CHAPTER 7

STEATITE ACQUISITION NETWORKS

CHAPTER INTRODUCTION: "STEATITE CIVILIZATION"

Steatite – a rock composed primarily of the mineral *talc* (hydrous magnesium silicate) in its massive form, was undoubtedly a material of tremendous importance at Harappa. Artifacts made from it comprise nearly 40% of the site's rock and mineral assemblage. This soft (Mohs ≈ 1 – 2.5), easily carvable stone was not only used for the mass-production of common items, notably the ubiquitous wafer-like disc bead (Figure 7.1 A) and the almost impossibly small "micro-bead" (note the human hair on which the bead in Figure 7.1 B is strung), but also for the closely controlled creation of objects with significant political and/or economic value such as stamp seals (Figure 7.1 C) and inscribed tablets (Figure 7.1 D). Steatite artifacts of one kind or another have been reported from practically every excavated Indus Civilization site. It has been observed that the aforementioned beads are so common that their presence alone could almost be considered a marker of a settlement's "Harappan" character (Vidale 1989c). The archaeometrist and renowned bead scholar Horace Beck even went as far as to characterize Indus society as a "steatite civilization" (cited in Vidale 2000: 59).

In terms of addressing the lines of inquiry outlined in Chapter 1, there are few rocks or minerals in Harappa's assemblage that hold as much promise as steatite (for a view to the contrary see Asthana 1993: 274). Sources of the stone are found in every major region surrounding the Indus Basin (Figure 7.2). However, in comparison to some of the other widespread rock varieties examined for this study (such as the different types of grindingstone, limestone and alabaster), occurrences of steatite tend to be much more geographically circumscribed within the regions where they are found. Steatite provenience data may, therefore, allow us to more precisely identify the region or regions with which Harappans were interacting (either directly or indirectly) when acquiring this material (Question 1). Furthermore, at different times during its development and existence, the Indus Civilization bordered numerous potential steatite source areas (Law 2002) and, at Harappa, the raw material is present in abundance throughout site's chronological sequence. This material sub-assemblage is, therefore, particularly well suited for examining diachronic change in inter-regional interaction networks (Question 2). Finally, the production of steatite objects was an activity that took place in each of Harappa's major habitation areas. In contrast to chert artifacts during the site's urban phase (Period 3), raw steatite exhibits a great deal of visual variability, which *could* indicate that multiple sources were used. This makes steatite a potentially excellent material for detecting intra-site variations in source area access that may be evidence of competition between residents of different parts of the site through the control of essential resources (Question 3). It is for all of the above reasons that I placed a great deal emphasis on the investigation of this variety of stone while conducting research for this book.

This chapter is an account of my attempt to systematically identify the geologic sources from which residents of Harappa and certain other Indus Tradition peoples acquired steatite. It is presented in four sections. The first begins with a brief overview of steatite use in the Indus Tradition. I

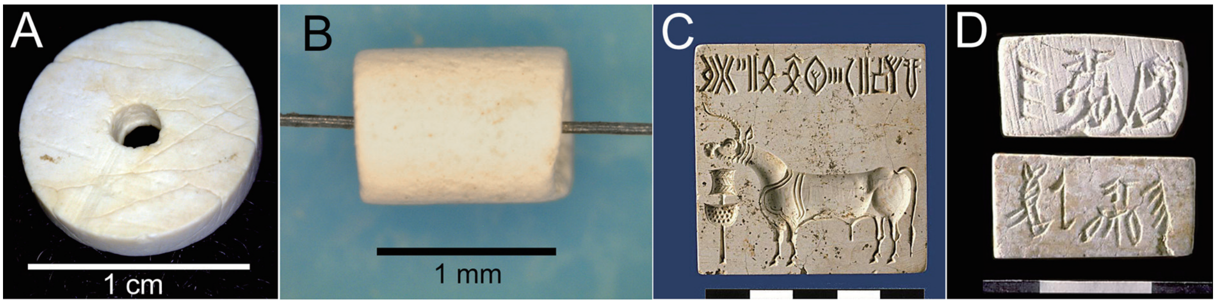


Figure 7.1 Various types of steatite artifacts from Harappa.
[A] Disc bead. **[B]** Micro-bead. **[C]** Stamp seal. **[D]** Inscribed tablets.

then provide details regarding this material sub-assemblage at Harappa and relate which samples from it were selected for geologic provenience analysis. I also provide details on steatite artifacts from eight additional archaeological sites – Mohenjo-daro, Nausharo, Mehrgarh, Mitathal, Gola Dhoro, Nagwada, Tepe Hissar and an unknown site in the Loralai district of northern Balochistan, which I was very fortunate to have been able to include in this study. In the second section of this chapter, I highlight certain aspects related to the petrogenesis of steatite that are important for understanding where deposits of the stone occur and are also necessary for evaluating the geochemical data produced in the analysis of artifacts and source material. I then provide a detailed, region-by-region review of steatite occurrences in the Greater Indus region. In the third section, I present the results of a geologic provenience analysis the steatite artifacts. One hundred forty-one artifacts from Harappa, along with 38 artifacts from the eight additional sites were analyzed using instrumental neutron activation analysis (INAA). These were compared, using canonical discriminant analysis (CDA) and cluster analysis (CA), to data from 442 geologic samples collected from 37 individual deposits of steatite from around the Greater Indus region. The analyses provided results that were, in many ways, surprising. The source composition of the steatite assemblage at Harappa was far less variable, both synchronically and diachronically, than anticipated. It also became apparent that Indus Tradition craftspeople were, in general, using raw material from a very specific kind of geologic deposit. In the fourth and final section, I provide a summary and discuss the implications of the provenience study results. I also argue that technological-aesthetic considerations (the need for stone that would become white when heat-treated), rather than proximity to sources, dictated which deposits Harappans acquired steatite from. All sites, regions and sources discussed in this chapter are identified on Figure 7.2.

STEATITE IN THE INDUS TRADITION

The first evidence for the use of steatite by Indus Tradition peoples goes back to the very earliest (ca. 7000 BC), pre-ceramic Neolithic levels (Period I) at Mehrgarh, where small cylindrical beads composed of black-colored steatite are present in an ornament assemblage predominantly made up of shell beads (Barthélémy de Saizieu and Bouquillon 1994: 47-48). The stone soon thereafter became the most abundantly utilized ornamental material at the site and it remained so throughout the long Neolithic/Chalcolithic sequence there and at nearby Nausharo (Barthélémy de Saizieu and Bouquillon 1997: Figure 1). During that time, there were numerous technological innovations involving steatite (documented in Barthélémy de Saizieu and Bouquillon 1994, 1997; Miller 1999; Vidale 1989a,

Figure 7.2 Sites, regions, and steatite deposits discussed in this chapter.

2000); the most important of which was the heat-treatment of the stone to increase its hardness and change its color to white (this process is discussed in detail in the final section of this chapter). Indus Civilization craftspeople inherited these innovations and themselves produced new ones. The recovery of "talc-coated clay dishes" at Harappa likely indicates that they had become aware of steatite's heat-resistant (refractory) properties (Miller 1999: 419-422). In addition to the beads, seals and tablets mentioned in the chapter introduction, steatite was used to create a wide range of other items such as amulets, pendants, cubical weights, inlays, miniature vessels, figurines and small statues (including the famous "Priest-King"). Horace Beck wrote (1934: 69) that the steatite objects produced by Indus Civilization craftspeople were remarkable "not only in their number and variety, but also in their extreme beauty and perfection of execution."

The steatite assemblage at Harappa and samples selected for this study

Roughly 22,000 steatite artifacts have been recovered at Harappa (precisely 21,872 have been tabulated to date but I say "roughly" because more are constantly being added to the total as large surface collections and micro-debitage samples are evaluated). About 80% of those are beads composed of heat-treated steatite or steatite-paste (Kenoyer 2005a: Table 2). The remaining 20% or so include all of the other items mentioned in the preceding section, unfinished objects (again mostly beads), manufacturing debris and pieces of unworked steatite. It is not necessary to provide a detailed breakdown of the spatial and temporal distribution of steatite artifacts at Harappa because, like chert artifacts, they are *everywhere*. They have been recovered (in abundance) in every excavation trench placed at the site and from secure contexts representing each of its chronological phases and sub-phases. This is not to say that the assemblage is completely uniform across time and space. The production of glazed steatite button seals, for instance, does not begin until Period 2 (Meadow and Kenoyer 2001) while incised steatite tablets do not appear until the middle of Period 3B (Meadow and Kenoyer 2000). Also, there is evidence that seals and tablets were only made and used in certain parts of the site (ibid.; Kenoyer 1992a). New styles of steatite beads emerged over time as new technologies were developed (Kenoyer 2005a). However, as a material variety, steatite was, in every sense of the word, *ubiquitous* at Harappa.

Out of the 22,000 steatite artifacts at Harappa, only around 3,000 (again roughly) have not been heat-treated. In the section on steatite in Chapter 4, I discussed the physical changes that result when stone of this variety is heated and I further elaborate on that process in the concluding section of this chapter. Although much less abundant, unheated (I will use the terms "unfired" and "raw" as well) steatite artifacts have also been recovered from each phase and in every part of the site (Figure 7.3). It is this

Figure 7.3 Spatial and temporal distribution of 2990 unfired steatite artifacts at Harappa.

Mound ↓ / *Period* →	*1*	*2*	*3A*	*3B*	*3C*	*4/5*	*surface & disturbed*	*total*
F	.	.	.	13	63	.	20	*96*
AB	160	63	264	31	44	6	86	*654*
E	.	8	184	71	201	.	197	*661*
ET	.	.	.	13	979	.	453	*1445*
cemetery & off mound	.	.	.	4	103	.	27	*134*
total	*160*	*71*	*448*	*132*	*1390*	*6*	*783*	***2990***

Type A. Grayish yellow (5Y 8/4) to Yellowish gray (5Y 7/2) to Brownish gray (5YR 4/1)

Type B. Grayish black (N2) to Black (N1) with Yellowish gray (5Y 7/2) patches

Type C. Light olive gray (5Y 5/2), sometimes with olive black (5Y 2/1) patches and swirls

Type D. Moderate brown (5Y 3/4) to Dark yellow brown (10YR 4/2)

Type E. Black (N1)

Type F. Med. Light gray (N6) to light gray (N7)

Type G. Dark reddish brown (10R 3/4) to Very dark red (5R 2/6)

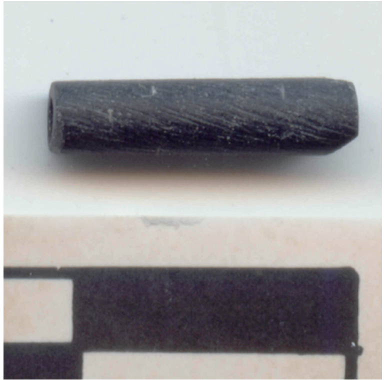
Figure 7.4 Seven main macroscopic types of raw steatite at Harappa (descriptions made using a Munsell Rock-Color Chart).

sub-assemblage that is best suited to be the subject of geologic provenience investigations as the original mineralogical structures of the artifacts in it are unmodified by heat.

It is clear from even a cursory inspection of the sub-assemblage of unfired steatite artifacts at Harappa that there are multiple, macroscopically distinct kinds of material within it. Massimo Vidale has speculated (2000: 56) that such variability (caused by secondary minerals in the rock) may be indicative of materials from different geologic deposits. Moffat and Buttler found (1986: 114) that visual comparisons of artifacts made from raw steatite to geologic samples was more effective (at least in their study area) than INAA in efforts to identify possible sources. For these reasons, it was deemed practical to create a macroscopic typology for unfired steatite at Harappa. This was undertaken using a Munsell Rock-Color Chart (Rock-Color Chart Committee 1995). Seven main macroscopic "types" of steatite were defined (Figure 7.4) after examining around 300 unfired steatite artifacts (roughly 10% of that material sub-assemblage) from surface collections and from secure contexts ranging from periods 1 through 5. As will most such typologies, the categories I created are highly subjective. They could be lumped together or split in any number of other ways. For instance, Type B might simply be an intermediate form between types E and A. Type G could be divided into several types as artifacts classified as belonging to it range from a dull muddy red brown to a deep red. Be that as it may, I would argue that these seven "types" represent very well the main visual variations exhibited by the raw steatite used at Harappa. Whether or not each is actually indicative of steatite from a different geologic source is something that was unclear when I created the typology, however. Although I examined only a portion of the sub-assemblage, there did not *seem* to be any temporal or spatial patterning in the distribution of the "types" that might suggest Harappans in different periods or parts of the sites used only certain "sources" (all types are represented on each mound and most types are present in each phase). Later, while conducting geologic field studies, I came to realize that the macroscopic appearance

Figure 7.5 Special unfired steatite artifacts from Harappa analyzed for this study.

A. Three views of a broken, unfinished seal (H96/7257-46). Front (left image), sawn edge (middle), broken side (right)

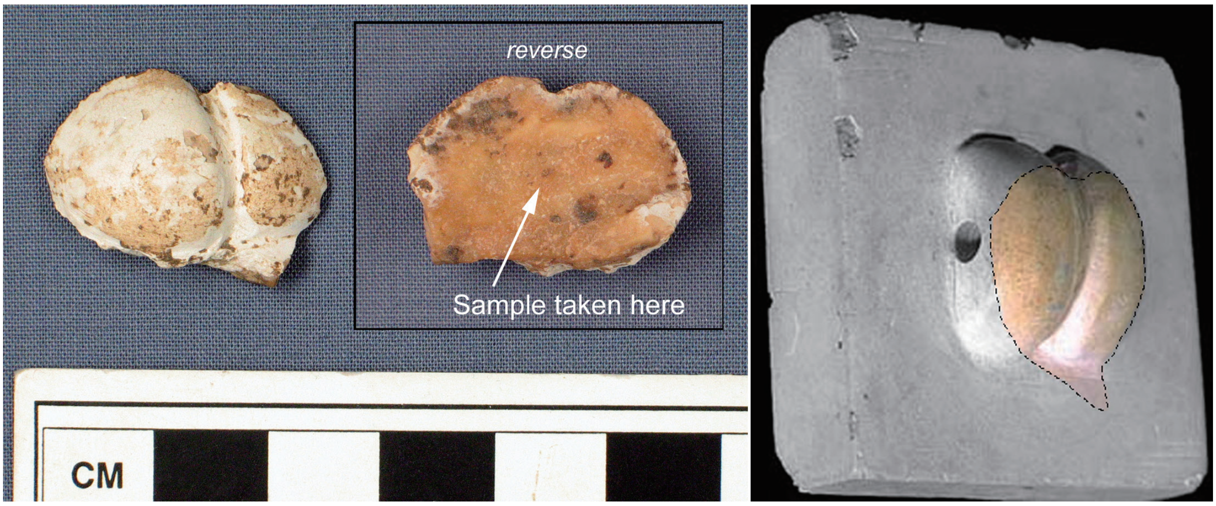


B. Cylindrical bead from Tr. 39, Mound AB (H96-7467-658)

C. Disc bead blanks, Tr. 54, Mound E (H2000-2301-176)

D. Disc bead blanks, Tr. 54, Mound E (H2000-2301-177)

E. Black wig (H98/8668-2) from Tr. 43, Mound F, Period 3C



F. Left - Front and reverse of a broken seal boss, Tr. 59, Mound E (H90/3208-68). Right - A reconstruction of the appearance of the boss prior to it breaking.

of steatite can be highly variable within a single deposit and even in an individual hand sample. It was becoming apparent that my typology might not end up having much utility in terms identifying the source of this type of stone. Still, I also observed that there are some highly distinctive and *recognizable* steatite varieties around the Greater Indus region (such as certain sub-varieties from the Las Bela area of Balochistan, which I have been able to identify on sight in jeweler's cases from Karachi to Rawalpindi).

I have, therefore, included the typology here and, later in the chapter, will be examining how it holds up against geologic provenience determinations made using INAA.

When selecting artifacts from Harappa's unfired steatite assemblage for geologic provenience studies, I tried to mainly choose from among the 700 or so fragments of *unmodified* stone recovered at the site; the reasons being, 1) I wanted to avoid subjecting any finished or semi-finished artifacts for destructive INAA whenever possible and, 2) I did not wish to damage any worked surface on examples of manufacturing debris. The study of saw marks on the latter artifact type has already provided valuable insights into the changing technological capabilities of Harappan beadmakers (Kenoyer 1997b). In the around three dozen instances when I did sample manufacturing debris (this was almost always when it was the only kind of raw steatite artifact available from a particular location and/or chronological context) great care was taken to avoid damaging any worked surface. In the end, 135 unmodified fragments or pieces of debris were sampled for this study.

In spite of my hesitation to sample finished or semi-finished objects, there were a few times when I could not pass on an opportunity to analyze a special artifact (Figure 7.5). The first of these is what appears to be an unfinished steatite stamp seal (H96/7257-46) that broke during the manufacturing process (Figure 7.5 A). It was recovered from a street deposit exposed in Trench 37 on Mound F and dates to Period 3B. The face of the seal had not yet been carved and there were still saw marks on its exterior edge. Using a drill with a fine tungsten carbide bit, I took a sample for analysis from the broken side of the seal.

I also analyzed a small cylindrical bead made of black steatite (Figure 7.5 B). This artifact (H96/7467-658) was recovered from a disturbed deposit in Trench 39 on Mound AB that contained mix debris from Period 2 and later levels.

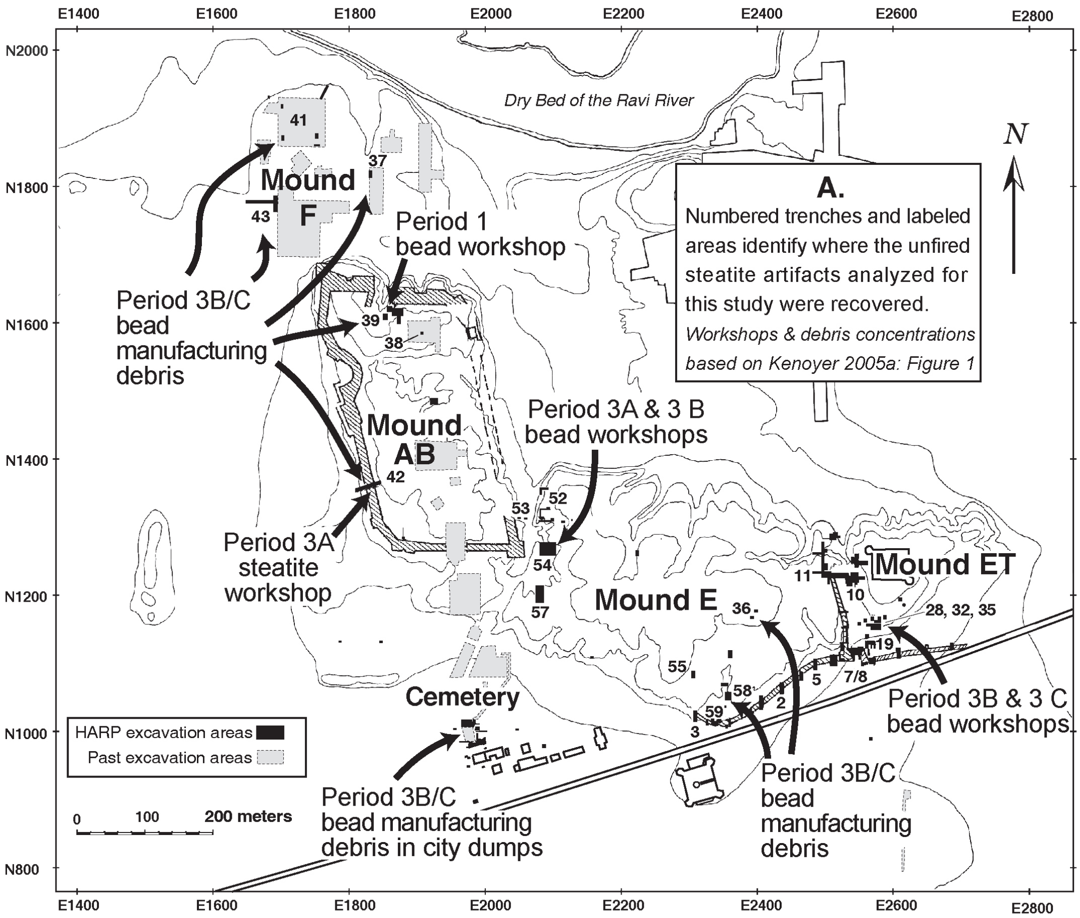
During the 2000 HARP field season, 177 tiny steatite bead blanks were recovered in an ashy debris layer in Trench 54 on the west side of Mound E (Meadow *et al* 2001: 14). They date to Period 3A and were likely dumped from one of the many workshops found in that area. It was quite exciting for me to analyze these particular artifacts as I was involved in the painstaking excavation and mapping of them. The bead blanks are composed of a steatite that is varying shades of grayish-yellow (Type B). A darker example (Figure 7.5 C) and a lighter example (Figure 7.5 D) were selected for analysis (H2000/2301-176 & 177).

A black steatite wig (H98/8668-2) that was likely part of small composite statue (the wig sits on a display bust in Figure 7.5 E) was recovered from later Period 3C levels in Trench 43 on Mound F. This artifact is identical to ones associated with the Bactria-Margiana Archaeological Complex (BMAC) of southern Central Asia and its recovery was an important new piece of evidence for Harappan interaction with peoples from that region (Meadow 2002). A tiny spur of material protruded from an area on the interior surface of wig, which Dr. Mark Kenoyer was able to carefully remove for analysis.

The final special artifact that I sampled was a portion (H90/3208-68) of a steatite seal *boss* (the perforated knob that is found on the reverse sides of most stamp seals) that had been recovered in Period 3C levels of Trench 59 on the southern side of Mound E (Figure 7.5 F *left*). Sometime prior to being excavated, probably during the Harappan Period, it broke from the seal to which it was originally a part of (see Figure 7.5 F *right* for a reconstruction what it probably looked like prior to breaking off) and the yellowish unfired or "raw" steatite that the seal was carved from is visible on the broken reverse side of the boss. A small sample of this unfired material was removed for analysis.

In the end, 141 unfired steatite artifacts recovered from Harappa were selected for geologic provenience analysis using INAA. Contextual and macroscopic type information for all artifacts in the set is

Figure 7.6 Distribution of the unfired steatite artifacts from Harappa analyzed for this study.



B: Spatial and temporal distribution of the141 unfired steatite artifacts analyzed for this study.

Mound ↓ / *Period →*	***1***	***2***	***3A***	***3B***	***3C***	***4/5***	***surface & disturbed***	***total***
F	*not present*	*not present*	*not present*	2	13	*none available*	*not sampled*	*15*
AB	2	17	21	11	2	2	3	*58*
E	*none available*	1	2	7	16	*none available*	12	*38*
ET	*not present*	*not present*	*not present*	1	19	*not sampled*	4	*24*
cemetery & off mound	*n/a*	*n/a*	*n/a*	*n/a*	4	*n/a*	2	*6*
total sampled	*2*	*18*	*23*	*21*	*54*	*2*	*21*	***141***
percent of total assemblage (see Figure 7.3)	1.25%	25.35%	5.13%	15.91%	3.88%	33.33%	2.68%	**4.71%**

listed in Appendix 7.1. Their spatial and temporal distributions are detailed in Figure 7.6. Although no formal strategy was employed in the selection process, an effort was made to assemble a set of samples that was representative of both the contexts where unfired steatite artifacts are found (which is to say all parts of the site and all of its chronological phases) and of the raw material itself (i.e., the seven main macroscopic "types"). I believe the effort was successful. Compare figures 7.3 and 7.6 B. Although the sampling of Period 2 was a bit heavy at the expense of Period 1, the temporal distribution of the set roughly mirrors that of the sub-assemblage. Likewise, the synchronic spatial distribution of the samples and the sub-assemblage correspond reasonably well with one another. In the set, there are 53 examples of Type A steatite, which is the most abundant type at the site and there are six examples of Type G, which is the rarest. The amounts of the other types fall in between, once again, much as they do in the assemblage.

Overall, the 141 artifacts selected for analysis represent a 4.71% sample of the unfired steatite sub-assemblage at Harappa. Importantly, many of the artifacts were recovered from contexts within or adjacent to bead workshops identified by the HARP. Most of the rest, although not clearly linked to workshops, were found among heavy concentrations of bead-making debris. These associations (see Kenoyer 2005a: Figure 1 and Figure 7.6 A above) strengthen our ability to use such artifacts to investigate questions regarding the control of resources and production by residents of different areas of the site.

Steatite samples from other prehistoric sites

I was fortunate to have been able to supplement the archaeological dataset with 38 unfired (or partially fired) steatite artifacts from eight other prehistoric sites in India, Pakistan and Iran (Figure 7.7). The inclusion of these samples has provided a more holistic picture of steatite acquisition networks in the Greater Indus region as well as a glimpse into what types of steatite people were using in areas sometimes far removed from Harappa.

Fifteen unfired steatite fragments (Figure 7.7 A) from the Indus city of Mohenjo-daro in Sindh were provided by Massimo Vidale (l'Istituto Italiano per l'Africa e l'Oriente [IsIAO], Rome) and Ghulam Mustafa Shar (Department of Archaeology, Shah Abdul Latif University, Khairpur). Both scholars have conducted extensive research at that site and jointly published an ethnoarchaeological study of steatite working in Balochistan and Sindh (Vidale and Shar 1990). All samples are surface finds collected during the mapping of craft activity areas. Although from non-secure contexts, they almost assuredly date to the site's Harappa Phase occupation (probably from the latter part of that phase). Samples MD-S7 through MD-S11 (Figure 7.7 A *middle row*) were recovered among various kinds of lapidary craft debris in the "Moneer" Area (Vidale 1987a, 1990). All others come from steatite-working areas discovered on the western side of area DK-A (Vidale 1987b, 1989c).

In the research collections of the Centre de Recherches Archéologiques Indus-Balochistan, Asie Centrale et Orientale at the Musée Guimet, Paris, there are a numerous steatite artifacts from the Neolithic/Chalcolithic settlement of Mehrgarh and the nearby (6 km southwest of Mehrgarh) Indus Civilization town of Nausharo. The sites are located at the foot of the Bolan Pass – a major route connecting the Indus Valley to the central Balochistan highlands and beyond to the Helmand Basin. Dr. Jean-François Jarrige, who directed excavations at both sites, graciously provided me with a set of unfired steatite artifacts for this study (Figure 7.7 B). The first seven of the 13 samples from Mehrgarh are black steatite bead roughouts (MR-s1 through MR-s3) and debris fragments (MR-s4 through MR-s7) recovered from a workshop (atelier) in area MR4 that dates to the early Chalcolithic Period (Mehrgarh IIB – ca. 5000 BC) (Jarrige 1981: 99). These artifacts and several

Figure 7.7 Unfired steatite artifacts from other sites analyzed for this study.

A. Fragments from Mohenjo-daro (MD)

B. Artifacts from Mehrgarh (MR) and Nausharo (NS)

C. Sawn steatite from an unknown site in Loralai (LOR-s1)

D. Black steatite beads from an unknown site in Loralai (LOR-s2)

E. Steatite fragment from Nagwada (NGW-s1)

F. Two views of a broken unicorn seal from Gola Dhoro (GD-s1).

G. Sawn steatite fragments from Tepe Hissar (TH)

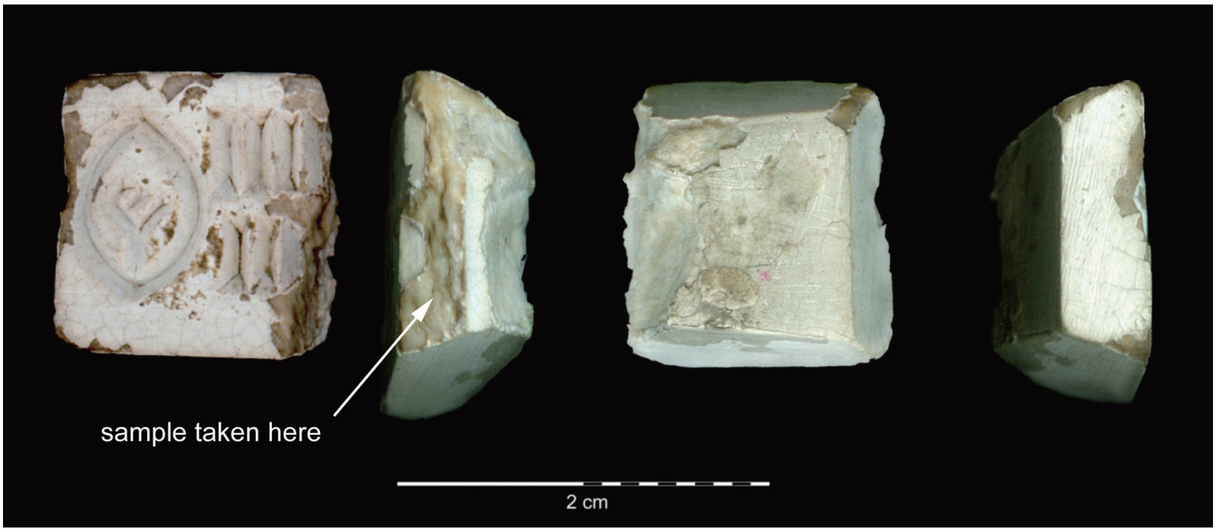


Figure 7.8 A steatite seal fragment from the site of Mitathal, Bhiwani District, Haryana.

hundred more like them from the same deposit were the subject of studies aimed at reconstructing the steatite bead manufacturing process (Vanzetti and Vidale 1994; Vidale 1995). The remaining six samples from Mehrgarh include a debris fragment (MR-s8) and several small red, green and black steatite beads or bead fragments (MR-s9 through MR-s13) from Period I levels (ca. 7000 – 5500 BC). A single broken bead (NS-s1) from Nausharo rounds out the sample set. It is composed of a bright red steatite and dates to Nausharo Period III, which is roughly equivalent to Period 3B at Harappa.

In March of 2001, I met with Mr. Syed Ghani – an Assistant-Director at the Geology Survey of Pakistan-Quetta, in order to discuss the geology of the Loralai District of northern Balochistan, which was his research area as well as his native place. At that meeting, he showed me a box containing stone artifacts given to him by the local people of that area. Among the mostly chert blades were two kinds of steatite artifacts – a red steatite fragment that had been sawed on one end (Figure 7.7 C) and a group of tiny black steatite beads (Figure 7.7 D). He said he believed the artifacts were from a mound in the Loralai Valley but he could not tell me its name or precisely where it was. Having seen many artifacts like these before, I felt fairly certain that both were from the prehistoric period. The fragment, in particular, caught my attention. Although somewhat reminiscent of Type G steatite at Harappa, the patterning and unusually deep red color of the stone appeared to me to be identical to a material used to make a number of the stamp seals at Mohenjo-daro. Compare Figure 7.7 C to, for example, the seal pictured on the cover of Asko Parpola's book *Deciphering the Indus Script* (1994). Mr. Ghani kindly allowed me to remove a small piece from the sawn fragment and select a few of the black beads for this analysis.

Dr. Kuldeep Bhan (Department of Archaeology, Maharaja Sayajirao University, Baroda) provided two samples for this study from Indus Civilization settlements located in Gujarat. The first was a piece of light-green steatite (Figure 7.7 E) removed (by Dr. Bhan) from a large chunk of unworked material (Hegde *et al* 1990: 193; Sonawane 1992: 165) recovered in Harappan Period levels at the site of Nagwada, which is located on the western edge of the North Gujarat Plain. The second was a sample taken directly from a unicorn stamp seal discovered at Gola Dhoro (also known Bagasra) in the northern part of the Saurashtra Peninsula (Bhan *et al*. 2004). The seal (Figure 7.7 F *left*), which was one of five discovered at that very small (≈ 2 ha) walled settlement, had been broken in antiquity and a zone of raw, greenish-grey steatite was exposed in its unfired interior (Figure 7.7 F *right*). Dr. Bhan was able to remove a small sliver of material from that area for analysis.

Also included in this study were four pieces of sawn steatite (Figure 7.7 G) collected (and again kindly provided) by Dr. Massimo Vidale from the surface of the Bronze Age site of Tepe Hissar (Schmidt 1937) in northern Iran (not shown on Figure 7.2). Numerous craft activities, including steatite working, have been documented at this site (Bulgarelli 1979; Tosi 1989), which exhibits limited evidence of long-distance contact with the Greater Indus region (Chakrabarti 1990: 7-8; Heskel 1984). Analysis of the fragments provides a way to compare Harappan steatite to raw material that was (presumably) acquired from geologic sources in that distant region (over 2000 km northwest of Harappa).

Lastly, a sample of unfired steatite was taken from the broken section of a rectangular seal fragment (Figure 7.8) recovered during a recent surface reconnaissance (Prabhakar *et al.* 2010) at the site of Mitathal, Bhiwani District, Haryana. Seals of this shape date to the later part of the Harappan Period, which is the equivalent of Period 3C and Harappa (ca. 2200 to 1900 BC).

Now that I have presented the set of 179 (141 from Harappa and 38 from elsewhere) archaeological steatite samples assembled for this provenience study, the next step is to outline and discuss the geologic sources to which they are (and are not) be compared.

