The Archaeology of Measurement

Comprehending Heaven, Earth and Time in Ancient Societies

Edited by

Iain Morley
Keble College, Oxford

Colin Renfrew
The McDonald Institute for Archaeological Research

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Measuring the Harappan world: Insights into the Indus order and cosmology

J. Mark Kenoyer

Introduction

The origins of certain types of weights and measures in South Asia can be traced back to the earliest cities of the Indus civilization. This chapter presents an overview of the types of artefacts that inform us about ancient Harappan measurement systems, in order to gain insight into their concepts of order and cosmology. The main focus is on recent discoveries at the site of Harappa, Pakistan, where detailed measurements have been made of a wide range of artefacts in an attempt to understand better the standardization and regional variation of Indus measurement systems.

The Indus civilization or Harappan culture refers to the first urban society that emerged in the greater Indus valley of Pakistan and northwestern India, between 2600 and 1900 BCE (Figure 9.1). After its discovery in the 1920s, in the course of excavations at the sites of Harappa and Mohenjo-daro (now in Pakistan), the Indus civilization was widely thought to have been one of the most highly organized urban societies in the third millennium BCE. This perception was based in part on general impressions about the layout of city streets, and the similarities of brick and weight sizes throughout the greater Indus valley. The north-south and east-west layout of the architecture and city streets, along with the relatively uniform proportions of baked bricks, was thought to reflect concepts of order, cosmology and standardization imposed by the rulers of the Indus cities. The most widely cited evidence for rigid standardization was the use of cubical stone weights whose "constant accuracy" was thought to reflect "civic discipline" (Wheeler 1968:83). These weights represented a "well defined system unlike any other in the ancient world" (ibid.). The pervasive nature of Indus ideology, order and standardization was further reinforced by the discovery of additional Harappan sites in the highlands of northern Afghanistan, in Kutch and Gujarat, and scattered along the now dry bed of the Saraswati-Ghaggar-Hakra River, which flowed to the east of the Indus.

Although some earlier excavators assumed that the emergence of the Indus cities was the result of migration or indirect influence from Mesopotamia through the western highlands of Baluchistan, it soon became evident that the Indus civilization was the result of indigenous processes. Their distinctive urban society was thought to have emerged suddenly, within a span of 100 to 200 years, beginning around 2600–2500 BCE,

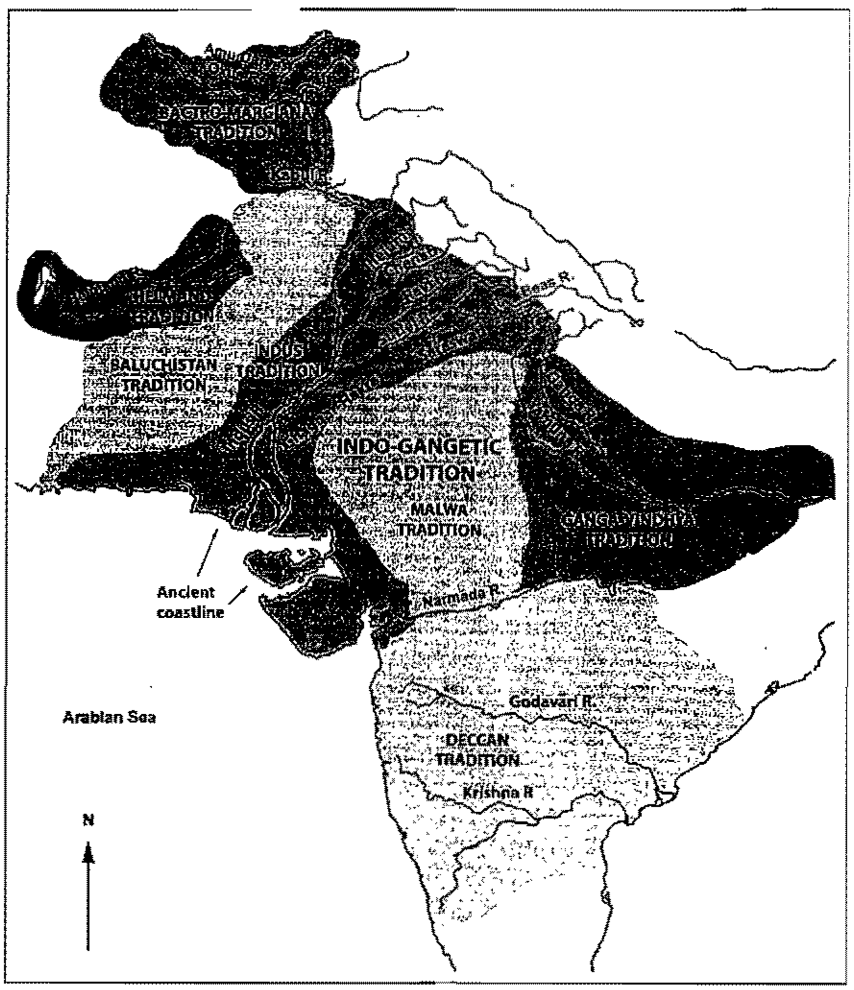

Figure 9.1. Major traditions of prehistoric South Asia.

and then disappeared rapidly around 1900 BCE (Jansen 1993; Possehl 2002). The distinctive features that are thought to have emerged rapidly are new styles of pottery and metal vessels, baked brick architecture and town planning, brick-lined wells, terracotta carts and triangular terracotta cakes, the distinctive stamp seals, standardized weights, and writing (Possehl 2002:51). Although it is not explicitly stated, this rapid development assumes that measurement systems were also rapidly standardized and adopted throughout the greater Indus valley region, an area of almost 680,000–800,000 km², comprising more than 1,500 settlements.

A different view, which will be explored in more detail in this chapter, argues that many diagnostic features of Indus urbanism had been developing for hundreds, if not thousands, of years prior to the construction of the first fired brick building or the manufacture of standardized cubical chert weights. After a brief introduction to the chronology and terminology, I will present an overview of the types of artefacts that inform us about ancient Harappan measurement systems, and how these artefacts changed or remained the same over time. The main focus will be on recent discoveries at the site of Harappa, Pakistan, where detailed measurements have been made of a wide range of artefacts in an attempt to understand better the standardization and regional variation of Indus measurement systems. In the absence of a script that can be read, these data provide an important perspective from which to investigate ancient Indus concepts of order and cosmology.

Table 9.1. *Indus tradition chronology: Harappa and early Mehrgarh*

Localization Era	
Late Harappan Phase	ca. 1900 to 1300 BCE
Harappa: Periods 4 and 5	*1900–1700 BCE*
Integration Era	
Harappan Phase	2600 to 1900 BCE
Harappa: Period 3C, Final	*2200–1900 BCE*
Harappa: Period 3B, Middle	*2450–2200 BCE*
Harappa: Period 3A, Initial	*2600–2450 BCE*
Regionalization Era	
Early Harappan (several phases)	ca. 5500 to 2600 BCE
Harappa: Period 2, Kot Diji Phase	*2800–2600 BCE*
Harappa: Period 1, A &B, Ravi/ Hakra Phase	*>3500–2800 BCE*
Mehrgarh, Period III	*4800–3500 BCE*
Mehrgarh, Period II	*5500–4800 BCE*
Early Food Producing Era	
Neolithic – Mehrgarh Phase	ca. 7000 to 5500 BCE
Mehrgarh, Period 1, Nonceramic	*7000–5500 BCE*

Chronology and general overview

Although the terms *Indus civilization* and *Harappan culture* are widely used in the literature, a more comprehensive term, the *Indus Tradition* (or *Indus Valley Tradition* (Shaffer 1992)), includes the wide range of human adaptations in the greater Indus region over a long span of history, approximately 10,000 to 1000 BCE (Kenoyer 2006a). This tradition did not evolve in isolation, and three other major cultural traditions relating to the initial emergence of Indus urbanism can be identified for the northwestern subcontinent: the Baluchistan, Helmand and the Bactro-Margiana Traditions (Figure 9.1). The Indus Tradition can be subdivided into eras and phases that are roughly correlated with major adaptive strategies and regional material cultural styles (Table 9.1).

The Neolithic or Early Food Producing Era (circa 7000–5500 BCE) has been documented primarily at the site of Mehrgarh, Pakistan (Jarrige and Meadow 1980; Jarrige et al. 1995) (Figure 9.2). The transition from hunting-foraging to settled agropastoralism is well documented at Mehrgarh during the course of the Early Food Producing and Regionalization Era. Wheat and barley agriculture and the herding of domestic cattle, along with sheep and goats, became the primary subsistence base at Mehrgarh. These same plants and animals provided the foundation for the development of larger towns and eventually cities in the Indus region.

