CHAPTER 4

THE ROCK AND MINERAL ARTIFACT ASSEMBLAGE AT HARAPPA

CHAPTER INTRODUCTION: ORGANIZING AND PRESENTING THE ROCK AND MINERAL ASSEMBLAGE

The rock and mineral artifact assemblage at Harappa is large. More than 56,000 individual items made of stone or metal have been tabulated since excavations by the HARP began in 1986. It is also very diverse. Around 40 distinct kinds of rocks and minerals are represented among the materials recovered at the site (Law 2001, Law 2005b: 113-114). The first purpose of this chapter is to organize and present this huge and highly varied body of data in a way that allows it to be examined on multiple scales. In order to make that possible, the different materials in the assemblage are placed into manageable categories that I call "varieties." Each variety is then discussed in terms of the general range of material types it encompasses, the quantities in which those materials are found at Harappa, how they are spatially distributed across the site and the chronological contexts with which they are associated. In the concluding sections of this chapter, all of that information is evaluated and then used to address one of the stated aims of this study, which is to examine Harappa's rock and mineral assemblage as a single entity composed of many different elements that may vary over space and time.

The eight chapters that immediately follow this one each focus on identifying the acquisition networks of one particular rock and mineral variety used at Harappa. The second, but no less important, purpose of this chapter is to provide pertinent details on the remaining varieties in the assemblage, which are not featured elsewhere in the book. Although these other varieties are not presently the subject of geologic provenience studies, simply identifying where in the Greater Indus region (Figure 4.1) they do and do not occur provides valuable information regarding the probable extent and direction of Harappa's rock and mineral acquisition networks during the chronological phases from which they were recovered. Doing this also helps to draw attention to specific regions and/or types of geological formations from which multiple varieties of rocks and minerals may have been derived. Although the results of the geologic provenience studies conducted for this study sometimes indicate a certain material variety or varieties probably came from a particular region, it is useful to know what other rocks and minerals found at the site were available in that region and may have also come from that region.

The final purpose of the chapter is to provide details relating to the identification or characterization of certain rocks and minerals in the assemblage. Many material varieties could be easily identified on the basis of their macroscopic appearance alone. For others, however, some sort of assessment of their physical properties, whether by using a simple method (such as specific gravity or hardness testing) or a more sophisticated one (XRD or EMPA), was required. Also, the nature and correct identification of a few varieties of stone in the assemblage has been (and will probably continue to be) debated. The characterizations made here can at least help to narrow down the probable material types of those varieties and their likely geologic source or sources.

Figure 4.1 Regions, sources and sites discussed in this chapter.

DETERMINING THE COMPOSITION OF THE ROCK AND MINERAL ARTIFACT ASSEMBLAGE

The first task was to determine the composition of Harappa's rock and mineral artifact assemblage by establishing exactly what kinds of stone are present at the site and in what quantities. To accomplish this, three information sources were used: tabulation data, the Harappa database and examinations and analyses conducted specifically for this study.

Almost every artifact recovered at Harappa has been individually examined by HARP co-director Dr. Mark Kenoyer and, based on its material and/

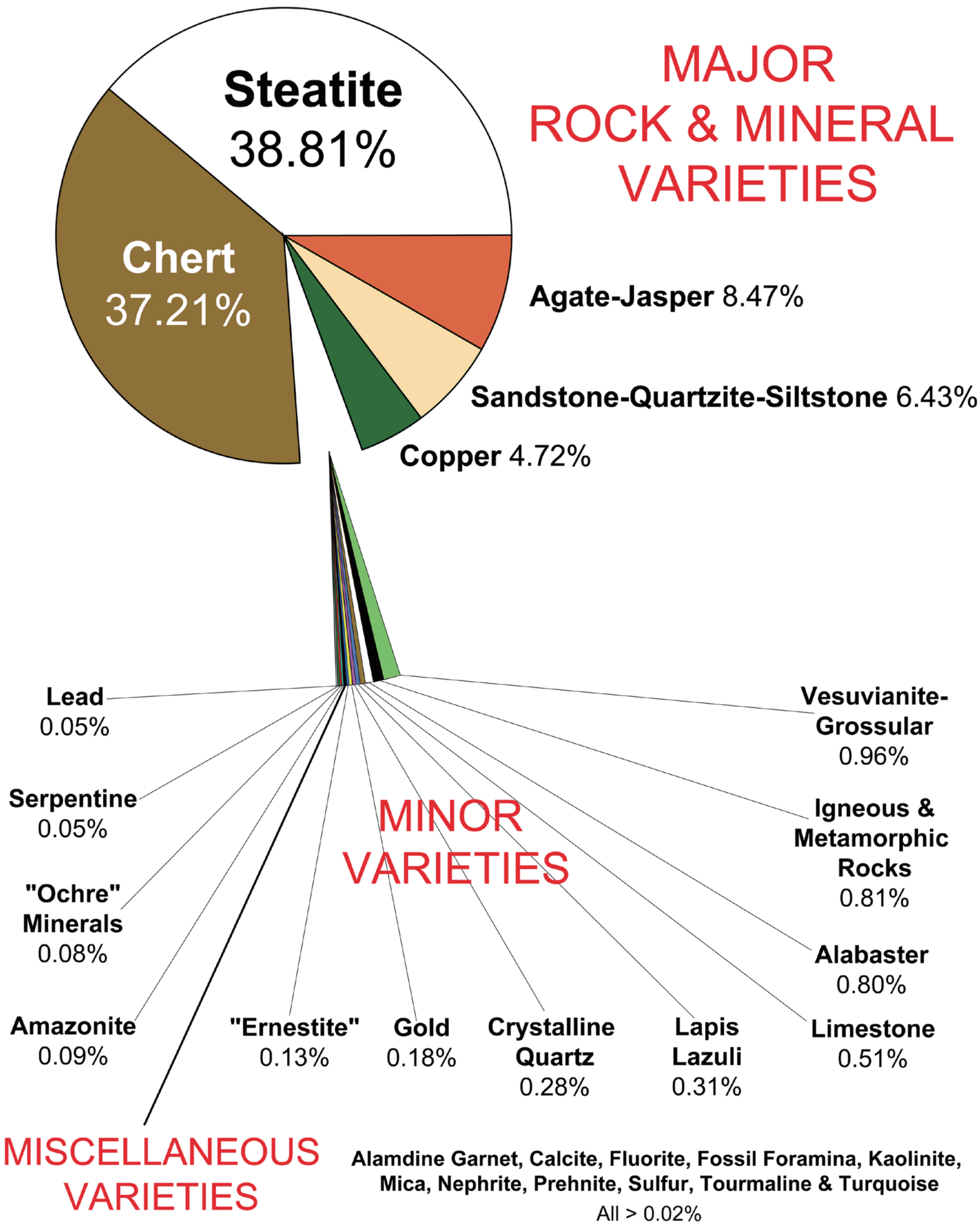
or technological attributes, placed into a *tabulation database* that he and Dr. George Dales developed with input from other project members (Meadow and Kenoyer 1992). As of 2005, this database contained 125 categories for objects made of stone or metal. For certain categories, the description of a tabulated artifact's material type is very explicit, such as those in which a "gold bead" or an "unmodified chert flake with 100% cortex" would be placed. Other categories are necessarily more generalized, such as the one for "truncated conical amulets," which are known to be made of any number of materials, not all of them stone.