IDENTIFYING POTENTIAL STEATITE SOURCES FOR INDUS TRADITION PEOPLES

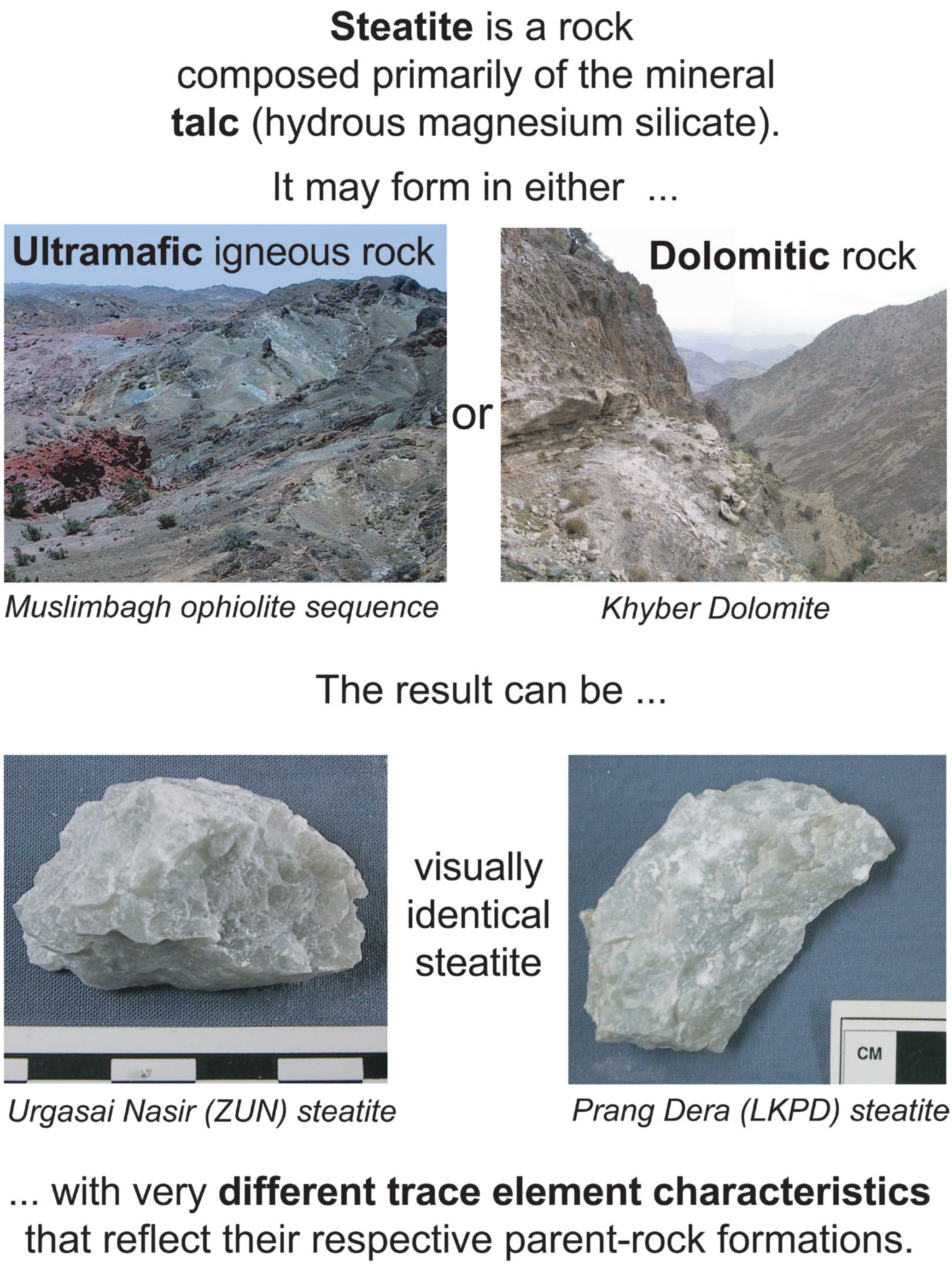
Dr. Mark Kenoyer has argued that "one important factor in the development and expansion of Indus trade networks is that many essential raw materials needed by the Indus cities were available in more than one locality" (Kenoyer 1998: 91). With regard to steatite – a raw material which the need for and the trade in was evidently "continuous and massive" (Vidale 2000: 58) – craftspeople and consumers at Indus cities would have quite possibly depended on having access to stone from multiple sources. Beginning with Sir Edwin Pascoe, who wrote the chapter entitled "Minerals and Metals" (Pascoe 1931) for the first Mohenjo-daro site report (Marshall 1931b), there has been a great deal of speculation by researchers about exactly where those sources might have been located (Asthana 1993: 274; Biwas 1996: 47; Fentress 1976: 306; Kenoyer 1998: 93; Lahiri 1992; Law 2002; Ratnagar 2004: 166-167; Shaikh 1987: 72; Thapar 1993: 11; Vidale 2000: 58). Some of the more recent speculation is well informed while some is merely a rehash of what Pascoe wrote 75 years ago. For this study, it was crucial to have an accurate and comprehensive knowledge of where steatite was available to Harappans in the Greater Indus region and to obtain samples for provenience analyses from as many of those sources as possible.

In this section, I first discuss the petrogenesis of steatite. This is helpful not only for understanding where deposits of this stone tend to be found but is it also necessary for evaluating the results of the geologic provenience analysis presented in the section that follows this one. I then say a brief word about the sampling of the steatite sources for this study. The bulk of this section is devoted to detailing where steatite *of the quality* that Harappans used occurs in the Greater Indus region and, importantly, where it does not.

Steatite petrogenesis

Steatite is called *soapstone* or *potstone* in the West and *zahr muhra*, *silkhari* or *ghia pattr* in South Asia. Some archaeologists (especially those working Arabia, Iran and West Asia) prefer to use the term "softstone" for steatite, chlorite, serpentine and other carvable rocks with a low Mohs hardness. This

Figure 7.9 A summary of the petrogenesis and character of steatite.



is understandable; particularly with regard to the materials just mentioned as they can closely resemble one another and, in certain geologic settings, co-occur in the same stone. However, I have avoided using the term here because it is simply too vague. Steatite is a rock composed predominantly of talc. XRD analyses (Appendix 4.1) have clearly shown that this is the variety of stone Harappans were using.

The mineral talc ($Mg_3Si_4O_{10}(OH)_2$) forms when magnesium-rich rocks are altered by low-grade stress, heat or hydrothermal action (Deer *et al.*1992: 330). "Talcose" rocks thus tend to occur at or near tectonic plate boundaries, in ophiolite zones (areas where plate tectonics have uplifted and emplaced large fragments of oceanic crust onto a continental landmass) or other areas where metamorphic processes have acted upon a suitable parent-rock. There are <u>two kinds of parent-rocks</u> suitable for the formation of talc. The first are *ultramafic* (high magnesium - low silica) igneous rocks. These include (but are not limited to) peridotites, dunites, pyroxenes and serpentinites, which are common in oceanic crust and, thus, the reason why steatite bodies sometimes develop in ophiolites. The second kind are calcareous sedimentary rocks (usually limestones but also some mudstones) that have had their calcite ($CaCO_3$) component converted to calcium magnesium carbonate ($CaMg(CO_3)_2$) in a process called *dolomitization* (Blatt 1992: 312). *Dolomite*, *dolostone*, *dolomitic limestone* and *magnesium limestone* are all terms used to refer to this type of rock.

Owing to its diverse geologic origins, steatite may contain, in addition to talc, any number of a wide variety of accessory minerals. Using XRD, Vidale and Bianchetti (1997) identified *dolomite* and *quartz* in steatite samples from Harappa (as did I – see appendices 4.1, 4.2 B and 4.2 C), *calcite* in a sample from Mehrgarh and *magnetite* and *clinochrysotile* in samples obtained from a modern craftsman. Barthélémy de Saizieu and Bouquillon (1994: 51) detected *anthophyllite* in steatite beads from Mehrgarh. Chlorite, serpentine and chromite are other accessory minerals that may be found in steatite. Vidale expressed (2000: 59) hope that XRD could be used to address questions of provenience by identifying mineralogical sub-groups within the steatite found at Indus sites and, to a certain extent, it can. Steatite containing dolomite is clearly of dolomitic origin. Magnetite is an extremely common constituent of igneous rocks (particularly serpentinezed peridotites and dunites) and, when detected, probably indicates steatite of ultramafic origin. With such knowledge one can focus on or exclude certain types of geologic formations as potential sources (e.g., there no need to go looking in ophiolites for the sources of steatite containing dolomite as an accessory mineral). However, XRD, at best, can really only take you that far. Accessory minerals are often present in amounts too low to be detected by XRD (note that only talc was detected in 20 of the 29 X-rayed samples from Harappa – Appendix 4.1).

Chemically pure talc is white. It is accessory minerals (detectable by XRD or otherwise) in the stone that provide steatite with its highly variable range of colors and patterns (recall Figure 7.4). Visual appearance could conceivably help to identify steatite artifacts from specific sources, provided that it is distinctive enough. For instance, among the modern samples that Vidale and Bianchetti analyzed (1997) was green steatite with prominent black spots. Vidale obtained this sample from a craftsman in Khairpur who himself had acquired it at the shrine of Shah Noorani in southern Balochistan (Vidale and Shar 1990). The stone actually occurs in the nearby Las Bela ophiolite (discussed below). In my experience, no other steatite with the exact same visual characteristics can be found elsewhere the Greater Indus region. It is used to make distinctive pendants and rosaries that are traded widely throughout Pakistan. Wherever I have encountered such stone in the *kabat* (portable display case) of a *johri* (professional stone seller), it was always attributed to Shah Noorani. Most steatite is not as visually distinctive as this, however. Moreover, the appearance of material within a single deposit can be highly variable. I have visited many deposits that contain stone resembling most of the macroscopic types present at Harappa. Also, the kind of parent-rock that steatite forms in does not necessarily endow it with a certain range of colors or patterns. I have collected samples from deposits of both dolomitic and ultramafic origin that, macroscopically, are indistinguishably from one another.

Ultimately, it is studies focusing on trace elements in steatite artifacts, rather than on mineralogy or visual appearance, that hold the most promise for determining their geologic provenience. Ultramafic rocks contain high concentrations of transition metals like chromium, cobalt and nickel (Dann 1988: 23). Truncer and others (1998) found that steatite deposits of ultramafic parentage could be differentiated using this class of elements. Dolomitic limestones have lower concentrations of transition metals and often exhibit unique rare-earth element (REE) characteristics (Miura and Kawabe 2000). This may allow dolomitic steatite deposits to be differentiated from ultramafic ones and from one another.

Figure 7.8 is a graphical summary of the main points of this section.

Sampling geologic sources

The geologic literature for South Asia contains references to hundreds of steatite deposits in the highlands adjoining the Indus Basin (in reality, of course, there are likely thousands). Obtaining a reasonable sample of the range of sources that were potentially available to Harappans may seem like an impossible task because of this. However, steatite in South Asia is unevenly distributed. The lion's shares of reported occurrences are in Rajasthan, in particular, southern Rajasthan. There are only, perhaps, four dozen or so *recorded* deposits elsewhere in the Greater Indus region. My regional sampling strategy was, thus, fairly straightforward – collect samples from as many recorded deposits in Pakistan, northern India and Gujarat as I could possibly to get to (and hopefully locate some unrecorded ones in the process) and then selectively sample occurrences in Rajasthan.

The sampling of an individual steatite occurrence typically involved walking along a zone of mineralization or across the breadth of a quarry and collecting the full range of the macroscopic types of *Harappan-quality* material present there. Steatite used by Harappans was, regardless of its color, patterning or mineralogy, almost always a very compact, physically homogenous stone. Materials from many of the deposits reported throughout the Greater Indus region, although perfectly suitable for modern industrial uses (Chatterjee 1978), would not have passed muster with Harappan seal-carvers or bead-makers because they were too impure (making them difficult to carve and saw) and/or their structure was too foliated (causing them to flake or split during manufacture or use). Not all of the nearly 60 locations I visited for this study contained Harappan-quality steatite. In the end, suitable samples from 37 different sources (18 in Rajasthan and 19 from elsewhere) were obtained.

Steatite occurrences of the Greater Indus region

Before we begin the overview of steatite occurrences, please refer to the map of the Greater Indus region found near the start of this chapter (Figure 7.2). Marked on it are the geologic sources and archaeological sites that are discussed in this section. Labeled ellipses indicate areas where multiple deposits were sampled. Detail maps (figures 7.10, 7.15 and 7.22 A to D) for those areas are provided throughout this section. Note that different types of symbols mark the sources and sites shown on the various figures. These maps and the symbols on them serve as the keys for the scatterplots used in next section of this chapter. On some maps deposits are labeled with a two-to-four letter source code. The full source names for those codes is provided in text but can also be found in Appendix 7.2, along with other locational (region, district/agency, geographic coordinates) and geologic (parent-rock type) information pertaining to the steatite sources sampled for this study. Marked with blue circles and/or labeled in blue are locations or regions that I discuss, but for which steatite samples were not analyzed. The reason for this was either 1) I was unable to visit the area; 2) the steatite at the location was of a very low-grade and not at all of the quality that Harappans used; or 3) steatite did not actually occur there as reported.

Refer again to Figure 7.2. We begin this overview in southern Balochistan and then move clockwise around the highlands surrounding the Indus Basin – first going through northern Balochistan and then

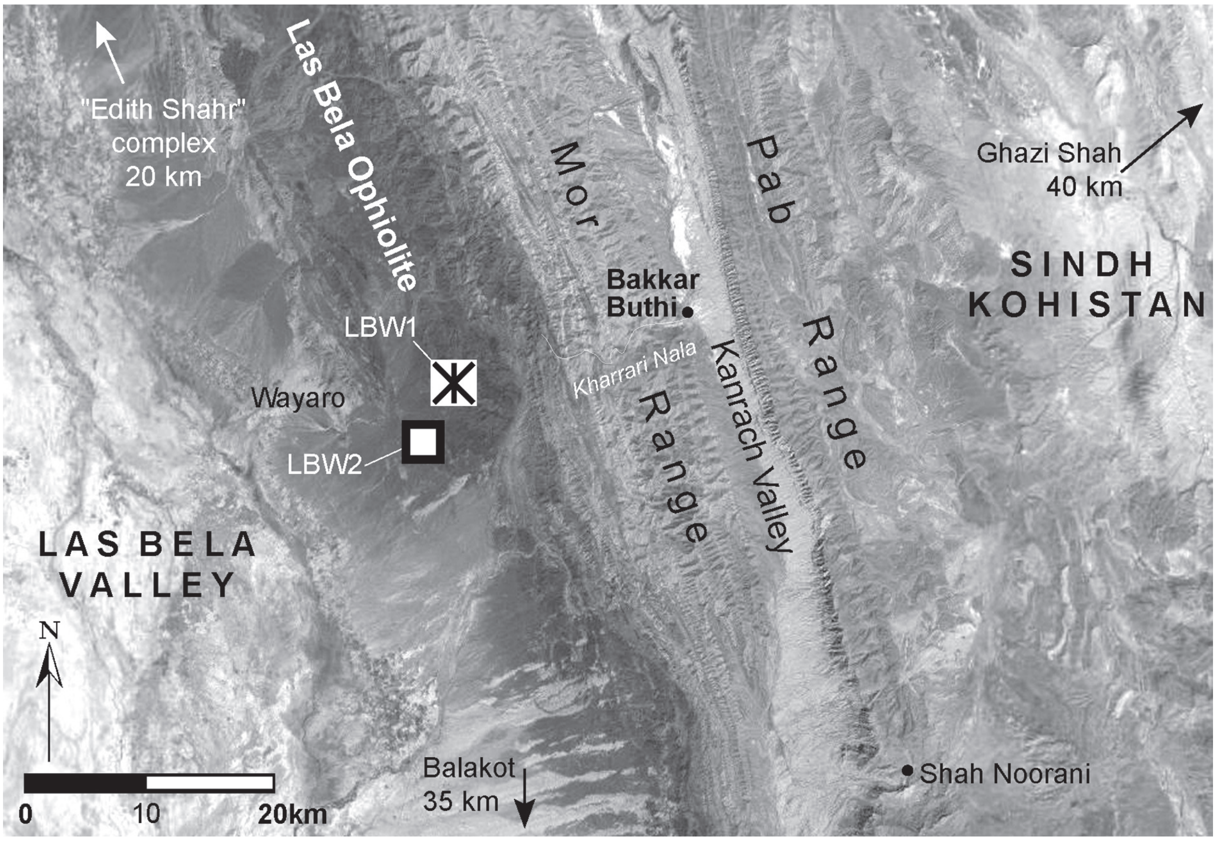


Figure 7.10 Sites, shrines and steatite sources in and around the Las Bela Ophiolite, Las Bela District, Balochistan.

on to the NWFP and Pakistan's Northern Areas. We then turn southeast to follow the Himalayas for 600 km. After that that point we jump across the Gangetic Plain to the Aravalli Range of Rajasthan and follow it from the northern to the southern part of that state. Our tour of steatite occurrences will end in Gujarat.

Steatite occurrences in Balochistan

- Las Bela District

Steatite occurs at a few places in the Las Bela District of southeastern Balochistan. Prior to sampling those deposits, I had not encountered any reference to them in either the geologic or historical literature. I only located them because I wished to visit the shrine of the Sufi saint Shah Bilawal Noorani (or just Shah Noorani), which I had first learned about in Vidale and Shar's study (1990) of traditional soapstone crafts in Sindh. According to a johri/steatite-carver they interviewed named Ashiq Hussain, the shrine was the place where he had learned his craft and to where he traveled annually to attend the *mela* (festival) for the saint. It was also where he replenished his steatite stocks as it was in the "land of zahr muhra" (ibid.). Steatite could be acquired from local Mengal tribesmen who transported the stone to the shrine from sources that were a two or three-day walk away.

In Vidale and Shar's 1990 study, Shah Noorani is described as being in the Makran District, near the modern town of Turbat and the prehistoric sites of Shahi Tump and Miri Qalat (Besenval 2005). However, I could not locate it on maps or in the gazetteer for that district. Moreover, there were no geological formations in the region that could have hosted steatite deposits (there are ophiolites in the Iranian Makran, however). I learned from a johri in Karachi that, in actuality, Shah Noorani lies some 400 km to the east of the Turbat area in the Las Bela District near the Balochistan-Sindh border (Figure 7.10). Mention is made of the shrine in the *Gazetteer of Las Bela* (1907: 38). You can catch a bus from Lee

Figure 7.11 A The Shrine of Shah Bilawal Noorani (Shah Noorani) is located within this oasis-like nala in the southern Pab Range, Las Bela District, Balochistan.

Figure 7.11 B Johris at Shah Noori.

Figure 7.11 C Prayer beads carved from Wayaro area steatite.

Market in Karachi and be there in just under six hours. I visited Shah Noorani (Figure 7.11 A) in May of 2001 and met with the johri/steatite-carvers there (Figure 7.11 B) who showed me their wares (Figure 7.11 C) and informed me that the actual sources of zahr muhra were in the Wayaro area, about 45 km to the northwest. This placed them squarely in the middle of the Las Bela ophiolite – a geologic formation that could undoubtedly host steatite deposits (as well as the chlorite and serpentine that the Shah Noorani johris are also known for carving and selling).

Later the same month, I visited the Wayaro area (Figure 7.10) with Khawar Akhbar of the Geological Survey of Pakistan–Karachi. With the help of a

Figure 7.12 Duddo steatite mine (LBW1), Wayaro area, Las Bela District, Balochistan

Figure 7.13 Thaddi steatite mine (LBW2), Wayaro area, Las Bela District, Balochistan

local man we located and sampled two active mines (Figures 7.12 and 7.13) at locations called Duddo (LBW1) and Thaddi (LBW2), which were about 5 km apart. Throughout the area there were pits and shear zones from which steatite appeared to have been removed long before. We found no artifacts to provide us with an indication of when exactly that might have been, however, and our guide did not know of any mounds or other evidence of old settlements in the immediate area. This came as no surprise. Ophiolite zones are notorious for being lifeless, moon-like landscapes (Dann 1988: xi) and the area around the Wayaro deposits was no different.

Prehistoric settlements were not a great distance away, however, in any direction. Bakkar Buthi, which was occupied by Indus Civilization peoples for a period of time (Franke-Vogt *et al*. 2000), lies less than 20 km away on the other side of the Mor Range in the central Kanrach Valley. The Wayaro steatite sources could easily be reached from there via Kharrari Nala, which transects the range at that point. The site of Balakot, which has Early Harappan and Harappan phase occupations (Dales 1974), is situated some 60 km due south of the Wayaro area. All across southeastern Balochistan and into Sindh Kohistan sites belonging to the Early Harappan Nal and later Kulli phases are found (Fairservis 1975: 185-216). The so-called "Edith-Shahr" complex (ibid.) is just to the north at the head of the Las Bela Valley. On the other side of the mountains of Sindh Kohistan lie Amri (Casal 1961), Ghazi Shah (Flam 1993a) and other Early Harappan / Harappan Period sites.

My reason for highlighting the proximity of other prehistoric sites to the Wayaro deposits was to emphasize their importance as *potential* sources of steatite for Early Harappan and Harappan phase peoples. In simple terms of physical distance between a known Indus Civilization site and a deposit of high-quality (or any quality for that matter) steatite there are no closer sources. Moreover, I show in Chapter

Figure 7.14 **[A]** Collecting Shah Noorani/Wayaro steatite. **[B]** Shah Noorani steatite beads for sale in Khairpur, Sindh. **[C]** A bead from Balakot that appears to be made from Wayaro steatite.

12 that lead ore at Harappa and Mohenjo-daro may have been acquired from deposits of that metal in the Kanrach Valley. For consumers in Sindh in particular, the Wayaro area of southern Balochistan *could* have been a very important source of steatite. Deposits there, although fewer in number, are over three times as close to Mohenjo-daro as those in Rajasthan, which has long been argued (Pascoe 1931: 679) to have been a major source of steatite for residents of that site. Most importantly, Early Harappans and Harappans were indisputably present in southern Balochistan and so the interaction networks through which steatite could have been brought to the Indus Valley were in place. Evidence that Harappans interacted with the peoples of Rajasthan, although it exists (Misra 1995, 1997), is much more tenuous.

One thing regarding these deposits gave me pause, however. As I mentioned above, Shah Noorani steatite (from the Wayaro deposits - Figure 7.14 A) has a very distinctive appearance. I had seen it on sale (Figure 7.14 B) across Pakistan but had only documented what I thought was the material at a single prehistoric site – Balakot, which is not surprising as that settlement is relatively close to the deposits. A small unfired bead (Figure 7.14 C) from that site composed of green steatite with black spots is in collections of the Department of Archaeology and Museum's Excavation Branch in Karachi. Nothing like it, however, is in the unfired steatite assemblage at Harappa or among the unfired artifacts from other sites that I have examined or seen photographs of. True, there are other macroscopic types of steatite at the Wayaro deposits. Perhaps Harappans were mining those instead. Or, perhaps, every single piece of this

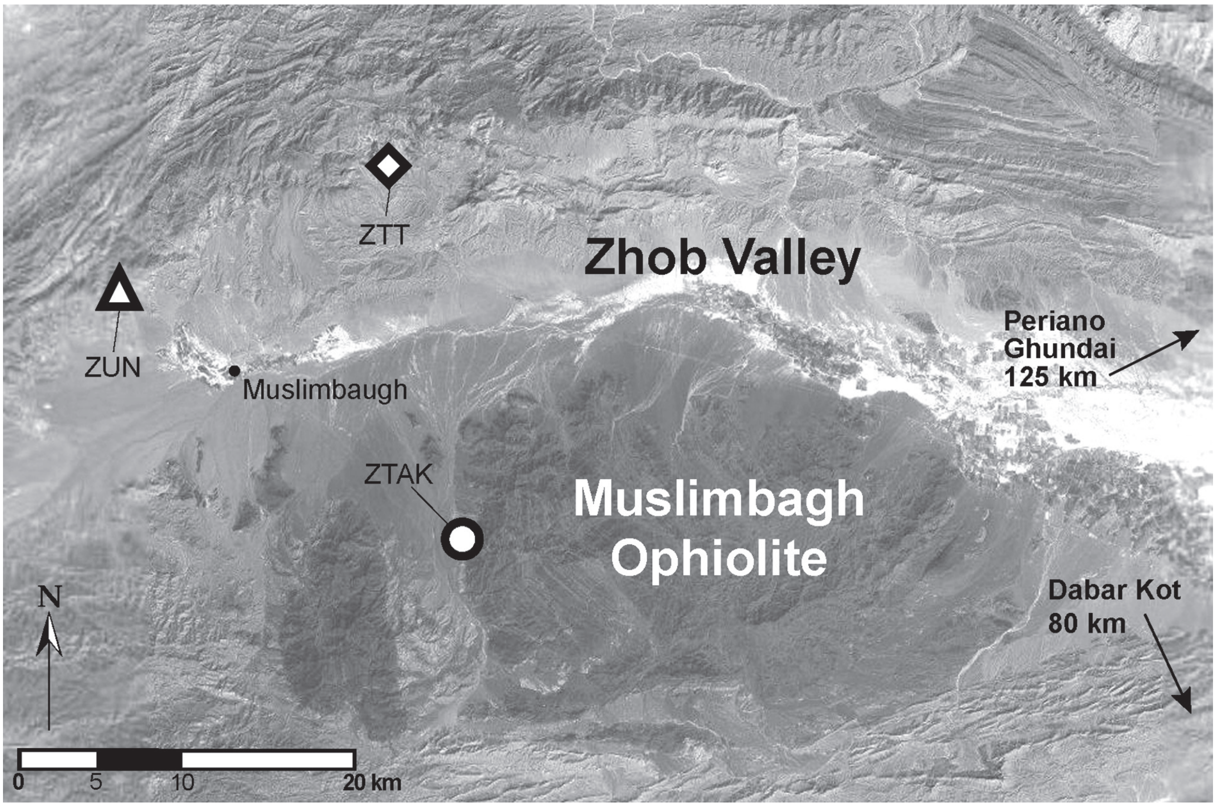


Figure 7.15 Steatite deposits of the Muslimbagh Ophiolite, southern Zhob District, Balochistan.

kind of steatite at Indus sites has been heat-treated, thus obscuring the original the appearance of stone. I have doubts about the latter possibility, however. Whatever the case actually is, a statement like Louis Flam's (1981: 168) – that the source of steatite for the Early Harappan peoples of southern Sindh (Amri Phase) "can be supposed to have been southeastern Iran," is now clearly untenable.

- Kalat District

Moving northward now to the Kalat District of central Balochistan, Tariq and others reported (1998: 16) a 7 to 12 cm thick vein of light-grey soapstone in the lower shale member of the Shirinab Formation near the village of Chuttock. At just over 90 km to the west-northwest, this is the closest reported steatite occurrence to the sites of Mehrgarh and Nausharo. Unfortunately, I only learned of this occurrence after my Balochistan fieldwork was completed and so no samples from it could be included in this study.

- Zhob District

Continuing on to northern Balochistan, Ahmad noted (1969: Figure 30, #9) soapstone in the southwest part of the Zhob District but provided no further details on the occurrence(s). Fortunately for me, the region was the research area of Dr. Khalid Mahmood of Center of Excellence in Mineralogy, University of Balochistan-Quetta. He was able to lead me to and assist me in the sampling of high-quality steatite deposits at three locations in the Muslimbagh ophiolite (Figure 7.15). The occurrence at Takhahen (ZTAK) in the main body of the ophiolite provides a good illustration of how, whenever possible, I approached sample collection. The zone of talc materialization there runs intermittently along a 2-km long north-south strike (Figure 7.16). Samples (n ≈ 50 total) were acquired from three points along the zone where the best quality material could be found (Figure 7.17, points 1, 2 & 3). The zone was treated a single deposit as it essentially occurs in the same block of *harzburgite* (a peridotitic rock). Samples were also

Figure 7.16 Direction of talc mineralization (looking north) at Takhahen in the Muslimbagh Ophiolite, Zhob, Balochistan

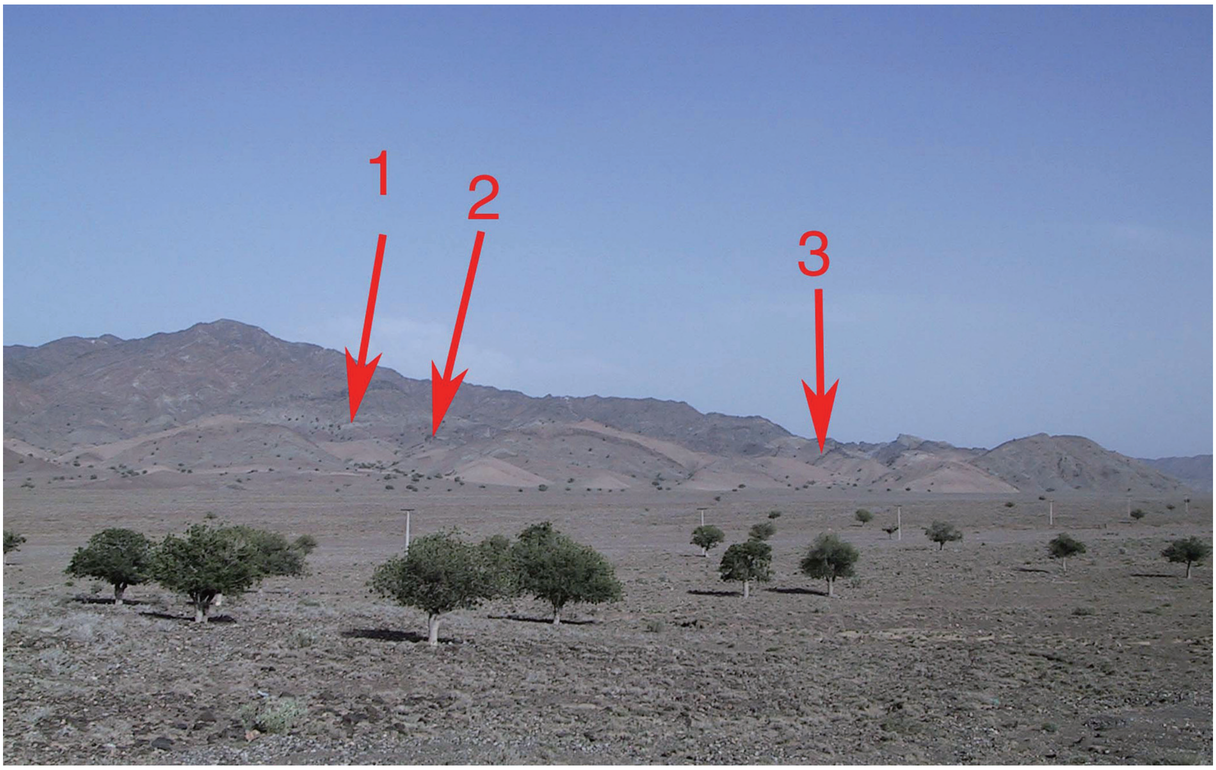


Figure 7.17 Points sampled along the zone of talc mineralization at Takhahen.

collected in this way from fragments of ophiolitic rock containing steatite on the opposite side of the Zhob Valley, to the north of Muslimbagh town at Urgasai Nasir (ZUN) and Tor Tangi (ZTT).

The Muslimbagh ophiolite steatite deposits would have been the ones most accessible (≈ 80 to 120 km distant) to the prehistoric peoples of the Loralai District. For this reason, they are the best candidates for the sources of the sawn steatite and black beads (Figure 7.7 C & D) in archaeological sample set said to be from a mound in that area. I have represented those two samples on Figure 7.2 using a red plus ("+"

for the sawn fragment) and a red circle ("O" for the beads). Steatite from the Muslimbagh ophiolite could have been accessible to residents of Harappa during the urban phase as there was a clear Indus Civilization presence in the Loralai region at the sites of Dabar Kot and nearby Duki Mound (Fairservis 1975: 149).

From Muslimbaugh, the Zhob Valley arcs north-northeast and terminates near the border with the NWFP. Soapstone or talc is reported at several locations around this region (Heron and Crookshank 1954: 138; Pithawalla 1952: 202), which evidently was a key zone of interaction between the northern Balochistan highlands and the Indus Valley during the first half of the third millennium BC. At the northern end of the Zhob Valley sits the site of Periano Ghundai. A strong Early Harappan Kot Dijian presence is documented there (Mughal 1970: 217-221) alongside the site's highland "Zhob culture" material assemblage. Clusters of Early Harappan and Harappan Period sites (Dani 1971; Durrani 1988; Khan *et al*. 2000; Mughal *et al*. 1996) are found where the rivers draining northern Balochistan meet the Gomal Plain / Derajat region of the western Indus Valley. Ceramic parallels as well as finds of "Zhob mother goddess" figurines indicate that peoples from at least one of these plains sites – Dhera, had very close ties with the adjacent highlands (Siddique 1996).