Beginning from the earliest occupation layers, Mehrgarh has evidence for the use of hand-formed mud bricks and well-laid-out compartmented buildings. During the Neolithic Period, the mud bricks of Mehrgarh varied in size (28 to 42 cm in length) and proportion (the average is 1: .6:5.2). Although there is no rigid uniformity in the orientation of buildings, they tend to fall along the cardinal directions (Jarrige et al. 1995). In addition to a well-developed architectural tradition, a wide range of crafts, such as bead making, stone working and shell working, were being developed (Jarrige 1991). These crafts continued in later periods at Mehrgarh and are found at other early sites. After 5500 BCE, pottery making and metallurgy became widespread throughout the Indus region, and distinctive regional artefact styles can be defined on the basis of surface treatment and shape as well as manufacturing technique (Mughal 1990; Shaffer 1992).

During the Regionalization Era (5500–2600 BCE), small villages became established in agriculturally rich

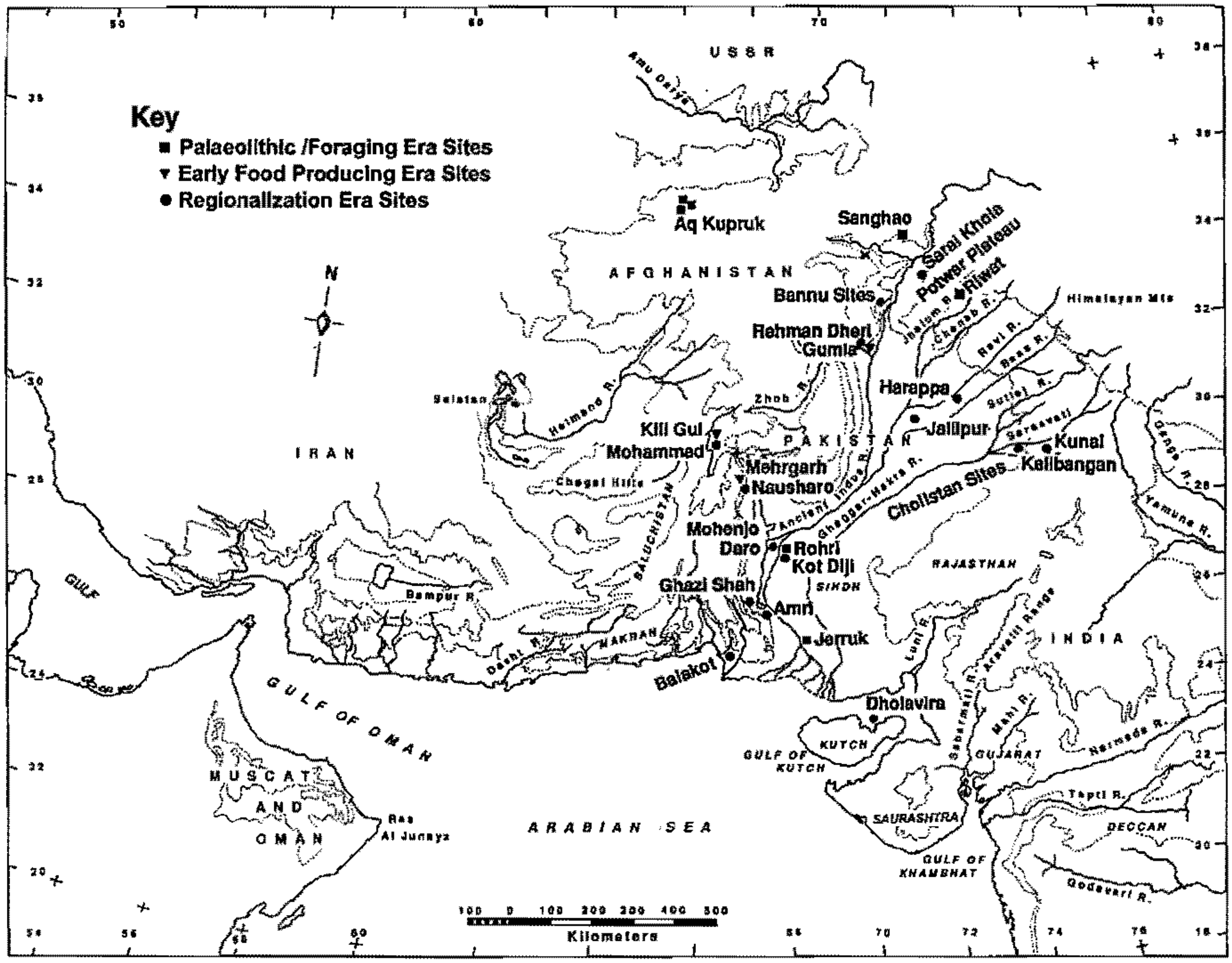

Figure 9.2. Early Food Producing and Regionalization Era sites.

areas and larger villages grew up along the major trade routes linking each geographical region and resource area. The term *Early Harappan* is used to refer to the earlier phase of cultural development that preceded the rise of cities such as Mohenjo-daro and Harappa (Mughal 1970). Mughal's reanalysis of artefacts from stratigraphic layers at the site of Kot Diji clearly demonstrated that many of the so-called diagnostic artefacts of the later Indus cities were already present between 3300 BCE and 2800 BCE, such as distinctive painted pottery, terracotta carts, triangular terracotta cakes, and well-laid-out mud-brick architecture oriented in the cardinal directions. More recently, excavations of the Early Harappan (Kot Diji Phase, 2800–2600 BCE) layers at the site of Harappa have revealed other examples of diagnostic artefacts including stamp seals, clay sealings, a form of Early Indus script, writing on pottery, and even a cubical limestone weight conforming to the later weight system (Meadow and Kenoyer 1997; 2001; 2005; Kenoyer and Meadow 2000; Kenoyer 2005; 2006b).

Sites, such as Harappa, grew to more than 25 hectares in area and were often divided into two walled sectors (Flam 1981; Mughal 1990; Kenoyer 1998). The manufacture of mould-made standardized mud bricks (1:2:4 ratio) for building city walls and domestic architecture began during this period. Small bricks were used for domestic structures, while larger bricks were used in platforms and city walls. Streets, city walls and domestic architecture were oriented to the cardinal directions and settlement planning was maintained over hundreds of years. The layout and maintenance of streets at Harappa and numerous other sites throughout the greater Indus region can be closely associated with the increased use of bullock carts for transport of heavy commodities into the settlements during the Kot Diji Phase.

Regional settlement patterns, along with site layout and the elaboration of specialized crafts, can be linked to the emergence of stratified socioeconomic and political organization systems associated with early urbanism

