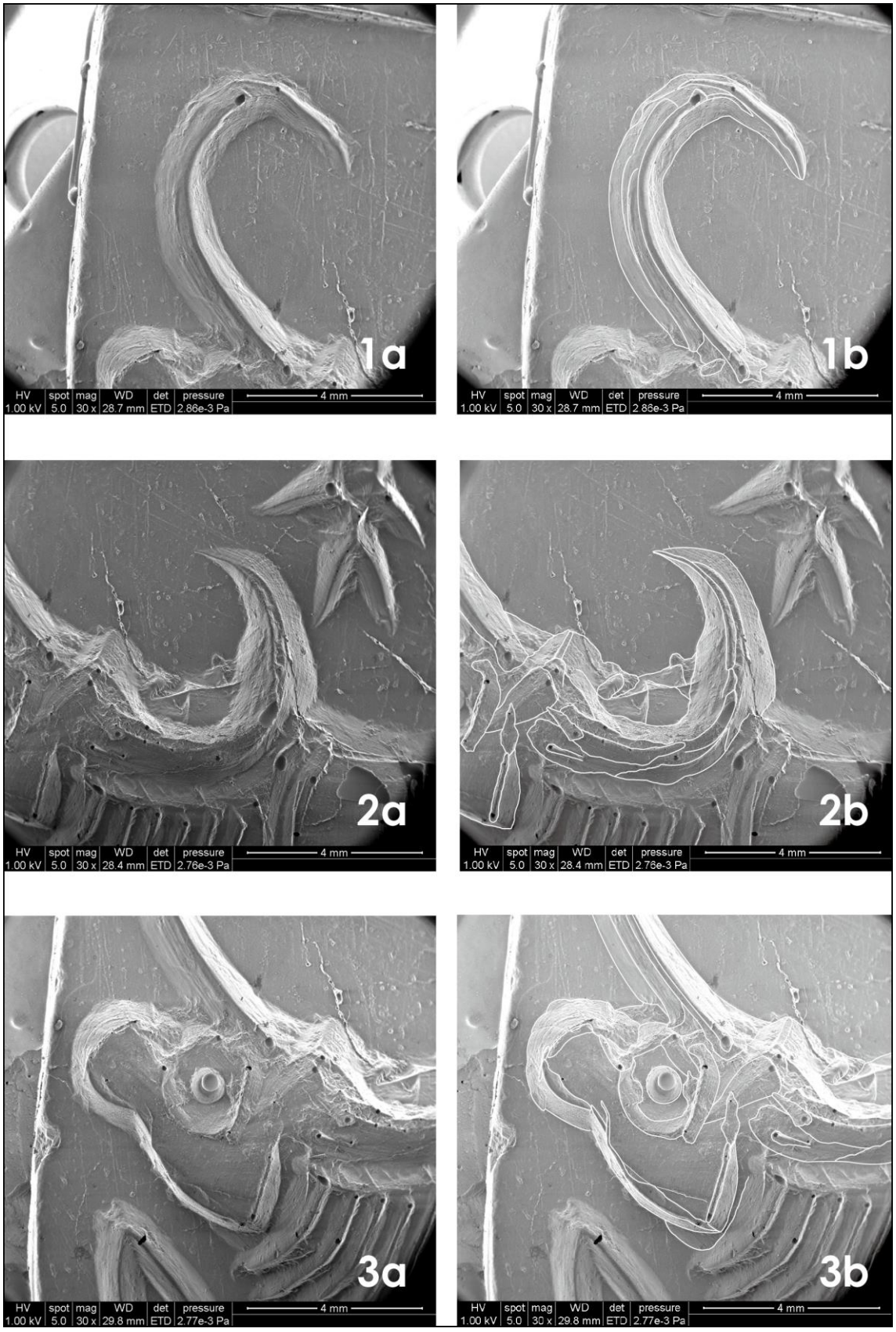

Figure 7: SEM images of FRN-1

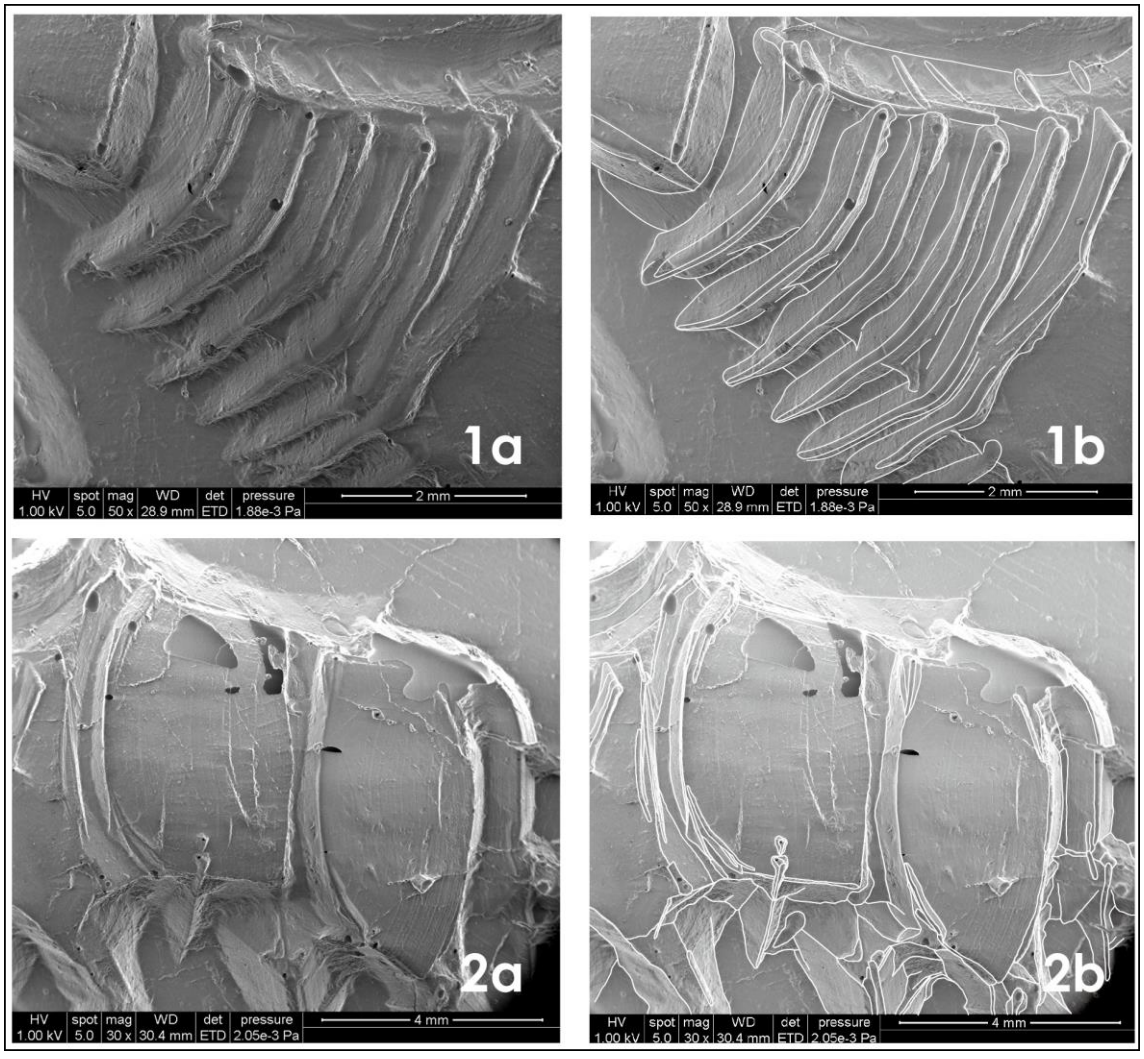

Figure 8: SEM images of FRN-1

There is no functional explanation to account for the fact that the animal on this seal faces right, why its compositional elements are for the most part deeply and broadly engraved, why the eyeball was drilled (instead of incised), and why there are six curvilinear incised lines below the left horn as opposed to one, five, ten, or none. These characteristics represent intentional carving choices made by the artisans who created them. Metric analysis may provide further evidence of signatures of the artisans who created the seal.