Pockets of ultramafic rock dominated by the Zhob ophiolite are found in the northern Zhob region (all within about 50 km of Periano Ghundai) and "veins of up to a foot or so in thickness of white steatite" have been reported to occur in them (Heron and Crookshank 1954: 138). I visited two reported locations with Dr. Khalid Mahmood. An afternoon of searching the area "east of the 22nd milestone on the Ft. Sandeman-Gul Kach road" (ibid.), which is in the main body of the Zhob ophiolite, yielded only serpentine and chlorite. The local people around had no knowledge of any soapstone occurrence or any former mining operation. At Wulgai Oba (ibid.), we found only thin seams of very low grade talcose stone in what turned out to be dolomitic slates rather than ultramafic rock. We forewent a visit to a third reported soapstone occurrence on the road to Shinghar as the deposit was said to consist of only small talc "veins, which have been worked by local inhabitants for whitewash paint" (Huntington Survey Corporation 1960: 500).

It is very possible that there are occurrences of talcose stone in northern Zhob that Dr. Mahmood and I failed to locate (particularly in the Zhob ophiolite) during our limited period of fieldwork in that region. However, from what we observed it appears likely that there are no occurrences of Harappan-quality steatite in this region.

Steatite occurrences in the NWFP, FATA and Northern Areas

- Kurram Agency

Beds of high quality steatite occur within the siliceous dolomite of the Safed Koh Range, which forms the Kurram Agency's northern border with Afghanistan (Badshah 1983; Bender 1995b: 273). Mian Sayed Badshah of the Federally Administered Tribal Areas Development Corporation (FATADC) organized a sampling expedition to this area for me in August of 2001. The steatite deposit (source code PD) that was visited (Figure 7.18) is located around 20 km northwest of Parachinar town in the Daradar Valley (an offshoot of the Kurram Valley) at an elevation of approximately 3000 meters. A larger, slightly higher deposit along Kharwala Nala in the western part of the range (Meissner 1975: 18; Ahmad 1969: 155) unfortunately could not be visited because of security concerns.

Elevation and steep terrain has limited exploitation of the Safed Koh steatite deposits in modern times. Whether or not the same would have been true during the Indus period is unclear. It is reasonable to believe, however, that Harappans might have had access to the Safed Koh and its resources. There is the ever present issue of "how did Harappans

Figure 7.18 Sampling expedition to the upper Daradar Valley steatite deposit, Safed Koh Range, Kurram Agency, FATA.

get to and from Shortughaï in northern Afghanistan?" Passage through the Kurram Valley offers the most direct route from the Punjab to central Afghanistan and, from there, to the north. Its use as a thoroughfare for caravans and invading armies rivals and, perhaps, even surpasses that of the more famous Khyber Pass to the north (Markham 1879: 47-50). Although no prehistoric sites have been discovered in the Kurram Valley itself, the Kurram River passes the south flank of the Safed Koh Range and flows southeast into the Bannu Basin, where there was a strong Kot Dijian presence that was evidently sustained through a "Late"

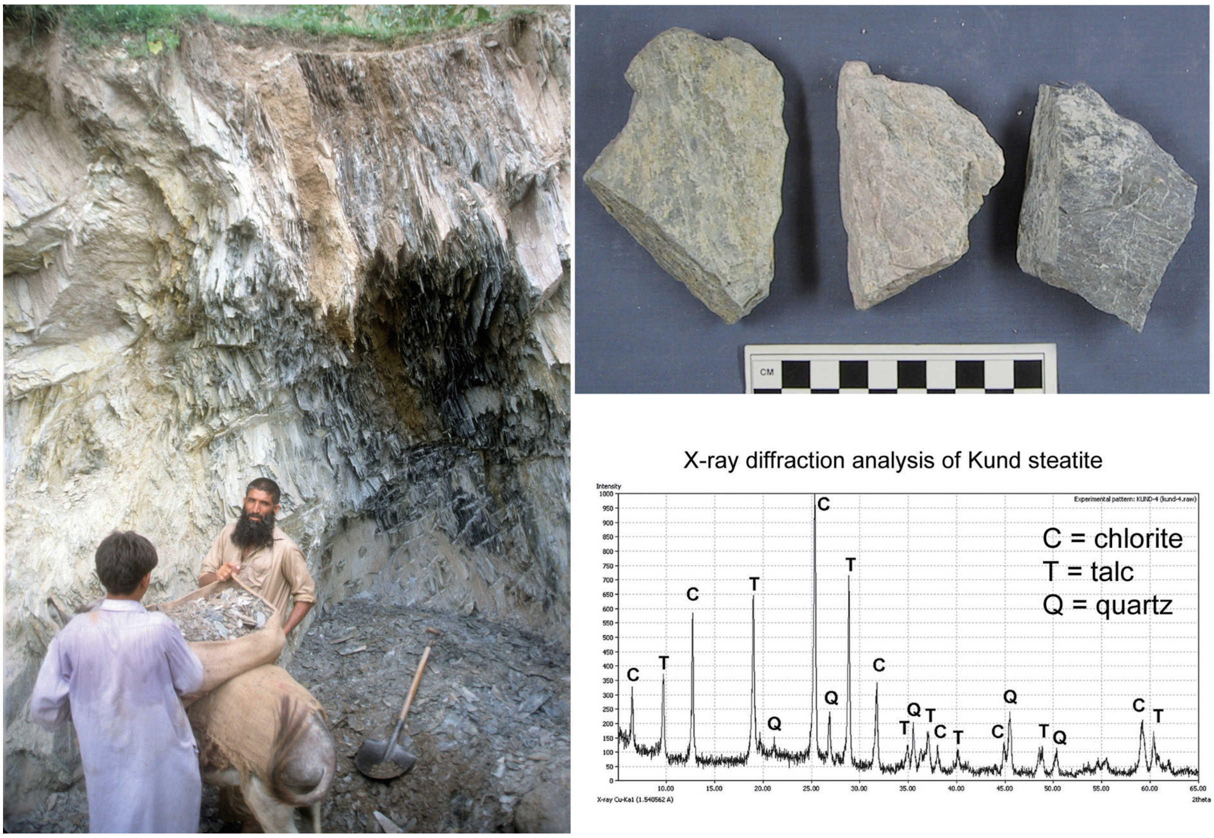


Figure 7.19 Sampling and X-ray diffraction analysis of the Kund steatite deposit.

Kot Dijian phase concurrent with the Harappan Period (Khan *et al.* 1988, 1991a, 2002a).

- Khyber Agency

Ahmad reported (1969: 154) that steatite occurs in dolomite around the Landi Kotal area of the Khyber Agency but did not provide a deposit name or an exact location. After a visit to the agency headquarters in Landi Kotal town in December of 2000, I learned that the stone could be found at Prang Dera, approximately 10 km to the south-southwest. I was provided with guards and guide and managed to visit the deposit (source code LKPD), which turned out to contain material of superb quality. I was told by local people that there were a handful disused mines in the area but was unable to visit any of them. The proximity of Prang Dera to the famous Khyber Pass at least opens the possibility that steatite from this source may have been accessible Harappans traveling to and from Shortughaï, that is, if it was one of the routes they took.

Also in the Khyber Agency, talc in dolomite occurs on the western side of the Peshawar Valley, 6 km north of the Khyber Pass entrance at Jamrud (Abbas *et al.* 1967). I visited this deposit in November of 2000 and found the steatite there to be foliated and filled with inclusions. Higher-grade stone could have been present in the past (the deposit has reportedly been worked for 50-plus years). However, the material described in a report by Abbas and others (1967) thirty years ago was also of mediocre quality.

- Peshawar District

In the southeast part of the Peshawar District, soapstone in metamorphosed Attock slate is found at Kund and nearby Kath Miani (Heron and Crookshank 1954: 138-139). At the outset of this project, I considered these deposits to be potentially very important because of their location at the entrance of the Peshawar Valley near the fording point of the Indus River at Attock, as well as because of their relative proximity (≈ 60 km) to the Early

Harappan sites of Sarai Khola and Hathial. However, after having visited the Kund deposit and analyzing samples collected there (Figure 7.19), I am of the opinion that Harappans probably did not acquire any steatite from these occurrences. Below, I go into slightly greater detail in my discussion of the Kund-Kath Miani deposits in order to provide an illustration of exactly how I made judgments as to what constituted sources of "Harappan-quality" steatite. Such judgments ultimately determined which sources were selected to be compared to steatite artifacts in geologic provenience analyses.

To begin with (and most importantly), Kund soapstone is heavily foliated and easily fractures into platy pieces. Harappan craftspeople would have found it to be completely unsuitable for sawing or carving. Secondly, XRD analysis (Figure 7.19 *bottom right*) indicates that the Kund material is a chlorite-talc soapstone rock with quartz impurities. No chlorite phases have ever been detected in any of the raw steatite artifacts analyzed from Harappa. These observations are backed up by a previous study of Kund soapstone by Qaiser and others (1980) who also described eight slately and friable samples, most of which had major chlorite phases and significant other impurities. Although I did not sample the nearby occurrence at Kath Miani, Heron and Crookshank's description (1954: 139) of the material there – "impure soapstone mixed with shale debris," suggests it is of the same low quality.

There is, of course, always the possibility that, in former times, a higher-quality steatite occurred at the Kund / Kath Miani deposits, but that it has since been mined out. However, given the foliated nature of the original parent-rock (Attock Precambrian slates) I doubt that is true. Vidale and Bianchetti analyzed (1997: 949) a block of "whitish steatite" that was purchased in Khairpur, Sindh but which was said to have been mined near Attock. XRD of that sample showed it to be pure talc. I highly doubt that that it could have originated in the Kund / Kath Miani deposits. It probably came from one of the other sources in the general region like those in the Hazara District or the Mohmand Agency, both of which are around 75 km away from the Attock area.

- Mohmand Agency

In the Mohmand Agency, steatite occurs in the western part of the Sakhakot-Qila ophiolite (Rafiq 1984: 58) located on the northwest margin of the Peshawar Valley. Good quality material was located during an August 2001 collection trip to that formation with Dr. Irshad Ahmed of the Center of Excellence in Geology, University of Peshawar. Samples were taken around Kot Mazarai (source codes Kot and Kot (MP)), which happens to be in the same vicinity as an important source of vesuvianite-grossular (Chapter 9).

- Chitral District

In the Shi Shi Valley – an off-shoot of the Chitral Valley in the southern Chitral District – good quality steatite occurs in the Drosh ophiolite near the village of Tar (Calkins 1981: 9). Samples were collected from this location (source code CHT) in July of 2000. Although this source is admittedly far removed from the Indus Valley, it should be noted that one of the important routes to the lapis lazuli mines in the Badakhshan District of northern Afghanistan passes through the Chitral Valley.

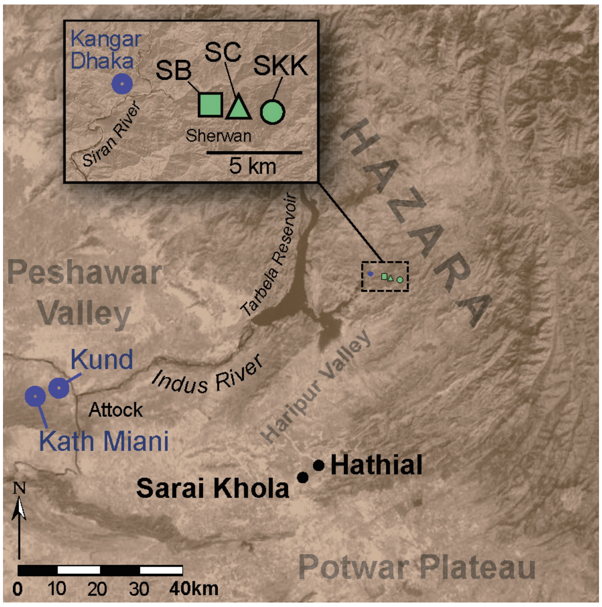
- Northern Areas

Like Chitral, Pakistan's Northern Areas may seem as if it is too remote to have figured significantly into Harappan steatite acquisition networks. However, major routes connecting South Asia to Central Asia traverse this region and ancient petroglyphs found alongside these routes provide evidence for the long history of their use (Jettmar 1991). Steatite occurrences in the region include those in the Chalt area in the Gilgit District (Bender 1995b: 273) and several in the Shyok Valley of the Skardu District

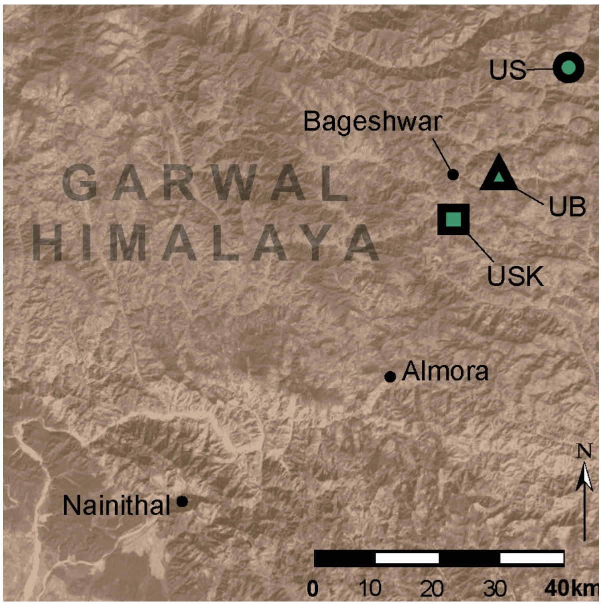
Figure 7.20   The Shewan area, Hazara District, NWFP.

Figure 7.21   The steatite deposit at Chelethar, Hazara District, NWFP.

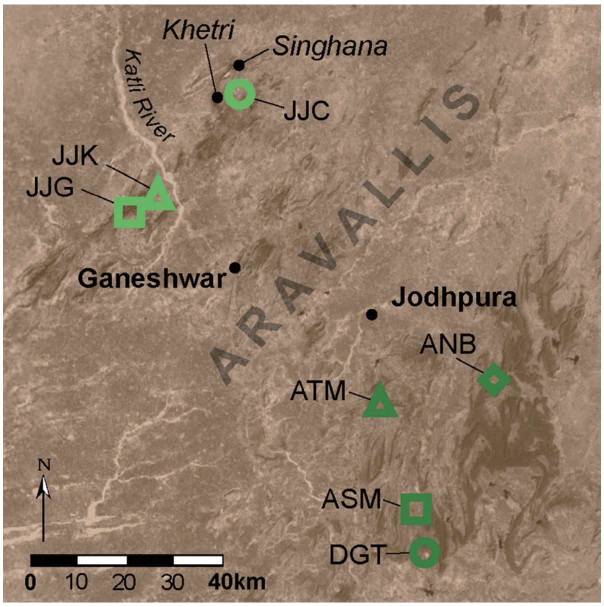
Figure 7.22 Details of regions where multiple steatite deposits were sampled.



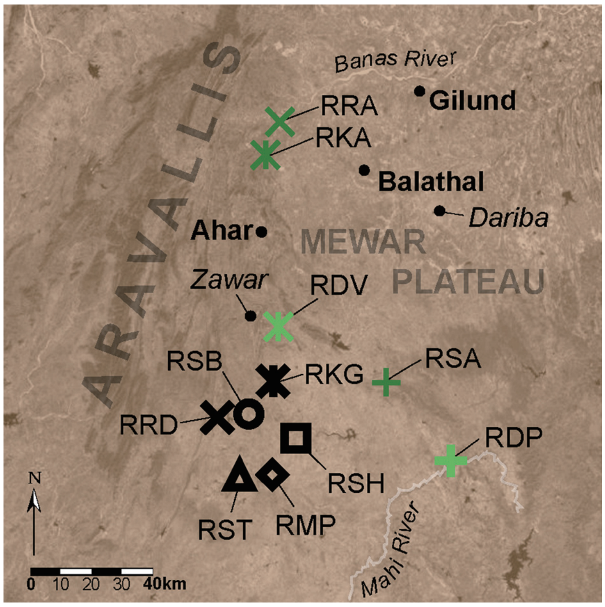
A. Sampled steatite deposits of the Hazara District, NWFP, Pakistan.



B. Sampled steatite deposits of the Bageshwar District, Uttaranchal, India.



C. Sampled steatite deposits of the Jhunjhunu, Alwar and Dausa districts, northern Rajasthan, India.



D. Sampled steatite deposits of the Rajsamand, Udaipur and Dungapur districts, southern Rajasthan, India.

(Kazmi and Jan 1997: 481). Superb quality steatite from the Ishkoman region near the Afghanistan border can be seen in the Geological Survey of Pakistan's Museum collection in Quetta (Case 22).

- Swat District

A major tectonic boundary (the Main Mantle Thrust) passes along the length of the lower Swat Valley and zones of talcose rock are found all along it (Di Florio *et al.* 1993). I examined several locations in the valley itself but failed identify any occurrence of artifact quality steatite (admittedly though, my sampling excursions there were brief and spotty). Excellent steatite does occur, however, in the eastern part of the Swat District (outside of the Swat Valley proper) within the dolomitic sequences of the Derai and Juragh areas (Ghani *et al*. 1994; Kazmi and Jan 1997: 312, 482). One deposit (source code BESH) in this zone, which I sampled with Dr. Mark Kenoyer in May of 2000, lies just 7 km from the Indus River near the town of Besham. The steatite at this location is of excellent quality.

- Hazara District

The most extensive steatite deposits in Pakistan are found in the Sherwan area (Figures 7.20, 7.21 and 7.22 A) of the Hazara District, NWFP (Shah 1977: 199). The deposits occur in the dolomite sequence of the Precambrian Abbottabad Formation and extend intermittently across a zone over 16 km long and 2 km wide (Ali *et al*. 1964: 29-34; Bender 1995b: 273; Calkins *et al* 1973). As the chapter continues, I frequently refer to these occurrences as the "Sherwan zone." I visited this zone with Dr. Syed Baqri of the Pakistan Museum of Natural History in August of 2000. We conducted sampling around three locations where some of the largest deposits occurred – Bandi (source code SB), Chelethar (SC) and Khanda Khu (SKK). Excellent quality material was available at each of these locations and numerous old pits and shafts were observed, especially around Khanda Khu. There are several important occurrences in the Sherwan zone that time did not permit us to sample. A deposit at Khangar Dhaka, which separated from the main body of occurrences by the Siran River, is said to contain the highest quality material in the area (Ali *et al*. 1964: 34).

The Sherwan deposits lie 50 to 60 km north-northwest of the Kot Dijian sites of Hathial and Sarai Khola (Figure 7.22 A). People dwelling at those settlements could have easily reached these sources by traveling up the Haripur Valley to the Siran River Valley (now partially flooded by the Tarbela Reservoir), which transects the zone along which they occur.

Steatite occurrences in the Himalayas

- Jammu and Kashmir

The steatite occurrences of Jammu and Kashmir take on a special significance in light of the clear evidence at the site of Burzahom for some form of interaction between the ancient peoples of the Kashmir Valley and those of the Indus Valley during the Early Harappan period (Saar 1992). There are a numerous routes into and out of the Vale of Kashmir that would have passed near to many of the deposits discussed in this sub-section.

Ali (1959: 10) reported an occurrence of soapstone at Chilhana Da Dana in the Muzaffarabad District but provided no details regarding it. In the Kotli District, soapstone deposits in dolomitic rock (at Palana and Nawal) are said to be "generally impure" (Ahmad 1981: 25). In the Zanskar area of Ladakh, "pockets of talc" are reported in ultramafic rock (Varadan 1977: 63). The descriptions of steatite at Nagri and, especially, at Chinchora in the Doda District give the impression that good quality material might be found at those locations (Indian Bureau of Mines 1992: 109).

In terms of this study, perhaps the most important steatite deposits in the entire Jammu and Kashmir region are those occurring in the southern part of the Great Limestone Formation in the Udhampur District (Chatterjee 1964: 436). The Early Harappan and Harappan Period foothills settlement of Manda (Joshi and Bala 1982) lies just 25 km to the southwest. Later, in Chapter 12, I present evidence showing that much of the raw lead ore found at Harappa quite possibly came from occurrences in the Great Limestone Formation. "Talc in compact form" is reported at four different locations in that formation – Kunian, Kashikaria, Nangal and Puran Daruhur (Indian Bureau of Mines 1992: 109). All are either adjacent to or in the vicinity of Vaishno Devi – the highly revered mountain-top shrine that is today one of India's major pilgrimage places. High security at the shrine and in the hills around it prevented me

Figure 7.23 Painthal steatite deposit, Udhampur District, Jammu.

Figure 7.24 Outcrop of grayish steatite at Painthal.

from reaching the sources. Fortunately, with the help of Ajay Kumal of the Geological Survey of India's office in Jammu, I was able to locate and sample another steatite deposit in the Great Limestone Formation at a place called Painthal (source code JAMPT), which is on a ridge-top (Figure 7.23) five kilometers due east of Vaishno Devi. The raw steatite occurring at this location (Figure 7.24) is generally gray in appearance with the occasional patches of khaki to grayish-green material. Significantly, an unfinished seal was discovered in Early Harappan/Harappan levels (Period 1A) at Manda (Joshi and Bala 1993: 241). Although it is difficult to tell from the black and white photograph (ibid: Plate LXXIII C), the seal would appear to be carved from a dark grey steatite very much like that found at Painthal.

- Himachal Pradesh

Only two occurrences of steatite have been reported in all of Himachal Pradesh – one near Asrang in the Kinnaur District and another at Nahan in the Sirmaur District (Chatterjee 1964: 436; Indian Bureau of Mines 1992: 109; Geological Survey of India 1989a: 52). The Asrang deposit, although remote, was easy to locate. However, I did not end up analyzing any of the samples collected there for this provenience study because the material I found was too soft, friable and impure to be Harappan-quality steatite.

"Good quality steatite deposits are reported nearby Nahan" (Indian Bureau of Mines 1992: 109) but when I traveled to that area in June 2003 I failed to locate any sign of them or any local person around who knew of them. I visited the Geological Survey of India's office in Chandigarh and met with N.L. Sharma and his colleagues, some of whom do research around Nahan. None of them had any knowledge of steatite or, for that matter, any kind of talcose stone in the area. Gypsum deposits and mining operations are found in southeast Himachal Pradesh around Nahan, however. The gentlemen from the GSI suggested that what was reported as steatite may have actually been that mineral. So at this point, I have to consider the report of steatite in the Nahan area to be unsubstantiated.

Figure 7.25 Sampling steatite deposits west of Bageshwar, Uttaranchal.

- Uttaranchal

In contrast to Himachal Pradesh, Uttaranchal (formerly part of Uttar Pradesh) is a steatite-rich state (Chatterjee 1964: 443; Dalela 1995; Indian Bureau of Mines 1992: 161-167; Valdiya 1980: 256-257). Sources in this region (Figure 7.22 B), although located in highly mountainous and often difficult to reach areas, are important because they would have been among the closest to Harappan and Late Harappan peoples living on the Gangetic Plain.

I was unable to reach an occurrence of reportedly high-grade material in ultramafic rock at Kandyal Gaon (Pandey 1967) in the central part of the Uttaranchal due to a rock-slide related road closure. However, in June of 2003 I did manage to collect samples of good-quality soapstone of dolomitic origin from three occurrences in the Bageshwar District (formerly part of the Almora District) around Bageshwar town (Bhattacharya 1980; Indian Bureau of Mines 1992: 161-164; Ray *et al*. 1977). The first were taken from Saling mine (source code US) in the Sarju Valley north of Bageshwar; the second from along a five kilometer zone of talc mineralization (Figure 7.25) that transects two valleys that extend to the west of the town (UB); and the third from an abandoned steatite mine to the south of the town called Shisha Khani (USK), which happens to be nearby a lead mine (of the same name) that I will be examining in Chapter 12.

Additional steatite occurrences can be found to the north of the Bageshwar District at high elevations in the Chamoli District (Rao and Pati 1981) and to the west in the Pithoragarh District near the border with Nepal (Bhattacharya *et al*. 1982). However, I decided to end sampling in the Bageshwar area for reasons of time and because I felt it (arguably) constituted the northeastern margin of the Greater Indus region.

Steatite occurrences in Rajasthan

Sir Edwin Pascoe (1931: 679) singled out the Indian state of Rajasthan (or "Rajputana" as it was called prior to 1947) as the most likely source area for the raw material used to make the steatite artifacts excavated at the site of Mohenjo-daro. Most of the other researchers (cited previously) who have weighed in on the subject of steatite acquisition by Indus Civilization peoples have either concurred or at least ranked the region high on the list of potential source areas. There is, of course, a very good reason for this. With all due respect to Ashiq Hussain and to the johris of Shah Noorani, if there is truly a "land of zahr muhra" it is Rajasthan. Steatite occurs in nine well-defined belts that run through 16 of that state's districts (Gahlot and Shukla 2000: 113) and, as of about a decade ago, there were 335 official mining leases there (Rajasthan Mineral Bulletin 1997b: 17). There are likely as many or more unofficially worked deposits and innumerable occurrences that are today considered too small to be commercially viable (*personal observations*).

Even though I devoted a large portion my available resources to the analysis of samples from this very rich potential source area (over one third of all the geologic samples analyzed came from deposits in Rajasthan), it simply would have been impossible to adequately assess steatite occurrences in all parts of the Rajasthan. So instead, I focused on obtaining samples from deposits in steatite belts situated in the northern and southern parts of the Aravalli Range, as these are the areas adjacent to regions where there were Harappan settlements (i.e, Gujarat in the south and Haryana in the north) as well as where there were well-known Chalcolithic cultures that Harappans may have interacted with (the Ahar-Banas complex of southern Rajasthan and the Ganeshwar-Jodhpura complex of northern Rajasthan). Multiple sampling trips were made between 2001 and 2003. For many of these journeys I was joined by Dr. Kishore Raghubans, who was at the time conducting his dissertation research on the Ganeshwar-Jodhpura complex of northern Rajasthan. On Figure 7.2, the six districts of

Rajasthan where sampling took place are marked with labeled ellipses. The ten remaining districts where steatite also occurs in the state (but which remain to be sampled) are labeled in blue.

- Northern Rajasthan

During the third millennium BC, peoples of the non-urbanized Chalcolithic Ganeshwar-Jodhpura society inhabited areas in and around the northern part of the Aravalli Mountain Range (Agrawala and Kumar 1982; Rizvi 2007). Harappan acquisition of steatite from occurrences in this region (Figure 7.22 C) would have necessitated interaction with them. The deposits discussed in this sub-section lie between 140 and 240 km south of the Indus Civilization city of Rakhigarhi in Haryana.

Jhunjhunu District

The Indian Bureau of Mines lists (1992: 142) only three deposits of steatite in the Jhunjhunu District – at Chirani-ki-Dhani (JJC), Gurda (JJG) and Kho (JJK), all of which occur in "dolomite country rocks" (ibid.). All three deposits were visited and, even though it was not abundant at any of them, samples of Harappan-quality material were acquired. Importantly, these deposits lie within what constitutes the northern part of the Khetri Copper Belt (Raghunandan 1975). If the Khetri belt was one of the major copper sources for Indus Civilization peoples as many researchers have proposed (see Chapter 12 for a full discussion), then steatite may have been a resource that was acquired from this area at the same time. Note that the occurrence at Chirani-ki-Dhani is located less than 10 km from both Khetri itself and the enormous copper smelting slag heaps at Singhana.

Alwar and Dausa districts

In the northeastern part of the Aravalli Range, steatite is reported at a few dozen places in the dolomitic limestone of the Riaolo Formation (Gahlot and Shukla 2000; Indian Bureau of Mines 1992; Rajasthan Mineral Bulletin 1997b). In the Alwar District, samples for this study were taken at Nangalhari-Bairaswas (ANB) (figures 7.26 and 7.27), Teori (ATM) and Samra (ASM). Like the deposits of the Jhunjhunu District, Harappan-quality stone was present but not abundant. Slightly farther to the south in the Dausa District (formerly part of the Jaipur District), the situation was very different, however. The huge open pit mine at Degota (DGT) is largest in Rajasthan and produces some of the highest grade soapstone in India. In fact, much of the stone that is being taken out of the mine is too good. That is, it was massive and compact (and would have carved beautifully) and pure white. None of the archaeological examples of raw steatite that I have ever seen have been pure white. Searches of areas along the margins of the mine (closer to the ground surface and country-rock) yielded colorful steatite samples that were much more Harappan-like in appearance.

- Southern Rajasthan

In southern Rajasthan (Figure 7.22 D), settlements belonging to the Chalcolithic Ahar-Banas culture complex (Shinde *et al*. 2005) like Gilund, Balathal and Ahar are found on the eastern flank of the Aravalli Range and Marwar Plateau area. Although no less than 250 km separated these non-urban agro-pastoralists from the Harappans of Gujarat, the rich rock and mineral resources of the region may have brought the two societies into contact.

The lithostratigraphy of southern Rajasthan consists mostly of Precambrian rocks that have been repeatedly "folded, faulted, metamorphosed and migmatized" over the course of last 700 million to two-and-a-half billion years (Prasad *et al*. 1997: 16). Throughout the complex geologic mélange of the region there are hundreds steatite deposits. They occur in zones or "belts" within ultrabasic (ultramafic) igneous rocks (in this case of the non-ophiolitic variety) and in sedimentary magnesium carbonate rocks (Gahlot and Shukla 2000: 111-112). Because

Figure 7.26 Steatite deposit at Nangalhari-Bairaswas, Alwar District, Rajasthan.

Figure 7.27 Detail of the steatite body at Nangalhari-Bairaswas.

Figure 7.28 The extensive open-pit steatite mine at Deola, Dungarpur District, Rajasthan.

Figure 7.29 The steatite outcrop at Shiv Bola, Udaipur District, Rajasthan.

these belts often cross district boundaries, I discuss the deposits that were sampled in this region according to their parent-rock types rather than their geographic location. Sources of dolomitic origin are marked with green symbols on Figure 7.22 D while black symbols mark those of ultramafic origin.

One note before proceeding. Throughout this entire section I have taken great pain to discuss not only the deposits of Harappan quality stone that I sampled but also all other occurrences (of any nature or quality) that I visited or read about in the geologic literature. This was necessary in order to provide a rough indication of how representative the sources that I sampled were of the deposits present in each region (or at least those documented in each region). In southern Rajasthan the situation is different, however. There were a dozen or so mines and outcrops in the region that I visited but sampled only sparingly (or not at all) because the material at them was subpar. There is no need to mention them below because there are unquestionably hundreds more like them. Nor is it necessary to try to list the plethora of excellent quality steatite deposits that I was unable to visit. It is enough to recognize that the materials collected, although carefully selected to be geographically and geologically representative, constitute an extremely small sample of steatite in this region.

Dolomitic occurrences sampled

The various dolomitic formations of southern Rajasthan all belong to the Early Proterozoic (ca. 2500 – 2000 m.y.a.) *Aravalli Supergroup* of rocks (Gupta *et al*. 1997).

In the Rajsamand District, a belt of steatite extending around 29 km occurs in the dolomitic marble of the Haldighathi Formation (Gahlot and Shukla 2000: 111-112; Gupta *et al*. 1997: *geologic map*). Samples were collected at two mines around five kilometers apart in the center of this zone – Karoli (RKA) and Rabcha (RRA). In the central Udaipur District, steatite in Kathalia dolomite was sampled at Dev Pura (RDV) mine. This deposit lies just 12 km southeast of the famous lead-zinc mines at Zawar (Freestone *et al*. 1985; Craddock *et al.* 1989). In the southeastern part of the Udaipur district, a belt of steatite in Jagpura dolomitic begins near Salumbar mine (RSA) and terminates 40 km to the southeast at the massive Deola (RDP) open-pit mine (Figure 7.28) in the Dungarpur District (Department of Mines and Geology 1992: 13; Gupta *et al*. 1997: *geologic map*). Samples for this study were collected from each of those locations.

Ultramafic occurrences sampled

Steatite deposits of ultramafic origin in southern Rajasthan are hosted within rocks of the Rakhabdev Ultramafic Suite, which occurs in three belts (Gupta *et al*. 1997: 158-159). Geologic samples for this study were taken in the southernmost and largest belt (it actually diverges into two sub-belts) that extends from the Udaipur District into the Dungarpur District. From north to south the six mines and/or outcrops sampled were: Kali Ghadi mine (RKG), Shiv Bola mine (RSB) (Figure 7.29)and the nearby (1.5 km) outcrop at Rishab-der (RRD), Khadi Ghati mine (RSH), Shala Shah Thana mine (RST) and Manpur mine (RMP).

Steatite occurrences in Gujarat

The southern fringes of the Aravalli Range extend across the Rajasthan border into the northeastern part of Gujarat. Geologically, the steatite-bearing formations in that trans-border area are continuations of those to the north. The steatite deposits found in them would have been the absolute nearest sources of that stone for the Harappans of Gujarat – a fact already noted by S.R. Rao (1985: 583) in his discussion of steatite artifacts at Lothal.

Steatite samples were collected around the Dev Mori (Devni Mori) area (at Bhiloda and nearby Kundol – DMB & DMK) in the Sabarkantha District (Indian Bureau of Mines 1992: 108; Middlemiss 1912) (Figure 7.30). These deposits and six additional ones found within 10 to 35 km of Dev Mori (see Chatteerjee 1964: 436 for deposit names) are part an outlying sub-belt of the Rakhabdev Ultramafic Suite, which was discussed in the preceding section.