When an artifact's material type was not determinable using tabulation data alone, the *Harappa database* was turned to. This FileMaker Pro database, which was developed by HARP member Sharri Clark and is maintained by HARP director Dr. Richard Meadow, contains a wealth of information relating to excavated materials including photographs of many objects, a data entry field listing specific material types and a field for descriptive entries that frequently provide additional information on an artifact's physical attributes. Material descriptions entered into this database were taken directly from the artifact recording sheets used by Mark Kenoyer as he examined objects after excavation and/or conservation. Material type for objects such as truncated conical amulets could usually be gleaned from this source. However, the Harappa database was not developed until the mid-1990s and updating it is an on-going and time-consuming process. Priority is given to registered objects and those accessioned into the Harappan Museum. Many artifacts, especially those from early excavation seasons at Harappa, have not yet been added to it.

In those instances where material type could not be determined using the tabulation database or the Harappa database, artifacts were examined first-hand and categorized based on information gained from either visual inspection or one of the analytical methods employed in this study. More than 100 examples were characterized using X-ray diffraction (XRD) analysis. Whenever possible, artifacts subjected to this destructive technique were chosen from among the large sets of materials recovered during surface surveys. Appendix 4.1 lists the major mineral phases for all samples characterized in this way, as well as some minor phases detected using electron microprobe analysis (EMPA). Rather than displaying the XRD peak profiles obtained for each of the 100 plus samples (a large portion of which are absolutely identical), scans representative of the various material types (and sub-types) that were identified are provided in Appendix 4.2. Some artifacts were characterized using EMPA or specific gravity testing. Those results are presented in the body of the text of this and subsequent chapters.

After all information on material types was gathered, it was decided that the artifacts should be re-categorized in a way that would help to make a very large dataset more manageable, but still highlight the assemblage's diversity and patterns of material usage within it. They were therefore re-organized into groups that I call "varieties." The majority of varieties still feature single material types, such as lapis lazuli or amazonite, which are macroscopically and mineralogically distinctive. Others varieties, however, were created by lumping or splitting material types. For example, rocks known as microcrystalline silicates, although mineralogically alike (all are basically quartz), exhibit enormous macroscopic variability and could have easily been divided into a dozen separate varieties. In the end, however, only two were defined – cherts and agate-jaspers, which were based not only their macroscopic differences but also on their functional attributes (more on this below). In other instances, several rocks or minerals types were lumped together based on a shared attribute, such as in the case of "lead," which includes finished lead artifacts as well as the various raw ore sulfides, oxides, of carbonates of lead found at Harappa. Admittedly,

Figure 4.2 The composition of Harappa's rock & mineral artifact assemblage. Percentages based on 56350 tabulated rock and mineral artifacts.



many of choices made when defining varieties were somewhat subjective and groupings could have been made any number of other ways. However, for the purposes of this study they are quite suitable.

With the varieties of rocks and minerals defined, percentages of each one present in the assemblage were generated based on the number of individually tabulated artifacts. A chart depicting the overall composition of Harappa's rock and mineral artifact assemblage can be seen in Figure 4.2. All material varieties that compose more than 1% of the overall assemblage are defined as one of the *major* rock or mineral varieties. All those for which there are more than ten examples in the assemblage, but that make up less than 1% of the overall total, are defined as the *minor* varieties. *Miscellaneous* rock or mineral varieties are those for which ten or fewer examples have been recovered at Harappa. The designations *minor* and *miscellaneous* do not necessarily mean that Harappans considered those materials to be less important, less desirable or less requisite than any of the more abundant stone types in the assemblage. On the contrary, it is probable that many of the less common varieties were highly valued. A material such as gold almost assuredly was. Differences in the relative abundances of the rock and mineral types might be due to recycling or re-use of certain materials and not others, variations in the amount of debitage produced when possessing different types of stone, or any number of other factors besides or in addition to frequency of use.

MAJOR ROCK AND MINERAL VARIETIES

Over 95% of the artifacts in Harappa's rock and mineral assemblage are composed of one of five varieties of rock or mineral. These are referred to as the *major* varieties (Figure 4.3). Examples of each one have been recovered in abundance on every mound, in almost every excavation trench and from every chronological phase at Harappa.

Steatite

Nearly 40% of all lithic artifacts from Harappa have been classified as *steatite*. Full details regarding the origin, potential sources, geologic provenience and use of this stone during the Indus period are presented in Chapter 7. Here, I discuss the issues relating to the identification and classification of this material at Harappa.

Commonly known as "soapstone," steatite is a "soft" (Mohs' scale hardness of 1 to 2.5) metamorphic rock that is primarily composed of the mineral talc (hydrous magnesium silicate) but may contain a wide range of secondary minerals. Its visual appearance is highly variable. The color in a single hand specimen can grade from deep black to pure white with intermediate shades of red, green or yellow. Because it often resembles other soft stones such as chlorite or serpentine, misidentifications can and do occur. For example, "intercultural" style stone vessels from the third millennium BC site of Tepe Yahya in southeastern Iran were thought to be made of steatite until Philip Kohl (1976, 1979) examined them using XRD and determined that most were actually composed of chlorite.