The seal measures 20 mm in length by 20 mm in width, with a maximum thickness of 6 mm excluding the boss, which is 11.3 mm by 10.3 mm with a maximum diameter of 2.4 mm in the drill hole. Our analysis of the metric properties of selected compositional elements of the buffalo motif on the seal are at present primarily descriptive (Table 2). Since most of the absolute values of the measurements of length and width for these are dependent on the overall dimensions of the seal and available space for its depiction, we also calculated ratios of length to width for selected compositional

attributes, as earlier studies (Jamison 2017) suggest they are more meaningful to identify patterns associated with different workshop and artisan carving styles (Table 3).

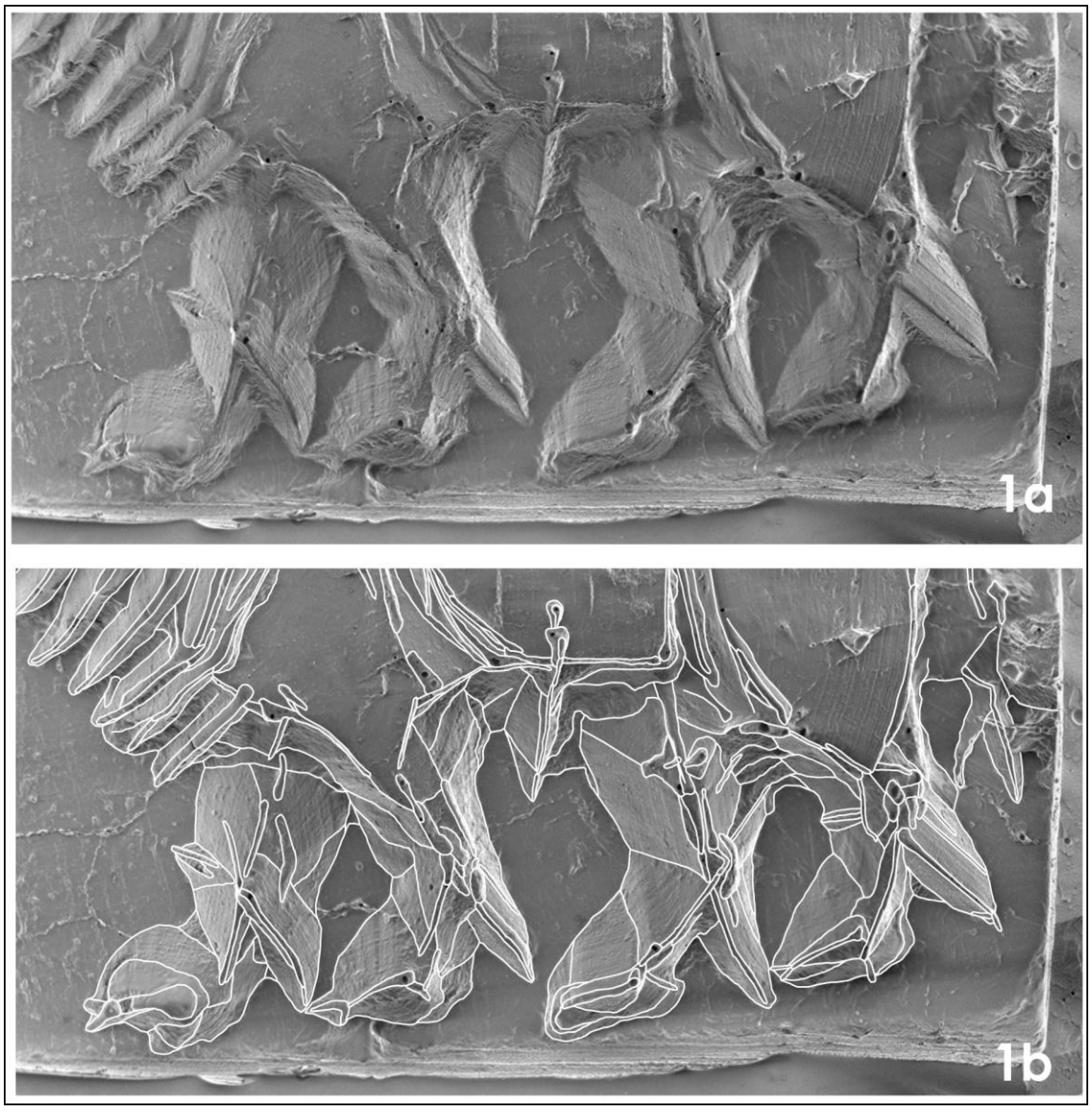

Figure 9: SEM images of FRN-1

Overall, these data provide information about the morphology of the animal's body, which can be characterised as short and broad, especially the neck. Some of this is correlated with the specific animal and the way it is usually depicted on Indus seals. Compared to unicorns, for example, the buffalo is shorter and broader in its appearance. The dimensions and proportions of both elements of the eye suggest that it is fairly large and well-defined, which is easily observed and has already been commented on above. And though it is not possible to determine why these decisions were made, we can attempt to identify patterns among multiple seals that reflect the carving styles and techniques made by different artisans and workshops.

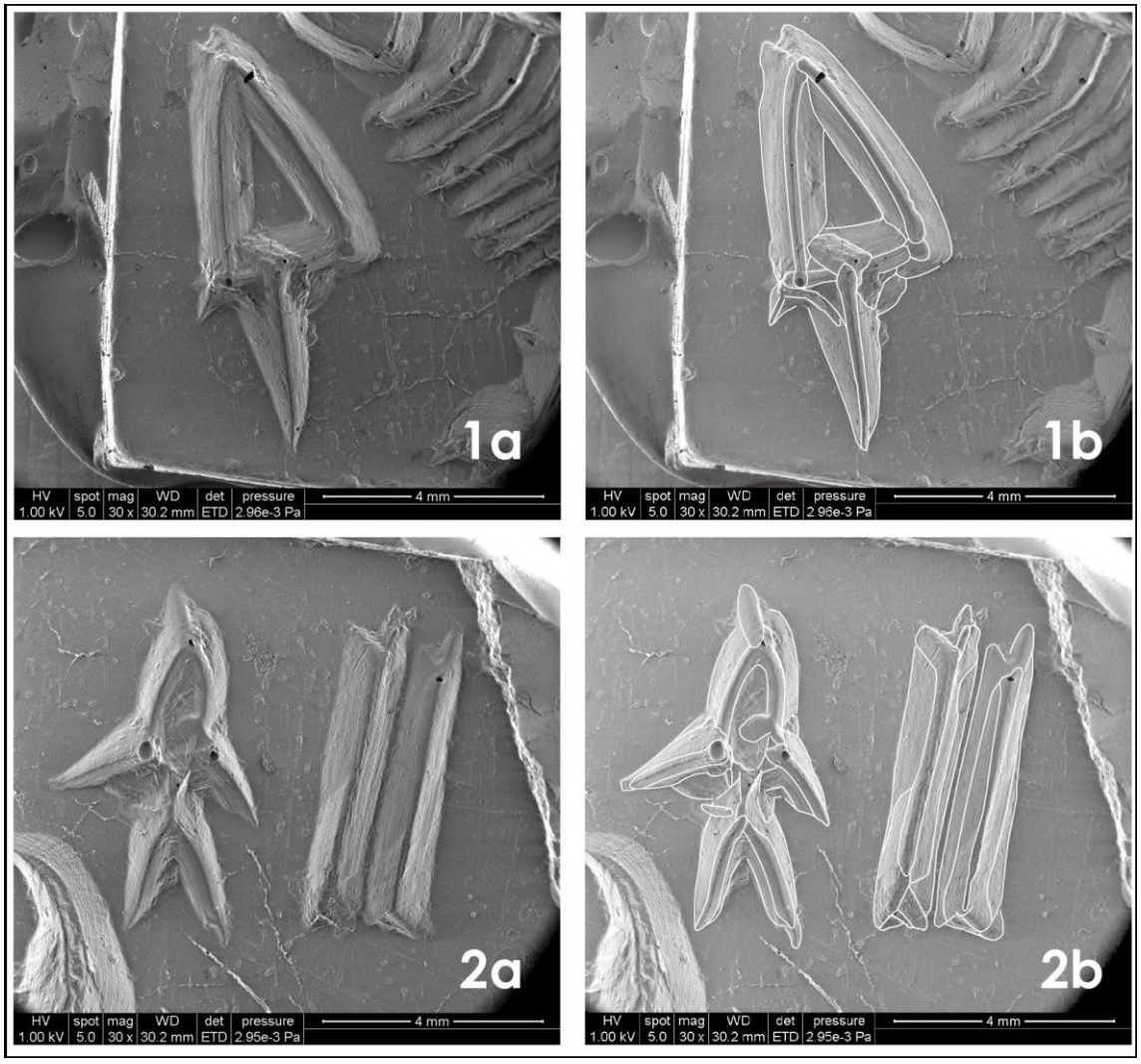

Figure 10: SEM images of FRN-1

This requires comparative analyses between this seal and published materials from other Indus sites. Previous research (Jamison 2018a) has addressed this in a cursory manner but warrants further discussion here. Although this seal is unique in many ways, we have uncovered stylistic parallels with two others, one from Banawali (B-7) and the other from Mohenjo-daro (M-269) (Figure 6). All three depict right-facing buffalos with bold, angular carving styles characteristic of early phase of the Urban period (Period 3A at Harappa) carving styles. Visual inspection and comparison reveal that all three of them have smooth, flat engraved surfaces in their bodies, necks, and legs, and though the seal from Banawali is damaged, the other two have similarities in the carving styles of their heads. Each seal also has broad, curvilinear horns with shared morphology, upturned snouts, and broad, deep, raised bands near the front and rear flanks of their bodies. Further evidence of shared carving styles is seen in the broad, angular hooves and prominent fetlocks on all three seals, and the presence of a V-shaped pizzle between the front and rear legs that is similar in dimensions and orientation on all three seals.