Around 125 km farther south, another cluster of steatite deposits is found in the Vadodara and Panchmahal districts (Geological Survey of India 2001a: 76). All occur in the dolomitic limestone formation of the Precambrian Champaner Group (Dwivedi 1984). Samples representing this cluster were taken at Gandhra (GPM) in the Panchmahal District.

Figure 7.30 The Dev Mori/Kundol steatite mine, Sabarkantha District, Gujarat.

A brief note on steatite occurrences in other regions

Two other regions should be quickly noted in closing. Because of the existence of Shortughaï, the steatite deposits of Afghanistan, especially those in its eastern provinces (identified in ESCAP 1995; Orris and Bliss 2002; and Peters *et al*. 2007), must be considered potential sources. Also, the clear evidence of Harappan interaction with the Oman region (Cleuziou 1992) opens the possibility that steatite from the extensive Semail ophiolite of the eastern Arabian Peninsula may have made its way, perhaps together with copper from deposits in that formation, to consumers in the Indus Valley. Using INAA and XRD, I recently analyzed a set of unfired steatite beads and bead manufacturing debris from the early 3rd millennium BC coastal site of HD-6 in the Ra's al-Hadd area of Oman (Cleuziou and Tosi 2000). Although those data have not yet been fully integrated into the present study, they do provide an important new perspective on the results and so I will referring to them in the discussion section of this chapter.

A GEOLOGIC PROVENIENCE STUDY OF STEATITE ARTIFACTS FROM HARAPPA AND SEVEN OTHER SITES

A set of unfired steatite artifacts from Harappa and eight other archaeological sites was presented in the first section of this chapter. The various steatite occurrences of the Greater Indus region from which those artifacts potentially may have been acquired were discussed in the second. In this section, I provide the details and results of a geologic provenience study in which INAA-derived data was used to compare the archaeological set to geologic samples collected from over three dozen of those potential sources. Before doing so, however, I review various geologic provenience studies of steatite artifacts that have been conducted in the past. In terms of the present undertaking, those studies provided both models to follow and examples of what to avoid.

Past geologic provenience studies of steatite artifacts

The use of quantitative methods in attempts to differentiate steatite deposits and/or assign geologic proveniences to steatite artifacts go back more than 60 years to Bullen and Howell's spectrographic analysis (1943) soapstone sources in New England. Although that initial study provided inconclusive results, more research later followed with varying degrees of success. Kohl and others (1979) used X-ray diffraction (XRD) analysis to examine 375 "softstone" vessels (most were actually chlorite but some were steatite) from sites across southwest Asia and Arabia. Although their results suggested that multiple sources were probably represented among the artifacts studied, the effectiveness of using ratios generated from X-ray peak intensities for provenience resolution proved to be limited (ibid.: 147). Turnbaugh and others (1984) employed macroscopic observations, petrography and major element profiling using atomic absorption spectrometry in a study of six southern New England soapstone quarries. Although they documented significant inter-quarry compositional variation, it was unclear if this combination of techniques could be used to confidently assign provenience to artifactual materials (ibid.: 137). Recently, Magee and others (2005) conducted a promising pilot study of 15 "softstone" (both chlorite and steatite) vessel fragments from two Iron-Age sites in southeastern Arabia using ICP-MS/OES (optical emissions spectrometry). Focusing on measured concentrations of transition metals, their results indicated that stone from multiple distinct sources was likely represented among the artifacts. This method could eventually be an effective tool for provenience determination when samples from geologic sources are included in a dataset.

The most successful geologic provenience studies of steatite artifacts to date have involved instrumental neutron activation analysis (INAA). The use of this method was pioneered by Ralph O. Allen and others at the University of Virginia who, after concluding that the relative concentrations of rare earth elements (REEs) remained more or less constant throughout steatite occurrences, characterized numerous quarries and soapstone artifacts in the eastern United States and Canada (Allen *et al*. 1975; Allen and Pennell 1978; Luckenbach *et al* 1975; Rogers *et al*. 1983). Measured REE concentrations from quarries were normalized by dividing them by REE in concentrations chondritic meteorites. An REE distributional curve profile or "fingerprint" for each quarry was generated against which chondrite-normalized REE profiles of steatite artifacts could be compared and matched. Although this seemed to work very well for Allen and his associates, Moffat and Buttler (1986) called the whole approach into question after finding that REE concentrations were too low and too variable in Shetland Islands steatite sources to be of use in provenience studies of artifacts from that region. To be fair, the extended count times employed by Allen and others (Pennell 1978 cited by Truncer 1998: 24) generated data that was much more precise than that produced by Moffat and Buttler's comparatively short measurements. However, some valid points were made regarding the need for more rigorous sampling to assess intra-source variability as well as about the usefulness of REE-profiles as quarry "fingerprints." Truncer and others (1998) took up these issues in a study at the University of Missouri Research Reactor (MURR) that partially involved the re-sampling and analysis of a number steatite quarries in eastern North

America previously characterized by Allen's group. They found INAA to still be an effective technique for differentiating individual sources and assigning geologic provenience, at least on a regional level, to soapstone artifacts. Importantly, they discovered that transition metals, rather than REEs, contributed most to steatite source discrimination and that canonical discriminant analysis (CDA) was a more appropriate method of data evaluation than REE "fingerprints."

The present study is largely modeled after Truncer and other's successful 1998 research project. It employs INAA (although irradiation and count times at the UWNR differ from those used at the MURR), focuses heavily on transition metals and relies mainly on CDA for source discrimination and provenience assignment. It differs somewhat from that and most of the other studies discussed above in its definition of what constitutes a steatite "source" and the expectations of provenience resolution stemming from it. Here a "source" area is considered to be a distinct *geologic formation* in which bodies of steatite occur, rather than an individual outcrop or quarry. For Harappa, which lays no less than 325 km from any steatite source, this level of geographic resolution is more than sufficient.

Details and results of the present study

One hundred forty unfired steatite artifacts from Harappa, thirty-seven such artifacts from the seven additional sites and 442 geologic samples collected from 37 deposits of Harappan-quality steatite around the Greater Indus region were analyzed using INAA. Sample preparation and irradiation followed those procedures outlined in Chapter 3. For the geologic samples, the measured concentrations for 11 elements (Al, Co, Cr, Eu, Fe, La, Mn, Na, Sc, V and Zn) can be found in Appendix 7.3. For the archaeological samples from Harappa those data are listed in Appendix 7.4; for Mohenjo-daro in Appendix 7.5; for Mehrgarh and Nausharo they are in Appendix 7.6; and for all remaining archaeological samples (from Gola Dhoro, Nagwada, Loralai, Mitathal and Tepe Hissar) they are in Appendix 7.7. INAA-derived data were evaluated using CDA and cluster analysis (CA), again following procedures discussed in Chapter 2. Appendix 7.8 lists the standardized (canonical) discriminant function coefficients for all scatterplots (below) generated using CDA.

Initial CDA and CA comparisons of all steatite artifacts to the geologic sources

Examination of the INAA results begins with a comparison of the geologic sources only. On Figure 7.31, the 442 geologic samples are plotted using the first and second discriminant functions generated from CDA of the 37 deposits. The symbols representing steatite samples from dolomitic parent-rock are those in shades of green (some have black or white elements) while the ones representing samples from ultramafic sources are in black and/or black and white. The map of the Greater Indus region (Figure 7.2) at the beginning of this chapter and the detail maps from the preceding section (figures 7.10, 7.15 and 7.22 A to D) serve as the symbol key for the geologic samples.

It is clear from the two distinct clusters of datapoints on Figure 7.31 that steatite deposits of dolomitic and ultramafic origin are geochemically distinct from one another. This is because the ultramafic steatite samples have a higher average concentration of certain transition metals (in particular Co, Cr, Fe, Mn and Sc) as compared to the dolomitic samples, which have higher concentrations of the two REEs Eu and La (Figure 7.33).

A minor amount of overlap between the two large clusters of deposits representing the two different parent-rock types is, however, evident on the plot. Most of it comes from two deposits – Urgasai Nasir (ZUN) and Takhahen (ZTAK), both of which are in the Muslimbagh ophiolite of northern Balochistan. At certain places, the ultramafic rock of that formation comes into contact with Mesozoic limestones and shales (Ahmad 1974: 4; Ahmad and Abbas 1979: 245). Although more detailed field studies are needed to confirm this, ZUN and ZTAK are *perhaps* deposits formed where hydrothermal alteration has occurred at the point of contact between the two types of parent-rock. The result might then be steatite bodies having concentrations of certain metallic elements that are higher than usual for dolomitic occurrences but somewhat lower than is typical of ultramafic ones.

A second area of overlap is associated with the Rabcha deposit (RRA) of southern Rajasthan. Three samples from that source had uncommonly high Co and Cr concentrations for a dolomitic deposit.

In spite of areas of overlap, good separation overall between the groups of samples comprising the full geologic set was achieved. When the leave-one-out cross-validation function was applied, exactly 69% of grouped geologic cases were classified correctly.

When the set of 179 artifacts are plotted as ungrouped cases in relation to the geologic samples (Figure 7.32), one thing becomes immediately clear. That is, the vast majority of the unfired steatite artifacts analyzed are composed of raw material derived from deposits of dolomitic origin. Only a handful (8 of 179) of the artifacts in the archaeological set plot in or near the cluster created by samples from ultramafic deposits. The first predicted group memberships (PGMs) for artifacts from Harappa made in this initial CDA can be found in Appendix 7.1 in the column labeled "full set" (meaning they were made in a comparison to the full geologic set). The two to five letter source codes listed correspond to those given in the text as well as those listed in column four of Appendix 7.2.

For the second round of CDA, the geologic samples were divided into two sub-sets according to their parent-rock type (ultramafic or dolomitic) and then those artifacts that had been predicted to belong to deposits of each type in the first round of analysis were compared to them as ungrouped cases. Slightly better separation than before was achieved for both sub-sets. For deposits of ultramafic origin (Figure 7.34), 71.2% of cross-validated grouped geologic cases were classified correctly while 71.3% for dolomitic sources (Figure 7.35)were classified correctly. The first and second PGMs for artifacts from Harappa made in these second-round analyses are listed in Appendix 7.1 under the column heading "parent-rock." Those results are examined in detail in the section that follows this one. The PGMs for steatite artifacts from the eight other prehistoric sites are discussed in the section after that.

Cluster analyses (CA) were also performed on 177 steatite artifacts[1] and the full set of geologic samples. Multiple clustering strategies were employed and the dendrograms produced in each one (not shown) were, on the whole, very similar to one another. Figure 7.36 is a dendrogram (divided into three parts in order to fit it on a single page) made using the *complete linkage* (also called *furthest neighbor*) method and a squared Euclidian distance measurement. In Appendix 7.9, it is reproduced on 15 pages (sections A through O) and the artifact/sample number for each case in it is provided. Preceding the number for most of the artifacts from Harappa is one of four short codes in parentheses – "(C1)" through "(C4)." These codes, which denote a numbered cluster in which the artifact is a member, are used in a later CA of 140 archaeological samples from Harappa (Figure 7.40).

Just as in the original CDA of the full geologic set (Figure 7.31), samples from ultramafic sources form a group/cluster that, for the most part, is highly distinct from those formed by samples collected from dolomitic deposits. Four "main" clusters – one entirely composed of ultramafic samples and three entirely or mainly composed of dolomitic ones, were

1) Two artifacts - the seal boss (H90/3208-68) from Harappa and the seal fragment from Mitathal - were added to this study at the last minute and, therefore, it was not possible to revise the cluster analyses presented in this chapter to include them.

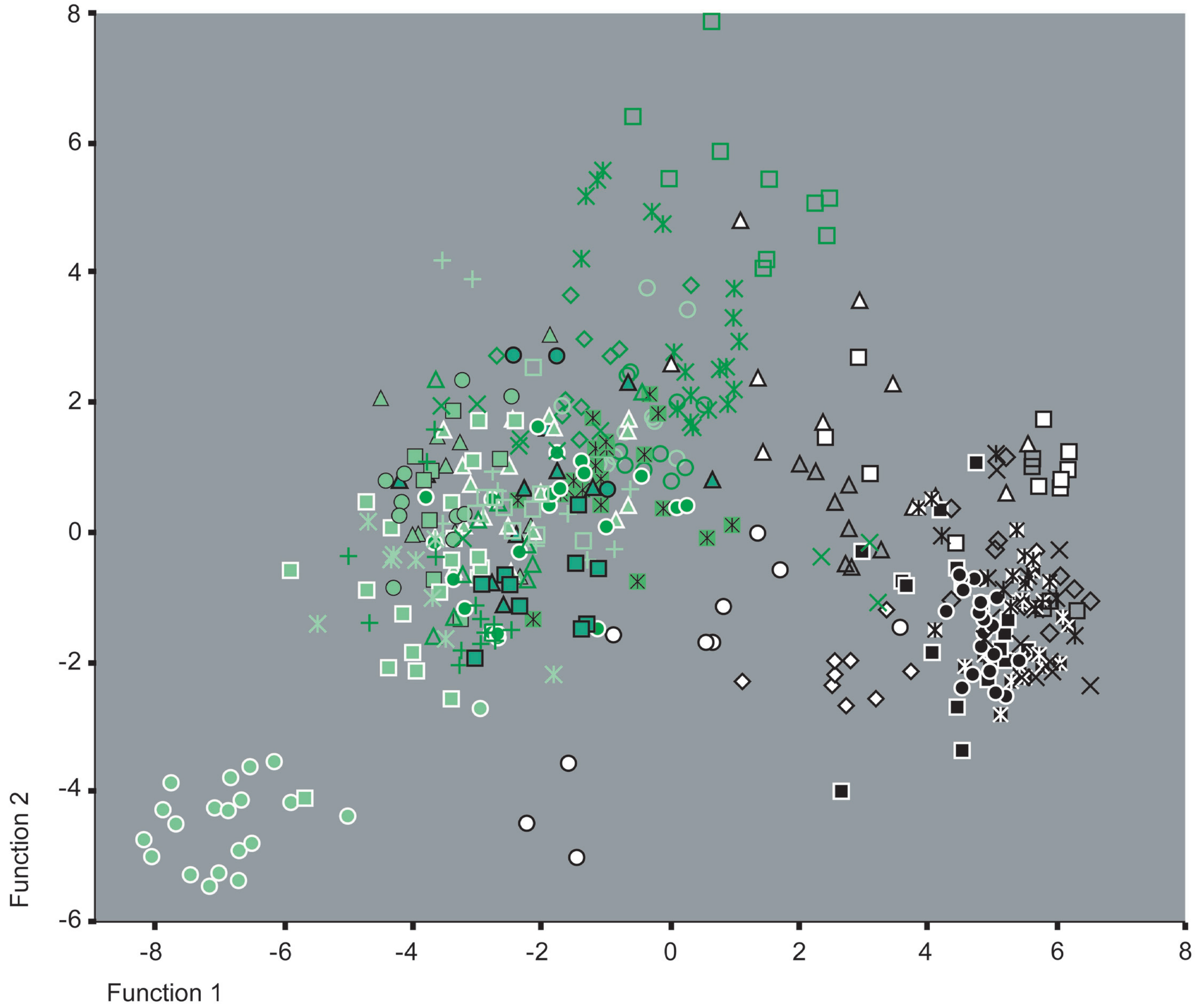


Figure 7.31

All 442 geologic steatite samples from the 37 locations are compared. Each location is evaluated as an individual group

Discriminant functions generated using the elements Al, Co, Cr, Eu, Fe, La, Mn, Na, Sc, V, Zn

Symbols representing samples from **dolomitic** parent-rock are those in shades of green (some of them have black or white elements). Symbols that represent steatite from **ultramafic** sources are in black and/or white only.

For **key** to source symbols see figures 7.2, 7.10, 7.15 and 7.22 A to D

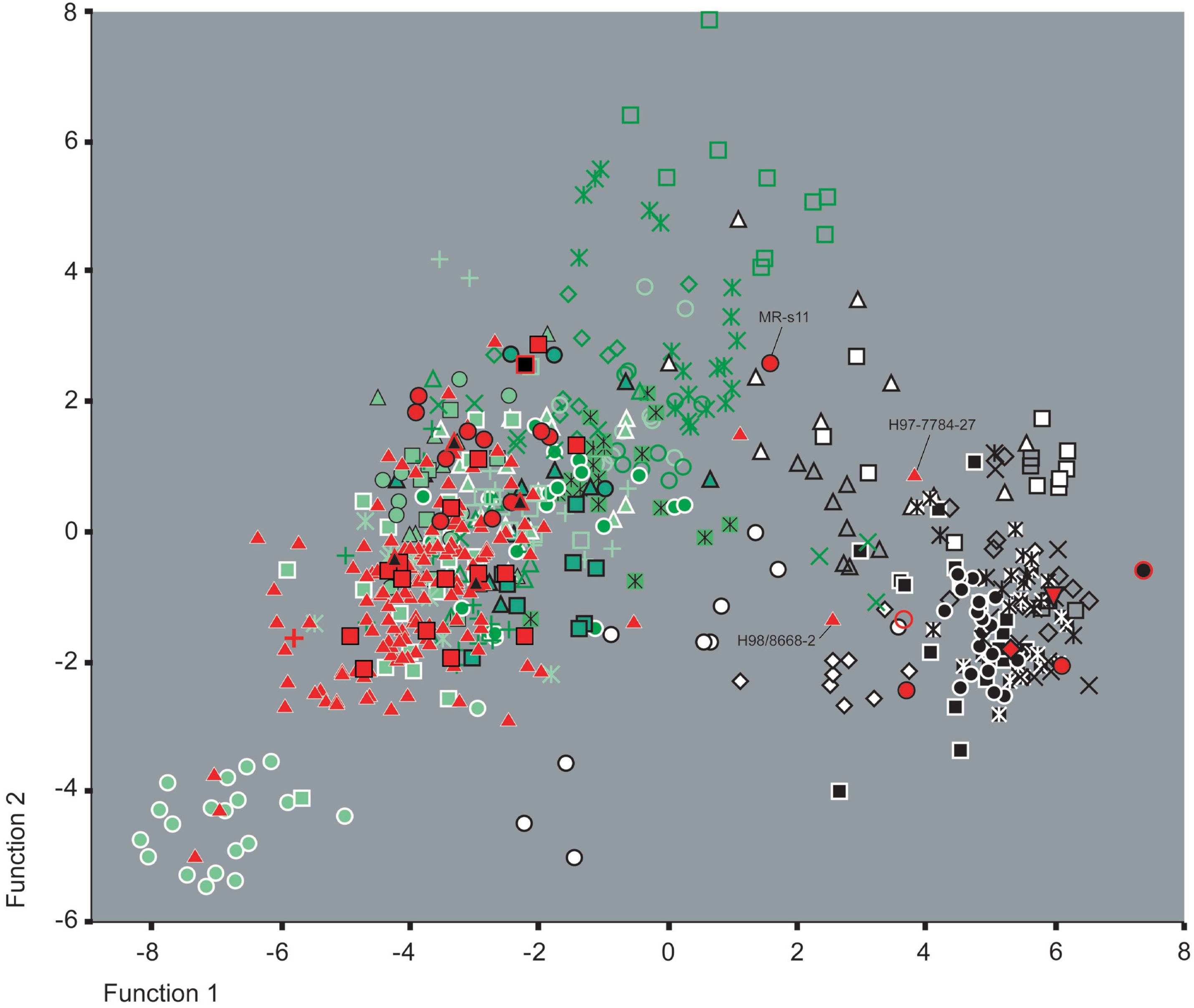


Figure 7.32

All 179 steatite **artifacts** analyzed for this study are plotted as ungrouped cases in relation to the 442 geologic samples.

Discriminant functions generated using the elements Al, Co, Cr, Eu, Fe, La, Mn, Na, V, Zn

Artifact key

- Harappa
- Mohenjo-daro
- Mitathal
- Mehrgarh
- Nausharo
- Loralai fragment
- Loralai beads
- Gola Dhoro
- Nagwada
- Tepe Hissar

Figure 7.33 Average elemental concentrations (PPM) in dolomitic vs. ultramafic steatite sources

element	Al	Co	Cr	Eu	Fe	La	Mn	Na	Sc	V	Zn
dolomitic *average*	15170	9.2	24	0.26	14854	3.69	80	1065	2.45	23.7	78.5
ultramafic *average*	13156	69.1	1297	0.16	30458	1.53	286	538	4.14	24.4	56.5

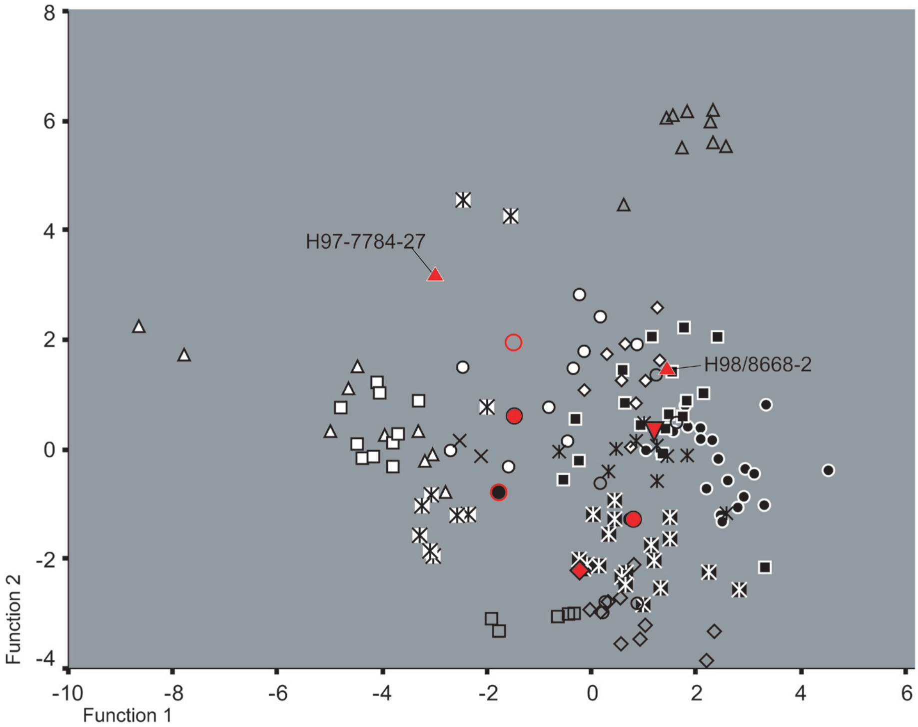


Figure 7.34:

Select steatite **artifacts** plotted as ungrouped cases in relation to the 153 geologic samples from 14 **ultramafic** steatite deposits.

Discriminant functions generated using the elements Al, Co, Cr, Eu, Fe, La, Mn, Na, V, Zn

For **source key** see figures 7.2, 7.10, 7.15 and 7.22 D

Artifact key
- Harappa
- Mehrgarh
- Nausharo
- Loralai beads
- Gola Dhoro
- Nagwada

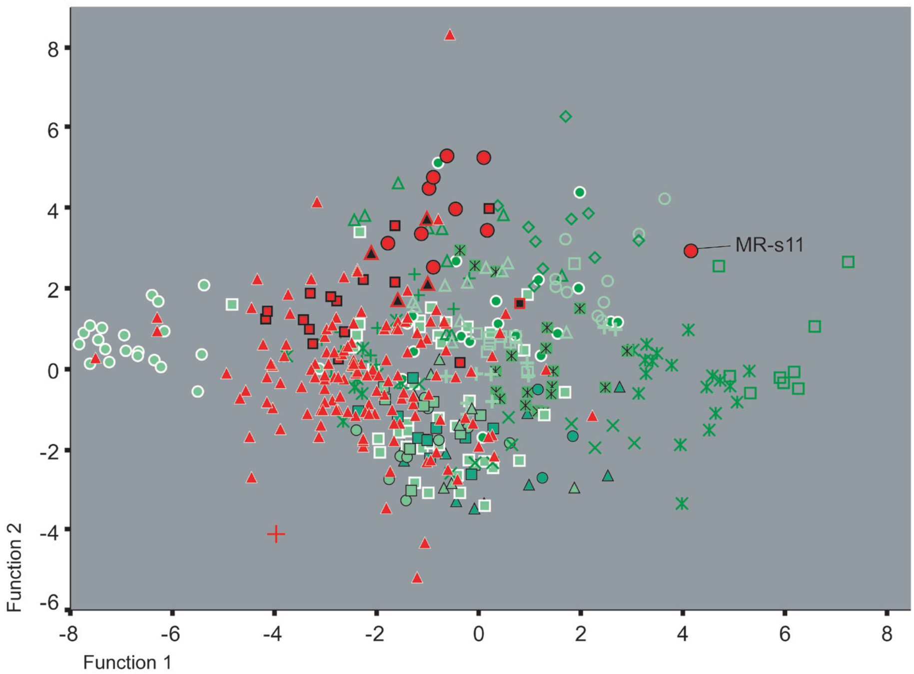


Figure 7.35:

Select steatite **artifacts** plotted as ungrouped cases in relation to the 289 geologic samples from 23 **dolomitic** steatite deposits.

Discriminant functions generated using the elements Al, Co, Cr, Eu, Fe, La, Mn, Na, V, Zn

For **source key** see figures 7.2 and 7.22 A through D

Artifact key
- Harappa
- Mohenjo-daro
- Mitathal
- Mehrgarh
- Loralai fragment
- Tepe Hissar

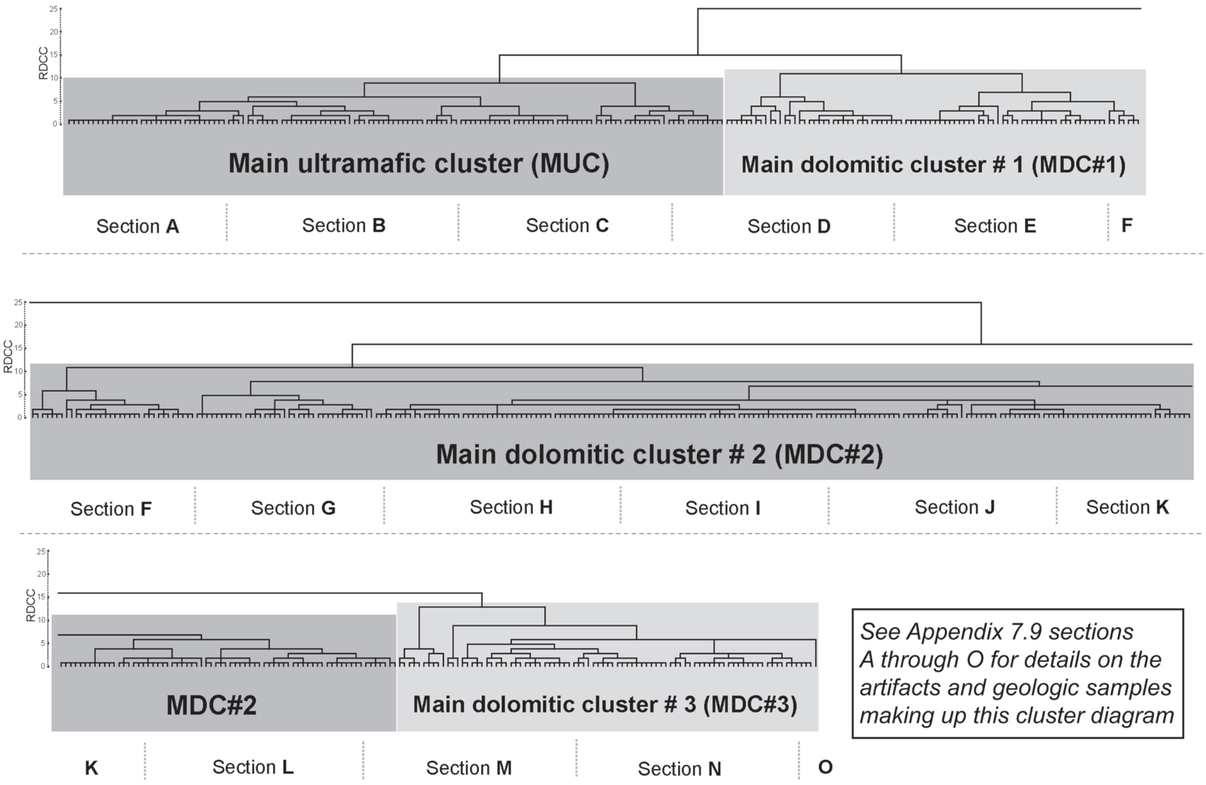


Figure 7.36 Cluster analysis of 177 steatite artifacts and 442 geologic samples.

designated (discussed below) and are labeled on Figure 7.36. There is a modicum of overlap between the two types of geologic parent-rock and, as before, it is due mostly to samples from two deposits (ZTAK and ZUN) in the Muslimbagh ophiolite clustering among the dolomitic sources. A small number (10) of samples from other ultramafic deposits (LBW1 and RST) also appear in the dolomitic clusters. None from dolomitic sources appear within the ultramafic cluster, however. The great majority of steatite artifacts (170 of 177) cluster with samples from the various dolomitic sources, just as in the original CDA comparison of the full archaeological set to the full geologic set (Figure 7.32).

On each dendrogram there is a numbered axis that is labeled *rescaled distance cluster combine* (or RDCC). This scale is used to indicate the similarity/dissimilarity between two clusters by providing the value for the point that they meet (join or split). RDCC values are generated by rescaling the various distance measurements made in the CA from 1 (closest or most similar) to 25 (farthest or least similar). In the initial CA of the archaeological and geologic sample sets (Figure 7.36), the two most dissimilar clusters (those that split at RDCC 25) were: 1) a combined group (macrocluster) consisting of both a cluster of ultramafic samples and artifacts and a cluster of dolomitic ones and 2) another macrocluster made up mainly of dolomitic samples and artifacts. The former macrocluster splits at RDCC 15 (noted in section D of Appendix 7.9) and was subsequently divided at that point into the "Main ultramafic cluster" (MUC) and "Main dolomitic cluster #1" (MDC#1). The latter macrocluster was divided into main dolomitic clusters #2 and #3 (MDC#2 and MDC#3) based on a split that occurs at RDCC 16 (Appendix 7.9 Section J).

There are numerous other distinct clusters evident within each of the four "main" ones that have defined (Figure 7.36). However, no designations are given to them at this point because none represent complete, geologically homogenous groups. That is to say, none of the individual geologic sources in the dataset can have all of its members encompassed into a single cluster without also having members from other geologic sources included in it. The reason for this is that many deposits in the geologic dataset are highly variable geochemically as well as compositionally similar to one another. Consequently, samples from many deposits spread widely across the dendrogram, clustering near those from different sources that are compositionally like them. Whereas there was a very minor degree of overlap between the ultramafic and dolomitic sources when they were considered as unified groups, at a level of comparison involving individual deposits the degree of overlap is much more significant. The outcome has already been seen in the results of the initial CDA of the datasets discussed above. Because of the overlap between various deposits in the geologic dataset, group discrimination is imperfect. This continues to be the case in CDAs performed in the next section. The correct classification success rate for cross-validated geologic samples will, at best, only ever approach around 80%. What it means for this study is that it is not possible to simply observe where an artifact falls on the CA dendrogram, note which geologic samples cluster with it and make a specific provenience determination based on that observation.

In spite of the overlap issue, a great deal of information, including much regarding the possible geologic proveniences of unfired steatite artifacts, can be gleaned from the dendrogram of the archaeological and full geologic sets (Figure 7.36). However, because the data depicted are very complex, effectively interpreting it requires having a full and detailed understanding of the variability of the geologic samples and of the associations that the artifacts have with them. This is gained through multiple CDAs of refined and regrouped versions of the geologic dataset along with CAs that focus on specific sub-sets of artifacts. These analyses are detailed in the next section, as artifacts from Harappa are first put through a series of CDA comparisons to the geologic set and then evaluated (both as a separate assemblage and in relation to the full geologic set) using CA. The results are then interpreted with reference to the three lines of inquiry outlined in Chapter 1. In the subsequent section, the artifacts from the other sites are similarly analyzed and interpreted.

Unfired steatite artifacts from Harappa

- Canonical discriminant analyses

When compared by CDA to samples from the 37 geologic deposits (Figure 7.32), the predicted group membership (PGM) for 139 of the 141 steatite artifacts from Harappa was one of the dolomitic sources. The two artifacts predicted to belong to an ultramafic deposit are labeled on figures 7.32 and 7.34. H98/8668-2 – the BMAC wig (Figure 7.5 E), was assigned to the Sakhakot-Qila deposit (KOT) of the NWFP. H97-7784-27 – a sawn fragment, was assigned to the Duddo deposit (LBW1) of southern Balochistan. These PGMs are evaluated and their implications discussed at the end of this section.

