Setting the wheels in motion: Re-examining ceramic forming techniques in Indus Civilisation villages in northwest India

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Abstract

The invention of rotational devices contributed to a range of developments in craft production technology, perhaps most visibly in the various forms of potter’s wheels. These technological innovations, and the adoption or non-adoption of those innovations, carry economic and social implications, which are significant for understanding past human behaviour. There has been debate around the introduction and use of the potter’s wheel in South Asia’s Indus Civilisation for almost a century, and opinions remain divided. This paper considers the emerging ceramic traditions identified at two Indus settlements in modern Haryana, northwest India. It presents evidence demonstrating that Indus Civilisation potters utilised multiple forming techniques for producing ceramic vessels and explores the evidence for the use of rotational gestures and rotational devices in regional ceramic production industries. Two dominant technological traditions are outlined, along with the implications of this discovery and future research opportunities.

Keywords: ceramic forming techniques; wheel-throwing; Indus Civilisation.

1. Introduction

The discovery of the rotational capabilities of the wheel was one of the most significant human inventions, and wheel-enhanced rotation is now pervasive in the tools and machines that we use in our everyday lives. Importantly, the wheel was a major contributor to a range of developments in craft production technology, perhaps most visibly in the various forms of potter’s rotational devices and wheels. There is considerable debate about the origins and dispersal of the use of rotation as a technological approach for forming pottery, and it is likely that the use of rotational devices to aid in the forming and finishing of vessels was innovated in several locations at different times. These technological innovations have important economic and social implications, often correlated with the development of prehistoric complex societies.

For almost a century there has been debate around the introduction and use of the potter’s wheel in the urban phase of South Asia’s Indus Civilisation (2500–1900 BCE), which spanned parts of modern Pakistan and northwest India (Petrie 2013; see Fig. 1). Opinion is clearly divided, but two main trends are evident in the literature. The first proclaims the use of the potter’s wheel at a very early stage in the development of social complexity, and suggests that the use of wheel-throwing techniques on a ‘fast wheel’ or rotational devices for making vessels were the most common forming techniques of Indus Civilisation urban phase ceramic industries (Dales and Kenoyer 1986; Wright 1985, 1989, 1991; Mughal 1991: 224, 232; Mughal 1970: 47, 59). The second asserts that rotational devices such as tournettes or turntables, were used rarely in ceramic manufacture and in a quite limited way, and possibly just for the final stages of production (Courty and Roux 1995; Roux and Corbetta 1989; Roux and Courty 1998, 7–8). This latter process of finishing was potentially associated with multiple ways of forming vessels (e.g. coiling, wheel-coiling, scraping), and different combinations of forming techniques may have been practised by potters in the same region.

This paper provides evidence from archaeological sites in modern Haryana, in northwest India, that Indus Civilisation potters in the urban phase adopted multiple forming techniques for producing ceramic vessels. It considers the emerging ceramic traditions identified at two settlements, and explores the evidence for the use of rotational gestures and devices in regional ceramic production industries. This study will first outline specific points about tools, technologies and terminologies, and then will offer a summary of the Indus potter’s wheel debate. Ceramic data from Lohari Ragho I and Masudpur I will be presented to characterise two dominant technological traditions, before the implications of
this discovery and future research opportunities are discussed.

2. Tools, techniques and terminology

Knowledge about the tools and techniques used for producing Indus ceramics is crucial to understand ancient technologies and the associated social dynamics, but at present this knowledge is limited by the vicissitudes of archaeological discovery. Tools here refer to the physical objects used in ceramic industries, such as strings, paddles, wheel or tournette, and techniques refer to the ways the potter uses these tools and their related motor habits. For instance, to date no secure examples of potters’ tools such as wheels, tournettes, pivots, or pits for a kick-wheel have been found at any Indus Civilisation site, not even from large-scale settlements such as Mohenjo-Daro (e.g. Dales and Kenoyer 1986: 64). Likewise, other tools such as paddles or anvils, often associated with ceramic production in South Asia in the present day, have yet not been securely identified (Miller 1999). Thus, indirect evidence for the use of the wheel in the form of physical and microscopic traces on the ceramics themselves have been used to build theories regarding the use of tools such as wheels or turntables (Dales and Kenoyer 1986; Mery 1994: 476–477; Miller 2007; Vidale 2000: 78-80). Some of these preconceptions will be discussed below (also see Ceccarelli and Petrie 2018, 2020 for an extensive review of past and current issues concerning theories and methods used to study Indus Civilisation ceramic materials, including tools and techniques).

The use of tools and techniques, including rotational devices and rotational gestures, can affect several stages of the production process or chaîne opéraire (Roux 2019a; Schlanger 2005), and may reflect broader aspects of technological practices in a region or among communities. Evidence for the use of these tools and techniques in the production of vessels helps delineate the sequence of actions required to produce ceramics. Analysis of such evidence also provides insight into the transfer of skills and traditions, social learning and social interactions, and clarifies and challenges some prevailing preconceptions about Indus Civilisation ceramic industries.