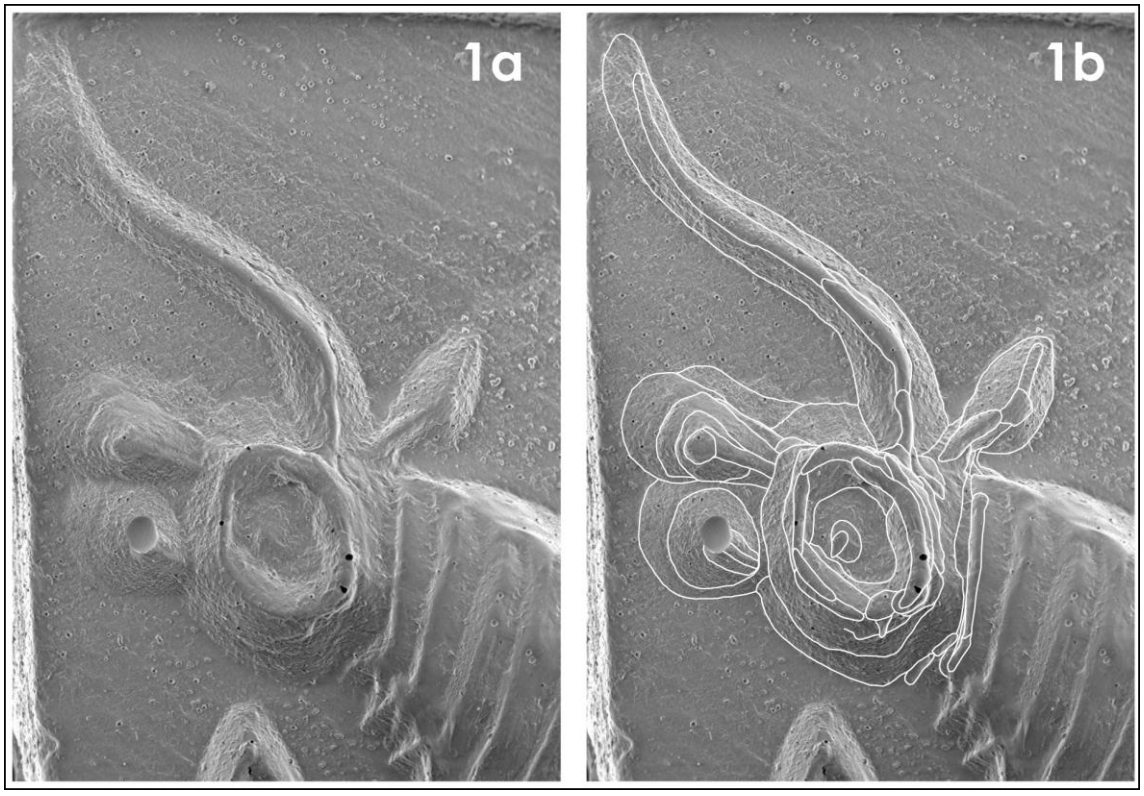

Figure 11: SEM images of FRN-2

Comparisons of the proportions of length to width for selected elements of the buffalo on all three seals reveal further evidence of similarities among them. The overall dimensions of the three seals are comparable, as are the measurements and ratios for most selected compositional elements of the buffalo under analysis here (Table 3). While the seals are not identical in their dimensions and proportions, this is not to be expected. Earlier research (Jamison 2013, 2017) demonstrates that some variation is to be expected among even stylistically similar seals, because they are small and were carved by hand, and this results in marked variation in metric properties do to minor, likely unintentional differences in carving techniques. However, overall their metric properties are much more alike than different. These similarities are most visible in the ratios of length to width for the necks and pizzles, which are morphologically and proportionately very similar. Two (FRN-1 and B-7) of the seals also have comparable ratios of L/W for the body, and the other (M-269) varies largely because of a prominent shoulder that extends above the horns on the engraved surface. Further similarities among at least two of the seals are seen in the proportions of the necks, heads, and pizzles.

We argue that these similarities are not coincidental and likely represent a distinct carving style of buffalo seals during the early stages of inscribed Indus seal production. This requires further testing of course but does provide important preliminary interpretations concerning the organization of early Indus seal production and use. That stylistically similar seals are present at multiple sites in different regions, even in

small numbers, supports a model of integration throughout the expansive Indus culture area. It further suggests that shared stylistic templates for how to carve seals were either shared across sites and regions, or that seals made by individual artisans and workshops, using their own idiosyncratic carving styles, were distributed and used in multiple places. Either possibility indicates that seal production and use were not centrally controlled or limited to a single site or elite group, supporting current inferences about the unique nature of Indus sociopolitical organization (Green 2020; Kenoyer 2014; Wright 2009). We hope to further evaluate these provisional interpretations in the future by examining the seals from Banawali and Mohenjo-daro using the methods applied to the one from Farmana discussed here.

FRN-2 (Unicorn): This seal (Figure 4: below) is fully intact, and all elements of the animal icon and inscription are well-preserved. It appears to have been fashioned of steatite that is tan in colour, which was subsequently surface treated to whiten it. Some of this exterior treatment has worn off, and the multiple colours visible in the photograph, particularly in the rear flank of the animal's body, suggest that the alteration took place after the icon was engraved. The seal depicts the most common animal on Indus seals, the unicorn (Marshall 1931). It is distinguished by its single horn and distinct body morphology. It is beyond the scope of this paper to discuss the origins of the unicorn and its significance in Indus iconography, both have been thoroughly examined in earlier studies (Kenoyer 2013; Parpola 2011). Here we focus on the unique character of this unicorn seal and what it tells us about patterned variation in carving styles and production methods.

The most striking feature of this seal is the right-facing animal, which is not common in the published corpus of Indus unicorn seals. There are over 1,000 published unicorn seals, of which only approximately 20 depict right-facing animals. This alone makes Seal #FRN-2 unique, but the fact that nearly half of these are from sites in the Ghaggar-Hakra region is likely not a coincidence. As discussed above, the archaeological context of this seal places it within Period 3A of the Harappa Phase and likely represents an early carving style during the Integration Era. The morphology of the reverse face of the seal, characteristics of the inscription, and absence of standard in front of the unicorn also support this interpretation. Our stylistic analysis has revealed evidence of similarities with FRN-1 and other right-facing unicorn seals that provide insights into the organization of production and technologies used in the early stages of Indus seal production.

Analysis of the unicorn on this seal reveals that it was crafted with a bold, angular carving style, similar to FRN-1 discussed above. The bases of the engraved surfaces of the body and neck are flat and smooth with angular, nearly linear edges. Most other compositional elements including the horn, ear, legs, hooves, and tail demonstrate different signatures. These are generally broad, deep, and have V-shaped profiles most clearly visible in the SEM images of the seal impression but are still easily distinguished from the body and neck in the photograph of the engraved surface of the

unicorn. A similar pattern characterises the two inscribed characters above the animal and another present below its head where the standard usually is on most unicorn seals.