Stone artifacts classified as steatite at Harappa often differ greatly in appearance (Figure 4.3 A). For this reason, the mineralogical characterization of a sample of artifacts representative of the different visual types found there was considered to be essential.

Vidale and Bianchetti (1997) were the first to characterize steatite artifacts from Harappa using XRD. They found that four green-colored fragments were all predominantly composed of talc with occasional secondary phases of quartz or dolomite. For this study, an additional 29 unmodified (not heat treated) fragments of soft stone from Harappa thought to be steatite were analyzed using XRD (Appendix 4.1). Samples were chosen to represent the full spectrum of visual types present at the site (see Figure 4.3 A *top row* for a selection of these). Three representative XRD scans can be seen in Appendix 4.2. Scans for 20 of the samples displayed diffraction peaks for talc alone (Appendix 4.2 A), five showed talc with a minor component of dolomite (Appendix 4.2 B) and four indicated talc with a minor component of quartz (Appendix 4.2 C). Despite their variable appearances, all samples could be characterized as steatite. These results and those of the earlier study provide confidence that artifacts of this variety have been correctly classified.

It is important to note that around 86% of the almost 22,000 steatite artifacts at Harappa have been heat-treated (four heated-treated steatite beads can be seen in Figure 4.3 A *bottom right*). The talc that such artifacts were originally composed of has wholly or partially converted to the mineral *enstatite* (magnesium silicate). In some cases heating may have also resulted in the formation of *cristobalite*

Figure 4.3 The five major rock and mineral varieties at Harappa.

A. Steatite artifacts.
Top row - fragments of raw (unheated) steatite debris
Bottom right - heat treated steatite beads

B. Three main types of chert at Harappa
Left to right –
tan-gray (1-3) and
tan-gray *banded* (4),
black-brown (5-8) and
purplish (heated?) chert -/ chalcedony (9 & 10).

C. Agate and jasper debris representing just a few of the macroscopically distinct types present at Harappa.

D. Siliciclastic rock artifacts. *Left to right*-
Coarse to medium grained sandstone quartzite quern, slate whetstone fragment, various silicified quartzite and fine grained pebbles and cobbles.

E. Copper artifacts.
Left to right – copper alloy rod fragment, copper alloy lump, chalcocite and malachite.

(SiO_2). Cristobalite is a high temperature *polymorph* (polymorphs are two minerals sharing the same chemical composition but having different crystal structures) of quartz. A full discussion of this process can be found in Chapter 7. Although the original mineral compositions of these heated artifacts have been considerably altered (technically making them a different mineral – enstatite), for the purposes of this study they are still classified as steatite.

Microcrystalline silicates

Chert, flint, jasper, chalcedony, agate, carnelian, bloodstone, heliotrope chrysophrase, novaculite, radiolarite, sard and onyx are all terms for closely related (in many cases mineralogically identical) sedimentary rocks. All are composed principally of microscopic crystals of quartz (either granular or fibrous) that form when silica chemically precipitates out of an aqueous solution (Luedtke 1992: 18). Numerous visually distinctive types of microcrystalline silicates are found at Harappa and, when considered in total, they are the most abundant variety of lithic material at the site. However, I have chosen to divide this diverse assemblage into two, albeit still broad, sub-varieties – cherts and a combined category consisting of agates and jaspers (agate-jasper). This division makes chert a close second and agate-jasper a distant third in terms of abundance of tabulated stone artifacts at the site. The decision to define two sub-varieties was based partially on the different macroscopic characteristics of microcrystalline silicates (described below) and partially on the different uses Harappans made of such materials. Chert was used mainly as a material for making tools and cubical weights. Agates and jaspers were primarily stones from which ornaments (mostly beads and pendants) were fashioned. Although some ornaments and other objects made of chert have been recovered at Harappa and numerous agate-jasper tools have also been found (notably in the site's earliest phase), the two material sub-varieties were *typically* used for creating different types of objects.

Chert

No hard and fast definition exists for the term "chert." Barbara Luedtke (1992) used it in a general way to refer to all microcrystalline silicates. She considered agate, for example, to be a translucent variety of chert (ibid.: 31). George Rapp (2002: 71-72) prefers to differentiate microcrystalline silicates based on their crystal structures – cherts are those with a granular structure while chalcedonies have a fibrous structure. At Harappa, classification has been based mainly on visual characteristics. Chert artifacts are generally defined as those opaque microcrystalline silicates having a color that is either neutral (ranging from light gray to black) or a shade of brown. The one exception to this convention is a type of chert/chalcedony with a purplish hue that was used to make tools during the Early Harappan periods. Artifacts fitting these descriptions make up over 37% of the rock and mineral assemblage. Examples of the three most common macroscopic types – tan-gray (sometimes banded), black-brown and purplish chert/chalcedony can be seen in Figure 4.3 B. Chapter 6 is devoted to examining the acquisition of these chert types.

Agate-Jasper

If you ask a geologist, mineralogist, gemologist and archaeologist each to define agate and jasper you may very well receive four different answers. The lack of consensus is mainly due to the fact that these types of microcrystalline silicates are so highly variable that they defy any absolute classification (Butler 1995). For this reason, it was decided that the criteria used in this study should be as straightforward as possible. Agates are simply defined as any wholly or partially translucent variety of microcrystalline silicate. Jaspers are those opaque microcrystalline silicates that are of colors other than the ones used above to define chert – generally this means shades of red, green or yellow. In Gujarat and again in Waziristan, I have seen microcrystalline silicates that grade from jasper to agate in an individual hand specimen. When considered as a single material variety (for reasons explained), agate-jasper comprises 8.47% of the site's rock and mineral assemblage. Not surprisingly though, the use of such broad, encompassing definitions means that artifacts in this category vary tremendously in their visual appearances (Figure 4.3 C).

Although defined here as belonging to the "agate-jasper" sub-variety, some jasper artifacts are dealt with (briefly) in the chapter on chert (Chapter 6). In Chapter 8, INAA is used to compare agate from sources (or proxy sources) in India and Iran to a set of archaeological samples from Harappa and several other prehistoric sites in South Asia.