There is significant variability in the terms used to describe the techniques and devices used to produce prehistoric ceramics. Rice (1987: 124-125), for example, notes procedures that are basic to forming procedures, such as pinching, slab-construction, moulding, casting, coiling and throwing (also Shepard 1956, 1977). This paper will mention the use of primary forming methods, such as coiling and slab-building, but it concentrates mostly on the use of rotational devices and rotational gestures, which may have erased macro-traces on ceramic sherds that are indicative of primary forming methods. The terminology

Fig. 1. Distribution of Indus Civilisation sites during the Urban period (after Ceccarelli and Petrie 2018; Petrie et al. 2017).
used by archaeologists, anthropologists and potters to describe the use of rotational devices varies widely and some confusion exists, so it is important to clarify the main terms used in this paper. Three concepts are often confused or used interchangeably: (1) wheel-throwing; (2) wheel-fashioning or wheel-finishing; and (3) rotational kinetic energy (RKE), which is the framing concept used to differentiate wheel-throwing and wheel-fashioning. The term ‘wheel-throwing’ is often used to refer to a variety of forming techniques that use rotational devices. In terms of rotational devices, it is occasionally possible to distinguish ‘slow wheels’, ‘fast wheels’, kick-wheels, tournettes, and turntables, although some of these terms overlap and are used interchangeably in publications. All of these tools make it possible to rotate vessels in the forming process so that the potter does not need to move around the vessel; also, all of these tools can be used at any stage of the forming process, from the initial forming through modification, finishing and the application of surface treatments. The term ‘wheel-throwing’ refers specifically to the use of rotational devices, usually for a considerable period and for continuously shaping vessels from clay lumps to the final form (Rice 1987: 132-134), and is often used to refer to a variety of forming techniques using turning tools. For instance, the key aspect that distinguishes wheel-throwing from the use of a ‘slow wheel’ is the speed at which the device rotates, and the potter’s use of the energy to shape the clay mass. Therefore, in an archaeological or ethnographic situation, the significant technological element for defining wheel-throwing is not the type of tool or the turning device, but the techniques used (Roux and Corbetta 1989), specifically: (a) the use of rotational motor capabilities, which fundamentally differ from the hand-building techniques; and (b) the use of throwing activity for shaping and thinning the walls of a block of clay. These parameters determine the way in which rotational tools are used—fully, partially, or not at all. The term ‘wheel-fashioning’ refers to the partial use of a rotational device during different stages of vessel forming. When vessels are shaped on a rotational device, but not wheel-thrown from a lump of clay, they are said to be formed using wheel-fashioning techniques (Roux 1994: 46–49; Roux and Courty 1998: 748; Choleva 2012: 351). This method is found in combination with other techniques, including hand- or coil-building, and wheel-coiling. For instance, when coils are used for making the ‘rough-out’ during a pre-forming stage of the manufacturing process, rotational devices and gestures can be introduced to transform the vessel into its final shape (see Table 1).

In the field of ceramic studies, the concept of ‘rotational kinetic energy’ (RKE) has been a relatively recent development and is used to describe archaeological and ethnoarchaeological, or traditional, pottery and sources of energy (e.g. Roux and Courty 1998; Roux 2003). RKE does not describe the pottery or the forming tools, but rather the means by which pottery was formed (Fig. 2). RKE can be defined as the movement energy an object has due to its spin or rotational velocity around its fixed central axis (adapted after Rodgers and Cavanagh 1984). When investigating pottery industries, archaeologists usually rely on a clear binary division: techniques that use rotational gestures with continuous or discontinuous RKE for shaping the clay; and those that do not (Roux and Courty 1998; Roux 2003). Besides the possible usage of rotational devices to generate RKE, such as a tournette or ‘fast’ wheel, when studying evidence for the use of RKE, several factors can be considered, including the: (a) methods, (b) portions of vessels, (c) stages of forming process, and (d) techniques, or modalities used to shape the clay paste (see Roux 2016: 4-6). RKE can be found linked to rotational gestures, with or without the support of tools such as rotational devices, or a variety of forming techniques, including wheel-finishing, wheel-fashioning and wheel-throwing.

Wheel-fashioning techniques differ from wheel-throwing techniques on three fundamental levels: (a) the use of rotational devices and gestures necessary to produce the vessel; (b) the morphology of the clay mass or rough-out shape of the vessel before using rotational energy; and (c) the moment in the forming process in which the rotational energy is employed (Choleva 2012). When rotational devices and gestures are used in the final stage of manufacture, the term ‘wheel-finishing’ is often used. Importantly, wheel-throwing and wheel-fashioning techniques can produce similar finished products, including vessels that are morphologically identical, and can also show similar sets of traces on surfaces (Roux 2009b: 197). Thus, the key method for distinguishing such processes is the identification of other features that are indicative of primary, or preliminary, forming techniques.

3. The debate on the Indus potter’s wheel

3.1. Wheel-throwing

Mackay (1938) was the first to notice certain surface features on Indus Civilisation ceramic vessels and suggested the possible use of rotational devices in Indus ceramic industries. The indicators used for detecting such techniques have been described in detail by Dales and Kenoyer (1986: 62-68), who stated that the presence of parallel surface striations, concentric markings on the base of the pottery, and the symmetry of a vessel’s morphology suggest the use of a ‘fast wheel’. Such visual evaluations has led to the conclusion that the wheel-throwing technique was consistently employed for producing many of the small and medium size vessels. Dales and Kenoyer (1986: 64) took this hypothesis one step further, and described the turning devices that were used by Indus potters—specifically suggesting the use of a foot-driven double or Persian wheel (Mackay 1930), and a Pathan wheel (Saraswati 1978: 18), which is made of two disks connected by a vertical axis and placed into a pit in the ground. This interpretation has been generally adopted for the study of a large number of Indus ceramic vessels from Mohenjo-Daro, Harappa (see Wright 1989, 2010, 1991: 78–82; Kenoyer 1994; Jenkins 1994; 2000; Rao 1969), and Nausharo (Mery 1994, Mery et al. 2007), and is currently generally accepted for the entire Indus Civilisation. It is important to note that the claim that a fast wheel was used is mostly based on visual observations of surface traces and the morphology of vessels, as no potter’s wheels or accompanying apparatus have yet been found (see above). This view has been strengthened by a perception of linear development of ceramic technology in South Asia (Kenoyer 1998: 151; see Ceccarelli and Petrie 2020).