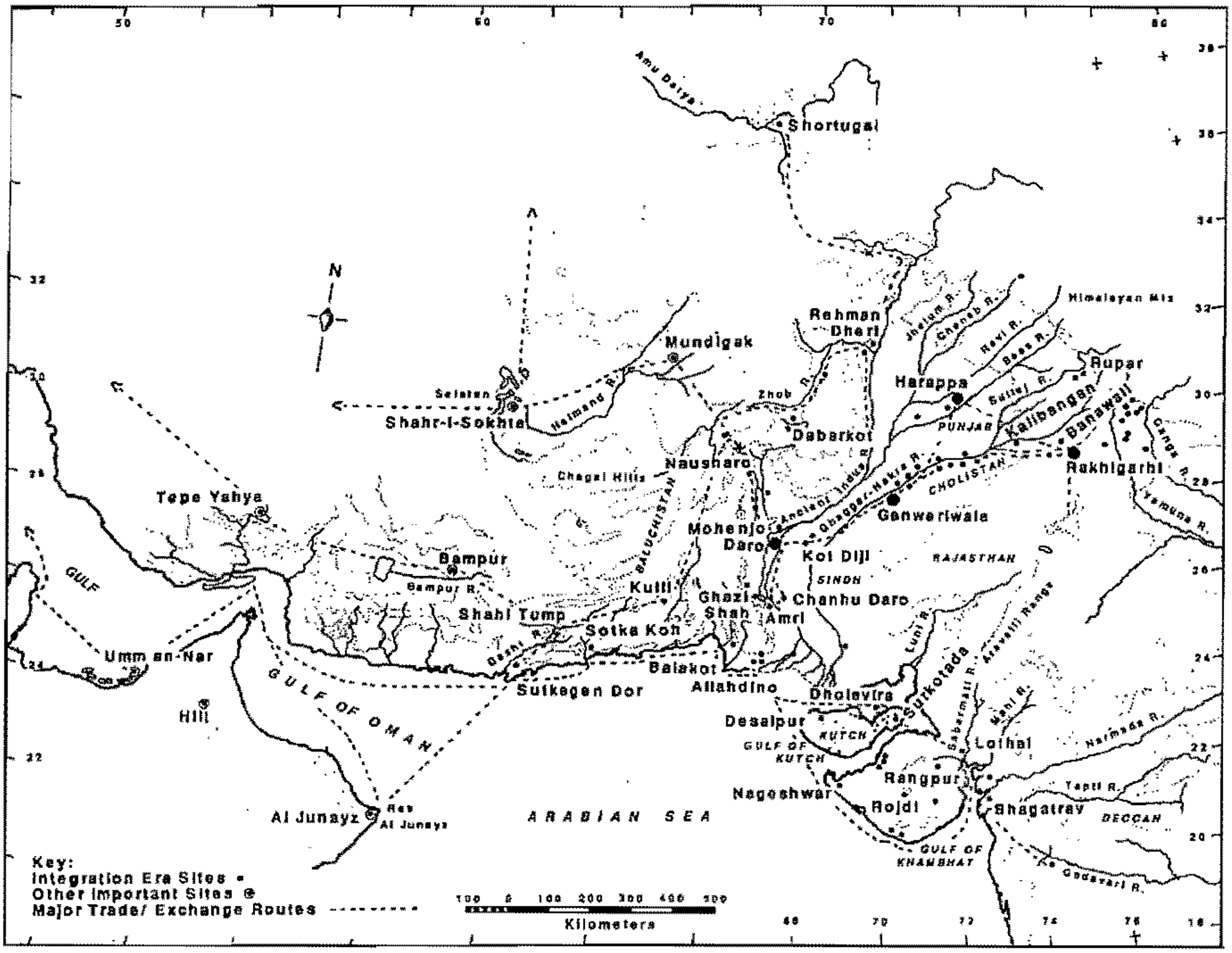

Figure 9.3. Integration Era, Harappa Phase sites.

(Kenoyer 2000, 2006a). These discoveries from Mehrgarh, Kot Diji and Harappa provide conclusive evidence that many of the diagnostic features of the later Indus cities, including systems for control and measurement, were already widespread during the Early Harappan Period, with roots extending back to the Neolithic Period.

The term *Indus civilization* or *Harappa culture* generally refers to the Integration Era, *Harappa Phase*, which dates from around 2600–1900 BCE and represents the major phase of state-level development and urbanism. Cities such as Harappa, Mohenjo-daro, Rakhigarhi, Dholavira and Ganweriwala grew to their largest extent during this 700-year time span. On the basis of radiocarbon dates from Harappa and other sites, the Harappa Phase can now be divided into three subphases as revealed by changes in pottery, use of seals and architecture: Periods 3A (2600–2450 BCE), 3B (2450–2200 BCE) and 3C (2200–1900 BCE). The term 'mature' Harappan Period (or Mature Harappan) is used by some scholars to refer to the entire 700-year time span. However, many of the diagnostic artefact types associated with the so-called mature Harappan Period, such as painted pottery, pointed base goblets, stone sculptures and figurines, narrative seals, and elaborate jewelry, actually only occur during the last half of this period.

It is during the Harappa Phase that mould-made fired brick become widely used in urban architecture, and standardized cubical chert weights are found throughout the greater Indus region and beyond. Massive mud brick walls surrounded most large settlements and appear to have functioned primarily for control of trade access into the cities. Devices for control of trade, such as seals and weights, are concentrated near gateways and in craft areas located near the gateways or along major streets. While the massive walls could have served as formidable defenses, there is no evidence for major conflict or warfare at any major center.

As will be discussed in more detail later, measurements have been made of all categories of artefacts from all periods of occupation at the site of Harappa. While there is some degree of standardization in terms of artefact proportions, such as the ratios of brick thickness to width to length (1:2:4), there is little evidence for rigorous standardization within the site itself. Generally speaking, when the data from Harappa are compared to evidence from other Indus sites, it appears that there is a degree of standardization within some artefact categories, particularly cubical chert weights, and a widespread use of similar proportions for other categories of artefacts, such as beads, bricks and pottery. However, on closer examination there appears to be considerable regional variation in most categories of objects throughout the greater Indus valley.

There is no evidence for hereditary monarchies or the establishment of centralized territorial states that controlled the entire Indus region, and there is a conspicuous absence of central temples, palaces and elaborate elite burials that are characteristic of elites in other early urban societies in Mesopotamia, Egypt and China. The largest urban centers such as Mohenjo-daro, Harappa and Dholavira may have directly controlled their surrounding hinterland and were clearly being ruled by influential elites. The Indus elites would have included merchants, landowners and religious leaders, who would have competed for dominance in different areas of the cities. Smaller towns and villages may have been run by corporate groups such as town councils or individual charismatic leaders. Hierarchical social order and stratified society are reflected in architecture and settlement patterns, as well as artefact styles and the organization of technological production. In the absence of an organized military or centralized hereditary elite, internal trade and exchange and a shared ideology appear to have been the primary mechanisms for integrating the diverse settlements and communities of the greater Indus valley. The specifics of the Indus ideology will only be understood after we have been able to decipher their writing, but the material representation of this ideology as reflected in patterning of material culture, and measurement, is something that we can study.

Early Harappan measurement systems: Ravi and Kot Diji Phase

During the Ravi Phase occupation at Harappa (>3500–2800 BCE) there is no clear evidence for the use of standardized measurement systems, such as weights or linear measures, but the lack of evidence may be due in part to the relatively small excavation area exposed so far (Kenoyer and Meadow 2000). There are, however, several categories of artefacts that demonstrate the beginnings of standardization in terms of pottery making, spinning and presumably weaving, bead making and brick making. Further excavations are needed to confirm the patterns seen from the small samples reported later, but they do provide a point of comparison for what is seen in later periods at the site.

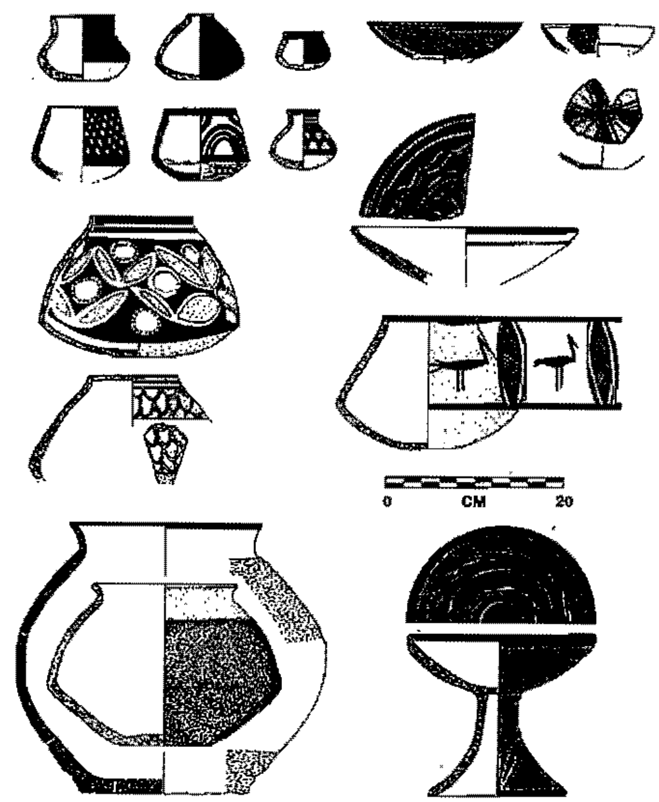

Figure 9.4. Ravi Phase pottery.

Pottery vessels with similar shapes were produced in a range of sizes that were probably developed with regard to functional features. Cooking pots with low center of gravity and external projecting rims were probably designed for preparation of liquid foods and cooking over small wood fires. The different sizes of pots may relate to the types of food being cooked or stored, the number of people being fed from a single pot or the optimal size of a vessel for carrying or dispensing liquid. Although some vessels may have been used as measures to hold liquid or grain, there is no evidence for precise standardization during the Ravi phase. Because of the fragility of terracotta, most measures in later historical periods were made of wood or metal, so it is not surprising that terracotta measures were not used in the prehistoric period either.

One category of artefact that reveals a degree of standardization, which can also be linked to function, is spindle whorls. Although the sample size for complete spindle whorls from the Ravi Phase is not large (n = 6), there appears to be a range of sizes that suggests two basic weights of thread being spun. The smaller category weighs around 16.6 grams while the larger size is around 28.4 grams (Table 9.2a). Although the sample is small, it appears that similar spindle whorl sizes and weights were used in the subsequent Kot Diji Phase. The larger two categories are roughly the same as those seen during the Ravi Phase, being 23.13 grams and 30.46 grams (Table 9.2b). However, two smaller categories of spindle whorls appear during the Kot Diji Period, and they could indicate the production of finer threads for higher-quality fabrics. Impressions of plain weave textiles with relatively fine threads have been found on terracotta beads. The thread impression is approximately 0.2 mm wide, and the fabric was loosely woven with an open weave of approximately 11 threads per centimeter. A variety of polished bone tools (pickers and separators) that may have been used in weaving have been found in association with the spindle whorls. Although we do not know the type of looms being used, they were probably simple backstrap looms similar to those used in many traditional communities in South Asia even today. Such looms result in specific lengths and widths of textiles that are often used as a standard form of exchange.