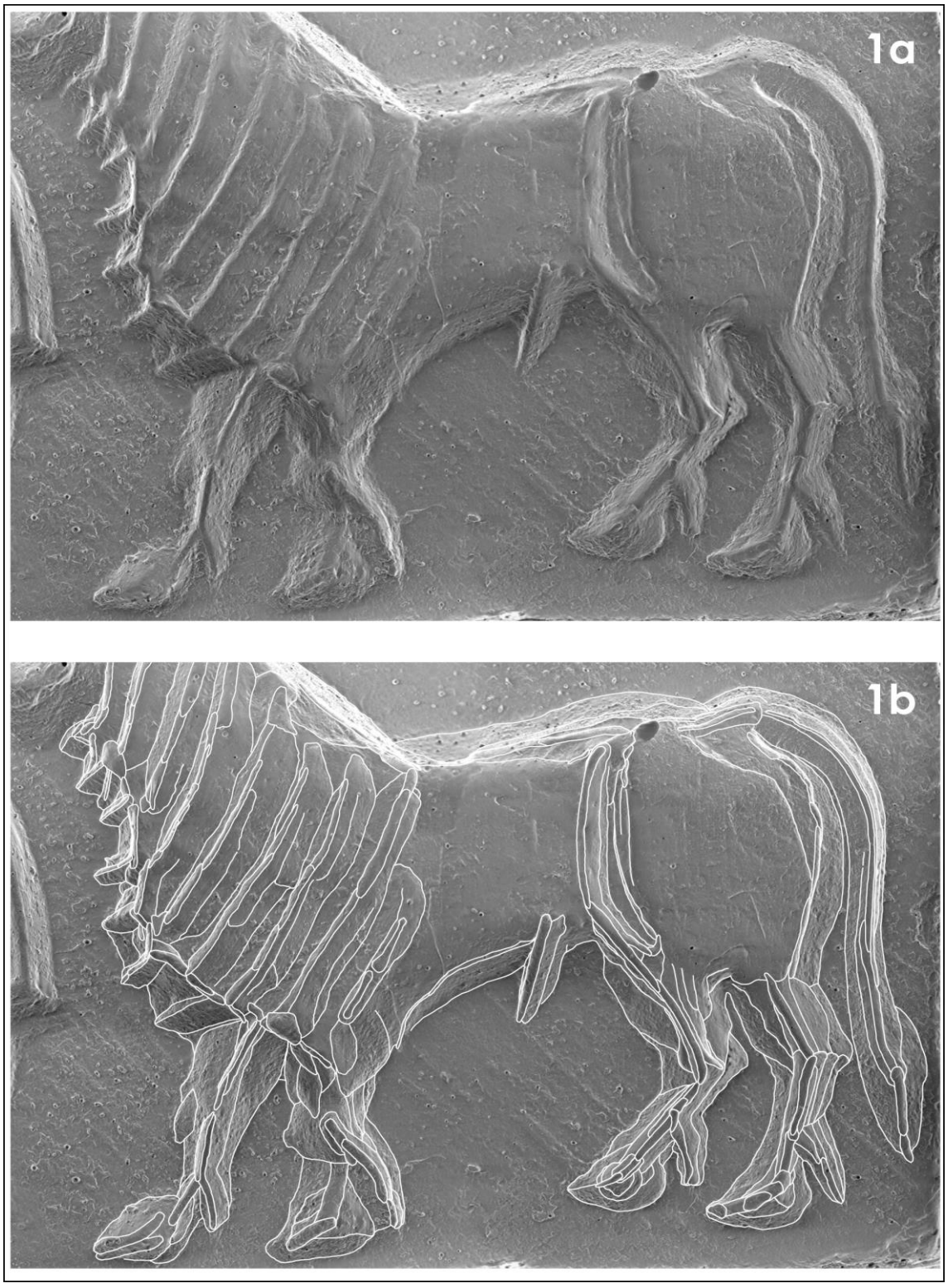

Figure 12: SEM images of FRN-2

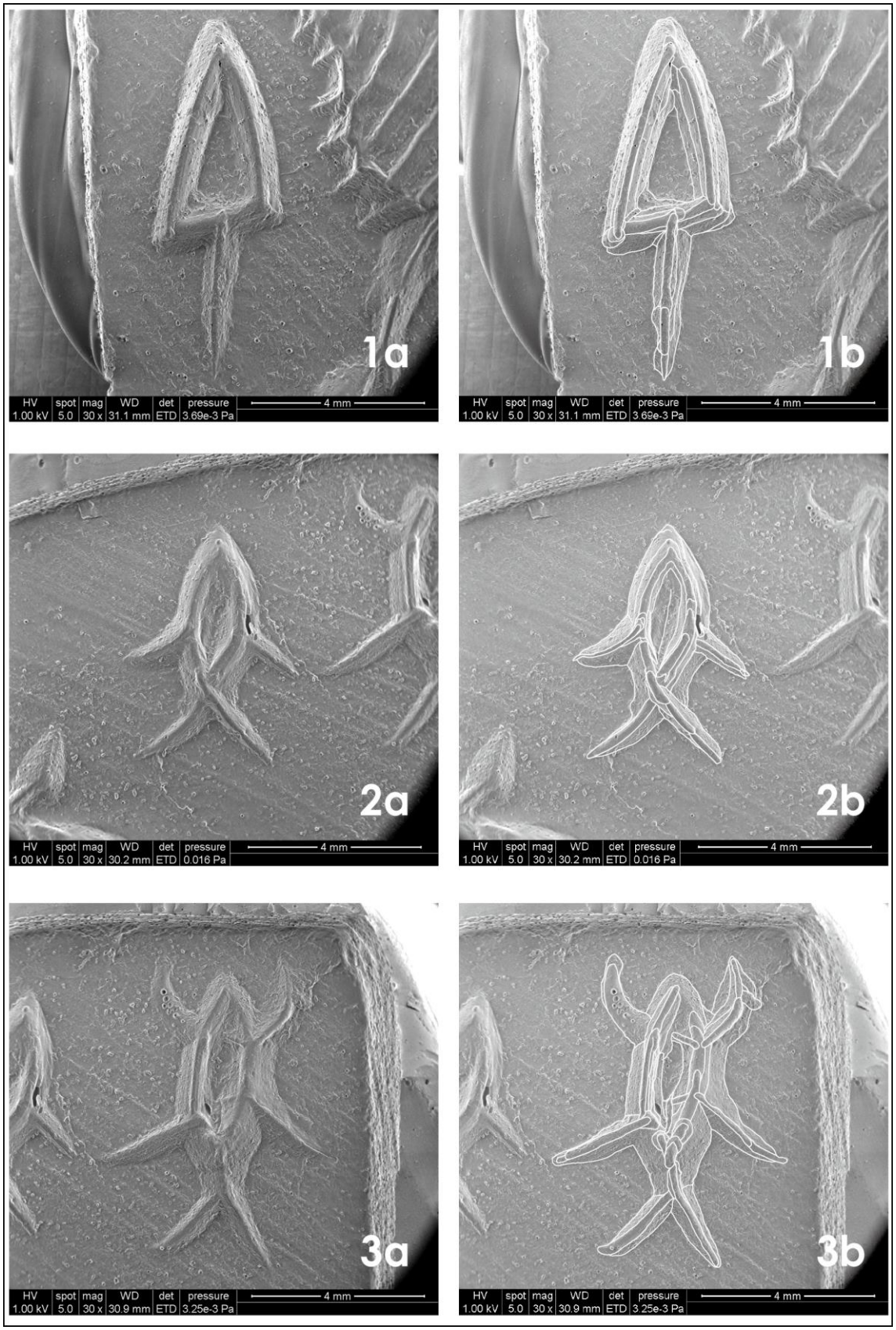

Figure 13: SEM images of FRN-2

Figure 14: Comparisons between FRN-1, FRN-2 and BRN-1

Like many unicorn seals, FRN-2 is adorned with incised lines on the neck and front flank. A total of eight are present, engraved as curvilinear, roughly parallel lines that extend from the interface with the head to the rear edge of the front leg. A partial line visible in the photograph beyond these, towards the medial section of the body, appears to be incomplete and was perhaps unintentional or a carving mistake, as it is the only one that is discontinuous. In contrast to the broad, deeply engraved incised line at the rear flank of the animal, above the inner rear leg, the incised lines on the neck and front flank are narrower and extend beyond the engraved edges of both features. The pizzle on this seal is also distinctive based on its orientation, single carving stroke, and intrusion into the lower part of the body. It appears as though the artisan who engraved it was left-handed and either careless or unconcerned about its aesthetics.

In terms of the unicorn, the head, face, and eye are the most interesting stylistic features on this seal. This interpretation is based on three observations:

1. They are the only elements of this seal not carved with angular styles; all depict more rounded edges.

2. They appear to have been engraved separately as opposed to decorative elements in a single compositional unit (the head).