3.2. Wheel-fashioning

Research on pottery from third millennium BC sites in Iran and north-west India have suggested that complex combinations of manufacturing techniques were being used. Moving away from the paradigm of a uniform tradition of ‘wheel-thrown’ vessels, several scholars have suggested the partial use of rotational devices for wheel-fashioning and wheel-finishing techniques was dominant in the Indo-Iranian region, associated with other forming techniques such as coil-building, wheel-coiling, moulding, beating, and paddle-and-anvil. The works by Hendrickson (1990; 1995) on pottery from Godin Tepe in Iran; Marano (et al. 1992), Meduri (et al. 1993), Vidale, Tosi and Laneri (Vidale and Tosi 1996; Vidale 1995; Laneri and Vidale 1998) on ceramics from Shahr-i Sokhta in Iran; and Courty and Roux (1995) on Indus pottery from Kalibangan in Rajasthan are prominent examples.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Sequence of actions in wheel-throwing and wheel-fashioning techniques (after Choleva 2012: 351).</th>
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<tbody>
<tr>
<td>Example of wheel-throwing techniques</td>
<td>Example of wheel-fashioning techniques</td>
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<tr>
<td>Centering the clay mass with RKE</td>
<td>Forming the coils with or without RKE</td>
</tr>
<tr>
<td>Hollowing the clay mass with RKE</td>
<td>Joining the coils with or without RKE</td>
</tr>
<tr>
<td>Lifting and shaping the rough-out with RKE</td>
<td>Thinning and shaping the rough-out with RKE</td>
</tr>
<tr>
<td>Finishing the clay mass with RKE</td>
<td>Finishing the rough-out with RKE</td>
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The lattermost is possibly one of the most debated, as it suggests that Indus ceramics in north-west India were initially “formed by coiling, then shaped on a wheel” (Courty and Roux 1995: 48). This statement has a range of social, cultural and economic implications, and is in clear contrast with the results and interpretations presented by other scholars (see Vidale 2000: 78). Roux and Courty’s study was, in some ways, revolutionary and, perhaps unsurprisingly, it has been questioned, with a certain degree of criticism being focused on the study’s methods and materials (see Vidale 2000: 79-80). Despite the critique, Roux and Courty’s work served to reopen the debate around Indus ceramic technologies through questioning certain concepts that were believed to be settled.

4. Economic and social implications

Gaining insight into the different forming methods used in ceramic industries has implications that lay well beyond the mere description of technological and economic aspects of prehistoric communities. It has often been assumed that there was a linear evolution in the use of wheel-throwing techniques and the fast wheel in prehistory (Foster 1959). However, several studies have observed the development of wheel-made pottery and revised the techno-economic determinism of traditional interpretations, which often correlated the appearance of the wheel with the invention of the wheel-throwing technique (see Choleva 2018: 49; Knappett 2016; Roux and Courty 1998: 747-748). These studies also helped to move away from the “causation equals correlation” interpretative frameworks of these inventions, which are often tied to debates concerning efficiency, standardisation, and intensification in pottery production. More importantly, they showed a more complex process of technological innovation and a non-linear trajectory of adopting rotational devices (Roux 2003, 2008, 2010; Ceccarelli and Petrie 2020). For instance, research efforts in the Aegean have demonstrated that multiple forming techniques coexisted among communities of producers in Bronze Age Greece and Anatolia, including wheel-based craft practice and combinations of techniques such as coiling and wheel-fashioning (Choleva 2018; Berg 2007, 2012; Knappett 2016; Kiriatzi et al. 1997; Spencer 2007; Türkteki 2014). The phenomena of coexisting diverse traditions and apparent resistance to the adoption of innovations have several social implications concerning community identities, teaching and learning mechanisms, and cognition within societies. These mechanisms of transmission reflect those most quintessential and continuing aspects of social identity, “such as kinship, language, gender, and class subdivisions” (Gosselain 2000: 193).