Siliciclastic sedimentary rocks

"Siliciclastic" rocks are those composed of *clastic* sediments (materials weathered or broken from pre-existing rocks) primarily derived from *silica*-rich, non-carbonaceous rocks. Rocks of this variety include conglomerate, sandstone, siltstone, greywacke, mudstone and shale. *Quartzites* form when the clastic sediments composing such rocks recrystallize to varying degrees due to heat and/or pressure. Although therefore technically a metamorphic rock, quartzite is included in this material variety as it is defined here.

Roughly 3600 siliciclastic sedimentary rock artifacts make up between 6 and 7 percent of Harappa's lithic assemblage. Over 70% of these are grindingstones – querns, mullers, mortars or pestles, which are typically composed of sandstone/quartzite (Figure 4.2 D *left*). The potential geologic sources of those rocks and the acquisition networks through which they were brought to Harappa is examined in Chapter 5.

Multiple types of sandstone, quartzite, greywacke, siltstone and mudstone were used to create the artifacts comprising the remaining portion of this material sub-assemblage, which includes implements like whetstones and burnishers as well as a variety of non-utilitarian items such as beads, amulets, cubical weights, balls, "gaming" pieces and small ringstones or mace heads. Determining the geologic provenience of artifacts composed of such common but variable stone is difficult to do beyond the regional level at best. Whetstones (used for sharpening edged tools), for example, were typically made from compact fine-grained sandstones or siltstones (Figure 4.2 D *center*). Although such rocks occur in numerous regions surrounding the northern Indus Basin, the various sedimentary sequences of the Sulaiman Range (Shah 1991) – 225 km directly west of Harappa, would have been the source of the most abundant and best quality material for this type of artifact (*personal observation*).

Several hundred whole and fragmentary siliciclastic pebbles (4 to 64 mm in size) and cobbles (64 to 256 mm) of various descriptions (Figure 4.2 D *right*) have also been found at Harappa. These could have come from *almost* anywhere. Water-rounded stones of all sizes, textures and colors are found in many of the Miocene-Pliocene Siwalik and later Quaternary sedimentary formations that run along the entire western and northern margin of the Indus Basin (Cheema *et al*. 1977: 89-98) as well as in the beds of rivers draining the highlands surrounding the Punjab Plain (*personal observations*). Those rivers, however, could not have carried these stones very far out onto the plains. All pebbles or cobbles found at Harappa, no matter how small, had to have been intentionally transported several hundred kilometers to the site.

Copper and copper minerals

The production of copper or copper alloy objects is the hallmark of *Chalcolithic* or Bronze Age societies in the Old World. For the purposes of this study, the material variety *copper* includes artifacts that are composed of processed copper metal as well as raw copper minerals. Throughout this book I refer to processed metal objects (copper and otherwise) as being part of the Harappa's rock and mineral assemblage, although it is recognized that such artifacts are, technically, neither rocks nor minerals. Like heat-treated steatite, the original nature of material composing metal objects has been significantly altered. However, unless made from native metal, most were originally derived from a metalliferous rock or mineral and so are classified as such.

At Harappa, copper artifacts make up less than 5% of the site's rock and mineral assemblage. It might appear then that use of this material, although noteworthy, was somewhat limited – especially in relation to a much more abundant material like chert. However, unlike chert, metal objects and scraps that are no longer considered useful can be collected, recycled and re-used indefinitely. The copper artifacts at Harappa that escaped recycling and entered the archaeological record almost assuredly under-represent, to a significant degree, the amount of metal that actually was used at the site.

Although most copper artifacts at Harappa (Figure 4.2 E) are either identifiable copper alloy objects or non-descript fragments, a handful of raw copper ores have been found. Using XRD these have been identified (Appendix 4.2 D & E) as *chalcocite* (copper sulfide) and *malachite* (copper carbonate hydroxide). The potential sources and possible geologic provenience (s) of these ores are investigated in Chapter 12.

MINOR ROCK AND MINERAL VARIETIES

Twelve materials make up most of the remaining 4.36% of Harappa's rock and mineral assemblage. These *minor* material varieties (Figure 4.4) are presented below in order of their decreasing overall abundance in the assemblage.

Vesuvianite-Grossular

Chapter 9 is entirely devoted to examining the potential sources and probable geologic provenience(s) of vesuvianite-grossular garnet – a hard (6.5 to 7.5 on Mohs' scale), translucent, green-colored rock (Figure 4.4 A) that, after steatite and agate-jasper, was the third most common material used by Harappans to make beads and other small ornaments. Full details relating to that stone's appearance, mineralogy and other physical properties are presented in Chapter 9. Here, I briefly discuss how this material was identified and in what contexts it occurs at Harappa.

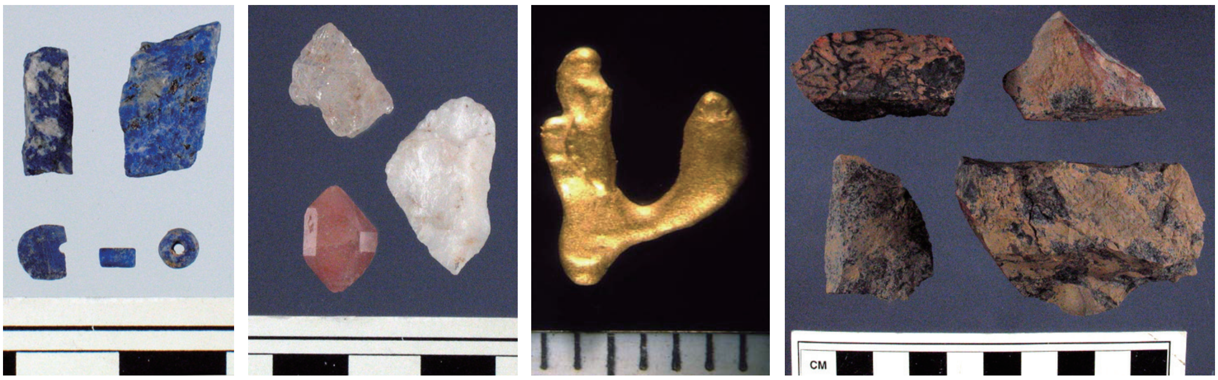
Vesuvianite and grossular garnet are two distinct minerals, which sometimes co-occur to form a massive gem-quality rock (Anderson 1966). To date, 543 objects and fragments composed of the co-occurring variety, which I simply call "vesuvianite-grossular," have been found at Harappa. Twenty-five of the fragments (roughly 5% of the material sub-assemblage) were directly identified using XRD. Appendix 4.2 F is a composite of four of those scans, which illustrates how the rock grades from pure grossular, to a vesuvianite-grossular mix, to pure vesuvianite, to a heavily weathered (chloritized) material with only traces of vesuvianite. One hundred eighty-two artifacts (nearly 30% of the material sub-assemblage) were classified based on specific gravity (SG) testing, which easily distinguishes dense vesuvianite-grossular (≈ 3.0 to ≈ 3.5) from lighter minerals like quartz or serpentine (both ≈ 2.6).