We now focus just on the 139 unfired steatite artifacts from Harappa that in the first CDA of the full geologic set (Figure 7.32) were predicted to belong to one of the dolomitic sources. Figure 7.37 is a summary table of the PGMs from that analysis and from three subsequent ones (PGMs are listed for each individual artifact in the final four columns of Appendix 7.1). Out of the 23 dolomitic deposits sampled (each of which was treated as an individual group during CDA) only 14 had any of the 139 artifacts assigned to them during the various CDAs. In the first two columns of Figure 7.37, those 14 are listed according to the region in which they are found. The third column shows the number of unfired steatite artifacts that were predicted in the initial "full set" CDA to belong to each of those deposits. The first highest PGM for 87 of the artifacts (or around 63% of the total number) was one of the three Sherwan zone deposits in the Hazara District of the NWFP. Seventeen were assigned to the Painthal, Jammu source; thirteen to the Prang Dera deposit in the Khyber Agency and five to the Daradar deposit in the Safed Koh Range of the Kurram Agency.

In total, 124 of the 139 artifacts most closely resembled steatite from deposits in a region 330 to 445 km north of Harappa. I will frequently refer to this as the "northern" region. Of the remaining 16 artifacts, the first PGMs for eight were in northern Rajasthan, six were in southern Rajasthan and the PGM of two was the Shisha Khani deposit in Uttaranchal. This initial CDA has not only shown that residents of Harappa were almost exclusively using dolomitic steatite, but also indicated that the majority of it was likely acquired from deposits in the "northern" region, in particular those in the Sherwan zone. Only a small percentage (≈ 12%) of this variety of stone appeared to be from deposits in other regions.

Next, we examine the results of the second CDA (Figure 7.35) in which artifacts of dolomitic origin were compared only to samples from the 23 dolomitic deposits in the geologic set. The fourth column of Figure 7.37 (heading "all dolomitic sources") shows the number of the 139 examples from Harappa predicted to belong to each of the 14 deposits that were assigned artifacts. The first PGMs for this analysis were largely the same as in the initial one. Only 19 artifacts (or around 14%) were reclassified. For several of those cases, the new prediction was another deposit in the same geologic formation (such as SKK being reclassified as SC in the Sherwan zone) and for many others it was another deposit in the same general region (such as SB in the Sherwan zone changing to JAMPT in Jammu). The first highest PGM for 79 of the artifacts (57% of the total number) was one of the three Sherwan deposits and, altogether, 117 artifacts were assigned to sources occurring in the general region to the north of Harappa. The remaining 22 were predicted to belong to deposits in Uttaranchal and Rajasthan. Two additional deposits – Karoli in southern Rajasthan (RKA) and Chatikhet/Kanda in Uttaranchal (UB), were assigned an artifact each.

Several additional rounds of CDA were performed in which those deposits *not* predicted to be a source of any of the artifacts were removed from the geologic set. The refined set was then re-analyzed and re-compared to the dolomitic artifacts from Harappa. Throughout this process the artifact PGM patterns remained more or less the same. Finally there came a point when 11 deposits remained in the dolomitic sub-set, each of which was predicted to be the source of at least one artifact. Figure 7.38 is the scatterplot from that last CDA. Nearly 80% (78.8%) of cross-validated grouped cases now classified correctly. The PGM summary is in Figure 7.37 under the column heading "11 dolomitic sources." This time around 94 of the 139 artifacts (68%) were assigned to one of the Sherwan deposits. Together with those from Jammu and the FATA, a total of 129 artifacts (93%) were predicted to belong to "northern" region sources. Only ten artifacts were assigned to groups made up of samples from deposits in Rajasthan or Uttaranchal.

One final CDA involving the 139 dolomitic artifacts from Harappa was performed. For this one, all dolomitic deposits occurring within the same geologic formations were combined to create new *regional* groups. So, for instance, the three deposits sampled in the Abbottabad Formation of the Hazara District, which had previously been treated as separate groups, were combined into one new group designated "Sherwan." In this way, new regional groups were created (and named) for "Uttaranchal," "Jhunjhunu," "Alwar & Dausa" and "southern Rajasthan." Those deposits that were the only occurrence sampled in a particular formation were left unchanged and retaining their original source codes.

It was expected that some discriminatory power would be lost by combining broadly related deposits in this way. Indeed, when the leave-one-out cross-validation function was applied to the regrouped dataset the correct classification success rate fell to 66.8% – slightly lower than what it had been for the original CDA of the full geologic set. However, combining deposits allowed significantly

Figure 7.37 Predicted group membership (PGM) summary table for four CDAs of the138 unfired steatite artifacts from Harappa belonging to dolomitic sources.

region	*deposit*	Full geologic set 1st PGM	All dolomitic sources 1st PGM	2nd PGM summary for All dolomitic sources analysis	11 dolomitic sources 1st PGM	Regional dolomitic 1st PGM
FATA	Kurram-Daradar (PD)	6	7	SBx4, SKK x2 USK	7	PD 15
	Khyber-Prang Dera (LKPD)	13	12	ATM, BESH x3, RDP x2, SB, SC x4, SKK	14	LKPD 15
NWFP	Sherwan deposits Bandi (SB)	57	47	ATM, JKK x2, PD x7, RSA x2, LKPD x7, SC x2, SKK x26	40	Sherwan (SB,SC, SKK) 83
	Chelethar (SC)	13	14	JJG, LKPD, RDP, SB x3,SKK x8	16	
	Khanda Khu (SKK)	17	18	PD, SB x10, SC x6, UB	38	
Jammu	Painthal (JAMPT)	17	19	BESH, LKPD, RSA x7, SB x5, SKK x2, USK x3	14	JAMPT 16
Uttaranchal	Bageshwar deposits Chatikhet to Kanda (UB)	0	1	SC	0	Uttaranchal (UB,US, USK) 2
	Shishi Khani (USK)	2	2	SKK x2	2	
Northern Rajasthan	Alwar deposits Nangalhari-Bairaswas (ANB)	1	1	ATM	2	Alwar &Dausa (ANB, ATM ASM, DGT) 0
	Teori (ATM)	4	4	JJK, RSA, SB x2	2	
	Jhunjhunu-Kho (JKK)	3	5	ATM x2, RDP, SB x2	0	Jhunjhunu (JJC, JJG, JJK) 5
Southern Rajasthan	Dungarpur-Deola (RDP)	1	1	SC	2	Southern Rajasthan (RRA, RKA, RDV, RSA, RDP) 3
	Udaipur-Salumbar (RSA)	5	7	LKPD, SB x3, SKK x2, USK	2	
	Rajsamand-Karoli (RKA)	0	1	PD	0	

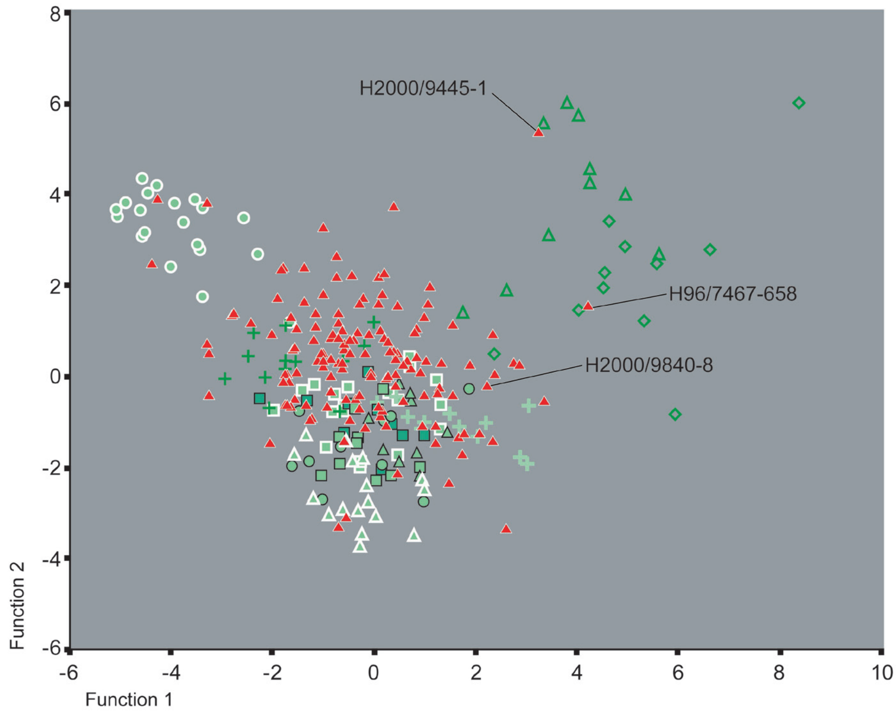


Figure 7.38:

Harappan steatite **artifacts** plotted as ungrouped cases in relation to the geologic samples from 11 **dolomitic** steatite deposits.

Discriminant functions generated using the elements Al, Co, Cr, Eu, Fe, La, Mn, Na, V, Zn

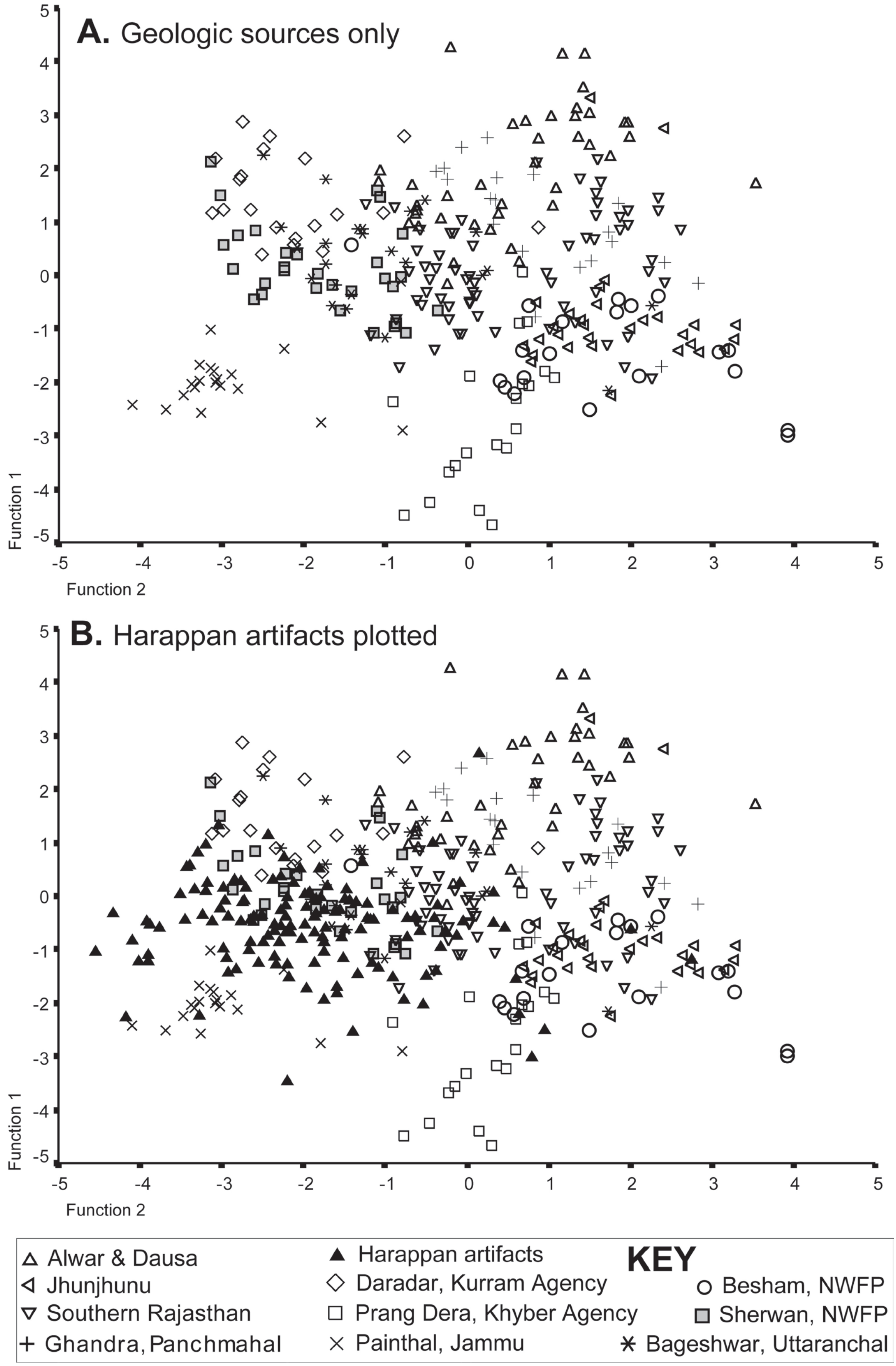
For **source key** see figures 7.2 and 7.22 A through D

larger groups to be compared, thus providing more statistically secure appraisals. Whereas in the subset of 23 dolomitic deposits no group had more than 20 members, the ten groups now in the set ranged in size from 20 (for the individual deposits) up to 65 members (for the southern Rajasthan group).

Figure 7.39 A shows the re-grouped geologic samples plotted according to their first and second discrimant functions. On Figure 7.39 B, the 139 Harappan artifacts are plotted as ungrouped cases in relation to the samples. The PGMs for this analysis are found in Appendix 7.1 and are summarized in Figure 7.37 under the column headings "regional dolomitic." Eighty-three artifacts were predicted to belong to the Sherwan group while 15, 15 and 16 artifacts were, respectively, assigned to the Daradar (Kurram), Prang Dera (Khyber) and Painthal (Jammu) deposits. Only ten artifacts were assigned to groups made up of samples from deposits in Rajasthan or Uttaranchal.

Repeated comparisons of the unfired steatite artifacts from Harappa to refined and/or regrouped versions of the geologic dataset produced PGMs that were largely consistent with one another from analysis to analysis. However, before simply using those as provenience determinations it is important to be mindful of a few things. First, in CDA each ungrouped case (artifact) is assigned a PGM regardless of its similarity or dissimilarity to any of the groups (deposits) within in a dataset. So in this study the possibility exists that one, several or even all of the artifacts do not actually belong to any of the deposits in the geologic dataset despite being assigned to one. Secondly, recall from the discussion of CDA in Chapter 3 that group membership is predicted based on an individual case's Mahalanobis distances to the various centroids of groups in a dataset. There is a chance that an artifact that genuinely belongs to deposit *A* will be predicted to belong to deposit *B* because it happens to lie closer (has a lower Mahalanobis value) to deposit *B*'s group centroid. The reason may be that the artifact is a distant compositional outlier of deposit *A* or because geochemical similarities between the deposits *A* and *B* have resulted in a degree of overlap among the individual cases making them up. Regarding the latter possibility, I would point out that the classification success rate for cross-validated grouped cases in the geologic set was, at best, around 80%. This indicates that although source discrimination was good, it was

Figure 7.39 CDA comparison of regional dolomitic steatite source areas and Harappan artifacts.



far from perfect. It is for precisely this reason that I have provided the *second* highest group membership predictions (as determined by which group centroid has the second lowest Mahalanobis distance value) after the first PGMs with the results of the "parent-rock" analysis (in Appendix 7.1 this is written as "1st PGM / 2nd PGM"). There is also a summary of these second PGMs in fifth column of Figure 7.37. As artifact provenience determinations are examined more closely below, these second PGMs will be helpful for considering possible alternative source associations.

In all the rounds of CDA, the first PGM for the majority of the artifacts from Harappa was one of the Sherwan zone deposits in the Hazara District, NWFP. The majority of that majority also had a second highest PGM in one of the Sherwan deposits. Because of this and because of the large number of assigned artifacts, I feel that this provenience association is a very strong one. Of the remaining artifacts assigned to Sherwan deposits, the second PGM for most was another one of the occurrences to the north of Harappa. Therefore, if any of those happen to actually not come from the Sherwan zone, there is a very good possibility they were derived from the "northern" region.

The provenience associations for artifacts assigned to the Prang Dera (LKPD) and Painthal (JAMPT) deposits appear, for the most part, to be fairly strong. Their numbers did not shift too drastically from analysis to analysis and around half of their second PGMs were deposits elsewhere in the "northern" region. On the other hand, some of them could be outliers of the Sherwan zone, like those assigned to Daradar (PD) perhaps are. In the first three CDAs, six to seven artifacts were predicted to belong to the Daradar source and the second PGM was in the Sherwan group for all but one of those cases. However, in the final regional-level analysis, nine additional artifacts, many of which had before been assigned to Sherwan, were designated as belonging to Daradar. This could indicate that a number of the artifacts assigned to Sherwan actually derive from other "northern" sources.

Turning now to the artifacts that had first PGMs in other regions, we see that very few (never more than three) were ever predicted to belong to occurrences in Uttaranchal. The second highest PGM for those cases in all analyses was the Sherwan Khanda Khu deposit (SKK). These are very likely compositional outliers from the Sherwan zone. The same is probably also true of many or all of the artifacts predicted to belong to southern Rajasthan deposits (from three to nine in various analyses). On the other hand, the ones assigned to occurrences in northern Rajasthan, although few in number, are somewhat more distinct and *may* be genuinely from that region. They often have second PGMs in the same zone and/or plot apart from the main body of artifacts in the scatterplots. Note, in particular, artifacts H2000/9445-1 and H96/7467-658 (both are identified on Figures 7.38).

Ultimately, it is probably best advised not to treat the PGMs made during the various CDA analyses as hard and fast provenience determinations. Although these predictions may oftentimes provide accurate information about the geologic sources of individual steatite artifacts, they are better (and more reliably) used collectively to reveal broad-scale patterns. When employed in this manner, they help to make a very strong case that most of the steatite acquired by Harappans probably came from sources to the north of their settlement, in particular, those in the Hazara District of the NWFP. Although I advise caution when treating PGMs as firm provenience determinations, I will use those from the refined "11 dolomitic sources" analysis in an upcoming dendrogram (Appendix 7.10) and two tables (figures 7.43 and 7.44) designed to facilitate detailed spatial and temporal examinations of steatite acquisition at Harappa. While doing so, however, close attention is paid to broad-scale patterns and the second PGMs of potentially misclassified artifacts.

- Cluster analyses

Cluster analyses (CA) were performed on 140 unfired steatite artifacts from Harappa (all except the seal boss) in order to determine if they grouped ways that might shed additional light on the previous CDA and CA results and, ultimately, provide insights into the use of this rock variety at the site. Analyzing them alone (instead of with other artifacts and geologic samples) allowed better detection of potentially meaningful clusters among the assemblage. Multiple clustering strategies were used, all of which produced very similar dendrograms. The one in Figure 7.40 was made using the same complete linkage method that was used to make the dendrogram of the archaeological set and full geologic set (Figure 7.36). Four clusters (numbered "C1" through "C4") having members that joined between RDCC between 3 (C2) and 7 (C4) were defined. See Appendix 7.10 sections A and B for information (number, contextual data, type and PGM) on the individual artifacts making up the dendrogram.

The first thing to note is that, with the exception of C4, none of the clusters are entirely homogenous in terms of being made up of artifacts assigned by CDA to a single deposit or to a single geologic formation. This was not unexpected since that the cross-validation success rate for the analysis that supplied the PGMs ("11 dolomitic sources") was only around 80%. There was a good chance that some may have been misclassifications. As a result, compositionally related artifacts assigned different PGMs may have clustered together. Another point to note is that although I have defined four main clusters of artifacts, each does not necessarily correspond to single steatite deposit or even an extended zone of steatite formation. There could be artifacts from several unrelated sources represented within a single cluster or, conversely, a single, compositionally diverse source or source area may be represented by multiple

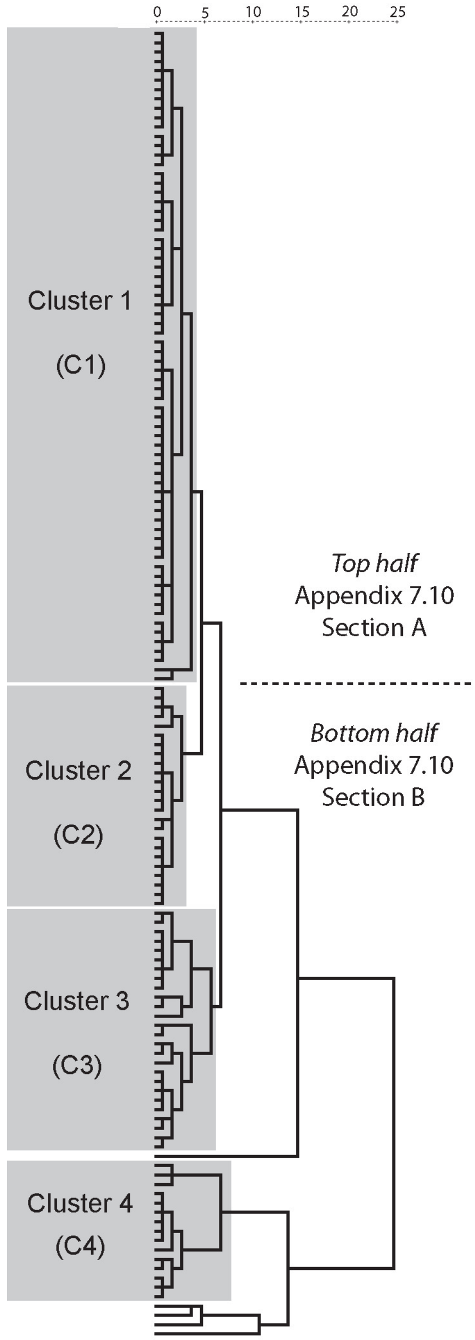


Figure 7.40 Cluster Analysis (Complete linkage / squared Euclidian distance) of 140 steatite artifacts from Harappa

clusters. This should be kept in mind as I discuss how the artifacts are distributed in the dendrogram.

Cluster 1 (C1) encompasses the largest group of unfired steatite artifacts. It has 70 members, 56 of which have one of the Sherwan deposits as their first PGM. Of the other 14 artifacts in the cluster, ten are "northern" sources that have second PGMs of Sherwan so it is possible they actually derive from that zone but were misclassified by CDA. Three of the remaining four were predicted to be from the Painthal, Jammu deposit (JAMPT). The final artifact in cluster has a first PGM in the Teori in deposit of northern Rajasthan (ATM) but may be an outlier of the Sherwan zone as indicated by its second PGM (which is SKK).

Eleven of the 15 artifacts predicted to belong to the Painthal deposit make up nearly half of the 24 members of Cluster 2 (C2). Nine of the remaining 13 are assigned to one of the Sherwan deposits. Three of those have a second PGM of Painthal, however. Two artifacts have a first PGM in the Shisha Khani (USK) deposit of Uttaranchal (with second PGMs in Sherwan) while one is assigned to Deola in southern Rajasthan (RDP).

Eleven of the 14 artifacts assigned by CDA to the Prang Dera deposit in the Khyber Agency (LKPD) are among the 26 members of Cluster 3 (C3). Twelve others artifacts in the cluster were predicted to belong to the Sherwan zone while the remaining three ones have Rajasthan deposits (ANB, RDP and RSA) as first PGMs.

All of the 15 artifacts making up Cluster 4 (C4) have first PGMs in the one of the Sherwan deposits and 13 of 15 of them also have second PGMs in that zone. This is the only homogenous cluster in terms of its members' predicted geologic proveniences.

There are also a few of smaller branches on the dendrogram that are distinct from the four primary clusters. Between C3 and C4 is a single artifact (H2000/9445-1) predicted to belong to Nangalhari-Bairaswas zone (ANB) of northern Rajasthan. Two of the cases in the final small cluster at the bottom of the dendrogram are the artifacts made from ultramafic steatite (discussed at the beginning of this section). Another case (H2000/9840-8) is a fragment assigned to the Sherwan Bandi (SB) deposit. When the ultramafic artifacts are removed and the same CA is performed on the set again (not shown) that particular artifact joins C4. The last artifact (H96/7467-658) on the dendrogram is assigned to the Teori (ATM) deposit of northern Rajasthan. Each artifact (except the ultramafic ones) is noted on the "11 dolomitic sources" CDA scatterplot (Figure 7.38).

The patterns exhibited by the dendrogram shown in Figure 7.40 and by others made using different clustering methods (not shown) helped to support and clarify and much of what CDA previously revealed about the set of dolomitic steatite artifacts from Harappa. Several artifacts that I had suspected were misclassified as belonging to deposits in Uttaranchal and southern Rajasthan were, in fact, shown to be compositionally similar to the numerous ones assigned to the Sherwan deposits and other sources to the north of the site. Others that were thought to genuinely come from sources outside of the "northern" region were confirmed to be compositionally distinct and likely unrelated to the majority of steatite used at Harappa. Although the PGM makeup of each cluster (except for C4) is mixed (no doubt due, in part, to misclassified outliers), artifacts predicted to belong to the same source or source area do have a tendency to group together (those assigned to Sherwan are found mainly in C1 and C4, to Painthal in C2 and to Prang Dera in C3).

Cluster analysis focusing solely on steatite artifacts from Harappa was necessary in order to gain a clear understanding of the compositional variability possessed that sub-assemblage. It is now possible to much better evaluate the distribution of those artifacts among the "main" clusters of the dendrogram generated in the CA of the archaeological set and full geologic set (Figure 7.36). To facilitate the examination of that dendrogram, the number for most of the Harappan artifacts appearing on it (Appendix 7.9) is preceded by the codes (C1 through C4) denoting the cluster that each belonged to in Figure 7.40.

On the full archaeological/geologic dendrogram (Figure 7.36 and Appendix 7.9) the artifacts that were members of C1 and C2 in Figure 7.21 are entirely encompassed in a large, closely related sub-cluster of "main dolomitic cluster #2" (MDC#2) that extends from Section G to Section K and joins at RDCC 4 in Section I. Within that sub-cluster, C1 and C2 artifacts do remain, more or less, distinct from one another suggesting that may represent different deposits or, *perhaps*, different outcrops or veins within a single deposit (the latter possibility is discussed more fully below). The geologic samples encompassed in that same sub-cluster of MDC#2 include 19 of the 20 samples from the Painthal deposit but only eight of the 30 from the Sherwan zone. Recall that C1 was dominated by artifacts with a first PGM in one of the Sherwan deposits and about half of the artifacts in C2 were predicted to belong to the Painthal source with most of the rest assigned to the Sherwan zone. It could be that many of the C1 artifacts assigned to Sherwan actually belong to a source in the Jammu region. However, over half (11 of 20) of the geologic samples from the Daradar deposit are in the sub-cluster too as are six artifacts assigned to that deposit. This just serves to illustrate and remind that overlap for geologic sources is very much a concern at this level and so PGM assignments should be considered tentative.

Most (18 of 26) of the artifacts that had been in C3 group together in a small but closely related sub-cluster of, aptly enough, MDC#3, which runs from Section N to Section O and joins at RDCC 3. Ten artifacts in that cluster have the Prang Dera, Khyber Agency (LKPD) deposit at their first PGM and three others have it as their second PGM. Half of the geologic samples in that same sub-cluster are from that deposit and so it can probably be regarded as fairly strong association. Six of the remaining eight artifacts that were originally in C3 grouped with the C1 and C2 artifacts in the same large sub-cluster of MDC#2 described above. The last two C3 members, both of which were assigned to the Sherwan zone, grouped in a cluster with three Sherwan assigned members of C4 in a sub-cluster (in Section F) of MDC#2 different than the one described above.

All of the Sherwan assigned artifacts that had made up C4 (with the exception of the three members just mentioned) group in MDC#1 (section D and E). That cluster joins at RDCC 6 but most of the artifacts in it are in a sub-cluster that joins at RDCC 2. Also in MDC#1 is H96/7467-658, which had been in the small branch of compositionally distinct artifacts at the bottom of Figure 7.40. Although the Teori (ATM) deposit in the Alwar District of southern Rajasthan is its first PGM, its second PGM is Sherwan Banda (SB) so it could be related to the other Sherwan assigned artifacts also now in MDC#1.

The artifacts that were not in one of the four defined clusters on the 140 Harappan samples dendrogram appear on the archaeological / full geologic set dendrogram in both expected and unexpected ways. The BMAC steatite wig (H98/8668-2) falls in the "Main ultramafic cluster" (MUC) in a small sub-cluster with geologic samples from the Sakhakot-Qila ophiolite. There can now be little doubt that this object is made from stone of ultramafic origin (possibly from the deposit it assigned to) and is very different from the steatite typically used at Harappa. The other artifact that had been predicted to belong to an ultramafic source – H97-7784-27, now is an outlying member of a small sub-cluster in MDC#2 (Appendix 7.9 Section G) made up of samples from the Degota deposit (DGT) in northern Rajasthan and the Khanda deposit (GPM) in Gujarat. This artifact could actually be an unusual dolomitic steatite with ultramafic properties (high Co and Cr concentrations). However, the opposite may be true as it lies nearby two of the samples from ultramafic sources (from ZUN in the Muslimbagh ophiolite) that in CDA and CA have been shown to overlap with the dolomitic sources. The final two artifacts that were compositionally distinct outliers – H2000/9445-1 (assigned to ANB in the Alwar District) and H2000/9840-8 (assigned

Figure 7.41 Artifact clusters with or more 10 members in each of the first three RDCC levels on the full archaeological/geologic set dendrogram (Figure 7.36)			
	RDCC 1 # of members (section/s)	RDCC 2 # of members (section/s)	RDCC 3 # of members (section/s)
Clusters	10 (G) 19 (H) 28 (H & I) 18 (I) 22 (J & K)	10 (D) 10 (G) 11 (G & H) 19 (H) 47 (H & J) 11 (J) 24 (J & K) 11 (N)	10 (D) 10 (G) 77 (G to J) 11 (J) 25 (J & K) 20 (N & O)
total	**5 clusters / 98 artifacts**	**8 clusters / 143 artifacts**	**6 clusters / 153 artifacts**

to Sherwan Banda), both appear in MDC#3 but are still very distinct from both one another and the other artifacts in that cluster.

Before shifting focus from the evaluation of the CA results to their interpretation (in the next sub-section), a few final observations need to be related about the way in which the geologic samples and the artifacts are distributed on the dendrogram of the full geologic and archaeological steatite sets (Figure 7.36 and Appendix 7.9).

To begin with, steatite artifacts (from Harappa and the other sites) tend to group in clusters of cases that are far more closely related to one another than most groups of geologic samples collected from individual steatite deposits. For example, in Section H and I there is a cluster containing 28 artifacts that are all joined at RDCC 1. In other words, they are as compositionally similar to each other as cases depicted on the dendrogram can possibly be. Twenty-five members of that cluster were predicted to belong to one of the Sherwan zone deposits (and the three that were not had second PGMs in that zone). There are many other groups of artifacts like that one. Figure 7.41 is a table listing all of the artifact clusters with ten or more members that join in each of the first three RDCC levels. I chose to define clusters of ten both because it was a good round number and it was close to the average number of geologic samples analyzed per source (n = 11.9). Well over half of the 177 cases in the archaeological set are encompassed in just five clusters at RDCC 1. At RDCC 2, more than four-fifths of the artifacts group together in just eight clusters. One large cluster containing 77 artifacts and five smaller ones are formed at RDCC 3.

To appreciate just how closely related large groups of steatite artifacts are to one another it is only necessary to compare them to the clusters formed by geologic samples from individual deposits. For instance, the 20 samples collected from Prang Dera (PD) in the Khyber Agency are distributed widely across dendrogram (from section G to section N). The various sub-clusters they appear in do not join into a single cluster until RDCC 16. That level of similarity (or dissimilarity) is typical of the geologic deposits in the dataset. Figure 7.42 is a table in which the 37 deposits are listed according to the RDCC level at which all of their members are joined in a single cluster. The average level at which the deposits form complete clusters is 17.8. The only sources whose members all join at RDCC 1 are the Dev Pura (RDV) and Khadi Ghati (RSH) deposits of southern Rajasthan. None of the others join into a single cluster until RDCC 6 or higher. The majority of the deposits in the geologic set (20 of the 37) do not, in fact, completely join until RDCC 25.

The differences in how steatite artifacts tend to cluster versus how samples from steatite deposits typically cluster are striking. The way the latter are

Figure 7.42 Rescaled distance cluster combine (RDCC) values at which all samples from a given geologic deposit can be encompassed into a single cluster on Figure 7.36.

RDCC	**1**	**6**	**7**	**8**	**9**	**11**	**13**	**16**	**25**
Geologic source	RDV RSH	KOT	RKA	JAMPT	ZTT CHT DMK LBW1 RKG RMP RSB	PD	JKK	LKPD SB RSA	ANB ASN ATM BESH DGT GPM JJC JJG RDP RRA SC SKK UB USK US LBW2 RST ZTAK ZUN RRD

dispersed on the dendrograms actually helps to clarify why certain artifact provenience assignments (PGMs) may be distributed in the manner that they are. For example, on both the full sets dendrogram (Figure 7.36 and Appendix 7.9) and on that for the 140 artifacts from Harappa (Figure 7.40 and Appendix 7.10), artifacts assigned to the Sherwan zone appear in every major cluster (except the MUC on Figure 7.36). Some of those clusters (C4 on Figure 7.40 and MDC#1 in Figure 7.36) are quite distinct from most others. This *could* indicate that the artifacts making them up, although they have the same PGMs as those in the other clusters, are from a different source(s). However, it is now clear that samples from most of the individual geologic deposits possess a significant degree of internal geochemical variability and are dispersed in a way not unlike the PGMs. It is very possible, therefore, that artifacts having the same PGM assignments but appearing in different clusters are indeed actually from the same geologic source. Still, the possibility that the compositionally distinctive Harappan artifacts comprising C4 in Figure 7.40 and again appearing (mostly) in MDC#1 on Figure 7.36 (and later in section D of Figure 7.46) are from a source different from that of the other archaeological samples in the set should be kept in mind as discussions of steatite acquisition take place in the next section.