Wheel-throwing and the fast wheel, however, continue to be seen to have facilitated mass production and standardisation of pottery in complex and urbanised societies, including those of the Levant and the Aegean (Kingery 1984; Blackman et al. 1993). The interpretation of economic aspects of wheel-made ceramics has been extensively questioned, and it appears clear that the introduction of the potter’s wheel did not lead to a dramatic, homogenous shift in techniques of production (Courty and Roux 1995; Roux 2003). For instance, Choleva (2012: 376) outlined at least two steps in the evolution of wheel technology among Bronze Age Aegean potters: first, the wheel-fashioning technique was assimilated, preserving part of the earlier and already-mastered tradition based on coil-building techniques; then, the new technique of wheel-throwing was adopted. In the Bronze Age Levant, evidence from Tel Yarmuth and Beth Shean suggest the use of a variety of forming tools and techniques for producing pottery in the same regions and periods, including the use of rotational devices such as tourrettes, which are efficient for wheel-coiling and wheel-fashioning techniques, but inefficient for wheel throwing (Roux and de Miroshchedji 2009; Roux 2009a, 2009b). The case of Tel Yarmuth also suggests the presence of only a limited number of potters using certain rotational devices, who were specialists attached to the elite of cities. These cases of Levant and Aegean pottery and producers offer useful comparative material to better understand how technological innovations, including the potter’s wheel, were adopted, rejected and used in Bronze Age communities.

5. Methods and materials

This study is part of a broader investigation of Indus ceramics, which adopted a combined holistic approach for studying the sequence of operations in pottery making, ranging from macroscopic observations to thin-section petrography, geochemistry and ethno-archaeology (Ceccarelli 2020). The broader study uses a chaîne opératoire approach (Roux 2019a; Schlanger 2005) for investigating several ancient traditions and their social implications, but the aspects presented here focus on the role of the rotational devices and gestures in Indus ceramic industries, specifically in the rural context. The analytical approach builds on the methods proposed by Roux and Courty (1998), Jeffra (2013), and Choleva (2012) for the identification of rotational gestures and devices, including early wheel use, in ceramic industries in the Levant, Minoan Crete and Early Bronze Age Aegean respectively.

The approach used here serves to explore elements of social variability associated with ceramic traditions (following Roux 2016; Roux and Courty 2007, 2013). There is one main assumption underlying this approach: when considering pottery forms and style in a technological study, we aim to understand what ceramic data can tell us about whether variability of pottery is due to multiple manufacturing traditions and communities of producers, or it is due to functional variability of containers within one single tradition. For instance, within an assemblage where several chaînes opératoires are attested, the recognition that a distinctive technological group, or a group of ceramic sherds sharing the same manufacturing processes is related to only one class of vessel forms (e.g., only bottles), suggests that a particular type of ceramic objects could be explained in functional terms (Roux 2016: 9). In that case, the functional explanation would discount the identification of that particular group of ceramics with a distinct manufacturing tradition, a social unit, or group of producers. However, when the morphological variability of vessels is higher within a given technological tradition (e.g., bottles, jars, dishes, bowls), then questions concerning different groups of producers and variable traditions can be
Archaeological materials from the Indus Civilisation sites of at Lohari Ragho I (trench EA, see Singh et al., 2018) and Masudpur I (trench XK2, see Singh et al., in press) in Haryana, India are presented here (Fig. 3). Lohari Ragho I was occupied during the pre-urban and urban periods, and Masudpur I was occupied during the urban and post-urban periods. A total of 27,502 sherds from Lohari Ragho I (LHR-I) and 16,752 sherds from Masudpur I (MSD-I), were recovered and documented. Overall, c.3% of each assemblage underwent detailed morphological and technological analyses – more specifically, 1095 and 846 sherds from each respective assemblage. Fine ceramic pastes are identified in all deposits at LHR I trench EA, and represent c.88% of the assemblage. At MSD-I XK2, fine-paste ceramic sherds represent c.52% of the assemblage, and c.44% of ceramic objects (7400 sherds, c.118.3 kg), such as ceramic building materials, organic-rich-paste vessels, and terracotta cakes, show coarse ceramic fabrics. Observations of ceramic material from Lohari Ragho I and other trenches at Masudpur I have also been published elsewhere (Singh et al. 2009, 2010, 2015, 2018; Petrie et al. 2009; Parikh and Petrie 2016, 2019; Suryanarayan 2021). The analysis of material from these rural sites close to the major Indus urban site of Rakhigarhi was carried out as part of the Land, Water & Settlement project, and helped set the framework for the TwoRains project (Petrie et al. 2017).

Multiple ceramic fabrics were identified at each of these settlements, but this study will concentrate on fine wares. Coarser ceramics were not included mostly due to their friable and fragmentary nature in the assemblage. Ceramics showing a fine fabric were first divided into groups of sherds that showed evidence for the use of rotational gestures, and those that did not. Sherds that did not show any evidence for rotational gestures were further sorted according to other visible macro-traces or evidence of manufacturing techniques (Roux 2019a). Those sherds were observed according to patterns of fractures, morphology of the walls, and other features to further study preliminary forming techniques. In this paper, thin sections are used solely to make general technological observations and will not be discussed in detail. Ceramic thin-sections were prepared from samples of sherds from LHR-I and MSD-I, following the guidelines provided by Quinn (2013: 23-29; 2018; see also Humphries 1992; Singh 2015). The thin-sections were studied under a Leitz/Leica 12 Pols polarizing microscope. Given the textural and micro-structural characteristics of ceramic thin-sections, they are classified and characterized using a visual and descriptive approach (Quinn 2013: 73). A modified version of the descriptive system developed by Quinn (2013: 80-102) was adopted.