Although there are terracotta beads/whorls within these same weight ranges during the later Harappa Phase, they do not fall into clear categories, and on the basis of the analysis of surface wear and cord marks, most of the terracotta beads/whorls found in the Harappa Phase at Harappa appear to have been used as net weights or loom weights and not as drop spindles. Harappan Phase spinning is thought to have been done with a spinning wheel rather than with drop spindles (Kenoyer 2004). The use of spinning wheels also results in finer and more uniform threads, which were being woven into plain textiles.

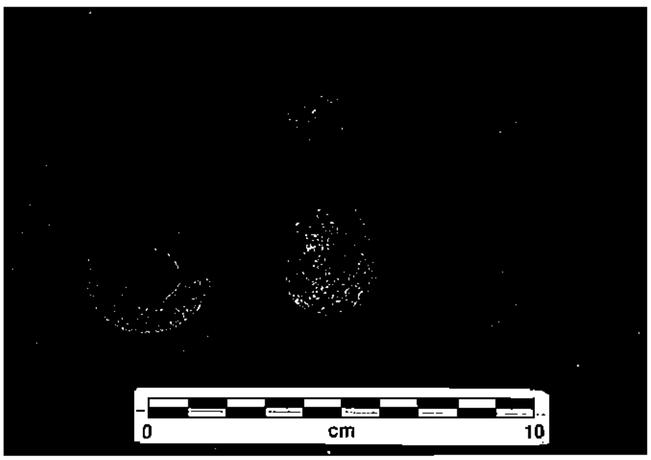

Figure 9.5. Ravi and Kot Diji Phase spindle whorls.

Table 9.2. *Early Harappan spindle whorls*

a. Ravi Phase spindle whorls

Size category	Average length	Average diameter	Average weight (gram)	Average ratio	Sample size
Small					
Medium	22.85	30.68	16.60	1.38	4
Large	26.67	39.15	28.40	1.47	2

b. Kot Diji Phase spindle whorls

Size category	Average length	Average diameter	Average weight (gram)	Average ratio	Sample size
Smallest	12.79	24.00	5.90	1.88	1
Small	22.66	30.23	13.90	1.41	3
Medium	32.26	42.96	23.13	1.78	4
Large	30.34	35.96	30.46	1.19	3

Terracotta and stone beads

During the Ravi and later Kot Diji Phases, a wide range of terracotta and stone beads were produced for local use and possibly for regional trade. While terracotta is locally available, other types of raw materials, such as steatite, carnelian, chert, jasper, lapis lazuli and amazonite, were being taken to the site from great distances. The early traders and craftsmen must have developed a mechanism for establishing value and trades of these raw materials as well as the finished beads. In this early period, small lumps of lapis lazuli or agate nodules may have been traded through barter or based on relative size. Strands of finished beads, or even individual beads, also may have been used as a form of standardized exchange, but preliminary analysis of the measurements and weights of Ravi and Kot Diji Phase beads do not demonstrate clear patterns of standardized bead sizes. The bead types include short or long cylindrical, bicone or barrel shapes with similar proportions of length to diameter, but the absolute range of sizes is quite continuous. This is not surprising, as the conservation of valuable raw materials would result in the manufacture of beads from any size of stone fragment.

Nevertheless, the technology involved in bead making would have required the use of precise measurements by craftsmen in order to prepare tools, such as saws and drills, as well as the finished beads themselves. For example, soft steatite taken to the site from various possible sources in the

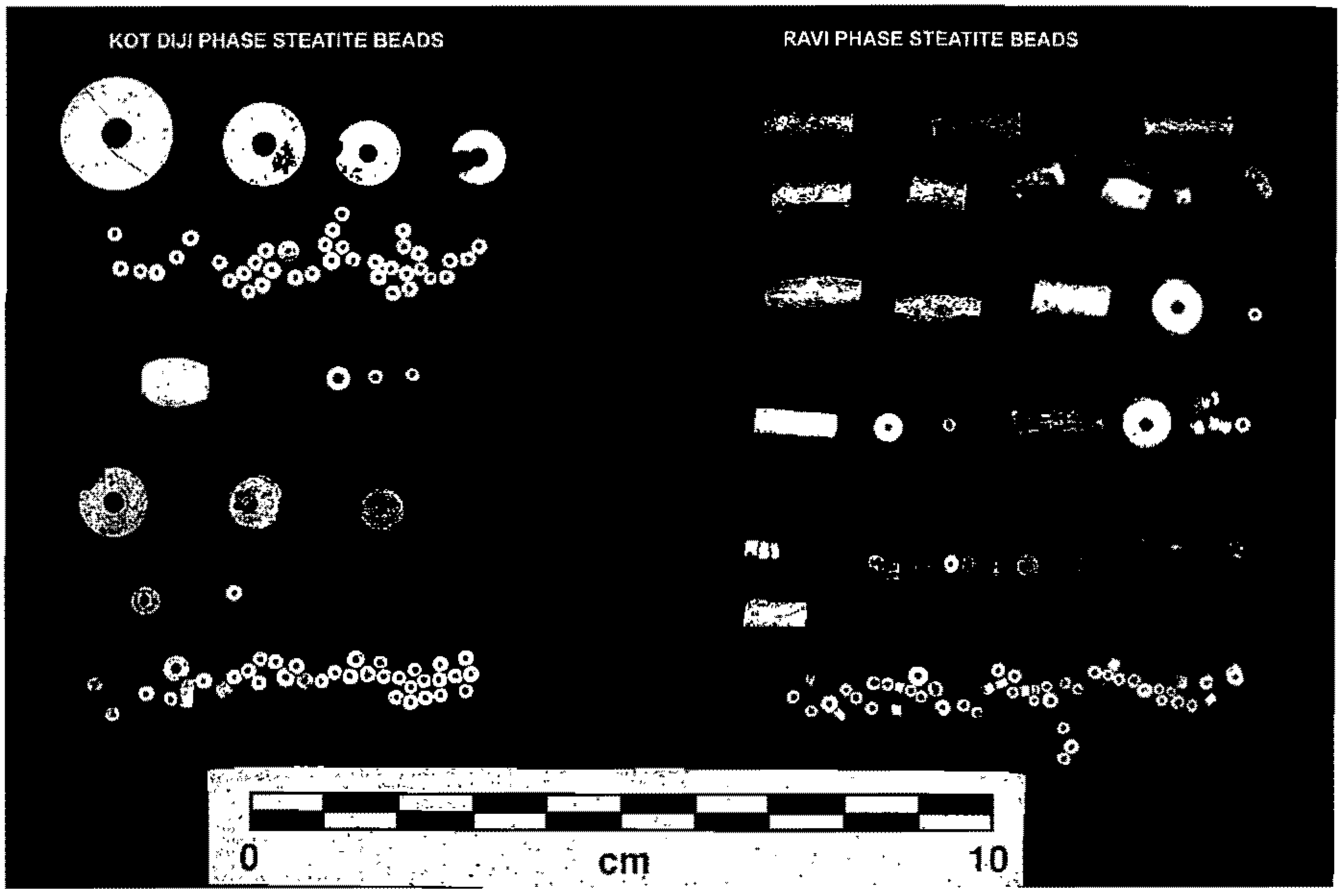

Figure 9.6. Ravi and Kot Diji Phase steatite beads.

northern Indus Valley or Baluchistan (Law 2002, 2005) was used to make a wide range of bead types. The soft stone was sawn into uniformly thin sheets (circa 1 to 2 mm thick) with an equally thin (0.75 to 1.1 mm), finely serrated copper blade. These thin sheets were snapped into tiny rectangular chips and then drilled with a copper drill that ranged from 0.75 to 1.1 mm in diameter. The beads were strung on fine cotton or woolen thread and ground to various diameters to create necklaces composed of beads either with uniform diameters or sometimes in graduated sizes. After final shaping the beads were fired at high temperatures (900° to 1000° Celsius) and glazed to make them white or blue-green colour.

During the Ravi Phase, extremely small steatite microbeads were produced, with measurements as small as 0.75 mm in length and 1.1 mm in diameter, and a minimal weight of 0.003 g. Over 6,100 microbeads would have been required to create a strand long enough to drape around the neck (61 cm or 24 inches). Experimental replication of such beads has been undertaken, but the total time needed to produce such a strand of beads is difficult to estimate because of breakage of beads in the course of manufacture. The firing of the beads to harden them would have taken a full day, and then it may have taken considerable time to restring and polish the beads. Needless to say, a string of steatite microbeads clearly represents a considerable amount of time and effort, and it is not unlikely that standard lengths of strung microbeads may have been used in trade and exchange.