The different clustering patterns for the archaeological and geologic steatite samples have also provided a potentially important insight into the exploitation and use of that variety of stone in antiquity. The large clusters of closely related steatite artifacts could conceivably represent groups of raw material from single geologic occurrences. However, as has just been discussed, few geologic deposits in the dataset even approach having the same level of compositional homogeneity as exhibited by the artifact clusters. I therefore submit that those clusters possibly represent raw material exploited from a very restricted area *within* an individual steatite occurrence, such as a single vein, pit or mine.

When I visited a steatite source for this study I had two objectives: 1) to collect examples of Harappan-quality stone and 2) to obtain the widest range (in terms of spatial distribution and macroscopic appearance) of that material as possible so as to document the geochemical variability of the deposit. With regard to the latter objective, I seem to have succeeded (judging from the dispersed geologic samples and the overlap between sources). The closely related groups of artifacts in the archaeological set may indicate that when Harappans (or their suppliers) visited a steatite source their objective was to acquire a specific kind of material, rather than just any seemingly good-quality stone found there. If they had been obtaining a wider variety of material from across a deposit or zone then the clustering patterns among the artifacts might be expected to look more like those of the geologic sources. Although we cannot be certain that of the all artifacts in a closely related cluster actually came from one source, the exploitation of a very specific kind of stone would fit with what I argue to have been a primary concern for Harappan craftspeople, which was the acquisition of steatite that becomes white when heat-treated.

- Interpretation of the results

The 621 unfired steatite artifacts and geologic samples examined in this chapter constitute the most complex dataset in of this entire study. The painstaking series of analyses and evaluations detailed in the preceding section were necessary in order to get to the point where the predicted group memberships of artifacts could be confidently interpreted and used to form responses to the lines of inquiry outlined in Chapter 1.

Figures 7.43 and 7.44 are tables designed to facilitate the detailed temporal and spatial examination of the steatite artifacts from at Harappa. They were created using the 139 PGMs from resulting from the "11 dolomitic sources" CDA analysis (Figure 7.19 / Appendix 7.1 column 8) and the two PGMs for Harappan artifacts from the ultramafic parent-rock CDA (Figure 7.16 A / Appendix 7.1 column 7). When the results of the two analyses were combined, a total of 13 geologic deposits had artifacts assigned to them. These deposits are listed alphabetically by source code (see Appendix 7.2 column 4) in Figure 7.43 and are cross-referenced with the macroscopic types and general contexts (mound and period) of the artifacts assigned to them (surface and off-mound contexts were not noted this table). Type and contextual data for the artifacts are also found on the reproduction of the 140 Harappan artifacts CA dendrogram (Appendix 7.10), which is also referred to in this examination. Several of the source codes are followed by an asterisk and the notation "actually Sherwan?" For reasons explained in the preceding section, I consider it likely that the handful of artifacts assigned to southern Rajasthan and Uttaranchal are actually from one of the deposits in the Sherwan zone. Some of those assigned to the Daradar (PD) deposit could be as well and so I have noted those along with the others.

In Figure 7.44, the PGMs for all 141 artifacts from Harappa are cross-listed by the area and period from which they were recovered. Multiple artifacts from one source are indicated by a "times" sign and number (e.g., SB x 4 = four artifacts from Sherwan Bandi).

Type associations

Before beginning the discussion of steatite acquisition at Harappa, the macroscopic categories or "types" (Figure 7.4) that were used to classify unfired artifacts at the site are briefly considered in relation to the CDA predicted group memberships and the CA results. As I began to suspect while still collecting geologic samples for this study, there appears to be no clear relationship between the various "types" of raw steatite and sources of that stone (at least those that are in the geologic dataset). The second column of Figure 7.43 shows which of the seven types (A through G) are associated with each of the 13 deposits to which artifacts were assigned None of them appear exclusively with any one source or source area (such as the Sherwan zone). In fact, each is associated

Figure 7.43 The 13 PGMs for the 141 steatite artifacts from Harappa and their type / contextual associations (surface and off-mound contexts not noted). See text and Appendix 7.2 for source codes.

Source (# of artifacts)	**Types**	**Periods**	**Mounds**
ANB (2)	F, G	3B, 3C	AB, F
ATM (2) 1*actually Sherwan?	A	1*	AB
JAMPT (14)	A, B, C, E	1, 2, 3A, 3B	AB, E
KOT (1)	F	3C	F
LBW1 (1)	A	3A	AB
LKPD (13)	A, B, C, F, G	2, 3A, 3B, 3C, 4/5	AB, E, ET, F
PD (8) *actually Sherwan?	A, B, C, E, F	2, 3B, 3C	AB, E, ET, F
RDP (2) *actually Sherwan?	A, D	2, 3C	AB, ET
RSA (2) *actually Sherwan?	A, E	3A, 3C	AB, F
SB (41)	A, B, C, D, E, F, G	2, 3A, 3B, 3C	AB, E, ET, F
SC (16)	A, B, E, F, G	2, 3A, 3B, 3C, 4/5	AB, E
SKK (38)	A, B, C, D, E, F	2, 3A, 3B, 3C	AB, E, ET, F
USK (2) *actually Sherwan?	A	3A	AB

Figure 7.44: Spatial and temporal distribution of the PGMs for the 141 artifacts from Harappa

***Period →* Mound ↓**	***1***	***2***	***3A***	***3B***	***3C***	***4/5***	***surface & disturbed***	***total***
F	*not present*	*not present*	*not present*	PD* SKK	ANB KOT LKPD RSA* SB x7 SKK x2	*not sampled*	*not sampled*	*15*
AB	ATM* JAMPT	JAMPT x6 LKPD PD* RDP* SB SC x 5 SKK x 2	JAMPT LKPD x2 LBW1 RSA* SB x2 SC x3 SKK x9 USK x2*	ANB JAMPT SB x3 SC x4 SKK x2	SB SC	LKPD SC	ATM SC SKK	*58*
E	*not sampled*	JAMPT	JAMPT x2	JAMPT x2 LKPD x2 SB x1 SKK x2	LKPD x3 PD x2 SB x5 SC SKK x5	*not sampled*	JAMPT LKPD PD* SB x 6 SKK x3	*38*
ET	*not present*	*not present*	*not present*	SKK	LKPD x3 PD x2* RDP* SB x6 SKK x7	*not sampled*	SB x3 SKK	*24*
cemetery & off mound	*n/a*	*n/a*	*n/a*	*n/a*	SB x4	*n/a*	SB SKK	*6*
total sampled	*2*	*18*	*23*	*21*	*54*	*2*	*21*	***141***

with at least three different deposits. Artifacts of the same "type" also seem to be, for the most part, highly variable compositionally. A perusal of the type codes listed next to terminal ends of the Harappan artifact dendrogram (Appendix 7.10) indicates that, aside from one or two minor areas (such as where six Type F artifacts fall together in Cluster 2), each type is distributed widely among the four clusters. Of course, samples from most of the geologic deposits are similarly distributed and so it is *possible* that artifact of a particular "type" come from the same source. Even so, these findings suggest it is very unlikely that the macroscopic appearance of unfired steatite artifacts (at least of those from Harappa) can provide reliable information about their geologic provenience.

Addressing the three lines of inquiry

The CDA and CA results are now brought to bear on the three lines of inquiry – the first being: *With whom were residents of Harappa interacting when acquiring steatite? What was the extent of those inter-regional interaction networks during different periods?*

The results of this study indicate that acquiring of most of the steatite used at Harappa would have entailed either direct or indirect interaction with non-Indus Civilization cultures dwelling in the highland region 330 to 445 km north of the city. Around 89% of the 141 steatite artifacts analyzed were predicted to belong to one of seven geologic sources in that region (JAMPT, KOT, LKPD, PD, SB, SB or SKK). When those artifacts that were likely misclassified as belonging sources in southern Rajasthan and Uttaranchal are factored in, the percentage is almost 95%. These percentages, and the others reported in this section, were generated by averaging the first PGMs of the four reported CDAs (listed in the last four columns of Appendix 7.1). When I discuss the provenience of specific artifacts I am relying on the PGM made from the "11 dolomitic sources" CDA unless otherwise stated.

Of the artifacts assigned to "northern" sources, around 69% (61% of the total from Harappa) appear to be most closely related to steatite from occurrences in the Sherwan zone of the Hazara District (SB, SB and SKK), which are around 50 to 60 km north-northwest of the Kot Dijian settlements of Hathial and Sarai Khola. Among these is the unfinished steatite stamp seal (H96/7257-46) pictured in Figure 7.5 A. Approximately 13% were predicted to belong to the Painthal deposit in Jammu, which is just 25 km from the Early Harappan and Harappan site of Manda. The bead blanks (H2000-2301-176 & 177) pictured in 7.5 C & D are assigned to this source. Another 11% of the artifacts assigned to "northern" sources had first PGMs of the Prang Dera source, Khyber Agency. However, it may be that around half of those may actually belong to the Sherwan zone as *perhaps* some or all of the roughly six percent assigned to the Daradar, Kurram Agency source do. The final artifact from Harappa assigned to a "northern" source is the BMAC steatite wig (Figure 7.5 E). Its first PGM, both when compared to the full geologic set and just to the ultramafic deposits, is the Sakhakot-Qila ophiolite (KOT) in the Mohmand Agency, FATA.

A few dozen sites belonging to the cultural phase that Stacul calls (1992, 1994) the "Inner Asian Complex" and that Possehl refers to as the "Northern Neolithic" (1999: 542-553) have been identified across the same general region where many of the "northern" steatite deposits are found. It is with the highland-dwelling farmers and pastoralists of this culture that residents of Harappa would have interacted with, either directly or indirectly, to obtain much of their steatite. Kot Dijian items found at Northern Neolithic sites in the Swat (Stacul 1987) and Kashmir (Saar 1992) valleys provide clear evidence for contacts between those highland and lowland peoples. Although the nature of those contacts is not known, there are several possible scenarios with regard to steatite acquisition.

1) Northern Neolithic peoples could have been

the ones who extracted steatite and transported it to the Punjab; perhaps along with some of the other raw materials that I later show also likely came from sources in the north such as vesuvianite-grossular (Chapter 9), alabaster (Chapter 10) and lead ore (Chapter 12). Although they primarily inhabited the mountain valleys of northern Pakistan and India, it is certainly not out of the question that they may have traveled to the south. Possehl reports (1999: 548) having identified Northern Neolithic sites near Leiah in the Thal Desert of the western Punjab. However, no items clearly related to that culture have yet been discovered at Harappa.

2) Northern Neolithic peoples might have mined steatite and then transported it only as far as the nearest Early Harappan or Harappan settlement. From there, the raw material could have been moved through internal Indus trade networks to sites in the south like Harappa while Indus trade goods (carnelian beads and Kot Dijian-style ceramics) could have been acquired and brought northward to the Northern Neolithic sites where they have been found. Hathial, Sarai Khola, Manda, Ropar and other settlements in the foothills and/or on the plain at the base of the Himalayas were certainly well-positioned to be nodes where this type of exchange between highland and lowland cultures could take place. However, it has never been established if such sites actually functioned as trading outposts.

3) A person or a group from Harappa (or another Early Harappan/Harappan site) could have traveled to the northern highlands and extracted steatite themselves from one of the sources found there. This still would have entailed some form of interaction with local populations. Importantly, it also would have permitted them to judiciously select raw material having properties that they (or their fellow Harappans whom they were supplying) desired. As I suggested above, the groups of steatite artifacts that are highly related to one another compositionally may represent stone extracted from the same vein, pit or mine shaft within a larger individual occurrence or zone. I also suggested that this focus on material from a restricted area (rather than from an entire deposit), if it is genuine, is probably indicative of the desire by Harappan craftspeople to acquire a very specific kind of steatite that turns white upon being heated. The macroscopic appearance of raw steatite does not provide any indication of what color it will become after being fired (*personal observations* discussed below). Therefore, the identification of areas where white-firing stone occurs within a deposit almost certainly would have involved some amount of experimental heating. Northern Neolithic peoples appear to have used very little steatite themselves (Pande [2000] reported that just eight of the 1488 beads recovered at Burzahom are made from steatite) and, as far as we know, none were heat-treated. Although this does not necessarily mean that those northern peoples would have been unable identify and exploit bodies of white-firing steatite, Harappans, with their advanced pyrotechnological capabilities and intimate knowledge of this variety of stone, were likely far more adept at it.

The scenarios above are not the only ones that could account for how raw steatite from "northern" sources was acquired by craftspeople at Harappa. Variations of all three could have taken place, either simultaneously or at different times. Perhaps an unknown third party was involved (Scenario #4). However, short of discovering artifacts at a mining site that are clearly associated with a cultural phase (Harappan or some other one) it is almost impossible to do more than speculate about who actually did the work of extracting the stone. Issues relating to exchange between highland and lowland cultures at settlements that may have been trading outposts cannot be addressed until further question-oriented excavations are conducted at such sites. With regard to the transportation of the stone, we really can talk only about whether or not the sources that appear to have been exploited are internal or external to the area encompassed by Early Harappan/Harappan cultures. Even then we must be cautious because, as Smith has pointed out (2005), models of cultures as bounded, homogenous socio-political entities are often based upon cartographic illusions.

Putting aside interpretive considerations for the moment, the above results constitute clear and compelling evidence for interaction between residents of Harappa and peoples in the highlands to the north of the site, especially those in the Hazara District and Jammu. It is unlikely to be a coincidence that (Late) Kot Dijian and/or Harappan sites are found in the same general vicinity as steatite deposits in those regions. Some degree of interaction with groups in the Kurram and Khyber agencies is also indicated. However, there are sources in Hazara (like the Khangar Dhaka deposit in the Sherwan zone) and in Jammu (multiple deposits in the vicinity of Vaishno Devi) that, when eventually analyzed, could be found to be the actual sources of some or all of those artifacts assigned to deposits in the FATA.

On that note, it is important to again acknowledge that the PGMs made here could change, perhaps drastically in some cases, as samples from more deposits are incorporated into the geologic dataset. In this regard, artifacts to be mindful of in future analyses include those making up the compositionally very distinct cluster number four (C4) in the 140 Harappan artifacts dendrogram (Figure 7.40). All are assigned to one of the Sherwan deposits but they do not join the other artifacts assigned to that zone until RDCC 25 (this is also true of most of those same artifacts on the full sets CA dendrogram [Figure 7.36]). I have discussed above how it is possible for artifacts to be from the same source but end up in very different clusters. This could be one of those instances. However, in an upcoming dendrogram it is evident that "C4" artifacts are *somewhat* more closely related to a similarly distinct group of artifacts from the site of Mehrgarh than they are to most of the others from Harappa (Figure 7.46). There is the possibility, therefore, that they might have been derived from an unsampled deposit in Balochistan. Only future analyses will tell.

One final artifact that was initially predicted to belong to a deposit in the highland region north of Harappa remains to be discussed. It is the BMAC steatite wig from Period 3C, which is assigned to the Sakhakot-Qila ophiolite source. Its PGM is important for two reasons. Firstly, it supports the stylistic evidence that indicates the wig is a non-Harappan object by showing that it was created from ultramafic steatite – a type rarely used by Harappans. Just one other unfired steatite object at Harappa (or at least just one other among the 4.68% of the sub-assemblage that was analyzed) and only a few from any of the other Indus Tradition sites in the archaeological sample set are composed of material of ultramafic origin. Secondly, this finding provides (or can provide) information about the avenues through which Harappans interacted with the Central Asians who probably made and used the wig. Evidence from Mehrgarh Period VIII and elsewhere suggests that BMAC peoples were entering the Sindh region via central Balochistan around the turn of the first millennium BC (Jarrige 1991a; Parpola 2005: 267). However, there are other routes from Central Asia and Afghanistan along which they could have traveled into the Indus Valley. If the wig is actually made from Sakhakot-Qila steatite then it would suggest that one of those alternate routes was through Peshawar Valley via one of the many passes (Khyber, Malakand, Bajaur) that connect it with regions to the west and north.

It is possible, however, that the wig is made of steatite from a different source. When it is compared to a refined geologic set (Figure 7.45) that includes the deposits that were its original first and second PGMs – Sakhakot-Qila (or KOT – 1st PGM) and Zhob Tor Tangi (or ZTT – 2nd PGM), it is re-assigned to its initial second PGM. So the wig *could* actually be from an ultramafic source in north Balochistan. This

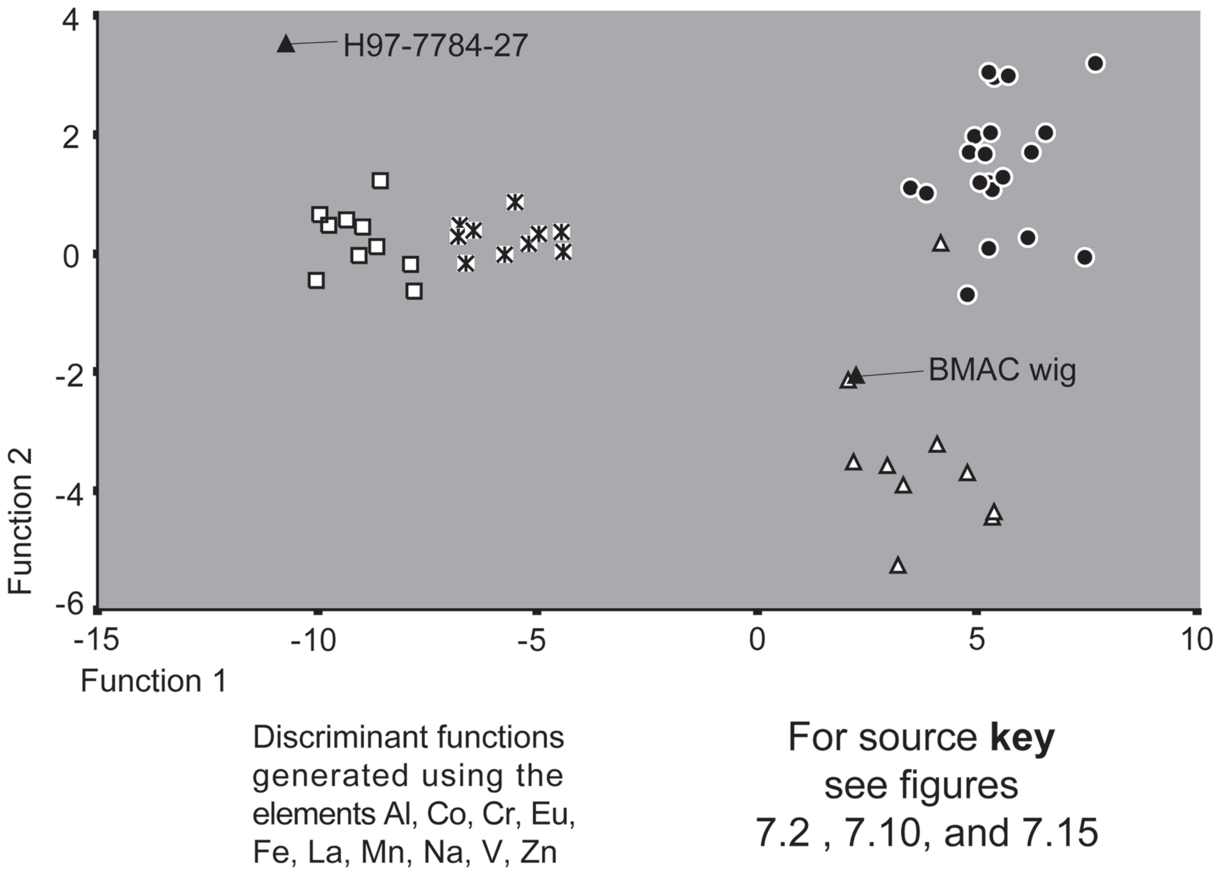


Figure 7.45 The two ultramafic steatite artifacts from Harappa compared to select ultramafic sources.

would still support the interpretation that it is a non-Harappan object although it might now indicate that BMAC peoples were indeed entering the Indus Valley via Balochistan rather than the NWFP. It is also possible that the steatite used to make the wig comes from a different source altogether, perhaps one nearer to the BMAC homeland, which, of all of the deposits in the geologic set, happens to be compositionally most similar to the ones at Sakhakot-Qila and Tor Tangi. The INAA results for the wig indicate that clearly the place to search for that deposit would be in an ultramafic formation, probably an ophiolite.

On average, only around five percent of the 141 steatite artifacts analyzed from Harappa appear as if they might be composed of raw material from sources outside of the region to the north of site. One of these is artifact H97-7784-27 – a yellowish gray (Type A) sawn fragment from Period 3A workshop debris exposed in Trench 42 on Mound AB. It is the only steatite object analyzed from Harappa other than the BMAC wig that appears to be of ultramafic origin. Although it does not resemble the distinctive type of green steatite with black spots that is so well-known in Pakistan today, it was predicted to belong to the same group of samples of that stone that were obtained from the Duddo mine (LBW1) in the Wayaro area, Las Bela District, Balochistan. Recall that this deposit is located less than 20km from Bakkar Buthi where there is an Indus Civilization phase equivalent to Period 3A and 3B at Harappa (Franke-Vogt *et al.* 2000: 199) and so it might then have been directly accessible to the Harappans living there.

There is, however, a good possibility that the raw material this artifact is composed of did not come from the exact deposit to which it has been assigned. When it is compared to a refined geologic set (Figure 7.45) that includes the deposits that were its original first and second PGMs – Duddo mine (or LBW1 – 1st PGM) and Thaddi mine (or LBW2 – 2nd PGM), it is re-assigned to the Thaddi deposit, which is only about 5 km away from Duddo. Note, however, that the artifact appears distinct (plotting away from) from both deposits. It may be that it was quarried from one of the many old pits and worked shear zones that I observed in the area rather than the modern mines. Or it might be from another occurrence. Although I have found no references to other deposits in the geologic or historic literature, the Las Bela ophiolite extends from the Wayaro area northward over 100 km, past Kulli culture settlements like the Edith Shahr complex (Fairservis 1975) and Nindowari (Casal 1966). The artifact could conceivably be from a geologically related steatite occurrence that was nearer to the ancient peoples of those sites. In any case, of all of the ultramafic deposits in the geologic set it is still most closely related to those from southern Balochistan.

Between four and ten artifacts from Harappa were, depending on the CDA results, predicted to belong to steatite sources in the Jhunjhunu and Alwar districts of northern Rajasthan. Like those originally assigned to Uttaranchal and southern Rajasthan deposits, many have second PGMs in one of the sources to the north of the site and could be, in fact, from that region. Artifact H96/7531-16 – a small fragment from Period 1, is one of these that are *perhaps* a misclassified outlier. It is noted "*actually Sherwan?" on Figure 7.43.

A few artifacts that were predicted to belong to a northern Rajasthan deposit appear on the CA dendrograms to be compositionally distinct from the majority of the other artifacts in the set, which is say that they are very different from most of the ones assigned to the Sherwan zone and other "northern" sources. The cylindrical bead (H96-7467-658) made of black steatite pictured in Figure 7.5 B was one of these. Although in the full set CDA it was assigned to the Sherwan zone, in the later refined 11 dolomitic sources CDA it was predicted to belong to the Teori (ATM) deposit in the Alwar District. Other similarly distinct artifacts include fragments H99/8760-77 and H2000/9445-1, both of which were assigned to the Nangalhari-Bairaswas zone (ANB). These, and the few others like them, may indeed be from deposits in northern Rajasthan (including some in Jhunjhunu). The presence of steatite at Harappa that is genuinely from that region would constitute evidence for interaction with peoples of the Ganeshwar-Jodhpura complex. However, it is possible that some or all of these artifacts actually are from a source or sources that are not in the geologic set. On the full sets CA dendrogram (Appendix 7.9), the artifacts noted in this paragraph, although assigned to northern Rajasthan deposits by CDA, do not actually cluster with or nearby any geologic samples from that region.

Next, the PGMs for the Harappan artifacts are used to address the question: *Did the patterns of steatite acquisition exhibited by residents of Harappa change over time?*

Based on a preliminary study conducted in 2003, I reported (Law 2005a: 118-119) that a significant diachronic shift in source utilization was evident in Harappa's unfired steatite artifact assemblage. I had interpreted four major clusters on a CA dendrogram to be roughly equivalent to individual sources or source areas. Two clusters, one of which was composed largely of artifacts predicted by CDA to belong to the Sherwan (Hazara) zone and the other of artifacts assigned mostly to the Prang Dera (Khyber) deposit, seemed to have been utilized mainly during the Early Harappan period. The two other major clusters, which at the time I thought might have represented sources in Jammu that had not then been analyzed, seemed to have been exploited mostly during the Harappan period.

Based on the CDA PGMs and the CA dendrograms produced for the current study, which involved additional archaeological samples and a substantially enlarged geologic dataset, I have concluded that diachronic changes in steatite acquisition patterns at Harappa are not nearly as significant as they were reported to be in 2003. In fact, I would now characterize source use as remarkably consistent throughout most, if not all, of the site's prehistoric sequence. There were no increasing or decreasing trends in the exploitation of certain sources such as are evident for grindingstone (Chapter 5). Nor was there any dramatic shift in material source/type use like that which is evident for chert (Chapter 6). Although there were some changes over time, for the most part they were very minor. The steatite assemblage is dominated in every period by raw material from sources north of the site. Thus, the acquisition networks appear to have been stable and mostly unidirectional.

Steatite acquisition through time can be examined using figures 7.43 and 7.44. Deposits in the Sherwan zone (SB, SC and SKK) were being accessed at least by Period 2 (some perhaps as early as Period 1 – discussed below) and they continued to be the primary sources of the stone through Period 5. The use of raw material from the Khyber Agency (LKPD), although evidently much less intense, follows the exact same temporal pattern. Steatite from Jammu (JAMPT) was used steadily from Period 1 through Period 3B. Its apparent absence in Period 3C simply may be due to it being missed in sampling. The 53 artifacts analyzed from that period represent only a 3.81% sample of the temporal sub-assemblage of material (Figure 7.6 B). However, it could be that acquisition of steatite from Jammu (or at least from the Painthal deposit) actually ceased after Period 3B. Regardless, all of these steatite provenience associations demonstrate that residents of Harappa were involved in early and sustained interaction networks with peoples (either Harappan or non-Harappan) dwelling in the region to the north of the site.

Steatite artifacts predicted to belong to deposits in Uttaranchal, southern Rajasthan and even some of those assigned to northern Rajasthan and the Kurram Agency, are very likely misclassified outliers of the Sherwan zone. Their firsts PGMs are left unchanged on figures 7.43 and 7.44 but their doubtful statuses are noted with asterisks. One artifact (H96-7531-16) with a questionable PGM is from Period 1. It was predicted to belong to Teori (ATM) in northern Rajasthan but *may* actually be a Sherwan outlier as it was assigned to that zone in the regional-level CDA. Even if it is actually from northern Rajasthan or another source area outside of northern Pakistan/India, Harappa's raw steatite assemblage during the Ravi Phase was, regionally speaking, as diverse as it ever would be.

The remaining few steatite artifacts from sources other than the main dolomitic ones in the north are found during Harappa's urban phase (Period 3). In addition to the BMAC wig and the artifacts that may be from northern Rajasthan, there is the ultramafic fragment from the Period 3A workshop on Mound AB that was predicted to be from the Wayaro area of southern Balochistan. The presence of steatite from this distant source (800 km southwest of Harappa) during Period 3A is not particularly surprising. At that time, Harappans were living in the vicinity (< 20 km away) of the deposit itself and marine shell (Kenoyer 1984b) and salted fish (Belcher 2003) were being transported from the nearby Arabian Sea coast. Steatite from southern Balochistan in a Punjab workshop is just another piece of evidence showing that the long-distance internal exchange networks characteristic of the Indus Civilization were firmly in place by that time. What is surprising is the rarity of this high-quality material. The 18 fragments analyzed from the Period 3A workshop represent an almost 10% sample of the steatite recovered from it. Had craftspeople there used raw material from Wayaro to a significant degree then chances are that at least a few more examples would have been sampled and identified. There is also the question of why, evidently, urban phase Harappans did not continue to acquire and use this kind of steatite. As is shown in my provenience study of lead artifacts (Chapter 12), raw materials from the southern Balochistan region were being transported to Harappa through the end of Period 3C. The reason why Wayaro steatite did not continue to be used probably lies with the physical properties of the material rather than the distance to its source. Although it is excellent stone for carving and sawing, it will not fire to the white color that was preferred by Harappan consumers of steatite items (discussed in the final section of this chapter).

The final question is: *Did synchronic variations in patterns of steatite acquisition exist between groups of people living in different habitation areas at Harappa?* The answer to that question is: evidently not – at least not any major ones. By and large, craftspeople at Harappa all seem to have had access to the same sources of steatite regardless of where they lived and worked within the settlement. When the PGMs on figures 7.43 and 7.44 are considered on the regional level, the chronological sub-assemblages for all mounds either entirely (usually) or predominately (occasionally) consist of artifacts from the broad source area 330 to 445 km north of the city. That is, of course, to be expected given that about 95% (if potential misclassifications are factored in) of the artifacts analyzed were assigned to deposits in that region. When source use is considered on the level of individual deposits and zones, there does at first appear to be some variation among mound sub-assemblages during the certain periods. However, most synchronic differences can be explained by some form of sampling bias. The very small sample sizes (just one or two artifacts each) for Mound E during periods 2 and 3A, mounds F and ET during Period 3B and Mound AB during Period 3C, almost assuredly do not capture the full range of raw material sources used in those areas at those times. For example, on average, around 16 artifacts each were sampled from the Period 3C levels of mounds F, E and ET. Six different deposits are represented among the artifacts on each of those mounds. Only two deposits are represented on Mound AB. I strongly suspect that when the Period 3C sample from Mound AB is eventually brought up (from its current size of two) to the level of the other mounds its assemblage will appear just as diverse as theirs. Also, the reason that some chronological mound sub-assemblages do not contain artifacts assigned to the Prang Dera (LKPD) source, which, overall, is widely distributed both temporally and spatially, is likely because of that deposit's low (≈ 11%) representation among the total analyzed assemblage. Artifacts having that PGM were fewer and more likely to have been missed in sampling. Ultimately, it comes down to this – assemblages in areas where a good-sized sample was obtained are fairly diverse in terms of their PGM compositions while those in areas where a small sample was obtained are not. Rather than interpret the differences as possibly genuine, I provisionally consider steatite source usage across Harappa to have been, more or less, synchronically consistent.

Having said that, the artifacts assigned to deposits outside of the "northern" region do provide some indication that craftspeople working in certain parts of Harappa might have had access to sources of raw material apart from those used by most other residents of the site. However, because such artifacts are so few in number, they must be interpreted cautiously. For instance, it would be a considerable stretch to argue that residents of the mounds where steatite fragments assigned to northern Rajasthan were recovered had exclusive access to and/or somehow controlled the raw material from that region, even if such artifacts might have been found only in the areas where they lived/worked. There are simply too few of them to confidently make such statements. Still, a close examination of artifact PGMs and their contextual details listed in Appendix 7.1 suggests that there might have been areas of the Harappa where, at certain times, some of the rarer kinds of steatite were used to a fairly significant degree. One of these areas is Mound F during Period 3C. In Trench 41, three fragments (H99/7636-8, H99/7637-32 and H99/7638-1) recovered from a group of Period 3C rooms adjacent to the city wall are possibly from northern Rajasthan even though they were not assigned to that region in the "11 dolomitic sources" CDA (in most of the other CDAs the three were assigned to one of the Jhunjhunu deposits). Not far away in Trench 43, a fragment predicted to belong to the Nangalhari-Bairaswas (ANB) zone was also found. In total, 13 of the 63 unfired steatite artifacts recovered from Period 3C levels of Mound F were analyzed and, of those, four might be from a source in northern Rajasthan. If this is an indicative sample of the mound then perhaps around one-quarter to one-third of the steatite acquired by craftspeople working there might have come from that region 400 to 500 km southeast of the site. Recall from Chapter 5 that it was also on Mound F where most of the Delhi quartzite (from outcrops 75 to 125 km directly north of the northern Rajasthan steatite sources) was being used during Period 3C (Figure 5.13). These results for steatite artifacts could constitute an additional piece of evidence indicating that, of all residents at Harappa, people in this part of the site had slightly stronger trade relations with groups in the eastern part of the Greater Indus region.

Overall, however, I would characterize the synchronic patterns of steatite acquisition at Harappa as being similar to those evident for chert during the site's urban phases. For the most part, everyone had access to and was mainly using raw material acquired from the same broad source area (the "northern" region for steatite and the Rohri Hills for chert). Within that region, multiple deposits were being exploited but one zone or deposit in particular (the Sherwan zone for steatite and the Rohri town deposit for chert) seems to have been the source for the majority of the stone used. Raw materials from other source regions (northern Rajasthan for steatite and the Mohmand Agency for chert) may have sometimes acquired, but only infrequently and/or in very minor amounts.