3. The morphology of each is distinctive compared to most unicorn seals and are therefore potential signatures of unique artisan and workshop carving styles

Collectively, these are the most salient features of this seal and provide the best evidence of the idiosyncratic carving methods used to create it. The lack of a clearly identifiable drilled eyeball is also noteworthy though not unique to this seal.

In terms of metric properties, the seal measures 21 mm in length and width and is 6 mm thick excluding the boss. Selected measurements of compositional elements of the unicorn are primarily descriptive (Table 4).

As with FRN-1 discussed above, they provide information about the morphology of the unicorn, which has an elongated body and long, broad neck. This mirrors the shape and body plan of most unicorns and can be used to distinguish it from other animals on Indus seals. The head on this seal is comparatively short and broad, a distinctive feature that is in part correlated with the fact it was engraved in multiple registers. Since the maximum values of length and width for all most compositional elements are dependent on the overall dimensions of the seal, ratios were also calculated for selected attributes, and these were used in comparative analyses with other right-facing unicorn seals (Table 5).

Comparative analyses with other right-facing unicorn seals have uncovered some evidence of patterned carving styles and metric properties that may reflect the products of the same workshops. Though most other published right-facing unicorn

seals are stylistically distinct from FRN-2, suggesting that they were made by different artisans and workshops who shared general stylistic templates for how to craft unicorn seals, we do find some parallels between this seal and one from Bhirrana (BRN-1) that we have investigated in an earlier study (Uesugi et al. 2016). Though they are not identical copies and demonstrate clear differences, the similarities in the unicorns and carving styles warrant further discussion here.

Table 4: Metric properties of selected attributes of the unicorn on Seal FRN-4

No.	*Attribute*	*Measurement (mm)*	*No.*	*Attribute*	*Measurement (mm)*
1	Body Length	13.65	10	Jaw Length	1.84
2	Body Width	4.66	11	Jaw Width	2.06
3	Neck Length	6.19	21	Pizzle Length	2.37
4	Neck Width	6.91	22	Pizzle Width	0.69
6	Head Length	6.26	17	Outer Foreleg Length	4.79
5	Head Width	4.22	18	Outer Foreleg Width	1.96
14	Ear Length	2.72	19	Inner Foreleg Length	4.03
15	Ear Width	1.30	20	Inner Foreleg Width	1.93
13	Eye Diameter 1	2.61	23	Inner Rear Leg Length	4.68
12	Eye Diameter 2	2.15	24	Inner Rear Leg Width	1.62
8	Snout Length	1.98	25	Outer Rear Leg Length	4.83
9	Snout Width	2.68	26	Outer Rear Leg Width	1.81

Table 5: Ratios of Length/Width for selected attributes of the unicorns in Seals FRN-4, and BRN-1

Attribute/Seal	*FRN-4*	*BRN-1*
Body L/W	2.93:1	2.61:1
Neck L/W	0.90:1	0.91:1
Head L/W	1.48:1	1.43:1
Ear L/W	2:09:1	2.16:1
Eye L/W	1.22:1	1.03:1
Snout L/W	0.74:1	0.68:1
Jaw L/W	0.89:1	0.60:1
Pizzle L/W	3.40:1	1.32:1

The most obvious similarities between the two seals are seen in the carving styles of their heads. Both were engraved in multiple registers, with distinctive eyes, snouts, and lower jaws. As discussed above, the surfaces of these features on both seals contrast with most of the rest of the body and neck in that they do not have flattened bases, suggesting the use of different tools to engrave them. The heads share similar

morphology, with upturned snouts. Both seals also depict well-defined, broad, deep eyes, though the lack of a clearly identifiable drilled eyeball on the specimen from Farmana contrasts with the example from Bhirrana. The two seals also share the same pattern and number of incised lines on the neck, though the placement and orientation vary. The tails are also comparable in their morphology, placement, and styles, especially at the tips. Further evidence of similarities can be seen by comparing their metric properties.

The overall dimensions of the two seals and proportions of length/width are very similar. Both are approximately 21 x 21 mm in length and width, though the seal from Bhirrana (BRN-1) is slightly wider (22.5mm) not as thick as the specimen from Farmana (9 mm compared to 12.5 mm). Since the two seals are nearly identical in their dimensions, it is relevant to compare the absolute values for measurements of length and width for selected attributes of the unicorn under analysis in this study, but for the sake of brevity and the fact that the full metric data for the seal from Bhirrana has already been published (Uesugi et al. 2016), here we focus on comparing the ratios (Table 5). These data demonstrate some variation, likely associated with the fact that the seals were carved by hand, and there is no reason to assume that the artisans who crafted them were concerned with making multiple seals to identical size and scale. Most of these differences are minor and visible in small, finely engraved details like the eye and pizzle or associated with variation in the amount of surface area used to engrave the unicorn.

In spite of these minor differences, it is remarkable how similar the ratios of length/width are for most attributes under study here. Though the maximum dimensions of the necks and heads on the two seals vary, their proportions of length to width are quite alike. A similar pattern characterises the ratios of length to width for several other features, including the ears and snouts. These similarities, in combination with those discussed above, suggest that these two seals may represent a regional carving style of right facing-unicorn seals in the Ghaggar basin. This can be further tested by examining technological aspects of production using Scanning Electron Microscopy.

Carving Technology of the Seals of the Stylistic Group 1 from Farmana

This section examines the carving technology used for making the seals. This examination is based on the observation of silicone impressions of the carved surface of the seals using the Scanning Electron Microscope (SEM). This method enables observation of details of carved areas that is difficult with the naked eye; the surface conditions of carved areas, the superimpositional relationships between carved strokes, and the motions of tools, the process of carvings and so on. When comparable examples examined using this method are obtained, it would become possible to differentiate the carving technologies used in the production of different seals to identify the skills of carvers, the style and technology of an artisan or workshop, the

relationships between artisans or workshops, diachronic changes of carving technologies, etc. It would lead to better understanding of the production organization of seals and the relationship between seals, community and society.

Horns

FRN-1 (Figure 7: 1a, 1b, 2a, 2b): The left horn is represented by an angularly curved stroke with a V-shaped profile, which suggests discontinuous motions of a carving tool to make a curved stroke. Thin strokes can be observed on the base of the curved stroke that is also angular.

The right horn also has a V-shaped profile. The carved surface of the outer surface shows continuous striations from its tip to middle, which suggest the use of a tool with a flat tip. The carving process was discontinuous like the left horn to result in an angular contour of the curved stroke. Several thin strokes can be seen on the base of the carved area. Between the horns, a hump was made using the carving technique similar to the horns as represented by a V-shaped profile with a thin stroke on the base.

FRN-2 (Figure 11: 1a, 1b): The single horn is represented by a S-shaped winding stroke, which has a V-shaped profile with thin strokes on the base of the carved area. Compared to the horns of FRN-1, the curved stroke of this specimen was better executed and the thin strokes at the base are more rounded.

Head

FRN-1 (Figure 7: 3a, 3b): The head part is composed of an eye and a muzzle. The eye consists of a circular stroke and a hemispherical hollow to represent a pupil. The circular stroke, which has a V-shaped profile, is angular in contour, suggesting discontinuous motions of a carving tool. In contrast, the pupil is better represented by a hemispherical hollow, which is likely to have been carved by the drilling technique using a tool with a rounded tip.

The muzzle, which was carved connecting to a jaw that have a bent profile, has a rounded shape. Both the snout and jaw are comprised of sloped sides and a flat base. At the border between the sloped sides and the base, thin strokes were added to make the transition from the side to the base stand out. The contours of the snout and the jaw are also angular as the horns. Subtle striations can be observed running vertically across the basal area. It suggests that a tool with a flat tip was used to make the surface flat and smooth. A wedge shape carved behind the eye may represent an ear.

FRN-2 (Figure 11: 1a, 1b): The head part of this specimen composed of an eye and a muzzle is remarkably different in execution from that of FRN-1. The eye is represented by a deeply-carved oval, at the base of which angular strokes were added. At the centre of the raised central area, a shallow hollow was carved to represent a pupil, but its execution not using the drilling technique, but the sticking technique is different from that of FRN-1. The muzzle, which consists of a snout and a jaw, are separately represented by ovals. Either of these ovals was carved with several strokes and

finished with thin strokes. The ear is clearly indicated by a leaf shape connected to the head with a short stroke.