Although it is not possible to determine how the prehistoric craftsmen measured thin slices of steatite or determined how thin to grind the beads once they were strung on a thread, it is evident that they were able to deal with extremely small units of value. This issue will be addressed later in the discussion of the Indus weight system, which may have evolved alongside or in conjunction with crafts such as stone bead making.

The tradition of microbead production reached its height during the Harappa Phase with the manufacture of beads that were about the same lengths as the early Ravi beads (0.75 to 1.13 mm) but were reduced in diameter to 0.75 to 0.85 mm. These Harappan microbeads weigh around 0.0004 to 0.0006 g and may have been threaded on fine wool or possibly silk thread, which can be spun much thinner and is stronger than cotton thread. What appears to be silk thread preserved inside copper wire beads has been found at Harappa dating to around 2450 BCE. This silk probably derives from the wild silk moth (*Antheraea* sp.) that is found in the Indus valley and other regions of South Asia (Kenoyer 2004).

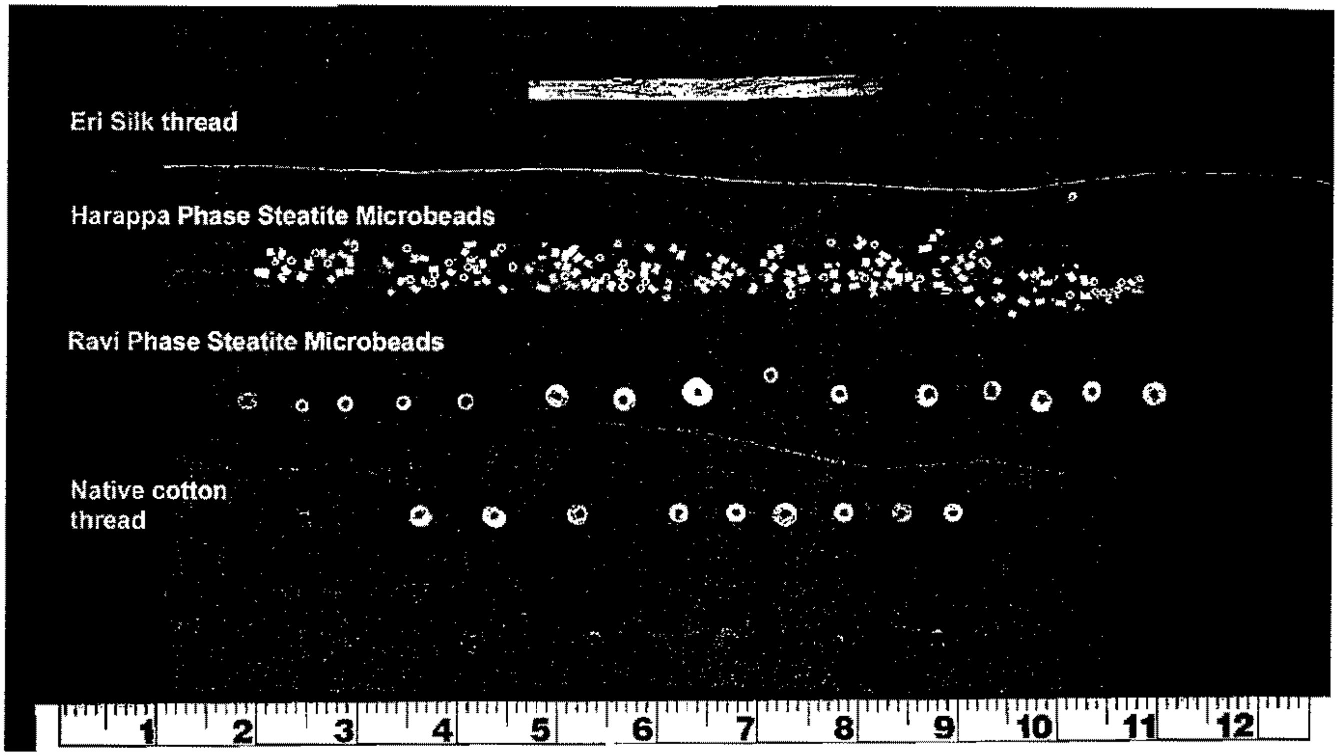

Figure 9.7. Steatite microbeads: Ravi and Harappan Phase.

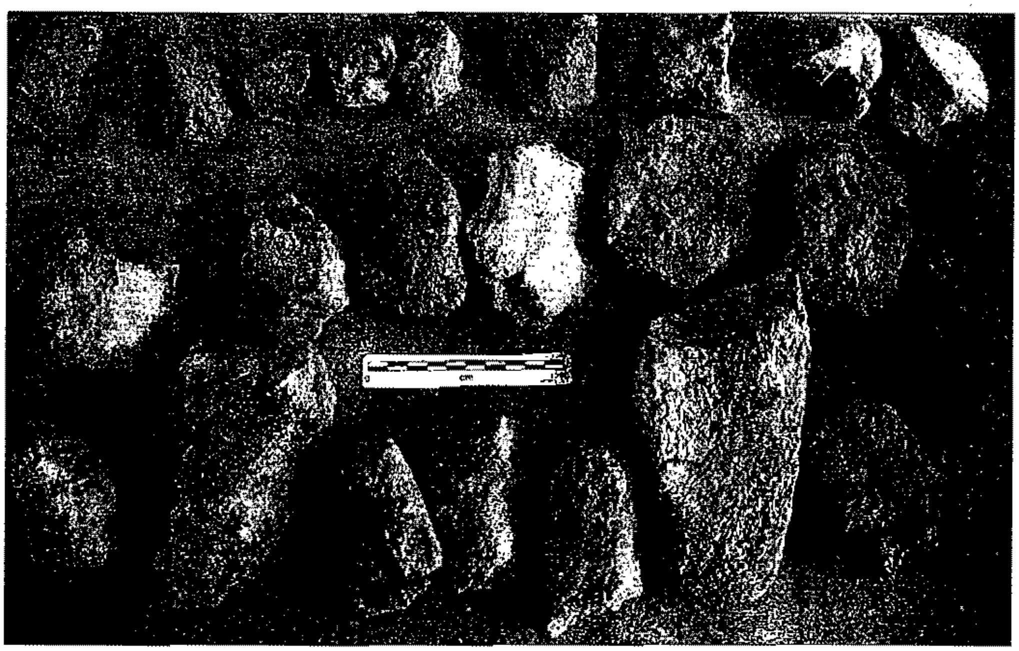

Figure 9.8. Ravi Phase mud bricks.

Architecture and bricks

The use of mud bricks was already well established in the Indus valley region as early as 7000 BCE, but so far only a few scattered mud bricks have been found from the earliest Ravi levels (Period 1A) and a fragmentary north-south oriented wall from the later Ravi levels (Period 1B). The small dump of burned and partly vitrified mud bricks from Period 1A suggests that they were being made at the site for use in kilns or hearths and possibly also for the construction of houses. These earliest mud bricks were hand formed and therefore do not have uniform shapes. Only two relatively complete examples and about two dozen fragments were recovered. The complete mud bricks were slightly wedge shaped, measuring 4.5 cm thick and 17.5

cm long. The wide end is 9 cm and the narrow end is 5.5 cm. The ratio for the brick, using the wide end, is 1:2:4, which is the basic proportion that becomes standard during the subsequent periods at Harappa and throughout the Indus valley in general. In excavations conducted in 1996, a fragmentary wall dating to the final Ravi Phase (Period 1B) was made of large mud bricks, 11 x 23 x 40 cm. This wall was oriented north-south and confirms the pattern indicated by the posthole structures of 1A.

The sizes of Kot Diji Phase mud bricks at Harappa are very similar to those made during the Ravi Phase, but they were much more uniform because they were mould made. Mud brick was used to build domestic structures as well as to construct platforms and city walls. Large mud bricks, measuring 10 x 20 x 40 cm, were used in the construction of the Early Harappan city walls around Mound AB and Mound E. On the basis of the different colours and compositions of the clay used in the city walls, it appears that the mud bricks were being made locally as well as in the surrounding hinterland. Each mound had its own distinct wall, and each wall had different colours of clay bricks, but the size of bricks is highly regular (Kenoyer 1991). This indicates that a standardized concept of measurement was being used by the people making bricks locally as well as in the surrounding villages.