6. Results: manufacturing techniques

A number of distinctive traces were identified on LHR-I and MSD-I sherds that suggest the use of coiling techniques during the initial phases of forming (Ceccarelli 2020). Figs. 4–6 show a range of morphological features that have been considered when assessing the forming techniques of vessels, especially in relation with coiling. Traces are not enough, however, to make a clear statement concerning possible wheel-coiling techniques. Of the studied ceramic sherds, c.38% at LHR-I and 32% at MSD-I showed evidence for a combination of forming techniques, including preliminary forming techniques for forming the rough-out of vessels such as coiling. Coils are also used to produce the ring-base of certain globular vessels (Fig. 6a).

After forming the rough-out using coils, most vessels were shaped using some form of scraping technique. Macro-traces identified on LHR-I and MSD-I sherds suggest that scraping was widely used, which parallels material from Farmana, Masudpur I and Masudpur VII (see Uesugi 2011a, 2011b, 2011c; Parikh and Petrie 2019: 257). This study has shown that scraping was performed in a variety of ways. For instance, interior walls of vessels appeared to have been scraped with the partial use rotational motion or devices, such as tournettes or turntables (Fig. 5: b-c) or without RKE (Fig. 5a), which is revealed by little to no parallel sets of grooves or striations. Overall, the percentage of sherds showing scraping as a technical action is relatively high: e.g. c.60% of MSD-I vessels’ fragments.

At LHR-I EA, out of 27,502 ceramic sherds, 10,368 (c.105.2 kg) showed a fine ceramic paste and evidence for a combination of forming techniques, including primary forming techniques such as coiling for forming the rough-out of vessels. This amounts to c.38% of the whole corpus, which also includes ceramics that show moulding or unclear sets of manufacturing techniques. The quantity of sherds showing clear evidence for the scraping technique is also relatively high: comprising...
c.28% of the whole assemblage (7881 sherds, c.83.7 kg). Evidence for the use of rotational gestures or devices have been found on c.34% of the whole assemblage (9,404 sherds, c.105.3 kg).

At MSD-I XK2, out of 16,752 ceramic sherds, 8693 (c.157.2 kg) showed a fine ceramic paste and evidence for a combination of forming techniques, including primary forming techniques such as coiling for forming the rough-out of vessels. The quantity of sherds showing clear evidence for the scraping technique is also relatively high: 5091 sherds (c.74.7 kg) present evidence for scraping as a finishing method and do not suggest the use of rotational kinetic energy; and c.32% fragments show traces suggestive of primary forming techniques such as coiling for forming the rough-out of vessels. Out of the 846 sherds that underwent detailed morphological assessment, 693 were fine-paste sherds; 305 showed clear used of rotational gestures or motion; and 382 show...
scraping or other finishing techniques which did not involve rotational energy. A total of 662 sherds were therefore used to reconstruct ceramic traditions A and B, while the remaining 184 were useful to identify other vessels that do not fit into those techno-groups.

In a first technological group of fine paste ceramics (Group A), traces on sherds suggest that vessels were likely formed without or with limited use of rotational gestures or rotational devices, and often show evidence for different degrees of scraping and smoothing. Rare striations, with quasi-parallel to non-parallel orientation are visible on this type of vessel. The marks can be very shallow or slightly deep, and coils and coil-joins are often visible (Fig. 4; Fig. 5a). Some fine-paste sherds show abundant striation, from nonparallel to moderately-parallel, and shallow as well as deep marks on the inner walls can be seen, with coils and coil-joins still visible (Figs. 4, 5b and 6). Other fine-paste sherds can also show very abundant striations, which can be confused with wheel marks due to their presence on the interior surface, but they are mostly found in proximity of the neck and on rims of vessels (Fig. 5c). The inconsistent nature of these marks on the fine-paste sherds seems to suggest rotational movements in the use of tools and scrapers, rather than the use of a rotational device. If a rotational device was used, the use of rotational gestures was minimal (see Fig. 5c and Fig. 6).

Horizontal striations seem to be found often associated with coiling, or possibly wheel-coiling techniques, suggestive of scraping techniques. These sherds show a set of unique finishing traces, including perfectly parallel grooves on the rims, indicative of the use of rotational devices and rotational gestures during the finishing forming phases. Clear evidence for the use of this combination of technical actions are often difficult to identify. However, as presented in Figs. 4 and 6, preliminary forming techniques, such as coiling, can be seen on sherds associated with clear parallel grooves, mostly identifiable near the rim, while sherds from lower portions of vessels seem to suggest the use of scraping technique for thinning and shaping the rough-out. These indications mean that different combinations of techniques were likely used in different parts on the same vessel.

A second technological group of ceramics (Group B) shows abundant and consistent parallel striations associated with some scraping marks on the interior walls of sherds. Parallel horizontal striations are present on the upper portion of vessels, mostly on the interior surfaces of rims and necks, and throughout the whole length of vessels – from rim to base, on both thick and thin walls. Traces on the upper portion of vessels seem to suggest that rims were possibly moulded separately and attached to the vessel using a rotational motion in a subsequent phase of manufacture. Alternatively, rotational devices could have been used only in the final stage of fashioning. The lower portion of vessels tend to show evidence for the combination of coiling, scraping and rotational gestures, along with clear joint zones at the upper wheel-finished neck.
and rim (see Fig. 4). Traces on the interior surfaces of vessels, as well as
breakage patterns, seem to suggest that necks and/or rims of certain
vessels were formed in a subsequent phase of the manufacturing process,
independently from the rest of the vessel’s body. Fig. 4 shows changes in
terms of striation patterns near the neck and rim of certain vessels,
suggesting a specific set of actions for obtaining the desired morphology.
The presence of visible coils near the neck, associated with changes in
striation patterns seem to suggest that the rims where often finished
using rotational gestures and possibly rotational devices.