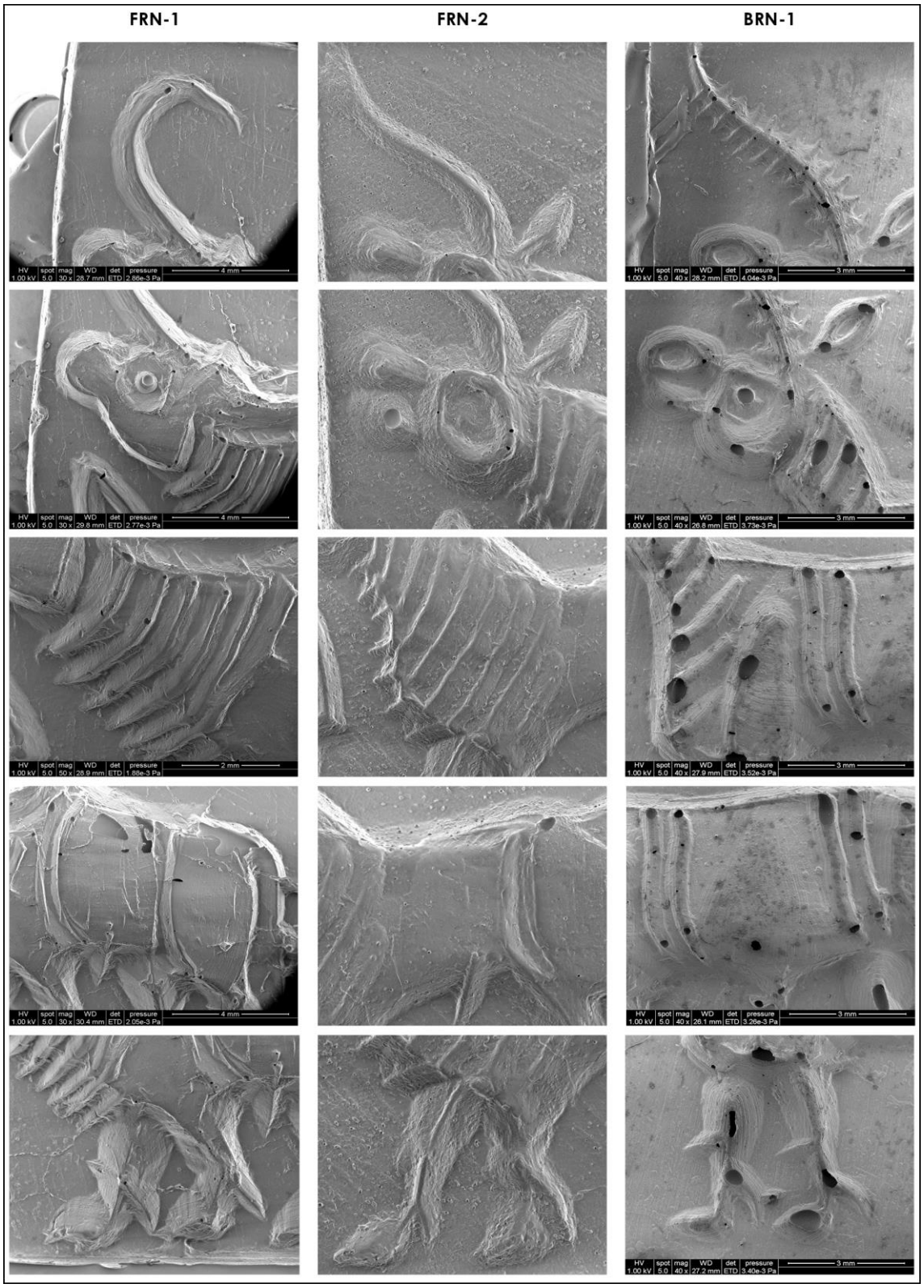

Figure 15: Comparisons between FRN-1, FRN-2 and BRN-1

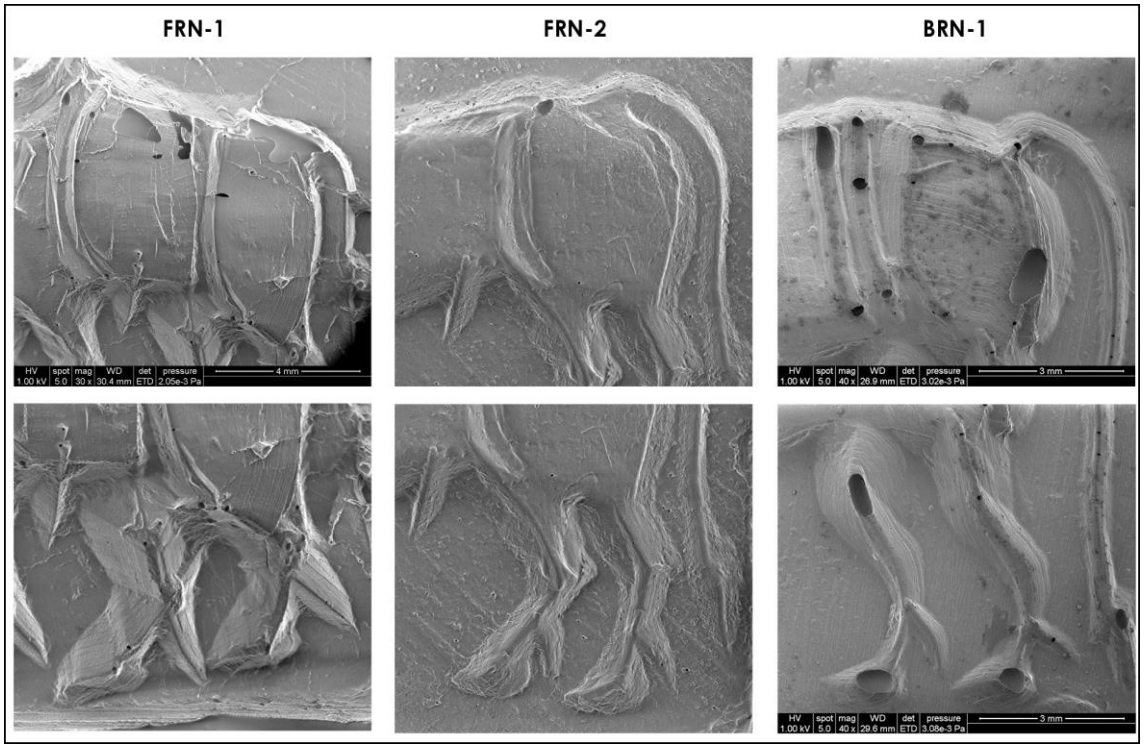

Figure 16: Comparisons between FRN-1, FRN-2 and BRN-1

Neck

FRN-1 (Figure 8: 1a, 1b): Six parallel strokes, which have a V-shaped profile, were carved on the neck part following the primary carving of the neck part. While the upper edges of strokes were shallowly left on the sloped side in the course of carving process, the strokes were finally finished in stretching from the upper edge of the basal area to the edge of the lower sloped area. The lower ends of the strokes are pointed. These strokes are also angular in contour. Regarding the order in the carving process between the head and the neck, the juncture between the two suggests that the head part was carved following the neck.

FRN-2 (Figure 12: 1a, 1b): The execution of the neck of this specimen is similar to that of FRN-1 as represented by the main carved area consisting of sloped sides and a flat basal area overlapped by nine parallel strokes. The strokes on the lower side of the neck are discontinuous with the ones on the basal area, showing a different execution from that of FRN-1. The profiles of the strokes on the basal area also differ from those of FRN-1 in having a "✓"-shape.

Body

FRN-1 (Figure 8: 2a, 2b): The body part is composed of sloped sides and a flat basal area as the neck part. Two vertical raised bands were placed across the body. The frontal one is gently curved while the rear one is straight. Both have a reversed V-shaped profile, but the executions are rough as the strokes associated with flattening the basal surface overlap the edge of the bands. Thin strokes can be observed along the

edges of the sloped sides as in the case of the body and the neck. Vertical striations are left on the flat basal surface as a result of flattening the surface using a tool with a flat tip as that of the head part. However, the surface is not so smooth. A pizzle is represented by a triangular shape of a V-shaped profile on the lower side of the body. Several thin strokes to finish the part can be seen starting from the lower part of the body.