The large-size mud bricks, 10 x 20 x 40 cm, were occasionally used for house foundations or platforms, and though there is some variation in the absolute brick measurements (e.g., 10 x 20 x 30 or 10 x 18 x 36 cm) and proportions, most have the ratio of 1:2:4. Divider walls and some of the upper structures were made of a smaller-size mud brick measuring approximately 7 x 12 x 24 cm to 7 x 14 x 28 cm (also 1:2:4 ratio).

Because of the limited exposure of Kot Diji Phase occupations at Harappa, it is not possible to get a full layout of houses, but they were generally oriented with the cardinal directions and situated along wide unpaved streets. On Mound AB, the north-south street measures approximately 5 meters wide. The house walls range in width from 7 cm, which is the width of one mud brick, to more than 1 meter wide for foundation or platform walls.

The long continuity in building orientation and brick sizes, from the Ravi through the Kot Diji Phase occupations, cannot be coincidental and must be linked to deeply held socioreligious beliefs associated with settlement organization. The orientation of houses according to the cardinal directions can be done using the morning and afternoon shadows cast by a stick placed in the center of a circle. More complex methods involve sighting on the stars or constellations that rise in the east or set in the west. The 'north star' at around 2300 BCE was a very dim star called Draconis, and it is unlikely that it was used for sighting during the prehistoric period (Parpola 1994). Astronomers calculate that the Pleiades would have arisen in approximately this same spot during each vernal equinox from 2720 to 1760 BCE, and this may have been the constellation used for orientating Early Harappan as well as Harappan buildings (ibid.).

Geometric button seals

While it is possible to speculate about the cosmological significance of building orientation and street layout, the discovery of geometric designs carved on bone or steatite button seals provides a more direct indication of specific ideologies related to space and organization. The earliest carved bone seal from the Ravi Phase is fragmentary but appears to represent one arm of the swastika motif that becomes widespread during the later Harappan Period. The swastika diagram can be interpreted as an effort to create order out of chaos. By dividing chaos into four quarters and turning it in the right direction, order, balance and progress are achieved. In later Hindu iconography, the swastika symbol is associated with Lakshmi, the goddess of wealth, and it is used as a good luck symbol to give wealth and success to the user.

Other geometric symbols found in the Kot Diji Phase occupations include circle and dot motifs, stars and stepped cross designs. All of these symbols can be associated with cosmic order and attempts by humans to give this order to their daily lives. Similar geometric seals have been found at Kot Diji Phase settlements throughout the greater Indus region, and the same designs also appear on painted pottery. The implication of these repeated patterns is the emergence of a repertoire of graphic symbols that appear to reflect a shared set of beliefs. Similar widespread use of images of

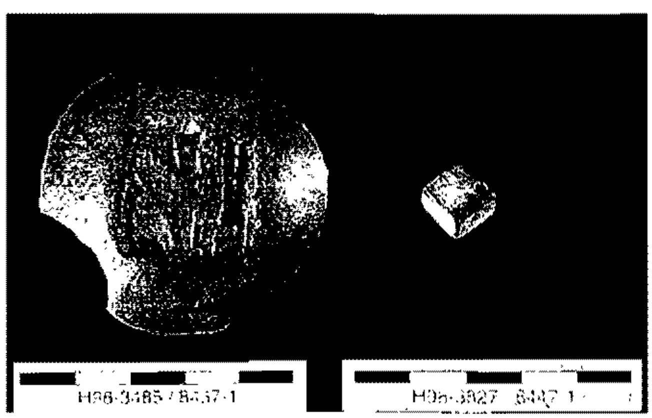

Figure 9.9. Cubical stone weight and seal impression: Kot Diji Period.

horned anthropomorphic deities and terracotta animal and human figurines also indicates shared ideology during the Early Harappan Period.

Cubical stone weights

Although the use of standardized brick sizes is a clear indication of a well-defined measurement system, the most important indicator of standardization is seen in the system of weights that first appears at Harappa during the Kot Diji Phase around 2800–2600 BCE. Two cubical stone weights have been found at Harappa, one from Mound AB (Trench 39 N) and the other from Mound E (NW corner, Trench 52). The stone weight from Mound AB was found stratigraphically associated with well-dated hearths (2800 to 2600 BCE) (Meadow and Kenoyer 2005) and with indicators of administrative control, such as geometric button seals, a clay sealing and a broken seal featuring an elephant. The weight was made from yellow limestone, measures 9.7 x 9.5 x 7.1 mm and weighs 1.7 grams. This weight belongs to the 'B' category or 2nd ratio of Indus weights as defined by Hemmy (Marshall 1931: 591, Table III) (see Table 9.3).

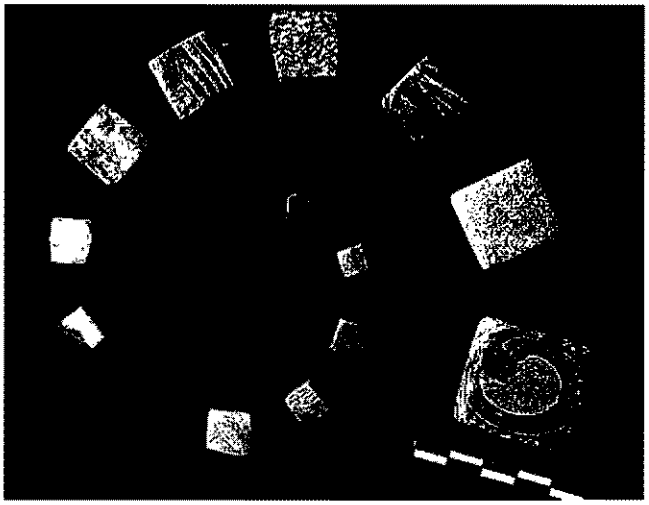

Figure 9.10. Cubical stone weights: Harappan Period.

The second cubical stone object has slightly rounded edges and one polished face and appears to have been a weight that was subsequently used as a hammerstone or pestle. This artefact was made of white quartzite and weighs 102.95 grams, which corresponds to the J category of Hemmy and the 160th ratio (see Table 9.3). The fact that one weight was found within the walled areas of Mound AB, and the other within the walled area of Mound E, suggests that both of the Early Harappan settlement sectors at Harappa were using the same basic weight standard. This pattern continues in the later Harappan Period, when weights of the same standard are found in all of the walled sectors of the site and at other Indus sites throughout the region.

Table 9.3. *Indus cubical weights from Harappa and Mohenjo-daro*

(New)		HARP	Vats	Mackay	HARP	Vats	Mackay
Designation	Ratio	Average weight	Average weight	Mohenjo-daro	No. of specimens	No. of specimens	Mohenjo-daro
(AAA)	1/3	0.30			2		
(AA)	2/3	0.60			1		
A	1	0.86	0.95	0.87	7	1	5
(A')	1 1/3	1.25			8		
B	2	1.78	1.66	1.77	13	12	13
Q	1/3 x 7	2.10			4		
C	1/3 x 8		2.66	2.28		4	2
D	4	3.52	3.50	3.43	12	20	31
E	8	6.61	6.83	6.83	8	27	45
F	16	13.86	13.67	13.73	10	28	91
(F')	18	15.50			1		
G	32	26.70	27.06	27.41	7	59	94
H	64	51.97	54.73	54.36	3	18	23
J	160	120.81	130.38	136.02	4	18	11
K	200			174.50			1
L	320	225.50		271.33	1	1	4
M	640			546.70			1
N	1,600			1,417.50			3

Many scholars have speculated on the origin of the Harappan weight system, and it is thought to have been derived from grains (Marshall 1931), such as wheat (0.048 grams) or barley (0.064 grams), or edible seeds, such as mustard or mung bean (*masha*). One poisonous seed that is widely referred to in ancient Indian texts on weights is the black and red seed (*gunja*) of the wild licorice plant (*Abrus precatorius*) (Marshall 1931; Mainkar 1984). This seed weighs between 0.109 and 0.113 grams and approximately 8 seeds would correspond to the 1st Indus weight ratio or 0.871 gram, as defined by Hemmy (Marshall 1931). Since the actual weight of these grains varies depending on where they are grown or the amount of water they receive, it is difficult to determine which of them was used to define the original Indus weight system. Regardless of what the base weight was, the system developed by the Early Harappans became widely adopted during the Harappan Period.

Harappa Phase measurement

Although the basic systems of measurement needed for the functioning of large towns had already been established in the Early Harappan Period, the pervasive use of these systems throughout the greater Indus region is only seen during the Harappan Period, from around 2600 to 1900 BCE. Contrary to views taken by many scholars, I do not feel that this adoption was rapid or explosive, but that it happened gradually, over the course of 200 or 250 years, between 2600 and 2450 BCE.