The use of vesuvianite-grossular at Harappa was largely restricted in time and space. More than 90% of artifacts made of this stone are found on conjoined mounds E-ET. Most of the remaining ones were recovered from Harappan Period refuse areas away from the main habitation mounds (e.g., the "Low Western" Mound and the debris layers above the Cemetery area). Ninety-seven percent of the total number of vesuvianite-grossular artifacts from secure stratigraphic contexts (n = 180) come from Period

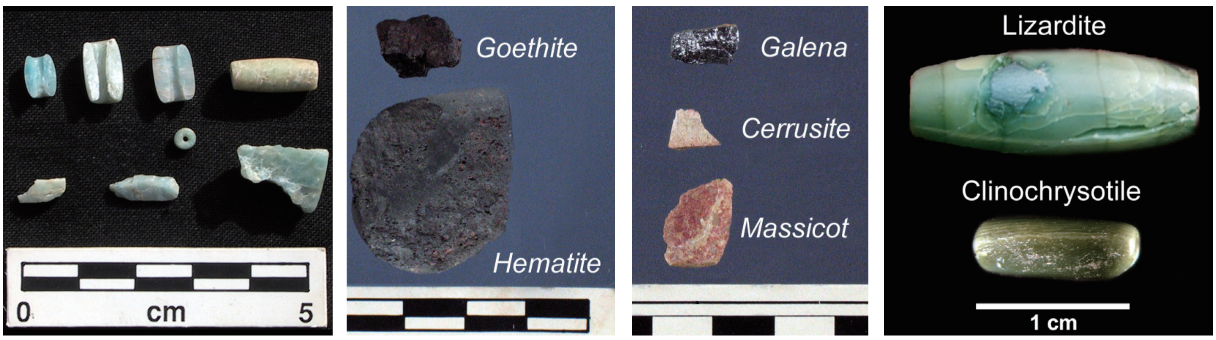
Figure 4.4 Minor rock and mineral varieties at Harappa.

A. Vesuvianite-glossular **B**. Igneous and metamorphic rocks (granite, schist, gabbro)

C. Gypsum – *alabaster* (left) and *selenite* (right) **D**. Limestone



E. Lapis lazuli **F**. Crystalline Quartz **G**. Gold **H**. "Ernestite"



I. Amazonite **J**. "Ochre" minerals **K**. Lead minerals **L**. Serpentine

3C levels. Ninety-seven percent of those are from mounds E-ET but a few examples were excavated on mounds AB, F and the Mughal Sarai area. A single flake each was recovered in Period 1 and Period 5 levels on the north side of Mound AB.

Igneous and Metamorphic rocks

A huge range of rocks are encompassed by the designations *igneous* (rocks formed from magma) and *metamorphic* (pre-existing igneous or sedimentary rocks altered by heat, pressure or chemically active fluids). Many of the "varieties" defined and described elsewhere in this chapter fall into these categories. For instance, steatite, quartzite and lapis lazuli are technically metamorphic rocks. However, for purposes of categorization, the materials that are classified as "igneous and metamorphic rocks" (Figure 4.4 B) here include a much more limited (albeit still very broad) range of material types than the two geologic terms normally encompass. The igneous variety at Harappa includes granite, andesite, rhyolite, gabbro and basalt. The metamorphic variety includes such rocks as gneiss, schist, phyllite and slate.

Altogether, 455 artifacts recovered at Harappa are of the "igneous and metamorphic rock" variety. Just over one-third (34%) of those are grindingstone artifacts such as querns or mullers (Figure 4.4 B *left*). These are discussed in greater detail in the chapter immediately following this one. Twenty-two percent are schist, phyllite or slate fragments, many of which are probably pieces from flat discs (palettes?) like the example (Figure 4.4 B *center*) in the Harappa Museum's reserve collection that comes from excavations carried out in the 1920s and 30s. Almost 15% are small non-diagnostic chunks and flakes of various igneous and metamorphic rock types that are probably debris from the manufacture of finished items. Many different types of finished it make up the remaining 30%. Gabbro was used to make cubical weights (Figure 4.4 B *right*), beads and small ringstones. There are basalt amulets, beads, large conical objects, hand mullers and several complete, apparently unmodified cobbles (Figure 4.5 A). The basalt cobbles may well have been "touchstones" (*kasoti* stones) like jewellers still used today for testing the purity of gold (Figure 4.5 B & C). Although some types of artifacts are found during certain periods only (for instance, truncated conical amulets made of basalt are found only in Period 3 levels), examples of igneous and metamorphic rocks have been recovered from all chronological phases and from all parts of the site.

Harappans could have obtained the igneous and metamorphic rocks they used from any one of the numerous geologic formations across northwestern South Asia in which they are found. Using EMPA, I conducted a small characterization/ provenience study of two basalt fragments from the site (Appendix 4.3). The results indicated that those particular artifacts probably were *not* related to the continental flood basalts known as the Deccan Traps, which lay far to the south of Harappa in peninsular India and Gujarat. Although I am in no way ruling out the possibility that other basalt objects or other kinds of igneous or metamorphic rock recovered at the site could have come from those regions, here I discuss only those sources located within or directly adjacent to the upper Indus Basin.