On vessels showing parallel grooves across the whole body, neck and
rim, which also show string cuts on the bases, the grooves still cannot be
used confidently to infer the whole sequence of actions for producing
vessels. In fact, ceramics can exhibit string cut marks on the outer sur-
face of the vessel’s base; yet, there may have been only limited trans-
formation of the rough-out with the help of RKE via a tournette, turntable
or wheel (e.g. ceramics from Tell el-Fa’arah; see Roux 2009b). Evidence
for the use of rotational motions or use of rotational devices for finishing
vessels have been found on c.34% of the whole assemblage at LHR-I and
c. 25% of all MSD-I vessels’ fragments.

Relic coils from vessel forming are usually identified by the orien-
tation of the voids and inclusions in thin sections (Quinn 2013: 177;
Cootes and Quinn 2017: 172; Travé Allepuz et al. 2014: 5). Several
samples from both Groups A and B exhibit a broadly concentric
arrangement of inclusions that are interpreted as relic coils or ropes of
clay that were not fully obliterated by secondary forming (Fig. 7). The
rough coil-built vessels appear to have been thinned by scraping or
rotational gestures. This process gave them a smoother finish on their
interior and exterior surfaces and resulted in the rough alignment of
elongate inclusions close to the vessel surface in thin section.

7. Indus Masudpur-Lohari A and Masudpur-Lohari B traditions

These observations about manufacturing techniques lead to the
identification of two dominant ceramic traditions at the studied sites,
which we propose calling Indus Masudpur-Lohari A tradition and Indus
Masudpur-Lohari B tradition.

7.1. Indus Masudpur-Lohari A

The Indus Masudpur-Lohari A (or ML-A) includes red vessels pro-
duced with no to limited use of rotational gestures (Fig. 8), often
showing an applied rustication, which was made of a clay paste rich in
fragments of limestone or kankar. Indus Masudpur-Lohari A fragments
have been identified in all deposits at LHR-I and MSD-I. As mentioned
above, these vessels seem to have been formed using a combination of
techniques, including coiling, scraping and smoothing. These vessels
range from low to high quality products. Rims and walls are often irregular, reflecting a certain degree of variability in the forming process. The outer surfaces tend to be smooth and red slipped and/or painted, while the inner surfaces tend to show scraping marks and incisions. The core of the walls tends to be red, thus indicative of a thorough oxidising firing process. Bowls, small jars, medium globular jars, and jugs seems to be the most frequent morphological categories. The most common forms are bowl with upright rims or jars with out-curved rims, hemispherical body and out-curved necks. Bases are usually concave or flat, and applied rings can also be found on the external surfaces of the bases. Some jars show a handle, attached directly on rim and body.

In terms of surface treatments, Indus Masudpur-Lohari A vessels show an applied rustication on the lower portion, especially of globular jars and bowls. The rustication is applied on the external surface, and is often associated with scraping marks on the inner surfaces (see Fig. 8). The composition of the slurry is visibly different from the composition of the vessels to which it applied on, showing abundant limestone, calcrite or kankar inclusions. Incised wavy lines and parallel combed incisions on vessel surfaces, as well as black painting, mostly bands or parallel black lines, also occur (Fig. 8). These surface treatments and decorations have also been observed on ceramics identified at Sothi, Siswal, and Kalibangan (Bhan 1975; Garge 2010; Lal et al. 2015; Madhu Bala 1997, 2003, 2015; Nigam 1996:7-14; Thapar 1975).

7.2. Indus Masudpur-Lohari B

The second most abundant group of wheel-finished red ceramics was named Masudpur-Lohari B (or ML-B), which were defined by a combination of sophisticated forming techniques and high control during the manufacturing process, including preliminary coiling and marks associated to abundant use of rotational gestures or devices (see Figs. 9 and 10). Parallel horizontal striations are not only confined to the upper portion of vessels, mostly on the interior surfaces of rims and necks, but they can also be found throughout the whole length of vessels—both on thick or thin walls. Most diagnostic fragments of rims show clear parallel striations. This pattern is still indicative of vessel rims possibly being crafted separately and attached to the vessel using a rotational motion in a subsequent phase of manufacture; or that the rotational devices were used more abundantly mostly in the final stage of fashioning. These types of vessels tend to show a red slip, and black-on-red painted decoration. Some jars, mostly medium or large jars, show a particular type of surface treatment: a fine applied rustication, using small-grain size clay slurry. No large-grain size temper or inclusions are visible in the slurry, which seems to have been applied by the producers using their fingers in a wavy motion, and is thus named fingers-applied rustication (see Fig. 9).