FRN-2 (Figure 12: 1a, 1b): The body part of this specimen is comprised of sloped sides and a flat basal part as in the case of FRN-1. A gently curved ridged band is placed only in the hind part of the body. The finishing of this band is quite rough, similarly to the case of FRN-1. The repetitive strokes along the edge of the band indicate the effort by the carver to make a curved band. Thin strokes were added to the border between the sloped sides and the basal part. Vertical striations on the basal part of the body are indicative of the use of a tool with a flat tip to flatten the surface. A short stroke of a V-shaped profile on the lower side of the body represents a pizzle.

Limbs

FRN-1 (Figure 9: 1a, 1b): For the forelegs, the one on the left in the SEM image is likely to have been carved in prior to the one on the right in terms of the superimpositional relationships between the legs and the body. The one on the right seems to have been carved following the body. Both forelegs, as well as the hindlegs, are composed of a leg, a fetlock, and a hoof. All of these parts are represented by carvings of a V-shaped profile associated with thin strokes. Most of the parts are made of straight strokes using a tool with a flat tip. While the sequential relationship between the leg and the hoof cannot be confirmed, it is clear that the fetlock was added later to the leg part.

For the hindlegs, the one on the left may have preceded the one on the right. Based on the superimpositional relationships between the body and the leg on the left, it appears that the leg was carved in prior to the body, but the possible repetitive carving process has made it difficult to determine the sequential relationships between parts. The carving technique and process are identical to the forelegs.

FRN-2 (Figure 12: 1a, 1b): Both the forelegs and hindlegs are common in consisting of a leg, a fetlock and a hoof, and in the carving techniques characterised by the combination of main carved parts and thin strokes. While it is difficult to determine the sequential order between parts in the carving process due to the ambiguity of the junctures between the body and limbs, the parallel strokes overlapping the legs suggests that the final finishing of the body was done following the completion of carving of the limbs.

Tail

FRN-1 (Figure 8: 2a, 2b): The tail is composed of a curved stroke extending downwards and another widened and pointed stroke for a tuft, both of which are represented by a V-shaped profile. Thin strokes were added to the base of the strokes. Compared to the horns, the curved strokes of the tail are better executed.

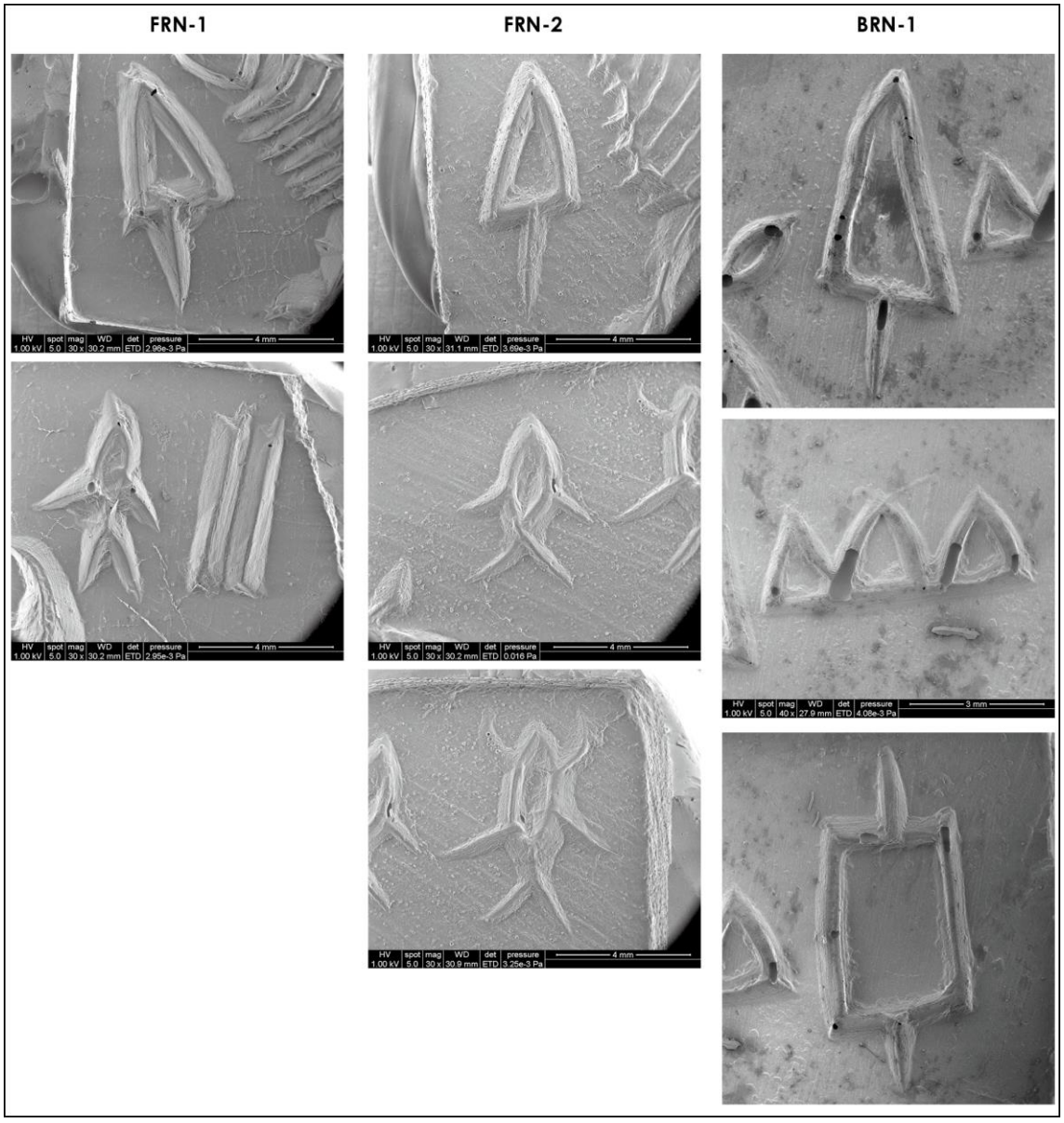

Figure 17: Comparisons between FRN-1, FRN-2 and BRN-1

FRN-2 (Figure 12: 1a, 1b): The representational style and the carving technique of the tail of this specimen is identical to that of FRN-1. The curved stroke is smooth.

Signs

FRN-1 (Figure 10): A total of three signs, one in the front of the animal and two above the animal, were placed. The one in the front of the animal (Figure 10: 1a, 1b) is an "arrow" sign composed of a triangle and a vertical stroke beneath the former. While it is not clear which part was carved first, the thin stroke at the base of the vertical stroke was made in the final stage of carving the sign. Each stroke of this sign has a V-shaped profile accentuated by thin strokes. The signs above the animal (Figure 10: 2a, 2b) includes a "fish" sign and a sign of two vertical strokes. The "fish" sign is comprised of a leaf shape that was carved first and four short strokes with a pointed end that were

added to the former. Each stroke was added with thin strokes at its base. Two vertical strokes of the other sign are identical in the carving style and technique to the other parts of carvings.

FRN-2 (Figure 13): As FRN-1, one sign is placed in front of the animal and two above the animal. The one in front of the animal (Figure 13: 1a, 1b) is "arrow" sign, which is composed of a triangle and an attached vertical stroke. The overall features of this sign is identical to that of FRN-1, although the one on FRN-2 is relatively better in execution. Both the signs above the animal are "fish" sign; while the one on the left in the SEM image (Figure 13: 2a, 2b) is identical to that of FRN-1, the one on the right (Figure 13: 3a, 3b) has additional horn-like strokes near its top. The carving style and technique are identical to each other, and to that of FRN-1.

Comparison Between the Seals from Faramana and Bhirrana

This section deals with comparison between two seals from Farmana and the one from Bhirrana to better understand the carving styles and technologies of Stylistic group 1 (Figures 14 - 17).

Horns (Figures 14 and 15): The shape of the horns is almost identical between FRN-2 and BRN-1, while the one of BRN-1 has hatches additionally. In both cases, the horns have a S-shape that gently curve. The carving style and technology also appear to be identical in these specimens. FRN-1, which differs from these two examples in the animal species, exhibits more angular contours in horns, although it is not certain whether this difference is due to the poor skill of the carver of FRN-1 or technical difficulty to make a curved stroke. However, the carving style marked by adding thin strokes along the base of horns are remarkably shared by these three specimens.