The closest occurrences of igneous and metamorphic rocks to Harappa are situated in the northern-most of the Kirana Hills outcrops (Alam *et al.* 1992), approximately 140 km directly north of the site, near the modern city of Sargodha. There, rhyolite, andesite, volcanic tuff, phyllite and slate are all found in the Precambrian Hachi Formation (ibid.). In Chapter 5, I demonstrate that during periods 1 and 2, residents of Harappa acquired most of the meta-sedimentary rocks they used for grindingstones from the Kirana Hills. It is, therefore, quite reasonable to assume that some of the igneous and metamorphic rocks found at the site during those periods also may have come from this region. Approximately 70 km

Figure 4.5 Basalt "touchstones" or kasoti stones for testing gold purity.
Basalt cobble (H2000/2194-51) from Harappa excavations (top left). Jeweler in Lahore holding a basalt kasoti stone (right). Streaking a gold ornament across a kasoti stone to test its purity (bottom left).

beyond the Kirana Hills is the Salt Range, where granite can be found in the boulder beds of the Tobra Formation (Shah 1980: 12; *personal observations*) and an area of heavily weathered basaltic rock called the Khewra Trap exists (Jan and Faruqi 1995). Cobbles of different varieties of igneous and metamorphic rock can be found in the conglomerate beds of the Siwaliks (Brozovic and Burbank 2000), which ring the western and northern margins of the Indus Basin. Around 350 km southeast of Harappa, in the vicinity of Tosham in southern Haryana (Grover and Kumar 1980; Pareek 1986), a series of igneous outcrops break the alluvial plain that may have been important potential sources for rock of this kind. Several Early Harappan, Harappan and Late Harappan Period settlements lie in close proximity (≈ 25 km) to these outcrops including the site of Mitathal (Bhan 1969, 1975). Finally, basalt, gabbro, gneiss and other dark, magnesium and iron-rich (*mafic*) igneous and metamorphic rocks can be found in the ophiolite sequences that occur at various points along the northern and western margins of the Indus Basin. Residents of the Harappan and/or Early Harappan Period sites of the Bannu Basin, Gomal Plain or far northern Balochistan would have been in the positions to acquire these types of stone from the northern Zhob or the Waziristan ophiolites.

Gypsum

The mineral *gypsum* (hydrated calcium sulfate) occurs in two forms – compact masses called *alabaster* and tabular crystals called *selenite*. Both forms have been recovered at Harappa (Figure 4.4 C) and directly identified as gypsum using XRD (Appendix 4.2 G). In Chapter 10, the potential sources and probable provenience(s) of alabaster (the more common of the two forms) are examined in detail. Alabaster objects and/or debris fragments have been recovered in all major areas of the site and from every chronological phase and sub-phase from Period 1 through Period 3C.

Limestone

Fewer than 300 artifacts made of limestone (a sedimentary rock consisting mainly of calcium carbonate) have been recovered at Harappa. It is somewhat surprising that rock of this type is not more represented in the site's assemblage given its widespread availability around the Greater Indus region. Also interesting is the fact that few artifacts made of this material are found in levels prior to Period 3C. During Period 3C, numerous distinct types of limestone were used residents of Harappa. The physical characteristics of the five most common types (Figure 4.4 D), their potential sources, probable geologic provenience(s) and questions relating to their use at the site are examined in Chapter 11. Three additional, less common, types of limestone are briefly discussed here.

Chalk

Several fragments (one is from Period 3C levels on Mound F, the rest are surface finds turned in by workmen at Harappa) of the soft, pure white form of limestone known as *chalk* have been found at Harappa. Chalk deposits, although extensive in many parts of the world, are limited in South Asia. It is reported to exist in different parts of the Kashmir Valley (Bates 1873: 19). In Sindh, the only reported occurrences are in the upper part of the Laki Limestone formation around Thano Bula Khan in southern Sindh (Jafry and Ahmad 1991: 61). After that, one must travel southeast to Gujarat to find this type of limestone. Large chalk deposits are found in the Junagadh District (Desai and Pathole 1979) while smaller occurrences lie near Lakhpat in Kutch (Merh 1995: 168-169).

Variegated and fossiliferous limestone

"Sang-i-Abri" (Cloud stone) is the colloquial term for a type of khaki to dark red *variegated limestone*. Just a few of artifacts (a bead and some blocks/slabs) made from this stone have been reported from Harappa (Vats 1940: 150, 177). "Sang-i-Miriam" (Stone of Mary) is a yellowish-brown to dark brown *fossiliferous limestone* that has long been used in South Asia both for decorative inlays (Figure 4.6 A) and for fashioning small ornaments. Only two artifacts have been found at Harappa made of this type of stone (Figure 4.6 B). The blocklet pictured on the right of the figure is from Period 3C levels in Trench 43, Mound F. Although the truncated conical amulet on the left is a surface find turned in by one of the workmen, it is clearly of Harappan design (amulets with the *exact* same form but made of different kinds of stone have been found in Period 3 levels).

Although fossiliferous limestones occur in many formations around the Indus region, those with the macroscopic characteristics of Sang-i-Miriam seem to be quite rare (*personal observations*). In the museum of the Geological Survey of Pakistan-Quetta there is a polished slab of Sang-i-Miriam said to be from Sangjani in the Rawalpindi District, Punjab. This would be the source nearest to Harappa. Sang-i-Miriam is also quarried today in the Jaisalmer District of Rajasthan near Habur (Figure 4.6 C). Further south, I have seen fragments and pockets of the stone near the Indus city of Dholavira on Khadir Island, in northern Kutch, Gujarat (Figure 4.6 D). Importantly, there are numerous finished objects and debris fragments made from Khadir Sang-i-Miriam in the collection of excavated stone from Dholavira (*personal observations* 2007-2008). The two artifacts from Harappa could have come from any one of these sources.

Figure 4.6 Sang-i-Miriam (fossiliferous limestone)
[A] Inlay, Lahore Fort, Pakistan. **[B]** Truncated conical amulet and worked block, Harappa.
[C] Sang-i-Miriam at Habur, Jaisalmer District, Rajasthan. **[D]** Sang-i-Miriam at Khadir Island, Kutch, Gujarat.