Harappan stone weights

The basic weight system that evolved during the Early Harappan Period became more refined and varied during the Harappan Phase. Extensive studies of weights at Mohenjo-daro, Harappa and Chanhu-daro have been summarized in the early excavation reports (Marshall 1931; Mackay 1938, 1943), but the excavations at Harappa have revealed the presence of several additional weight categories that were not reported previously (Table 9.3). Weights were used with matched scale pans, which were made of copper/bronze and occasionally of terracotta. Two sets of scale pans, along with a bronze cross-beam, a broken arrow-shaped pointer and a hook and chain, were discovered in 1996 in the course of conservation work on Mound F at Harappa (Nasir 2001). The scale pans were made in two sizes; one set is around 6 cm in diameter with three holes for hanging the plate evenly, and the larger set is around 63 cm in diameter. These sizes would be appropriate for the small and medium sizes of Indus weights but not the largest ones.

The first seven Indus weights double in size from 1:2:4:8:16:32:64. There are exceptions to this general pattern, with some anomalous categories such as the 8/3 ratio (approximately 2.28 grams). The most common weight is the 16th ratio, which is approximately 13.7 grams. At this point the weight increments change to a decimal system where the next largest weights have a ratio of 160, 200, 320, and 640. The next jump goes to 1,600, 3,200, 6,400, 8,000, and 12,800. The largest weight found at the site of Mohenjo-daro weighs 10,865 grams (approximately 25 pounds), which is almost 100,000 times the weight of the 'gunja' seed.

The new categories of weights found at Harappa have been designated using a modification of Hemmy's system. Categories AAA, AA and A′ and F′ conform to the earlier categories or represent slight variations (Table 9.3). Categories AAA (0.3 gram) and AA (0.6 gram) are quite small and they may have been missed by the earlier excavators because they did not screen all of the excavation areas. Categories A′ and F′ may simply be anomalies. A comparison of weights from different areas of Harappa itself indicates that all of the cubical weights from the entire Harappa Phase conform to one single system.

In addition to cubical weights, a new style of weight was introduced in the latest phase of the Harappan Period, Period 3C. These weights were generally made from agate or chalcedony and were truncated spheres, with two flat opposing surfaces to prevent them from rolling away. The truncated spherical weights generally conform to the same system as the cubical chert weights. Their shape variation may have had some ritual or cultural significance, but they are found in all the major mounds at Harappa, as well as at Mohenjo-daro (Mackay 1938), Chanhu-daro (Mackay 1943), Lothal (Rao 1979) and even the small site of Rojdi (Possehl and Raval 1989).

During the Harappan Phase cubical stone weights were predominantly made from a distinctive variety of banded chert obtained from the Rohri hills in Sindh. While some weights were made from agate, granite or other patterned stones, the chert varieties are the most widely distributed throughout the city and the Indus region in general. Distinctive manufacturing debris for cubical chert weights has been found in the agate bead making areas of the site. In addition, some perfectly spherical agate balls that may be unfinished weights of the second type have also been found in association with bead making areas. This pattern suggests that bead makers were also involved in the preparation of the highly standardized weights.

Most scholars assume that these weights were used for everyday market exchange, with the smaller weights being used for precious stones and metals, perfumes and valuable medicines. The larger weights are thought to have been used for grain or large quantities of goods. The fact that there are relatively few weights given the size of the cities and market areas suggests that this explanation is probably not valid. It is much more probable that the weights relate to taxation or tithing. The recent excavations at Harappa reveal that the highest concentration of weights is located in association with gateway areas or in craft production areas, where goods entering the city may have been weighed and taxed. Furthermore, many of the smaller sites such as Allahdino have only a single set of weights in the middle range of values, while only the largest sites such as Mohenjo-daro and Harappa have one or two extremely large weights.

Some scholars have proposed a different grouping of the weights by combining all the weights from Mohenjo-daro, Harappa, Chanhu-daro and Lothal and recalculating the averages (Mainkar 1984). This approach assumes that the entire system was centrally standardized and obscures the presence of regional variation. Ongoing studies suggest that each major city had its own internal system of weights that was highly standardized, with general comparability to weights used in other cities, but that there was a certain degree of regional variation. More precise measurements and the examination of weights to determine their condition (chipped or worn) need to be undertaken to investigate this theory fully.

Even if the weights are not absolutely standardized throughout the Indus region, there is a general standard that was followed by all the Indus settlements. One of the key questions that remain to be answered is who was responsible for maintaining the general standardization of the Indus weights over such a large area and for over 700 years. This standardization could not have been simply the result of a shared belief, but must have been rigorously maintained by people who were most concerned with the profits or benefits of using the weights. Rather than political or ideological elites, merchant communities and traders may have been the primary agents in maintaining weight standardization. This interpretation is supported by the fact that the use of cubical stone weights disappeared at the end of the Harappan Period, but the actual system of weights continued to be used during the Early Historical Period and is still used today throughout South Asia (Marshall 1931; Mainkar 1984). Other artefacts associated with Indus political authority as well as trade and ideologies are inscribed seals, many of which included animal symbols such as the 'unicorn' or other totemic animals. At the end of the Indus cities, the Indus script and the use of seals with the unicorn motif do disappear and never emerge again in the Early Historic Period.

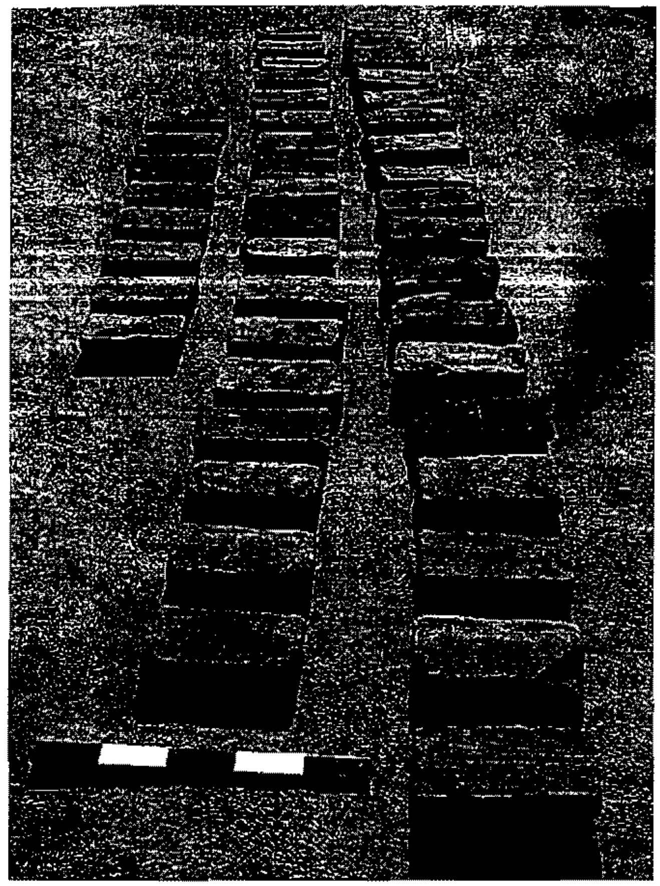

Figure 9.11. Harappan bricks.

Harappan linear measurements and brick sizes

On the basis of two rare discoveries of what have been referred to as scales, combined with careful analysis of architectural features, the earlier excavators calculated that there were two systems of linear measurement at use in the Indus cities, the foot (13.2 inches or 33.35 cm) and the cubit (20.8 inches or 52.83 cm) (Marshall 1931; Mackay 1938; Vats 1940). A fragmentary bonze rod (1.5 inches long) with incised lines found at Harappa is thought to have been a measuring tool, with four divisions that average 0.37 inch or 0.93 cm (Vats 1940: 365–366). An incised shell plaque from Mohenjo-daro had five divisions of 1.32 inches or 3.35 cm (Mackay 1938: 404–405). These measuring devices made of bronze and shell may have been prepared for some special occasion or elite consumer, but the average person living in these cities probably used other means of measurement.

One of the most common measurements in traditional South Asian culture is the width of the hand (four finger widths or *angula* – approximately 7 to 9 cm). Other measurements include various types of hand spans, the distance from the elbow to the tip of the finger (cubit), the foot, two feet, a pace, the distance between the tips of the fingers of both outstretched arms and the vertical distance from the feet to the tip of the hands stretched above the head. The hand measurement is perhaps the most relevant for understanding Harappan architecture, because it is basically the same as the thickness of a wet mud brick.

Experiments with mud brick manufacture show that the wet clay shrinks around 0.5 cm in thickness and width and up to 2 cm in overall length. If a mud brick is made with the width of the hand for thickness, and double that for width, and double that for length, one ends up with a brick that measures 8 x 16 x 32 cm. After drying, the brick will measure 7.5 x 15.5 x 30 cm, and when a brick is fired there is even more shrinkage. This system of measurement is the most likely explanation for the standardized brick shapes, and the proportions are evidence of a specific cultural choice that also has an optimal benefit for architectural constructions.