In terms of styles and morphologies, Indus Masudpur-Lohari B group is possibly the most evocative of a regional Indus flavour (Fig. 9). Distinctive forms, such as dishes, bowl jars with tall and narrow necks, jars with wide mouths, and goblets are the most common shapes. These forms have also been identified at other sites in the macro-region (see Quivron 2000), including Rakhigarhi (Nath 1998, 1999, 2000), Girawad (Uesugi 2011c; Shinde et al 2011b), Masudpur I/VII (Parikh and Petrie 2016, 2019), and Mitathal (e.g. from Trench A4, MTL-1; see Bhan 1975; Kumar et al. 2012; Prabhakar et al. 2010), but they also resemble examples seen in the assemblage from Farmana, including Harappan jars (Uesugi 2011a: Fig 6.30; Uesugi 2011b: Fig 9.40, 9.51), Harappan bowl types (e.g. Farmana Burial no. 10; see Uesugi 2011b: Fig 9.7) and non-harappan bowl types 2 and 3 (Uesugi 2011b: Fig 9.19).

8. Discussion and conclusions

This paper has demonstrated that different ceramic forming methods were practised during the third millennium BC in northwest India. The rediscovery of these variable practices has a range of implications, and it is likely that the diversity of forming methods corresponds to different technological and cultural behaviours, and can be used to explore ancient social structures. The identification of diverse forming and finishing techniques improve understanding of the development of technological traditions, but also the reasons behind diversification, innovations and resistance to innovations of certain communities of producers, including the possible development or adoption of the potter’s wheel. The macroscopic observations of the ceramics from Lohari Bagho I and Masudpur I have allowed us to identify two main technological traditions, namely the Indus Masudpur-Lohari A and Indus
Masudpur-Lohari B. These traditions show several forming, fashioning and finishing methods, the former without, or with limited, use of rotational gestures, and the latter with extensive use of rotational gestures that are associated with the use of rotational devices such as turntables or tournettes.

These observations help to reconstruct part of the complex sequences involved in the ceramic forming processes, including coiling, scraping and other finishing methods, and importantly in identifying different uses of rotational gestures. It is notable that no secure evidence for the use of wheel-throwing techniques has been found in the assemblages, including in the two main traditions. The lack of evidence for wheel-throwing techniques in the production of small, medium or large size vessels, offers a different perspective from the interpretations given to the vast majority of similar types of Harappan or Indus ceramic forming techniques in the past.

Further understanding of the landscapes of social relations between urban and rural producers helps to explore the social factors behind certain innovations, including the response to those innovations, and other factors such as diverse subsistence strategies, shared values among communities, or diversity of norms and behaviours. It seems clear that different manufacturing methods were practiced simultaneously and that different settlements in the Indus zone may have witnessed diverse

Fig. 8. Above: some rusticated vessels of Indus Masudpur-Lohari A tradition, or Indus Masudpur-Lohari A, such as globular and elliptical jars Samples LHR-EA-511–202, 203, 201, 200. Below: examples of fragments of Indus Masudpur-Lohari A vessels.
The identification of two distinct ceramic traditions at LHR-I and MSD-I suggests the presence of distinctive communities of producers, or potentially different social units, within and/or around these settlements. Two distinctive dominant traditions, the Indus Masudpur-Lohari A and Indus Masudpur-Lohari B, characterised the Pre-Urban and Urban period at LHR-I and MSD-I (Fig. 11). The technological variability identified at the studied sites appears to be due to variants of a similar technological tradition, or more likely of two traditions with common ancestral origins (Roux and Courty 2007, 2013). These traditions bear similar technical elements that signal a common derivation, especially in terms of shared manufacturing techniques and methods (e.g., the above-discussed coiling and scraping techniques, and application of slurries.). They are likely representative of diverging local rural Indus manufacturing traditions, where it is possible to perceive a broader sense of shared features. On the one hand, the diverse traditions can be linked to a sense of pluralism in Indus northwest India, as manifestations or expressions of social identities and distinctiveness among different groups of people (see Petrie et al. 2018; Ceccarelli 2020), which was a phenomenon that has already been observed at Indus sites such as Harappa, Bagasra/ Gola Dhor and Shikarpur (Kenoyer 1991, 1997; Clark 2003, 2009, 2017; Chase et al. 2014, 2016; see Davis 2018). On the other hand, it is possible to observe a certain degree of shared knowledge and behaviours, especially in terms of manufacturing techniques, pottery forms and decorative styles. The production and consumption of these objects may have had cultural or symbolic values attached, and have also signalled a ‘same-ness’, or a sense of belonging to a broader social network (see Davis 2018: 158). In the context of our

devlopment of technological traditions and ceramic forming processes.

Fig. 9. Fragments of Indus Masudpur-Lohari B pottery, or Indus Masudpur-Lohari B from LHR-I: Wheel-finished storage Jars, dishes and medium jars.

Fig. 10. Examples of vessels of the Indus Masudpur-Lohari B tradition, or Indus Masudpur-Lohari B from MSD-I.
data, a broader sense of ‘Indus-ness’ could be perceived in the ceramic assemblage in terms of tools and methods for productions, which to an extent align with the metaphor of an Indus-veneer suggested in past publications (Meadow and Kenoyer 1997: 139; Chase et al. 2014; Petrie et al. 2018: 468). However, even though the material expresses a certain phenomenon of amalgamation, and a sense of connection and same-ness between sites in the studied region, it does not contradict the hypothesis of diverse and distinctive groups of producers and associated social units.