Lapis Lazuli

Most of the 174 lapis lazuli artifacts recovered during HARP operations are beads, unfinished beads and fragments of manufacturing debris (Figure 4.4 E). Examples have been found on every mound at the site and from all of its chronological phases and sub-phases (Appendix 4.4 *Figure 2*). Lapis lazuli is a rock that may contain varying amounts of several minerals including calcite, diopside and pyrite, but it is *lazurit*e (sodium calcium aluminum silicate sulfur sulfate) – a mineral isomorph of haüyne and sodalite – that provides the stone with its characteristic blue color (Leithner 1975; Hogarth and Griffen 1976a; Webster 1994: 263). Although other blue-colored minerals, such as azurite and sodalite, are sometimes mistaken for lapis lazuli, in most cases it is sufficiently distinctive so that an experienced individual may confidently identify it based on visual inspection alone. That is, if one has looked at enough genuine examples it is generally easy to spot (based on hue, luster, crystal habit and visible mineral associations) a different stone for which the blue color is probably not due to the presence of lazurite. Still, misidentifications can be made. Shaffer reported (1982: 193) that Walter Fairservis had analyzed "lapis lazuli" samples from several Indus Civilization sites including Mohenjo-daro and found them to actually be the mineral *azurite* – a hydrated copper carbonate with a brilliant blue color. So to be on the safe side a few of the more ambiguous-looking debris fragments from Harappa were analyzed using XRD (see Appendix 4.2 H for an example of one of those scans). The primary mineral phase in those samples was most definitely lazurite and I am quite confident that all other artifacts from the site that are classified as lapis lazuli are actually made from this stone.

In Appendix 4.4, I examine in detail the question of where the lapis lazuli used by residents of Harappan and other Indus Civilization peoples originated. As small study is conducted comparing the sulfur isotope ratios of archaeological lapis lazuli from Harappa and several other sites to geologic samples from multiple sources. Based on those results and given all other evidence that is presently available, I have come to the conclusion that the Sar-i-Sang area mines in the Badakhshan region of northern Afghanistan would have been the *only* viable sources of that stone. Lapis lazuli is therefore one of the few materials found at Harappa (the others being marine shell and the remains of oceanic species of fish) that provides unequivocal evidence for both the direction and extent of long-distance acquisition networks during the periods in which they are present.

Crystalline quartz

Quartz (silicon dioxide) is the most abundant substance in the earth's crust after feldspar (Deer *et al.* 1992: 469). Making a firm statement regarding the possible geologic proveniences of artifacts made from such a commonplace mineral is therefore problematic. It is possible to say that the crystalline varieties of quartz found at Harappa (Figure 4.4 F) usually (but not always) occur in association with igneous or metamorphic rocks (Pough 1988: 220-221). The 160 crystalline quartz artifacts recovered include beads or fragments of clear "rock crystal", "smoky" quartz, "milky" quartz, "rose" quartz and pink-colored bi-pyramidal crystals known as Mari "Diamonds." Nearly half (79 of 160) of these come from stratified contexts representing all periods and sub-periods from 2 through 3C. The majority (78%) of those that date to Period 3C and although they were recovered from each of the site's mounded areas as well as the cemetery area dump, the heaviest concentration (56% of the total for this period) were found in Trench 43 on Mound F.

The quartz crystals known as Mari "Diamonds" are highly distinctive and, because they were very likely derived from alabaster deposits in the Salt Range, they are discussed in the portion of this book (Chapter 10) featuring the alabaster provenience study. All or some of the remaining kinds of crystalline quartz at Harappa can be found (usually in granitic rock) in numerous parts of the Greater Indus region. Such areas where occurrences are found lying within or directly adjacent to the upper Indus Basin include the Kirana Hills (Heron and Crookshank 1954: 131; *personal observations*), the Northern Areas of Pakistan (Kazmi 1995b: 288), Himachal Pradesh (Geological Survey of India 1989a: 47), southern Haryana (Geological Survey of India 1989b: 34) and northern Rajasthan (Department of Mines and Geology 1989: 48-49; *personal observations*).

Gold

Artifacts made of gold (mostly small beads and leaf or foil fragments) have been found on every major mound at Harappa. Approximately half of the 120 examples recovered come from securely dated strata spanning Period 1 through Period 3C. The other half are from surface or disturbed contexts and, therefore, it is possible that at least some of those were originally deposited in Late Harappan levels that were subsequently disturbed. The best evidence for gold-working at the site comes from Trench 54, where a gold droplet[1)] (Figure 4.4 G), small crucibles, a basalt touchstone (used in modern gold bazaars to test the purity of an item by observing the streak it leaves on the stone's black surface - see Figure 4.5) and an unusually heavy concentration of gold beads and fragments were found in deposits eroding from Period 3B and 3C levels (Meadow *et al.* 2001: 14-15).

The number of gold objects that have been found at Harappa and other Indus Civilization sites almost assuredly represents but the tiniest fraction of what was actually used. Any amount of the precious metal left over from the manufacture of finished items no doubt would have been scrupulously recovered and recycled, just as it is by modern goldsmiths in South Asia (or anywhere else for that matter). Also, in contrast to practices in other contemporaneous Old World civilizations, Harappans generally were not inclined to inter their dead with much in the way of wealth items (made of precious metals or otherwise). Although a few gold artifacts have been found in graves at Harappa (Dales and Kenoyer 1989a: 89, 91), most were apparently kept in circulation rather than permanently buried. Precisely how much was in circulation is difficult to estimate, but finds of jewelry hoards, such as those unearthed at Harappa (Vats 1940: 63-66) and Mohenjo-daro (Mackay 1931c: 522-524), suggest that the amount was probably substantial. Recently, the Archaeological Survey of India recovered ten kilograms of gold and silver ornaments from a hoard, which that had already been

1) this gold "droplet" may actually be a tiny placer nugget (J.M. Kenoyer *personal communication* 2001)

heavily looted, at the Late Harappan site of Mandi in western Uttar Pradesh (Sharma *et al.* 2000; Tewari 2004).