Head (Figures 14 and 15): As to the head, FRN-2 and BRN-1 show a similar style consisting of a large eye, upper and lower jaws. Their eyes are composed of a deeper stroke of an oval shape for the contour and a circular hollow of a pupil. While the pupil of FRN-2 seems to have been made using the sticking technique, the one of BRN-1 is likely to have been drilled. The execution of the upper jaw is also different between the two; while that of FRN-1 is represented by an oval hollow added with thin strokes on the base, BRN-1 has an oval stroke leaving the inner area uncarved. The overall feature of the ear is similar between FRN-2 and BRN-1, but as the case of the upper jaw, BRN-1 has a leaf-shaped contour stroke leaving the inner area uncarved along with straight strokes, while the eye of FRN-2 is composed of a hollow and strokes. The depiction style of the head is considerably different in FRN-1; the snout and jaw were jointly carved and the eye was relatively smaller than FRN-2 and BRN-1 in terms of the proportion of the eye in the head part. In this example, the pupil was clearly represented by the drilling technique.

Neck (Figures 14 and 15): All these three specimens share the depiction style of the neck characterised by parallel strokes; however, the carving style is different between

the two specimens from Farmana and BRN-1. Those of BRN-1 are not so well-executed in that the parallel strokes have a rounded profile showing a contrast to those in FRN-1 and FRN-2 that were finished with additional thins strokes along the base. It suggests that less care was paid to the execution of the strokes by the carver of BRN-1.

Body (Figures 14 and 15): While the carving style of the body, which is comprised of sloped sides and a flat base, are identical among three examples, the execution of the vertical borders on the body are remarkably different between the two specimens from Farmana and BRN-1. In FRN-1 and FRN-2, the vertical borders on the body are represented by raised band, and BRN-1 has two pairs of vertical carved strokes with a rounded profile. Another remarkable feature of BRN-1 is an elongated hollow between the neck and the two vertical strokes in the forepart of the body.

Limbs (Figures 14 and 15): While a similar depiction style can be seen in the limbs of the three examples, the carving style differs between the two examples from Farmana and BRN-1. As in the other parts of carvings, the limbs of BRN-1 are not so accentuated by the additional thin strokes along the base, although thin strokes were added. In contrast, the strokes of the limbs of FRN-1 and FRN-2 exhibit a well-executed V-shaped profile.

Tail (Figures 14 and 16): The depiction style of tails, which consists of a gently curved stroke and a widened pointed stroke for tuft, are almost identical in the three specimens. The carving style is also similar in that thin strokes were added along the base of the main stroke to make the profile V-shaped.

Signs (Figures 14 and 17): In FRN-1 and FRN-2, an "arrow" sign is placed in front of the animal. The carving style and technique are remarkably identical between the two specimens. Each of the strokes was well executed in a straight contour and a sharp profile. Compared to these two specimens, the "arrow" sign, which is depicted among three signs above the unicorn in BRN-1, looks poorer in quality of carving. The strokes are not so straight and sharp in spite of the fact that thin strokes were added to the base of the main strokes, which can be observed in the other two signs as well as the other parts of the carving in BRN-1. In FRN-1, a "fish" sign and a sign consisting of two vertical strokes are depicted above the buffalo. Their overall feature of carving is identical to that of the "arrow" sign in front of the animal. The two "fish" sign on FRN-2 also exhibit the carving style and technology comparable to those on FRN-1. Thus, FRN-1 and FRN-2 resemble each other in the carving style and technology of signs, while those of BRN-1 are quite distinctive. The differences in the carving style and technique of signs between the two seals from Farmana and BRN-1 are commonly seen in the other parts of the carvings of these three seals.

Perspectives for Future Studies

The stylistic and technological analyses on the seals from Farmana and Bhirrana discussed in the previous sections have revealed new insights into similarities and differences in the carving styles and techniques of three seals classified as belong to

Stylistic group 1. While it is essential to conduct the same analyses on the other two seals from Farmana (Stylistic group 2) and additional materials from other sites to clarify the differences between the Stylistic groups, the results of our analyses are summarised in this section to show perspectives for better understanding the relationships between the Stylistic groups 1 and 2 in particular and future research in Indus seals in general.

The three seals from Farmana and Bhirrana are common in having an animal facing right. While the two seals from Farmana differ in the animals depicted, a buffalo on FRN-1 and a unicorn on FRN-2, the representation of an "arrow" sign in front of the animal is shared by the two. The one from Bhirrana that depicts a unicorn has no object in front of the animal, but an "arrow" sign is included in the signs carved above the animal. Regardless of the animal depicted, these three seals commonly have parallel strokes on their necks and vertical borders on the body. All three of the seals also depict engraved lines on their bodies, broad, well defined eyes, and short inscriptions. Thus, it can be said that these three seals share stylistic features in a general level, in spite of some differences in details. The semicylindrical knob on the back is another feature that is shared by these specimens.

In terms of carving technologies, our analysis shows strong similarities among all three seals. Especially, the carving style of the body is marked by sloped sides and flat base that were carefully rendered using a tool with a flat tip. This carving style can be termed as the angular style. Each of the strokes for depicting the head, neck, limbs and tail is distinct in having a V-shaped profile that was accentuated by adding thin strokes to the base of the stroke. It is also remarkable that the curved strokes are not so smooth but angular, as they are composed of short strokes to make a curved one. This technical feature can be seen in the carving of eyes. The prominent presence of parallel striations along the uncarved surface, which can be regarded as the ones created during the grinding process, is also a common feature shared by these three examples.

Differences can also be pointed out in the carving styles and technology of these seals. FRN-2 and BRN-1 show a similar execution of the head part, while FRN-1 exhibits a remarkable difference in composition of the head part. The former two have a large eye accompanied by a muzzle consisting of a snout and a jaw, and FRN-1 depicts a smaller eye as well as unseparated representation of the muzzle. In terms of the carving technique, FRN-1 and FRN-2 exhibit almost identical features. In contrast to the well-executed strokes of these two examples, the execution of the strokes of BRN-1 are inferior in that they are less sharp having rounded profiles, demonstrating less care to the finish of strokes.

Although it is difficult to identify the factors that created these differences at this moment, 1) the different skills of individual carvers, 2) the different workshops that respectively share different carving styles and technologies, and 3) the different developmental stages of the carving technology (for example, if BRN-1 is regarded as

representing a stage in which the carving style and technology was not developed, FRN-1 and FRN-2 may be considered as belonging to a stage that the seal production became more established), may hypothetically be supposed. Much more samples are needed to testify these hypotheses.

In summary, the three seals examined in this paper can be viewed as exhibiting an identity in the representational style of iconographic elements and the carving style in a general sense; on the other hand, there are marked differences between the two seals from Farmana and the one from Bhirrana in terms of the carving technique or skill. While the differences in the carving techniques between the Stylistic groups 1 and 2 will be discussed in another paper, the images of seals published in the CISI volumes amply suggest many differences between the Stylistic groups not only in the directions of animals but also in representational and carving styles.

Conclusion

This paper has investigated two inscribed Indus seals from Farmana and provided new insights into diachronic variation and patterning in carving styles and techniques. Two seals from one site is not a large or significant sample, but our analyses and interpretations are. Using multi-faceted methods to explore stylistic and technological aspects of production, we have identified patterns that likely represent diachronic signatures in Indus seal production. Comparative analyses with published materials from other sites suggest that there are connections among seals that represent larger social, economic, and political structures that need further investigations to understand more about the organizational dynamics of the Indus Civilization. Studying seals is a good way to do this.

Our analyses have uncovered patterns in carving styles and techniques among the seals discussed that are likely not coincidental. Collectively, similarities in the ways in which seals were carved and decorated, visible through formal stylistic and SEM analyses, support our interpretations about regional carving styles during the early part of the Harappan Period. Both seals from Farmana examined in this study depict right-facing animals and have broad, angular carving styles, and short inscriptions. Comparative analyses with similar materials from other sites demonstrate that this style, which we define as Stylistic Group 1, is limited in number, distribution, and is chronologically associated with the early urban phase of the Indus Civilization. This supports earlier studies and provides ideas and goals for future research.

The site of Farmana has produced four Indus seals, of which only two have been thoroughly examined in this paper. Our first future goal is to study the other two using the methods employed in this paper to learn more about diachronic variation in carving styles and production methods from a single site. With the exception of Harappa, no such data set exists from any other Indus site. Continued analyses of seals from Farmana using the methods in this study will provide further insights into variability in carving styles and production technologies. This will allow us (and other

interested scholars) to gain a better understanding of chronological changes in Indus seal carving styles and techniques and increase our recognition of the fact that in small details we can learn much about one of the world's earliest and most significant urban civilizations.

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