Even though multiple communities of producers may have occupied the same region or even settlements, they made a clear effort to differentiate themselves from others. Producers shared the use of some manufacturing techniques, styles and forms, but they also did not share or adopt other techniques, including technological innovations, used by contemporary producers in the region. These differences include the lack of wheel-finishing technique in the Indus Masudpur-Lohari A tradition, which is observed in the Indus Masudpur-Lohari B tradition. The identification of multiple techniques or traditions operated by groups of producers in ancient Haryana is not entirely surprising: diversity of ceramic industries and multiple techniques in the production of Indus ceramics has also been observed at excavated sites in Pakistan, Gujarat and elsewhere in northwest India, including at Harappa and Mohenjo-daro (Krishnan 2018; Vidale 2000: 76-84; Lindstrom 2013). Moreover, this is not the first time that a similar scenario has been observed: i.e., groups of people who lived in the same regions of the Indus zone, but maintained different methods and traditions within an area of production. For instance, the scenario of two or more groups of people who lived in the same settlements or region, but performed different tasks has already been proposed (Chase et al. 2014; Lightfoot et al. 2020). Data here presented here suggest the possibility of at least two groups or lineages of ceramic producers, each likely associated to a group of people or a specific social unit, which facilitated the transmission of technical knowledge, symbolic knowledge, and values across generations.

The groups of rural potters made a clear statement of being willing to keep alive their distinctive traditions for generations and centuries, and shared certain practices with other local communities of producers. Such a phenomenon may also occur when cultural groups interact with each other; forging networks and influencing communities of practices, and therefore providing a sense of regional consistency of technological traditions through the borrowing of technological traits (see Roux 2013; also e.g. Livingstone Smith 2001; Gosselain 2008). This dynamic also explains the high level of consistency in the use of coil-building and scraping techniques, perhaps considered a shared value among producers of different communities or traditions. Individually, the settlements at LHR-I and MSD-I present, on a local scale, assemblages consistent with their own local traditions. Further implications of these observations for understanding socio-economic dynamics, relationships and social structures of the Indus Civilisation are ripe for further research.

It is also important to clarify that this paper does not want to present a clear divide between rural and urban pottery use or production. As mentioned, Indus Masudpur-Lohari B group is strongly evocative of regional Indus features, especially of vessels identified at sites such as Rakhigarhi, Girawad, Mitathal, and Farmana (Shinde et al. 2008, 2011a, 2011b). Some of these larger settlements offer meaningful comparative material, and data presented here does not allow us to address questions of diversity of production between villages and cities. Similarly, the traditions discussed here are named “rural” to emphasise the significance of the place of use and production of containers (see Parikh and Petrie 2019). Moreover, the paper does not make direct comparative observations with the well-known excavations at Harappan and Mohenjo-daro, given the fact that data from those sites are not presented here and the distance (c.800 km, or c.500 miles) that separates the latter settlement with the studied villages. However, the present study does not discount the possibility of observing similar products at urban sites.
in the region or beyond, and it suggests we should explore future opportunities to study the phenomenon of knowledge exchange, segregation or specialisation within urban contexts.

Elsewhere, we have offered a critique of simplistic unilinear evolutionary interpretations of ceramic technologies (Ceccarelli and Petrie 2020). The critique to this approach is mostly oriented towards two points. Firstly, unilinear evolutionary interpretations risk to erase the role of social and material environments as agents in the constitution and transmission of cultural knowledge. Secondly, there are many recorded archaeological and ethnographic cases where potters may ‘learn’ about or get in ‘contact’ with a new trait or technique, but reject it and choose not to adopt it. Moreover, the use of rotational devices, especially their functions in production stages and how they were used, requires teaching by an experienced mentor, usually thought apprenticeship (Roux and Corbetta 1990; Roux 2019b), and significantly relies on social and material spaces (Caporael 2014). These factors suggest that certain manufacturing techniques cannot be equated to simple information packages that can be stored and exchanged (Jordan 2014), and perhaps should not be seen just as transferable cultural traits. The evidence and critique presented here suggest that the picture is more diverse than previously thought, and can be visualised as a complex network of learning and influences that reflects mechanisms of adoption of new tools and techniques, rejection and resistance to innovations, and the different paths through which knowledge and skills can be transferred (Petrie 2011; Knappett 2016: 108; Jürcke et al. 2021).

The Indus Civilisation case study presented here highlights that different trajectories of technological developments can co-exist. Even though no evidence was found to support previous theories concerning the use of wheel-throwing techniques, data suggests a variety of tools and practices used by Indus potters in the rural context. While innovation occurs, it is not necessarily readily adopted by those who are exposed to it, and often potters may not be interested in changing, or be able to change their traditions. Such patterns of technological choice are known in many regions of the world in the past, and the discovery of the resistance to innovations in regional contexts indicates strong traditions of regional identity in the Indus context. Moreover, the sustainability of rural ceramic traditions before and during the urban phenomenon in the region suggests that, while settlement patterns changed and urban settlements were formed close to these settlements (see Green et al. 2018), village-based activities steadily continued, many of which appeared to have been characterised by household-scale production (Petrie 2017; Bates et al. 2017; Petrie et al. 2018). Future studies on ceramics from northwest India, but also studies of raw materials, clay pastes and networks of producers, will contribute to better understand the practices of Indus potters and their society.

CRediT authorship contribution statement

A. Ceccarelli: Conceptualization, Data curation, Formal analysis, Investigation, Visualization, Writing – original draft, Writing – review & editing. P.S. Quinn: Supervision, Resources, Methodology, Writing – review & editing. R.N. Singh: Resources. C.A. Petrie: Supervision, Resources, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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