Unfired steatite artifacts from other sites

In this sub-section, the unfired steatite artifacts from Mohenjo-daro, Mehrgarh, Nausharo, the "unknown" Loralai site, Gola Dhoro, Nagwada, Mitathal and Tepe Hissar are examined. Before focusing on the CDA results for each site individually, I present and discuss a CA performed on 177 of the steatite artifacts (the entire set excepting the Mitathal seal and seal boss from Harappa). This was conducted in order to first get a clear understanding of how compositionally similar or dissimilar the steatite artifacts from the other sites examined were to the kinds of raw materials that were being used at Harappa. The CA dendrogram in Figure 7.46 was generated using the same complete linkage method that was employed to make the others in this chapter and its appendices. On it, the branches representing artifacts from the seven sites are noted using their two or three letter site codes (a key is provided on the figure). The branches representing artifacts from Harappa were left blank (it was too busy with artifact numbers). The specific numbers for all of the artifacts are found in the full size reproduction of the dendrogram (Appendix 7.11 sections A through D). Preceding the number for most of the artifacts from Harappa in Appendix 7.11 is one of four short codes in parentheses – "(C1)" through "(C4)." These codes denote the numbered cluster each one was originally a member of in the CA of just 140 artifacts from Harappa (Figure 7.21).

The 177 artifacts form two main clusters that split at RDCC 25. I first briefly discuss the distribution of the Harappan artifacts. The larger main cluster (to the left of the split) contains most of the artifacts from Harappa that had been in clusters C1 through C4 on Figure 7.40. The smaller main cluster (right) contains two former C4 artifacts as well as three had been outlier not assigned to clusters. Within the largest main cluster the Harappan artifacts group in much the same way as they did in Figure 7.40. The one difference is that around half of those that had been

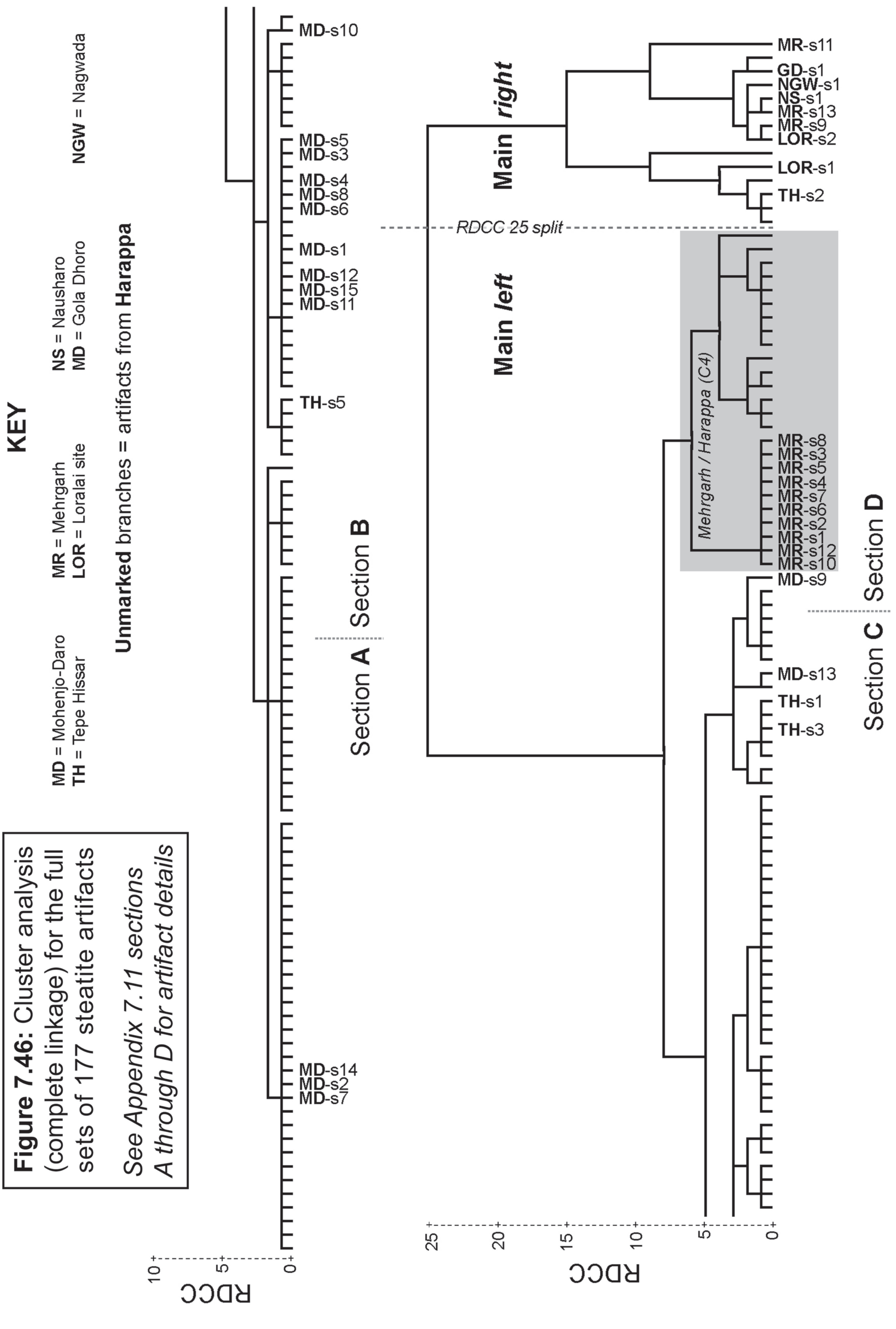


Figure 7.46: Cluster analysis (complete linkage) for the full sets of 177 steatite artifacts

See Appendix 7.11 sections A through D for artifact details originally been designated as C3 now appear with C1 artifacts while the other half still form a distinct sub-cluster of their own.

The manner in which the artifacts from the seven other prehistoric sites fall on the dendrogram is both interesting and informative. Compositionally, the 15 fragments from Mohenjo-daro (MD) are closely related to those from Harappa, which suggests that they may be from the same source or sources. Ten of the 13 artifacts from Mehrgarh (MR) group together in a very closely related (RDCC 1) sub-cluster that, within the larger main cluster, is set well apart from the Harappan artifacts. At RDCC 6, it joins another sub-cluster made up of Harappan artifacts, most of which had been in C4 on Figure 7.40. This Mehrgarh/Harappa-C4 sub-cluster is itself distinct from the other artifacts from Harappa (and Mohenjo-daro) in the larger main cluster. All of the Harappa-C4 artifacts have been predicted by CDA to belong to one of the Sherwan zone sources. However, their comparatively close association with the Mehrgarh artifacts raises the possibility that they *may* have actually been derived from a related deposit nearer to that site in Balochistan.

The majority of the remaining artifacts from the other sites are all members of the smaller main cluster on the right side of the RDCC 25 split. These appear to be composed of kinds of steatite that are very different from most of that used at Harappa. The exceptions are three of the four fragments from Tepe Hissar, which of all the artifacts in the archaeological set, seem to be compositionally most closely related to those from Harappa.

Informed by the results of the above CA, the artifacts from each of the seven other prehistoric sites are now examined using CDA. The parent-rock association of each artifact was determined in the CDA of the archaeological set and full geologic set (Figure 7.32). Most of the PGMs discussed in the sub-sections below were generated during either the ultramafic parent-rock (Figure 7.34) or the dolomitic parent-rock (Figure 7.35) CDA. In a few instances select artifacts are compared to refined or selected subsets of samples.

- Mohenjo-daro

Indus craftspeople working in both the DK-A and Moneer areas at Mohenjo-daro would appear to have been involved in the very same steatite acquisition networks as were their counterparts at Harappa. The first PGMs for nine of the 15 unfired steatite artifacts (Figure 7.7 A) analyzed from the site (listed in the second column of Appendix 7.5) are "northern" region sources – six are assigned to one of the Sherwan zone deposits and three are predicted to belong to the Daradar (PD), Kurram Agency source. Three of the remaining six artifacts have second PGMs in the Sherwan zone and so could be compositional outliers that came from that source. However, the first PGMs for five of those six is in a northern Rajasthan deposit (either ANB or ATM). One final artifact has a first PGM in a southern Rajasthan deposit (RDP) but it has a second PGM in a northern Rajasthan one (ANB) and, thus, may very well be a compositional outlier from the latter source area. The close compositional similarities exhibited by steatite artifacts from Mohenjo-daro and Harappa on the CA dendrogram (Figure 7.46 and Appendix 7.11) enables me to argue with a good deal of confident that those artifacts from both sites having the same PGMs are very likely from the same geologic sources. Later, I discuss artifacts from Mehrgarh that have also been assigned these same PGMs but which are quite clearly compositionally distinct from the Harappa and Mohenjo-daro artifacts.

Although the sample of artifacts from Mohenjo-daro is roughly one-tenth the size of that from Harappa, it nonetheless has permitted some interesting similarities and differences in steatite acquisition patterns between sites to be observed. To begin with, like at Harappa, the majority of steatite used at Mohenjo-daro seems to come from sources in the "northern" region and the majority of that majority is from the Sherwan zone of the Hazara District. However, whereas only around 5% to 10% (at the very most) of the analyzed artifacts at Harappa genuinely appear to have come from sources other than those in the north, up to 40% of the artifacts from Mohenjo-daro were likely acquired from deposits located in northern Rajasthan. Interestingly, this acquisition pattern for Mohenjo-daro much more resembles that of just Mound F at Harappa than it does of that entire site.

Also like at Harappa, it appears as if craftspeople working in different parts of Mohenjo-daro had access to the same sources of steatite. Artifacts assigned to the Sherwan zone, Kurram Agency and Alwar District deposits are found in both the Moneer and DK-A areas. Examples of steatite from two other source areas accessed by residents of Harappa – the Khyber Agency and Jammu, were not identified among the Mohenjo-daro artifacts. With regard to Jammu, the use of stone from the deposit analyzed in that region (JAMPT) seems to have ceased after Period 3B at Harappa. This could account for its absence on the surface of Mohenjo-daro, which is roughly equivalent to Period 3C. However, the absence of Khyber Agency and Jammu steatite may simply be due to the low sample size. On that note, it is important to recognize that the patterns of source usage suggested by the mere 15 samples from Mohenjo-daro could change dramatically when additional steatite artifacts are analyzed. The ones discussed here, thus, should be considered provisional.

The analysis of the Mohenjo-daro fragments has, nonetheless, generated new insights into Indus Civilization steatite acquisition networks as well as new questions about them. At this point it appears that residents of Mohenjo-daro did not acquire steatite from any of the three potential source areas nearest to their city (southern Balochistan, northern Balochistan or southern Rajasthan/Gujarat). One sample (MD-s13) did have a first PGM in southern Rajasthan's Deola (RDP) deposit but, like those artifacts assigned to this region at Harappa, I believe it to be a misclassified outlier. The results instead indicate that the majority of the Mohenjo-daro artifacts analyzed probably came from sources 800 to 900 km to northeast of the city in northern Pakistan while a large minority came from sources around 800 km due west in northern Rajasthan. That the steatite acquisition networks city residents were involved in could be that far-reaching is not at all surprising. Throughout this book I show that raw materials such as chert (Chapter 6), agate (Chapter 8), limestone (Chapter 11) and lead (Chapter 12) were being transported, sometimes in bulk sizes, over equal or greater distances from the southern part of the Greater Indus region to the northern part. The Mohenjo-daro steatite artifacts constitute new evidence that an important variety of raw material was being moved, probably via the same trade networks, from the north and northeastern parts of the Greater Indus region toward the south.

These results, however, raise the question – Why did craftspeople at Mohenjo-daro (or their suppliers) not exploit much closer sources of seemingly good quality steatite, most especially the very nearest ones in Balochistan that were in the general vicinity of Indus Civilization settlements? In the case of the Wayaro sources of southern Balochistan it could just be an issue of timing and artifact recovery. Ute Franke and others report (2000: 199) that the Harappan occupation of Bakkar Buthi (the site nearest the Wayaro deposits) ended sometime prior to what is equivalent to Period 3C at Harappa – or the "Late Phase" at Mohenjo-daro. This fits well with the evidence at Harappa itself, which indicates some Wayaro steatite was brought to that site during Period 3A but not thereafter. If raw material from the same source was likewise acquired by residents of Mohenjo-daro only at that time then any remnants of it probably lay deeply buried beneath the city's "Late Phase" surface levels. But the question then would be

– Why did Indus Civilization peoples (at Mohenjo-daro and Harappa) not continue to use steatite from southern Balochistan? Even if Harappans quit that region in the latter part of the urban period and, consequently, did not have had direct access to its steatite resources they likely could have still obtained the stone indirectly through interaction with the highland Kulli peoples dwelling there. I have concluded (and will argue in the final section of this chapter) that the reason why steatite from the Wayaro area and the other source regions closer to Mohenjo-daro were apparently not used by craftspeople at that site was probably because when it was heat-treated it did not transform into the white color they desired.

- Mitathal

Although a surface find, the small rectangular seal fragment from the site of Mitathal (Prabhakar 2010) almost certainly dates to the latter part of the Harappan Phase (ca. 2200 to 1900 BC or Period 3C at Harappa). In the CDA of the archaeological and full geologic set (Figure 7.32), the seal was assigned a first PGM in the dolomitic steatite deposit at Gandra, Panchmahal District, Gujarat and a second PGM in the Nangalhari-Bairaswas of the Alwar District, northern Rajasthan. In this instance, it was decided to assign provenience to the artifact based on its second PGM. Several factors led to this decision. To begin with, Gandra is 725 km south of Mitathal as the crow flies. While it is clear that Harappans transported steatite over even longer distances, a PGM in this particular deposit still seems anomalous. No other artifact examined in this study was predicted to come from Gandra, not even those from sites the same region at it such as Gola Dhoro, Nagwada or, as recent but still unpublished analyses shows, Dholavira. On the other hand, the deposit at Nangalhari-Bairaswas and related ones in the Alwar District are among the closest sources to the site of Mitathal and, most significantly, steatite from northern Rajasthan seem to also have been used, if only to a limited degree, at the cities of Harappa and Mohenjo-Daro.

- Mehrgarh and Nausharo

Although the 13 steatite artifacts from Mehrgarh (Figure 7.7 B) date to before the foundation of Harappa, their analysis has informed the current study by providing valuable glimpses of unsampled raw material sources that are probably located somewhere in the Balochistan and/or Afghanistan regions. One of those sources is represented by 10 of the 13 artifacts, which together form the closely related and highly distinct sub-cluster highlighted on Figure 7.46. Admittedly, I am making an assumption that all ten artifacts are from the same deposit. They could be from ten different deposits in ten different geologic formations that just happen to be highly similar to one another compositionally. I very much doubt that is the case, however. The same ten artifacts comprise a single, equally related and distinct sub-cluster (see Appendix 7.9 section G) on the dendrogram of the archaeological and full geologic sets (Figure 7.36). All are dolomitic in origin (as indicated by the initial CDA – Figure 7.32), are black or dark grey in color and the majority (7 of 10) were found together in the MR4 area atelier that dates to the site's early Chalcolithic Period (Mehrgarh IIB) (Jarrige 1981: 99). Although in the dolomitic parent-rock CDA (Figure 7.35) all were assigned to one of the northern Rajasthan deposits (ANB, ATM or JJK), the actual location of the source is probably not in that region 800 to 900 km to the east-southeast of Mehrgarh. Instead, it is likely somewhere closer to the site in Balochistan or Afghanistan. The Muslimbagh and Las Bela ophiolites can be ruled out as potential sources as the artifacts are composed of dolomitic steatite. In all likelihood, the Neolithic and early Chalcolithic craftspeople at Mehrgarh who used this stone acquired it from an occurrence in central Balochistan such as the one reported (Tariq *et al.* 1998: 16) in Shirinab Formation shales at Chuttok in the Kalat District, which is just 90 km west of the site.

This can only be confirmed, however, after samples from that and related occurrences in the region are collected, analyzed and compared to the Mehrgarh artifacts.

It would appear that the "source" suggested by the ten Mehrgarh artifacts, wherever it is actually located, was used for at least two millennia. Three of the ten artifacts (MR-s8, MR-s10 and MR-s12) were recovered from the site's Period I levels (ca. 7000 to 5500 BC) and the remaining seven (MR-s1 through MR-s7) date to Period IIB (ca. 5000 BC). Artifacts from the site's later periods will eventually need to be analyzed in order determine if the "source" continued to be used after that. As it now stands, there is no evidence that it was. The single bead from nearby Nausharo, which I discuss shortly, is ultramafic in origin and so cannot be from the same "source." Although many of the 15 dolomitic steatite artifacts from Mohenjo-daro have the same PGMs as the ten from Mehrgarh, on the CA dendrograms (appendices 7.9 and 7.11) they are clearly very different from them compositionally. The artifacts from Harappa with those PGMs likewise appear very different on the dendrograms. On Figure 7.46, I highlighted a sub-cluster of Harappan artifacts that joins the Mehrgarh sub-cluster at RDCC 6. Those artifacts were assigned to the Sherwan zone and I drew attention to them in order show how they may actually be from a different source, *perhaps* in Balochistan, due to their comparatively (in relation to other artifacts from Harappa) close association with the Mehrgarh sub-cluster. I do not, however, believe that they are from the same "source" as the ten Mehrgarh artifacts.

Experimental studies conducted by Barthélémy de Saizieu and Bouquillon (1997: 64) and by myself (Appendix 7.12) have shown that black steatite from Mehrgarh becomes pure white when heated to a sufficient temperature. It is somewhat of a mystery then why the proposed "source" was not exploited by Indus Civilization peoples as this was evidently one of the properties they desired. It might be that the deposit itself was exhausted of good material prior to the Harappan period. Or, perhaps, Indus peoples simply did not have access to the source area, wherever that might have been. Maybe the situation was like that of chert. That is, perhaps one (or just a few) high-quality type of steatite from an extensive source area was used to the almost total exclusion of raw material from minor sources.

The three remaining artifacts from Mehrgarh are each beads or bead fragments from the site's Period I levels. In the first CDA (Figure 7.32), both MR-s9 (composed of a red steatite) and MR-s13 (made from a black steatite) were assigned to ultramafic deposits – DMB and LBW1 respectively. In the second, ultramafic parent-rock only CDA (Figure 7.34) their first PGMs respectively shifted to RSB and ZTT. In short, MR-s9 appears more closely related to samples from ultramafic deposits in the southern Rajasthan/Gujarat region while MR-s13 is much more like steatite from the ophiolites of Balochistan. However, with regard to MR-s9, I argue (below) that it is probably actually from a source in a region to the west of the Indus Valley. When it and MR-s13 are compared to a geologic set made up of only the Balochistan sources (Figure 7.47), they are both assigned to deposits in the Muslimbagh ophiolite (MR-s9 to ZTT and MR-s13 to ZTAK).

Artifact MR-s11 (made from a pale green steatite) is somewhat unusual. Although in the initial CDA it was assigned, like the first ten Mehrgarh artifacts, to a dolomitic northern Rajasthan deposit (JJG), its higher than normal concentrations of certain metallic elements sets it apart from those and all other dolomitic artifacts in the archaeological set. Note its distinct positions on the scatterplots (figures 7.32 and 7.34) and dendrograms (appendices 7.9 and 7.11). Although it was not assigned a first (or second) PGM in one of the Muslimbagh ophiolite sources, on the initial CDA scatterplot (Figure 7.32) it falls among the Urgasai Nasir deposit (ZUN) samples, which was one of the ultramafic sources that overlapped

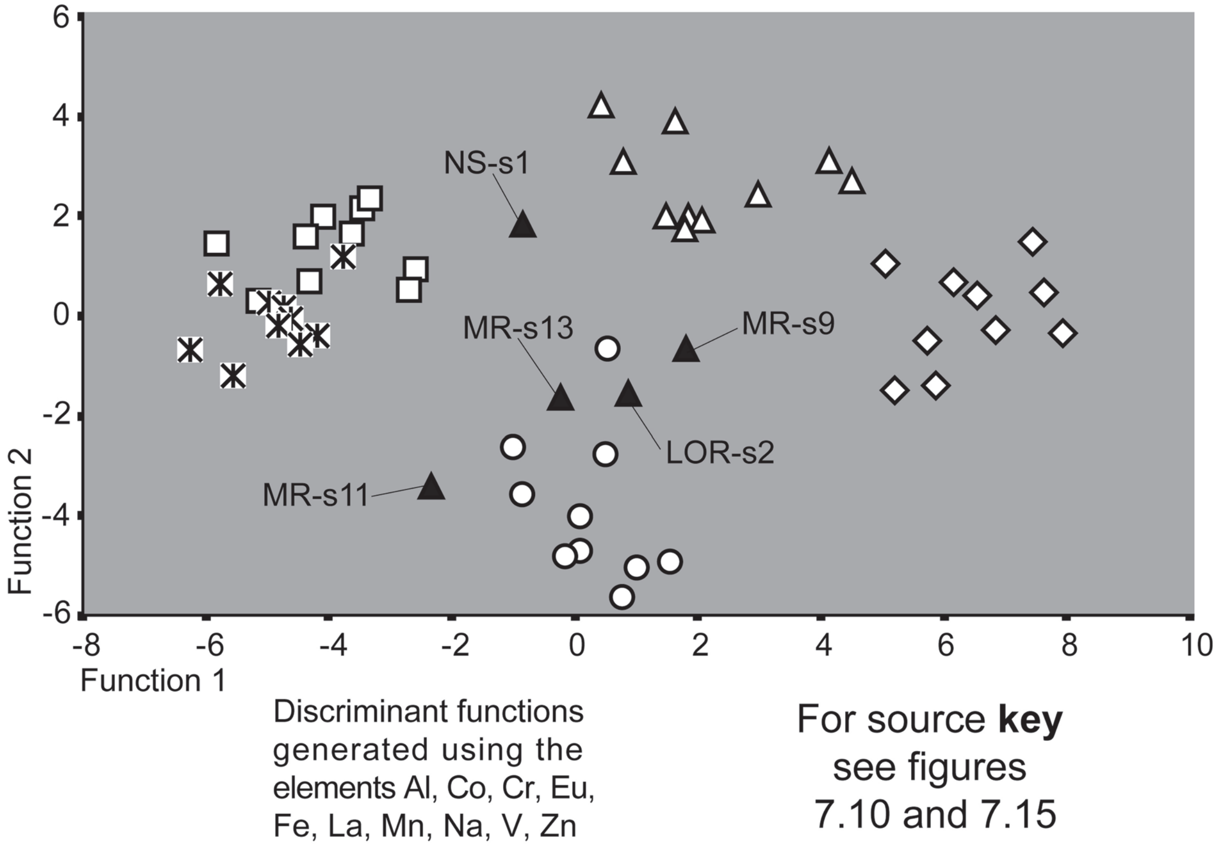


Figure 7.47 Steatite artifacts from Mehrgarh, Nausharo and Loralai compared to ultramafic steatite sources in Balochistan.

the dolomitic ones. Recall that I speculated that this overlap might reflect the deposit's possible formation in a contact zone between magnesium-rich sedimentary rock and the ultramafic rock of the ophiolite. This may have resulted in dolomitic-like steatite bodies with higher than normal concentrations of metallic elements (or vice-versa). Artifact MR-s11, although perhaps not from ZUN, may be from this type of an occurrence. When it is compared to the geologic set made up of only the Balochistan sources (Figure 7.47), it is assigned to the Takhahen (ZTAK) deposit in the Muslimbagh ophiolite.

The broken red steatite bead (NS-s1) from Period III (ca. Period 3B at Harappa) levels at Nausharo clearly appears to be from a source in southern Balochistan. In both the initial (Figure 7.32) and ultramafic parent-rock CDA (Figure 7.34), it was assigned first and second PGMs in one of the Wayaro area deposits (LBW1 or LBW2). It was likewise assigned to that region (LBW2) in the CDA using the refined set of samples from the five Balochistan sources only (Figure 7.47). However, on that scatterplot it falls somewhat away from the Wayaro datapoints suggesting that, although it still most closely resembles steatite from this source, it may not have been obtained from one of those exact deposits. This is not surprising as the geologic samples it is being compared to were collected from modern steatite mines. The raw material for the bead likely came from one of the many old workings and exhausted shear zones (noted above) in the Wayaro area.

The Nausharo bead is one of the very few Harappan period artifacts analyzed in this chapter that is composed of steatite from an ultramafic source. The only others are the fragment (H97-7784-27) from Period 3A at Harappa and two artifacts from Harappan sites in Gujarat (which I discuss shortly). The Nausharo bead and the Harappa fragment are the only ones from the Wayaro source. The bead's Nausharo III / Harappa 3B date means that the raw material could have been acquired via interaction with Indus Civilization peoples who at that time still occupied the settlement of Bakkar Buthi (Franke-Vogt *et al*. 2000: 199), which is less than 20 km from the source. Later, I argue that Wayaro steatite, although apparently accessible, was not widely used during the Harappan period because it does not fire to a white color. The Wayaro/Shah Noorani-like steatite bead (Figure 7.14 C) that I observed in the Balakot collection was probably finished and not meant to be fired. The thick-walled style of the Nausharo bead (Figure 7.7 B bottom row, far right) suggests that it might not have been intended for heat-treatment either.

In the end, it is possible to state with a good degree of confidence that one of the beads (MR-s13) from Period 1 at Mehrgarh is made of steatite from a source in the Muslimbagh ophiolite of northern Balochistan, while the bead from Period III at Nausharo is composed of steatite obtained from a deposit in the Las Bela ophiolite of southern Balochistan. The remaining Mehrgarh artifacts (MR-s9, MR-s11 and the ten representing the unknown "source") *could* genuinely be from the deposits in Rajasthan or Gujarat that they were assigned to in the initial CDAs. However, given what is currently understood of the early cultural sequence at Mehrgarh (Jarrige *et al*. 2005), I would argue it is far more probable that their actual sources are located to the west of the Indus Valley rather than to the east of it. The recovery of lapis lazuli and marine shell beads in periods I and II levels (Barthélémy de Saizieu 2003: tables 9 and 12) indicates that the interaction networks site residents then participated in stretched northward to Afghanistan and southward to the Arabian Sea. Some of the unsampled sources across that broad area (I have already noted possibilities in eastern Afghanistan) may compositionally resemble those of the Aravalli Range and, thus, steatite from them could have been misassigned to sources in Rajasthan and northern Gujarat. The ten fragments representing the black steatite "source," in all likelihood come from known but unsampled dolomitic occurrences in central Balochistan. Beads MR-s9 and MR-s11 *may* both be from a deposit in the Muslimbaugh ophiolite. If not, then they are still most likely from a source located in Balochistan or Afghanistan.

- "Unknown" Loralai site

Although without secure proveniences, the analysis of the sawn fragment and black beads (Figure 7.7 C and D) attributed to an "unknown" site in the Loralai district have provided an informative glimpse of prehistoric steatite usage in northern Balochistan.

In both the initial (Figure 7.32) and dolomitic parent-rock CDAs (Figure 7.35), the sawn red steatite fragment (LOR-s1) was assigned first and second PGMs in one of the Sherwan deposits (SC or SKK). However, although clearly of dolomitic origin, the fragment is compositionally quite different from most of the other dolomitic artifacts in the archaeological set, the majority of which were assigned to the Sherwan zone. Note its position apart from the main body of steatite artifacts on Figure 7.35 (it is identified on the figure using a red "+") as well as on the dendrogram of the 177 archeological samples (Figure 7.46 and Appendix 7.11). Rather than being from the Sherwan zone, it is more likely that the artifact is either from an unreported dolomitic source in northern Balochistan or, perhaps, one of the unsampled potential sources I noted (above) in eastern Afghanistan.

The black beads are composed of an ultramafic steatite that quite clearly appears to be from a source in the Muslimbagh ophiolite of the northern Zhob District, which is approximately 100 km to the northwest of the Loralai Valley. In both the initial (Figure 7.32) and ultramafic parent-rock CDAs (Figure 7.34), the bead analyzed was assigned a first

PGM in the Tor Tangi deposit (ZTT). It was assigned to the Takhahen deposit (ZTAK) when compared to the five sampled sources in Balochistan alone (Figure 7.28).

Unlike the ten black steatite artifacts from Mehrgarh that are from the unidentified dolomitic "source," steatite from the ultramafic Muslimbagh ophiolite will not become white when heated (unless it is already white to begin with – and then it turns a dull white). I have confirmed this through heating experiments involving geologic samples from that source formation (Appendix 7.16) as well as one involving the black beads from the "unknown" Loralai site. In the latter, I heated a single bead in a muffle furnace for one hour at 1200°C. That time and temperature is more than sufficient to turn any steatite white *if it is predisposed to do so* (see appendices 7.12 and 7.16). The bead became a dull reddish-gray color when heat-treated in this way. That, however, was likely not an issue for the craftspeople who fashioned the Loralai beads from Muslimbagh steatite as they probably intended them to remain black. Harappan craftspeople, on the other hand, would not have desired raw material with this property. This is very likely one of the main reasons why steatite from the Muslimbagh deposits, despite being in the same general region as a very large Indus Civilization settlement like Dabar Kot, has not been identified among the Harappan period artifacts examined in this chapter.

- Nagwada and Gola Dhoro

The INAA results for the fragment from Nagwada and the broken unicorn seal from Gola Dhoro (figures 7.7 E & F) indicate that Harappans at those sites were involved in steatite acquisition networks that were very different from those of their contemporaries at Harappa and Mohenjo-daro. On the scatterplot from the CDA of the archaeological and full geologic sets (Figure 7.32), both artifacts fall squarely among the large cluster of geologic samples from ultramafic sources. This alone sets them apart from 99% of the steatite artifacts analyzed from Harappa and all of those analyzed from Mohenjo-daro.

The Nagwada fragment (NGW-s1) is most closely related to steatite occurring in ultramafic deposits located in the northern Gujarat / southern Rajasthan region. In both the initial (Figure 7.32) and ultramafic parent-rock CDAs (Figure 7.34), the fragment was assigned a first PGM in the Shiv Bola (RSB) mine of the Udaipur District, Rajasthan and a second PGM in the Dev Mori-Kundol occurrence (DMK) in the Sarbarkantha District, Gujarat. Both deposits are part of the Rakhabdev Ultramafic Suite of the southern Aravalli Range and when the fragment is compared to samples just from the occurrences in that formation (Figure 7.48) it is assigned a first PGM of DMK. That occurrence is the closest source to the Nagwada. Harappans living at that site might have acquired the steatite by making the 175 km journey east across the North Gujarat Plain themselves or, perhaps, through interaction with the hunter-gatherer populations of that region (Possehl 1980: 73).

The precise source of the steatite used to carve the unicorn seal from Gola Dhoro is somewhat more difficult to pin down. In the initial CDA of the archaeological and full geologic sets (Figure 7.32) it was assigned a first PGM in the Sakhakot-Qila ophiolite deposit (KOT) of the Mohmand Agency. In the CDA involving just ultramafic deposits (Figure 7.34), it was again assigned a first PGM of KOT and it was given a second PGM of CHT, which is the source code for samples collected from the Drosh ophiolite near Tar village in the Chitral District. In spite of these consistent assignments to the ultramafic deposits in the ophiolites of northern Pakistan, I consider it most unlikely that the steatite used to carve the seal was actually derived from that region. My doubts on this matter do not stem from the great distance that exists between Gola Dhoro and the KOT and CHT deposits (around 1250 and 1400 km

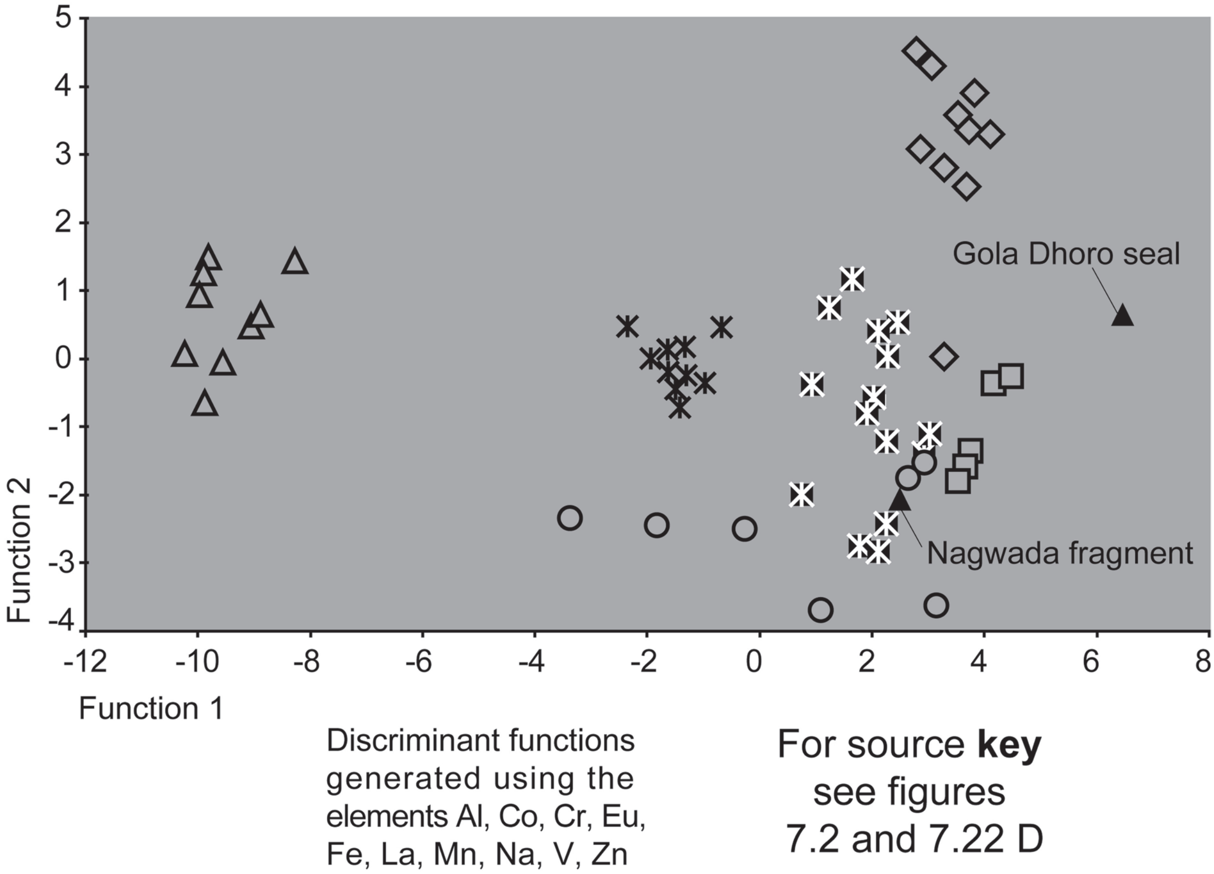


Figure 7.48 Steatite artifacts from Nagwada and Gola Dhoro compared to ultramafic steatite sources in southern Rajasthan and northern Gujarat.

respectively). Beads made of lapis lazuli – a stone that originates even farther away (≈ 1475 km) in northern Afghanistan, have been recovered at the site (IAR 1996-97: 25). Rather, I base my reservations on what we are now beginning to understand of steatite use and acquisition at Indus Civilization settlements located between northern Pakistan and the Gujarat region. The seal could have been manufactured at a settlement that was comparatively closer to the KOT and CHT deposits, such as Harappa or Mohenjo-daro, and then discarded by a trader or some other person visiting or returning to Gola Dhoro. However, the results of this study suggest that it is not likely to have been made at either of those cities as craftspeople at them seldom (if ever) used any ultramafic steatite, much less any from those particular sources in northern Pakistan. The seal could have also been made at a Harappan settlement in Gujarat using raw material obtained from the distant KOT or CHT deposits. But if this was the case then the evidence would indicate that the acquisition/trade networks for that kind of steatite, which presumably would have gone through the Indus Valley, bypassed the major Indus urban centers. I consider that to be an unlikely possibility. Admittedly, however, the low sample sizes from those cities (particularly Mohenjo-daro) means that examples of ultramafic steatite artifacts from northern Pakistan sources may have simply missed being detected.