In the past, the uniformity of brick ratios was thought to represent the presence of a strong centralized government that enforced strict building codes, but this interpretation is no longer supported, though it still appears in much of the secondary literature. The brick ratios clearly reflect a style of technology (Lechtman 1977) that has its roots in the Early Harappan Period and was spread throughout the Indus region. Concepts of measurement and proportion were probably linked to rituals or ideology and passed down from one generation of builders to the next. Given the fact that the bricks are based on specific proportions it is not surprising that similar proportions are reflected in the rooms of houses, in the overall plan of houses and in the construction of large public buildings (Jansen 1991).

The continuities of mud brick from the Early Harappan to the Harappan Period are evidence of cultural continuity in terms of measurement systems, as well as cultural choice regarding overall brick proportions that are optimal for the construction of specific types of buildings.

Fired bricks

The most significant change between the Early Harappan and the Harappan Phase is the introduction of fired bricks. Although some excavators report the use of fired brick during the Early Harappan Period, for example, the construction of fired brick drains at Kalibangan (Lal 1979), most Early Harappan sites did not use this type of building material. Even at Harappa, fired bricks did not appear suddenly at 2600 BCE, but were introduced gradually for construction of drains and eventually buildings, after the beginning of Period 3A. The size of fired bricks corresponds to the smaller size of unfired mud bricks used for domestic architecture. The earliest fired bricks produced at Harappa measure around 7 x 14 x 28 cm (1:2:4 ratio). Unlike mud bricks, which tend to crumble if they are reused for later constructions, fired bricks and brick rubble can be reused repeatedly for hundreds of years. In fact, many modern houses in Harappa town have been constructed with ancient bricks looted from prehistoric buildings. This reuse of fired bricks has made it difficult to determine whether there were changes in brick size over time.

However, careful documentation of brick walls and rebuilt structures in the gateway area of Mound E and ET indicates that there may in fact be changes in absolute brick size over time. The earliest pristine structures in the gateway area date to around 2450 BCE (Period 3B) and were constructed with finely made bricks, measuring 7 x 14 x 28 cm. By the final phase of construction, circa 2000 to 1900 BCE (Period 3C), the walls were being made with relatively small bricks, measuring

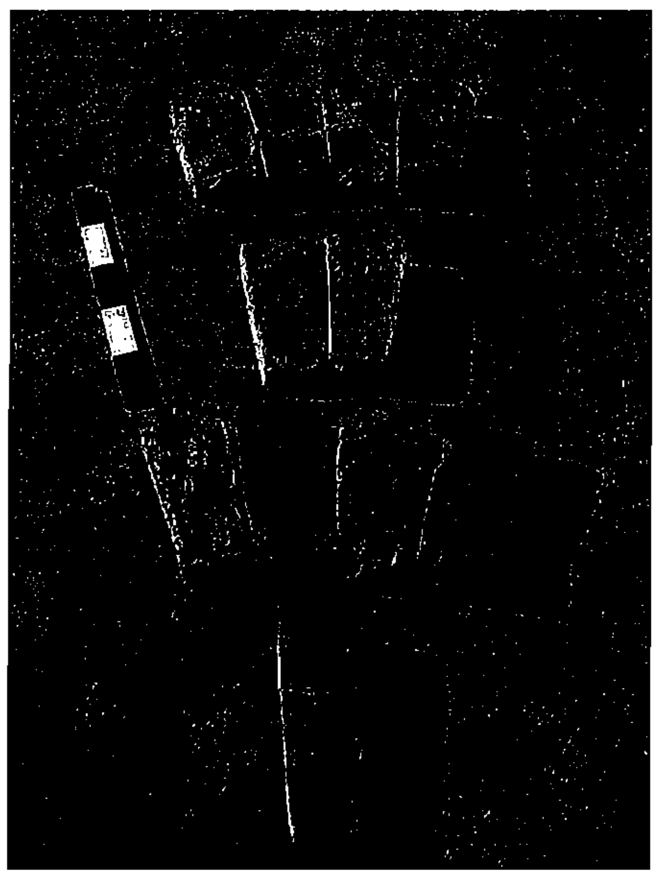

Figure 9.12. Harappan well bricks.

Figure 9.13. Harappa: Reconstruction of city walls and gateway, Mound E and ET. Painting by Chris Sloan.

around 5 x 12 x 24 cm. The overall ratio of the bricks remained the same, but the absolute measurements had changed.

Comparison of the absolute measurements of fired bricks is an ongoing project that requires more rigorous dating of structures and the periodization of the bricks, but preliminary studies indicate that there is variation in the absolute brick sizes between the major sites.

Well bricks

One new type of brick that was not found in the Early Harappan Period at Harappa is the wedge-shaped brick that was used to construct cylindrical wells. Although there are not many wells at the site, examples of wells along with different sizes of well bricks have been found on all of the major mounds. One well on Mound AB measured 1.2 meters internal diameter. The bricks were 26 cm long and 36 bricks were used to construct each course (Dales and Kenoyer 1989). One interesting feature of these bricks is the presence of two vertical lines on the outside edge of each brick. This suggests that all the bricks for this well were prepared on commission in order to fit together precisely. Other wells at Harappa range in diameter from 1 meter to as much as 2 meters, and the wedge-shaped bricks for each size of well have been prepared precisely to ensure a tight fit.

City walls and streets

During the Harappa Period, the massive city walls were made of large mud bricks (10 x 20 x 40 cm) faced with small fired bricks (7 x 14 x 28 cm). Although there is evidence of general city planning, the city walls were not standardized in terms of their orientation or size. The original layout of the city walls around each mound is impossible to determine because of the fact that they were rebuilt and repaired numerous times. However, in a few excavation areas, it was possible to cut through the wall and define what a portion of it looked like. On Mound E, the original Early Harappan city wall measures 2 meters wide and has been traced for over 15 meters. The subsequent rebuilding directly on top of the earlier wall was 2.5 meters wide, but the height of this wall is not known. The later Harappan city wall was offset to the east but was oriented along the same alignment, 10° west of true north. The earliest Harappan city wall was 2.5 meters wide and appears to have been built up against the Early Harappan mound as a revetment wall. The exterior of the wall is battered at a very small angle of 5°. Along the south side of Mound E, the city wall is freestanding and is 5.4 to 6.5 meters wide on either side of the southern gateway, but at the gateway the width increases to 8.0 to 8.4 meters. The gateway itself is relatively narrow, 2.8 meters wide, just enough for one ox cart to pass through, but the main street leading north into the center of the city is 5 meters wide, allowing for two-way cart traffic. This pattern of a narrow gateway and wider internal streets is also seen to the east, where a major gateway with an entrance of 2.6 meters was constructed at the edge of Mound E and ET (Figure 9.13).

Major streets transect the city from east to west and north to south as well as along the interior and exterior of the city walls. Most of these streets are 4 to 5 meters wide, though some are even wider. On the basis of these few examples it is evident that the layout of streets, gateways and walls of Harappa, and Indus cities in general, was based more on functional aspects of access and movement. Gateways were narrow to control access, while interior streets were wider to allow free flow of traffic and quick access to all major neighborhoods.

Conclusion

The preceding discussion has attempted to provide new data and interpretations on the nature of measurement in the Indus civilization, with specific reference to the site of Harappa. In contrast to many earlier generalizations about the rigorous standardization and state control, much of the standardization seen in various crafts and measurement systems is related to proportions rather than absolute measurements. Where there is a degree of standardization, as in the case of bricks or even of stone weights, it is possible that the basic measurements themselves are at the root of the standardization and not some type of overarching authoritarian political or economic force. The width of hands or the weight of specific types of grains would have been generally uniform throughout the greater Indus valley, and consequently the measures derived from them would have been relatively uniform. This explanation does not however negate the importance of a shared system of measurement between the major cities and the smaller rural sites. There clearly was some form of unifying ideology that ensured the continued use of a shared system of measurement and weights for over 700 years during the Harappan Period.

Future directions for research on Indus weights and measures need to focus on refining the chronology of the use of specific measures both within each site and at a regional level. A higher degree of precision may allow more concrete interpretations that could be linked to socioeconomic and political control by elites. What is even more important to note is that after around 1900 BCE, the use of cubical stone weights disappeared from the Late Harappan settlements, but the basic weight system used by the Indus cities reemerged during the Early Historic Period in the northern subcontinent during the second phase of urbanism, beginning around 600 BCE (Kenoyer 1997). Finally, in later historical periods in South Asia, there is evidence for minor changes in weight ratios and brick proportions that were established and maintained by the ruling elites as a means to control and benefit from regional exchange. The precise nature of this continuity between the Indus and Early Historic Period remains to be fully investigated using more precise studies of Early Historic and Historical Period weights recovered from archaeological excavations.

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