In all likelihood the Gola Dhoro seal was manufactured in Gujarat using ultramafic steatite from a deposit located somewhere other than northern Pakistan. The artifact's compositional similarity to samples from the Sakhakot-Qila and Drosh ophiolites suggests that the actual raw material source *might* be found in the same type of geologic formation. The Las Bela ophiolite of southern Balochistan is the nearest such formation but, as I have already noted several times and will discuss further in the next section, steatite from deposits occurring in it evidently does not become white when heated. Thus, the white Gola Dhoro seal is probably not composed of raw material derived from that formation. The Semail ophiolite of Oman (not shown on Figure 7.2), although located 1200 km to the west across the Arabian Sea, should be considered a potential source because of the clear evidence for the existence of maritime interaction networks between Eastern Arabia and the Gujarat region during the Harappan Period (Chakrabarti 1998; Edens 1993; Possehl 1997a; Rao 1979b). However, until samples from deposits in that formation are collected and analyzed, it is impossible to do more than speculate as to whether or not steatite was among the raw materials that may have been exchanged through those networks.

In the end, it is most probable that steatite used to make the Gola Dhoro seal came from one of the ultramafic deposits nearest to the site itself. In the initial CDA of the full archaeological and geologic sets (Figure 7.32), the second PGM of the seal was the Dev Mori-Kundol occurrence (DMK) in the Sarbarkantha District of northern Gujarat. If the KOT and CHT deposits are removed from the full geologic dataset and another CDA is performed (not shown) then DMK becomes the artifact's first PGM. When the seal is compared to just the sampled ultramafic deposits of southern Rajasthan and northern Gujarat (Figure 7.48), it is assigned a first PGM in the Rishab-der deposit (RRD) of the Udaipur District and a second PGM of DMK. Note that on the scatterplot for that CDA the artifact plots away from the clusters representing those deposits. This suggests that it is perhaps not from either one of those exact sources, which not surprising as they are modern mines. It could still very well be from a related deposit in the same geologic formation, however. There are a half-dozen reported occurrences around the Dev Mori area (Chatteerjee 1964: 436) in addition to the two sampled for this study (DMK and DMB). Moreover, scores of other sources might have been accessible to Harappans (or their suppliers) elsewhere in the Rakhabdev Ultramafic Suite, which continues northward from Gujarat into steatite-rich southern Rajasthan (Gupta *et al*. 1997). It is hoped that an expanded program of sampling across that formation will one day permit a more geographically accurate identification of the source of the steatite used to make the seal.

- Tepe Hissar

When the four pieces of sawn steatite from the site of Tepe Hissar (Figure 7.7 G) in northern Iran are compared to all 37 deposits in the geologic dataset (Figure 7.32), each is predicted to belong to a dolomitic source located in Rajasthan (TH-S1 and TH-S3 = RSA, TH-S2 and TH-S5 = ATM). The results were the same when the fragments were compared to samples from just the 23 dolomitic deposits in the dataset (Figure 7.35). On the CA dendrogram of the 177 archeological samples (Figure 7.46), one of the fragments (TH-s2) groups apart in a small distinct cluster to the right of the RDCC 25 split but the rest are very similar compositionally to artifacts from Harappa and Mohenjo-daro. Had the four fragments been recovered at one of those sites instead of in Iran then there would be little reason to argue that they were derived from a source area other than the one that they were predicted belong to by CDA. However, because of the artifacts' archaeological provenience their PGM assignments must be regarded cautiously.

It is not impossible that the four Tepe Hissar fragments are genuinely composed of steatite that was extracted from deposits in Rajasthan and then transported over 2200 km to consumers in northern Iran. Raw materials and/or finished items were sometimes moved tremendous distances across late Bronze Age southern and western Asia (Ratnagar 2004). This fact is best exemplified by the distribution of lapis lazuli artifacts at sites from

Egypt to the Indian Subcontinent (Casanova 1997; Herrmann 1968; Tosi 1974; von Rosen 1990). The unmistakably Harappan-style "etched" (bleached) carnelian beads recovered in Tepe Hissar IIIC levels (ca. late 3rd / early 2nd millennium BC) and at several other late Bronze Age sites in Iran (Heskel 1984: 341) demonstrate that some material goods made it to that distant region from South Asia during the Harappan Period. However, there was only one viable source of lapis lazuli in this part of the ancient world (see Appendix 4.4) and the Harappans were the only ones who were creating "etched" carnelian beads at that time. There were no other sources available to consumers in ancient Iran (or elsewhere) who wished to posses such items. Steatite, in comparison, would have been widely available. Although I will shortly argue that raw material from certain deposits was, depending on what was being manufactured, preferred over that from other deposits, there is no reason at this point to believe that those preferable types only occurred in South Asia. If we presume that the Tepe Hissar steatite was from a source closer to that site in Iran or Afghanistan then it would indicate that there are dolomitic deposits in those regions to the west of the Indus Valley that are compositionally similar the ones in Rajasthan. This possibility allows the PGMs of some of the artifacts analyzed from other sites to be considered in a new light.

I previously argued that artifacts from Mehrgarh assigned to steatite deposits in Rajasthan were very likely to have been, in actuality, derived from a source or source area located to the west of the Indus Valley in central Balochistan or, perhaps, in Afghanistan. Although the Tepe Hissar fragments do not appear to be from the same source(s) as those particular artifacts (observe their dissimilarly on the CA dendrogram of Figure 7.46), they do, as already noted, closely resemble some of the ones from Harappa and Mohenjo-daro. Respectively, around 5% and 40% of the artifacts analyzed from those two cities were predicted to belong to steatite deposits in Rajasthan. One may ask – If the PGMs assigned to the Tepe Hissar fragments are questionable, then might those artifacts from Harappa and Mohenjo-daro that are likewise predicted to belong to sources in Rajasthan potentially be misclassified? And if so, then is it possible that the steatite such artifacts are composed of instead came from the same source or source area as the compositionally similar Tepe Hissar fragments? The answer to both questions is – most definitely yes, it is *possible*.

The evidence provided by the Tepe Hissar artifacts, although indirect and limited, suggests that occurrences of dolomitic steatite that are compositionally analogous to those in Rajasthan may exist in regions to the west of the Indus Valley. This means that artifacts from Harappa and Mohenjo-daro that were assigned PGMs in Rajasthan deposits could *possibly* instead be from occurrences in Afghanistan or, perhaps, even Iran. However, this possibility cannot be tested until samples from dolomitic sources in the latter two regions are obtained, analyzed and compared to the artifacts from those sites. Therefore, for now, the northern Rajasthan provenience assignments made for certain artifacts from Harappa and Mohenjo-daro will stand and be used to designate a regional point of origin in the upcoming summary of Indus tradition steatite acquisition networks (Figure 7.49). Nevertheless, it should be recognized that although all provenience determinations made in this chapter are provisional, the PGMs for those artifacts are perhaps the most liable to change when samples western regions are eventually incorporated into the geologic dataset.

- Addendum: Recent findings from Dholavira and Rakhigarhi

Data from the analysis of steatite artifacts excavated at the Indus cities of Rakhigarhi in Haryana and Dholavira in Gujarat were received as this book was being prepared for publication. Although these data have not yet been fully evaluated, my initial

Figure 7.49 Indus Tradition steatite acquisition networks (provisional)

impressions of the results are briefly stated here.

All of the artifacts analyzed from Rakhigarhi and over two-thirds of those from Dholavira are composed of dolomitic steatite that appears to originate from the very same "northern" sources preferred overwhelmingly residents of Harappa and Mohenjo-Daro. Most of the remaining artifacts from Dholavira seem to be made from steatite derived from either the Dev Mori source in eastern Gujarat or geologically related deposits just across the border in southern Rajasthan.

SUMMARY AND DISCUSSION

Steatite occurs in every major highland region surrounding the Indus Basin. Yet the provenience composition of the raw steatite assemblage at Harappa is far less variable, both synchronically and diachronically, than might be expected given the evidently high demand for this variety of rock and the geographical wide distribution of potential sources. For the better part of two millennia, residents of Harappa acquired most of the raw material they used from only a handful dolomitic sources located in the northern part of present-day Pakistan and India. In this final section, I first review the various steatite acquisition networks that were identified in this chapter. I then discuss the heat-treatment of steatite by Indus Tradition peoples and their need for raw material that would become white when it was fired. I argue that this need is probably the main reason behind the sustained use by Harappans of one type of steatite from a single, albeit broad, source region.

Figure 7.49 depicts the Indus Tradition steatite acquisition networks provisionally defined in this chapter. Each are indicated using a line with an arrow on its terminal end. Green lines are networks for dolomitic steatite and black lines are networks for ultramafic steatite. The routes from the sources to the sites are entirely conjectural. Variations in line thickness for networks to Harappa, Mohenjo-daro and Mehrgarh are meant to approximate the overall assemblage provenience compositions for those sites. For example, the network from the "northern" region to Mohenjo-daro is drawn with a line 6-points in width as 60% of the artifacts analyzed were assigned to sources there. A 4-point line was used to represent the 40% of artifacts from that site assigned to northern Rajasthan sources. Dashed lines (with a "?") indicate networks for which the steatite source is conjectural.

Temporal change was not illustrated on Figure 7.49 because to do so would have required either multiple maps or a single one with many more lines/ arrows and labels (this was attempted but was too busy visually). A phase-by-phase review of the steatite acquisition networks for Harappa is presented as part of the Chapter 13 summary of all geologic provenience studies presented in this book. Despite the lack of time depth, the figure does effectively depict the general acquisition patterns that are now evident for each site and for the Greater Indus region as a whole. With the final caveat – some or all of the networks defined here may change dramatically when additional steatite sources are incorporated into the geologic dataset; the following summary of the results is presented.

Indus Tradition steatite acquisition networks (provisional)

The Harappans' Indus Tradition predecessors at Mehrgarh acquired black dolomitic steatite from a source that was probably located relatively close by that site in central Balochistan. They also used some ultramafic steatite from the Muslimbagh ophiolite of northern Balochistan. Prehistoric peoples dwelling somewhat farther to the north in the Loralai Valley likewise acquired raw material from the Muslimbagh ophiolite, as well as red dolomitic steatite that was either from some unreported local occurrence in northern Balochistan or, perhaps, one of the known dolomitic deposits of Afghanistan. Later craftspeople at Harappa and the other Indus Civilization sites examined do not appear to have utilized steatite from any of the same sources as the ancient peoples of Mehrgarh or the Loralai Valley. However, the fragments analyzed from Tepe Hissar in Iran suggest that there were other dolomitic occurrences in the regions to the west of the Indus Valley from which some of the artifacts from Harappa and Mohenjo-daro could have *possibly* originated.

The earliest residents of Harappa (Ravi Phase / Period 1) used dolomitic steatite acquired through networks that extended 330 km northeast to Jammu and, perhaps, 500 km southeast to northern Rajasthan. By the Kot Diji Phase (Period 2) the largest percentage of raw material brought to the site was derived from dolomitic deposits located 400 km north in the Sherwan area of the NWFP. The Sherwan deposits remained the primary source of steatite for craftspeople at Harappa throughout the urban phase (Period 3) and into the Late Harappa Phase (Period 5). During that time, raw material continued to be brought from Jammu (through Period 3B) as well as other dolomitic sources in the "northern" region like Prang Dera in the Khyber Agency (through Period 5) and Daradar in the Kurram Agency (intermittently through Period 3C). Only very minor amounts of steatite were acquired from sources other than those to the north of Harappa. At least some raw material of ultramafic origin was obtained during Period 3A as indicated by a single fragment from the Wayaro source in the Las Bela ophiolite of southern Balochistan. A few examples of dolomitic steatite from periods 3B and 3C suggest that residents of Harappa had some degree of access to sources in northern Rajasthan at that time. Overall, however, Harappa's unfired steatite artifact assemblage is, in all periods and parts of the site, dominated by raw material acquired from "northern" region occurrences, in particular stone from the Sherwan area deposits (thus on Figure 7.49 the thickest network line is drawn from it to Harappa).

When provenience data from the other Indus Civilization cities and towns examined in this chapter are combined with that from Harappa, a much more complex picture of steatite acquisition in the Greater Indus region during the Harappan Period begins to emerge. We see that the residents of Nausharo in central Balochistan had access to the ultramafic deposits of the Wayaro area, which is around 380 km to the south in the Las Bela region. Interestingly and significantly, however, there is at present no evidence that raw material from those deposits was brought to Mohenjo-daro, despite them being the absolute closest sources to that city (≈ 200 km to its southwest). The single ultramafic fragment from Period 3A at Harappa, which was derived from a Wayaro area deposit, might therefore have been transported to that site along a network that passed through central Balochistan rather than Sindh (on Figure 7.49 I have drawn the conjectural route for that network through Nausharo).

Craftspeople working at Mohenjo-daro in Sindh and at Rakhigarhi in Haryana utilized dolomitic steatite from the same "northern" region sources overwhelmingly preferred by residents of Harappa (on Figure 7.49 the "northern" region network to those sites is conjecturally routed through Harappa). At Mohenjo-daro, they were also acquiring a smaller but significant portion of the raw material they used from dolomitic deposits in the northern Rajasthan region. A steatite seal from the site of Mitathal in southern Haryana is probably composed of stone from the same source area.

Dolomitic steatite from the "northern" region was apparently the preferred raw material as far south as Dholavira in Gujarat. However, ultramafic steatite from sources in eastern Gujarat and southern Rajasthan was also utilized at that city as well as at smaller Harappan settlements in the region like Nagwada and Gola Dhoro.

These are the steatite acquisition networks of the ancient Greater Indus region as they are currently understood. There is every reason to expect that at least some of them might change when the comparative dataset of geologic sources is enlarged. Likewise, the regional picture of the networks is almost certain to become considerably more complex as artifacts from additional sites are analyzed. Nevertheless, even at this initial stage and in spite of the provisional nature of the provenience determinations, several major new insights into the acquisition and use of steatite by Indus Tradition peoples have been gained. To begin with, we have learned that, despite the wide distribution of potential sources around the Greater Indus region, craftspeople at Harappa, regardless of the chronological phase or part of the site in which they lived, mainly used steatite derived from a limited number of deposits located in the northern parts of Pakistan and India. Raw materials from sources in other regions, such as northern Rajasthan, southern Balochistan, and eastern Gujarat, were exploited to a limited degree at Harappa and/or at some other Indus sites. By and large, however, it appears that there existed an inter-regional distribution network for "northern" steatite that extended through the Punjab (perhaps even via Harappa) to Haryana, Sindh and Gujarat. Finally, it seems that Indus Tradition craftspeople, from the Neolithic Period at Mehrgarh through the Late Harappan Period at Harappa, were, with some notable exceptions, either mainly or exclusively using steatite of dolomitic origin.

The last insight is especially significant as it may help to explain, at least in part, why certain steatite sources, some of which were relatively close by Indus Tradition settlements and presumably assessable, were used either rarely or not at all. If stone that would become white when heated was desired (and it evidently was), then, as I discuss next, it appears that only certain dolomitic occurrences could have provided raw material with that property. I argue, therefore, that technological/aesthetic considerations, more than source proximity/accessibility, dictated which steatite sources were used.

Heat-treating steatite and the desire for "white-firing" stone

Massimo Vidale noted (1989b: 180) that "in all Harappan craft production, a major emphasis [was] placed on the creation of artificial substances more than on the employment of precious, well recognizable raw materials." Few rocks or minerals would have satisfied the impulse to transform a raw material into something new better than steatite – a stone that undergoes significant physical changes when it is subjected to high temperatures. By heating steatite, Harappans and their Indus Tradition predecessors sought to greatly increase its durability by making it harder and dramatically alter its appearance by turning it white. Studying the mineralogical composition of heated artifacts enables archaeologists to assess and track the ability of Indus craftspeople to transform steatite in this way.

When sufficiently heated (also referred to as "fired" or "burnt"), steatite undergoes a variety of physical transformations. The mineralogical changes that result from the dehydration and thermal decomposition of talc (steatite's primary mineral constituent) are very well-documented (see Bose and Ganguly 1994 for a discussion of dehydration kinetics and Wesolowski 1984 for a review of various heating studies). Typically, talc decomposes to *enstatite* (magnesium silicate) and amorphous silica between around 900°C and 1000° C. At temperatures above 1100°C the amorphous silica will begin to crystallize as *cristobalite* (the high-temperature polymorph of quartz). Firing time, atmosphere and the composition of the raw material can all differentially affect the rate and temperature at which these changes take place, however. Experimental studies on steatite, similar to those conducted to replicate the firing conditions of Harappan ceramics manufacture (Kenoyer 1994a), are currently being undertaken by Dr. Mark Kenoyer and

Gregg Jamison at University of Wisconsin-Madison. Experiments also have been conducted by Barthélémy de Saizieu and Bouquillon (1994) and by myself (appendices 7.12 and 7.16) that involved the heating of raw steatite in electric kilns at different temperatures and the analysis of those samples using XRD. These studies (and the others cited above) have provided a framework for using the mineral phases detected in heated steatite artifacts to judge the approximate temperatures to which they were subjected (note that I am referring to objects made from massive steatite and not talc glazes or objects that some researchers believe to be made from powdered steatite "paste").

As noted near the beginning of this chapter, black steatite beads recovered in the very earliest (ca. 7000 BC) pre-ceramic Neolithic levels (Period I) at Mehrgarh constitute the first evidence for the use of that stone by Indus Tradition peoples. The first indication that Indus craftspeople might have begun to heat-treat steatite comes later in that same period at Mehrgarh (ca. 6200 BC – formerly the beginning of Period IB) in the form of white beads composed of *anthophyllite* and talc (see Barthélémy de Saizieu and Bouquillon 1994: 51 and Appendix 7.13 of this book). Those beads could be made from natural, unheated stone as anthophyllite (magnesium iron silicate hydroxide), like talc, is sometimes white in color (Deer *et al.* 1992: 232-236). On the other hand, an anthophyllite phase intermediate to talc and enstatite reportedly can develop when talc is heated between 667 and 745°C (Greenwood 1963). The beads could, therefore, represent the initial modification of steatite using relatively low heat. However, an anthophyllite phase was not replicated in either Barthélémy de Saizieu and Bouquillon's experimental heating study of Mehrgarh steatite (1994) or in my own (Appendix 7.12). For this reason, the heat-treatment of steatite during Period I at Mehrgarh must, at present, be considered unconfirmed.

Steatite was unquestionably being heat-treated by the late Neolithic (Period IIB ca. 5000 to 4500 BC) / early Chalcolithic (Period III – ca. 4500 to 3800 BC) periods at Mehrgarh. Using XRD, I analyzed two white beads recovered from a Period IIB level at that site (Appendix 7.13). Both exhibited minor enstatite peaks among the talc peaks, which suggest that they were probably heated to around 900°C for about one hour (or perhaps at a slightly lower temperature for a longer period of time). During Mehrgarh Period III, 93% of the beads in the site's assemblage are composed of heat-treated steatite (Barthélémy de Saizieu and Bouquillon 1994: 52). By the third millennium BC, Indus Civilization craftspeople were firing steatite at temperatures that clearly exceeded 1100°C (perhaps closer to 1200° C) as evidenced by artifacts analyzed from across the Harappan realm that in XRD scans exhibit cristobalite phases (Hegde *et al.* 1982: 243; Vidale 2000: 63 and Appendix 7.14 of this book).

Depending on its mineral composition, raw steatite can have a Mohs' hardness value of anywhere between around 1 (for types that are almost pure talc) to around 2.5 (*personal observations*). Low hardness combined with the compact, homogenous nature of good quality steatite allowed it to be sawn into thin chips that could be easily perforated and ground into beads (Vidale 1995), as well as shaped into seals (Rissman 1989) and tablets (Meadow and Kenoyer 2000) onto which inscriptions and/or various motifs were carved. However, in its raw form the stone is not very durable (it can easily be scratched with one's fingernail). By heat-treating steatite, Indus craftspeople could raise its hardness considerably. This has been documented Beck (1934: 77-82), Ritchie (1973: 48) Hegde and others (1982) and by myself (Appendix 7.16). The formation of enstatite imparts a steatite object with a hardness of between 5 and 6 (Deer *et al.* 1992: 155) and cristobalite of between 6 and 7 (ibid.: 457). Although increased hardness would have made such objects more durable, I would argue that this was not the main reason that they were heat-treated.

With the exception of the Neolithic period at

Mehrgarh, when unfired black steatite beads were most abundant (Barthélémy de Saizieu 2003: 24), the vast majority of *finished* steatite artifacts recovered at Indus Tradition sites are white in color and appear to have been heat-treated. Most are fired white completely throughout. Some artifacts, like stamp seals, have a white veneer that is the result of heating and either the application of a talcose glaze (Mackay 1931d: 379) or an alkaline surface treatment (Beck 1934: 80-81; Vidale 2000: 62). I tend to slightly favor the former explanation based on observations that I have made (Appendix 7.15). However, both techniques may have been used, perhaps at times in combination with one another. In any case, it is probably safe to conclude that, in most instances, a white appearance was the desired outcome when Indus Tradition craftspeople subjected objects fashioned from steatite to high temperatures.

Indus craftspeople apparently did not acquire and use raw steatite that was already white to begin with. None has been encountered among the nearly 3000 unfired artifacts and fragments at Harappa and to my knowledge none has been reported from other Indus Tradition sites (except, perhaps, the previously discussed white talc-anthophyllite from Mehrgarh, which may or may not be natural). Although it is possible that every scrap of white raw material was heated (and, thus, none was left to be recovered), such a scenario seems to me unlikely. It could be that this type of steatite, being the most chemically pure and least hard, was too soft and friable to be good carving stone. Or it might be that it was difficult to obtain since white stone does not tend to be found near the surface or at the easily accessible margins of steatite deposits (*personal observations*). However, it may be that Indus Tradition peoples preferred to use steatite that was colorful because it fulfilled an impulse to transform a raw material into something different. As heat is increased, the transformation of colored steatite to white is "visually impressive ... it might have been perceived as a magic process and might have suggested to the ancient craftspeople the idea of progressive purification" (Vidale 2000: 59).

In her doctoral dissertation on Indus Tradition pyrotechnologies, Heather Miller wrote (1999: 306) that "although found in various colors from white to creme to green to black, all varieties [of steatite] become white when fired to high enough temperatures." This would appear to be an unstated assumption of many South Asian archaeologists. However, this is simply not true. I have conducted a series of heating and characterization studies (Appendix 7.16) using geologic samples from several dozen of the steatite deposits examined in this study. Although these studies are still ongoing, one thing is already quite clear. That is, there are some types of steatite will become a pure bright white when fired and there are other types of steatite that will never become white regardless of how long or how high they are heated. Those types that do become white (or near white) when they are heat-treated are almost invariably from **dolomitic deposits**. Moreover, of the various dolomitic deposits examined in this chapter, those that exhibit the whitest firing steatite are the very same sources from which the majority of the unfired steatite artifacts at Harappa and Mohenjo-daro were predicted to have been derived. My apologies for the liberal use of emphasis in this paragraph but these are observations that go to the very core of two important issues raised by the results of the provenience study conducted in this chapter, which are: Why did Indus Tradition peoples mainly use dolomitic steatite and why did Harappans (at least those at Harappa and Mohenjo-daro) mainly acquire it from just a handful of deposits in the "northern" region when there were other, often closer sources? I now briefly look at both of these issues.

First. *Why the emphasis on dolomitic steatite?* In his examination of ancient steatite vessels from Eastern Northern America, James Truncer made a pertinent observation about the use of raw material from ultramafic and dolomitic (which he calls *sedimentary*) deposits:

> No steatite vessel quarries have been documented at outcrops of sedimentary origin, a distinction not previously recognized by archaeologists. The use of ultramafic steatite is consistent with the largely held assumption that steatite vessels functioned as fireproof containers because steatite vessels of sedimentary origin would perform poorly in fire (Truncer 2004: 490).

I would argue that raw material of dolomitic origin was favored by Indus Tradition craftspeople for precisely the same reason that it was disregarded by vessel-makers in Eastern North America – because of the way it behaves when subjected to high temperatures. Indus Tradition consumers needed steatite that would become white when fired and my experimental heating studies (Appendix 7.16) indicate that dolomitic steatite is more apt to do that than ultramafic steatite. I strongly suspect that the reason for this has to do with, at least in part, the different concentrations of metallic elements that are found in the two kinds of steatite, i.e. – very high concentrations in stone of ultramafic origin vs. very low concentrations in dolomitic steatite. In my heating experiments, the ultramafic geologic sample that was lightest in appearance (although not pure white) after being fired came from the Urgasai Nasir deposit (source code ZUN) of northern Balochistan (see Figure 3 in Appendix 7.16). Recall from the CDA of the full geologic set (Figure 7.31) that this was one of the ultramafic deposits that partially overlapped with the dolomitic ones because some samples from it had untypical low concentrations of certain metallic elements.

So in both parts of the ancient world we see that technological considerations – the need for white-firing steatite in the Greater Indus region and for fire-resistant material in Eastern North America, influenced which kinds of steatite deposits were exploited.

Now on to the second issue – *why did residents of Harappa and Mohenjo-daro acquire the majority of their dolomitic steatite from deposits in the "northern" region?* For consumers at Mohenjo-daro, deposits in northern Pakistan and India definitely were not the closest occurrences of dolomitic steatite. With regard to Harappa, some of the "northern" sources (those in Jammu) did constitute the nearest locations where steatite of that kind could be acquired. However, the others (those in the Sherwan zone and in the FATA) were more or less the same distance from the site as the dolomitic deposits of northern Rajasthan. In fact, those other sources may have been more difficult to reach than the ones in Rajasthan due to the fact that there are many more rivers and mountain ranges that lie between them and Harappa. So why, then, of all the potential dolomitic sources in the Greater Indus region, was steatite from a few deposits in northern Pakistan/India the preferred raw material at those two Harappan cities? After having heat-treating samples from most of the dolomitic deposits examined in this chapter (Appendix 7.16, Figure 8), the answer would seem to be that steatite from "northern" region sources fired the whitest. Thus, I would argue that the aesthetic requirements of Harappan craftspeople (their desire for white-firing stone), more than source proximity and/or difficulty of access, probably dictated which dolomitic steatite deposits were exploited.

The heating experiments reported in Appendix 7.16 have also provided information that may help to clarify patterns suggested by the cluster analysis of the full geologic and archaeological steatite sets. Recall that on the dendrogram (Figure 7.36 and Appendix 7.9) there are several large groups of the artifacts that exhibit a degree of compositional homogeneity that is more pronounced than even that of geologic samples collected from individual steatite deposits. I suggested that those closely related artifact clusters possibly represent raw material exploited from a very restricted area within an occurrence, such as a single outcrop, vein, pit or mine. Heating experiments indicate that steatite from within the individual deposits of the Sherwan zone – the source that the majority of artifacts from Harappa were predicted to belong to, is itself variable in terms what will become white and what will not. Samples from the Chelethar (SC) and the Khanda Khu (SKK) deposits became white in one heating but failed to do so in another (Appendix 7.16, figures 3 and 8). When sampling those locations, both of which extend over several hundred meters and encompass numerous pits and mine shafts (both old and modern), I was concerned with documenting intra-source variability and so collected a spatially wide range of material from them. However, it is highly likely that prior to transporting just any seemingly good-quality stone over 400 km to Harappa, whoever was extracting steatite from those (or any other) deposits during the prehistoric period would have located the specific, perhaps very restricted places within them where the whitest-firing material occurred. The intensive and sustained exploitation of raw material from such intra-source locations *could* account for the clusters of highly compositionally similar artifacts evident on the CA dendrogram.

Before concluding it is important to again acknowledge that eight of the 179 steatite artifacts analyzed in this chapter were determined not to be composed of dolomitic steatite. Although many of those were finished beads or other objects like the BMAC wig that were never meant to fired, one of them – the Gola Dhoro seal (Figure 7.7 F), clearly has been. That artifact does not have a bright white exterior like most Harappan steatite seals and beads, but it is much lighter in appearance than any of the samples from ultramafic deposits that I heat-treated in Appendix 7.16 (save for the previously mentioned ZUN sample, which [1] was white to begin with and [2] had low concentrations of metallic elements). There are a small number of finished, heat-treated steatite seals from Mohenjo-daro that exhibit a muddy red-colored exterior (for examples see Shah and Parpola 1991: color plates 7, 15 and 17) that resembles the post-firing appearance of many of the geologic samples I tested (Appendix 7.16, Figure 3B). Such seals were probably carved from and/or glazed with steatite that was not predisposed to fire to the white color that was desired by their manufacturers. The very light-gray color of the Gola Dhoro seal indicates that its makers had either succeeded in identifying/acquiring a type of ultramafic steatite that would fire near white *or* had the ability to lighten the exterior of non-white firing stone, perhaps by employing the same technique used to bleach white designs onto carnelian beads (Mackay 1933). I attempted to whiten that kind of steatite using different alkali solutions (detailed in Appendix 7.16) but was unable to affect any change in the stone's appearance. Although my failure does not prove that Indus Tradition craftspeople were incapable of bleaching stone of ultramafic origin, it does appear as if those working at Harappa (and probably Mohenjo-daro too) either could not or chose not to whiten this kind of steatite. Had they done so on any significant scale then odds are that more than one example of ultramafic stone would have been identified among the 139 fragments and unfired artifacts (≈ 5% sample of the sub-assemblage) that were analyzed from the site. The real point, however, is that they did not have to. The results of the provenience study indicate that people at those cities acquired the majority of their steatite from "northern" region sources that, as shown by the heating studies, contained raw material that was predisposed to fire white.

What then of the Gola Dhoro ultramafic steatite seal? Perhaps it indicates that the makers of that object did not have access to white-firing stone from the "northern" region and, like the Harappans of Nagwada, had to make due with the nearest available steatite, which was ultramafic in origin. This may have prompted them to invent or adapt whitening technologies that their fellow Harappans in the Indus Valley either did not possess or, more likely, did not need to use on steatite (because they had access to white-firing stone).

CHAPTER CONCLUSION

From the Ravi through the Late Harappa phases, residents of Harappa acquired almost all of the raw steatite they used from dolomitic sources located in the northern part of present-day Pakistan and India. Craftspeople in different parts of the site seem to have had access to raw material from that same broad source area. "Northern" dolomitic steatite was transported as far south as Mohenjo-daro but apparently was not used in Gujarat. In the next chapter, I examine agate – a broad variety of stone that appears to have been transported from several sources in Gujarat to Harappa and other sites in the Indus Valley.