Where did Harappans obtain gold? There are many possibilities as it is a metal with a remarkably wide distribution across South Asia – a fact noted by Sir Edwin Pascoe when he discussed (1931: 674-675) the possible geologic sources for the gold artifacts found at Mohenjo-daro. Comprehensive and reasonably up-to-date accounts of the many occurrences, both major and minor, in Pakistan and India already exist (Ahmad 1969: 23-25; Nanda 1992; Radhakrishna and Curtis 1999; Shams 1995b: 240-243; Ziauddin and Narayanaswami 1974) and so only the most pertinent regions or occurrences are reviewed here. The Kolar gold fields of southern India have been the most productive in modern times (Wadia 1975: 444) and some scholars have proposed that Indus Civilization consumers may have obtained this precious metal through long-distance interaction with the Neolithic cultures of that region (Agrawal 1984: 165; Allchin and Allchin 1997: 102; Bhardwaj 1989: 327; Ratnagar 2004: 156; Rao 1985: 632-33). Although this is certainly a possibility that should not be dismissed, the goldsmiths of Harappa were in much closer proximity to other regional sources of that metal, three of which I discuss below.

A substantial portion of the gold produced in the modern world comes from *porphyry copper* deposits (copper mineralized in association with intrusive igneous rocks) that are rich in noble metals (Kesler 2004; Sillitoe 1979). The Khetri copper belt of northwestern Rajasthan is one of these deposits. Both gold and silver are recovered at the Hindustani Copper Ltd. smelting plants operating in this region today (Rao *et al.* 1997). If the Khetri belt was one of the major sources for the copper used by Indus Civilization peoples as has been proposed (Agrawala 1984), then some Harappan gold may have been derived from northwestern Rajasthan. Gold is also currently being recovered from porphyry copper deposits in the extreme western part of Balochistan around Saindak (Lamb 1988; Mining Magazine 2001; Shams 1995b: 241; Wolfe 1974). Ancient workings and smelting areas can be found throughout that region (Vredenburg 1901) and into eastern Iran (Bazin and Hübner 1969: 153-157). Immediately to the north, in the Gardan Reg region of southwestern Afghanistan, immense spreads of copper production debris were found in association with graves and ceramics dating to the third millennium BC (Dales and Flam 1969; Dales 1992; Fairservis 1961; Vredenburg 1901: 264-265). George Dales reported (1992: 26) that the analysis of a copper slag sample from Gardan Reg indicated that its "gold assay was very high, high enough to be commercially valuable."

The closest and most "obvious" sources from which residents of Harappa may have obtained gold, however, are the myriad rivers and streams that drain the mountain ranges north of the upper Indus Basin (Kenoyer and Miller 1999: 120). To this day, "gold-washers" work the placer deposits of the Indus and other rivers in the far north of Pakistan (Ahmad *et al.* 1975; Khan 1999; Tahirkheli 1960), the Soan (Gold) River and several of its tributaries on the Potwar Plateau (Heron and Crookshank 1954: 79), tributaries of the Jhelum river (Ahmad 1969: 25), the Beas River and other numerous other smaller streams in Himachal Pradesh (Director - Punjab Haryana and Himachal Pradesh Circle - Geological Survey of India 1971), the Sutlej drainage basin (Ruby 1998) and the Siwaliks at the base of the western Himalayas (Lal *et al.* 1985). Although occurrences there have been characterized as "meager" (Ahmad 1975: 176) and barely profitable for those working them in the modern era (Wadia 1975: 445), historical accounts from the Greek through the Mughal periods suggest that the mountainous regions and rivers of north of the Punjab were, in former times, major sources for gold (for discussions of the many literary references to gold from this region see Biwas 1996: 327-328; Nanda 1992; Peissel 1984; Ratnagar 2004: 156-157). I would even submit that a phenomenon not unlike a "gold rush" could have taken place in this area during the later prehistoric period.

Gold rushes of eras past (Green 1993; Morrell 1941) all played out in the same basic way. Rich, previously unexploited deposits were discovered and all of the easy-to-recover metal was quickly consumed. After the initial "rush," gold became progressively more difficult to extract and the sources were abandoned or worked on a greatly reduced scale. The first gold artifacts in northwestern South Asia appear during the latter half of the fourth millennium BC in the Punjab, at Harappa and at Jalilpur (Mughal 1972b: 119). From this time forward, the precious metal is a constant feature in the archaeological and historical records of that region (Nanda 1992). It is therefore entirely possible that sources north the Punjab have been *continuously* exploited for more than 5000 years. The amount of gold recovered in the modern era is, in all likelihood, a pale reflection of what may have existed at the time sources there initially were worked. Consider the mid-19th century AD gold rush of northern California in the western United States. A survey of that region today would likely provide little indication of the incredibly rich alluvial deposits that once existed there and which, in a mere two decades, were largely exhausted (Clamage 1998). I am not necessarily suggesting that the deposits north of the Punjab were similarly rich or that a "rush" of the same scale or intensity as California's took place in northwestern South Asia during the Harappan Period, only that we should not evaluate the potential of this region as a gold source based on the amount of metal that is being recovered there today.

Admittedly, no material evidence has ever been found in regions north of the Punjab that would indicate that gold was being exploited there during the prehistoric period, nor is it ever likely to be. Ancient gold-washers would, quite obviously, have had little or no archaeological impact and it is highly unlikely that camps or settlements associated with such activities would be persevered in a dynamic mountainous environment like the Himalayas. The notion of a Harappan Period "gold rush" in this region is entirely hypothetical. It is, however, a hypothesis that eventually can be *tested*. There is every reason to expect that it might be possible to differentiate alluvial gold derived from sources in northwestern South Asia from that originating in the Precambrian rocks of South India, the gold-rich copper ores of Rajasthan or Balochistan, or from sources elsewhere. Geochemical comparison of Harappan gold artifacts with geologic samples collected from these regions is certain to be an important and productive area of inquiry in the future.

"Ernestite"

"Ernestite" is the name given by Kenoyer and Vidale (1992) to an extremely fine-grained khaki-colored stone that is mottled with dark-brown to black patches and dendritic veins (Figure 4.4 H). It is a hard (Mohs hardness of at least 7), very tough (does not break or fracture easily) and fairly dense stone (SG ranging from ≈ 2.8 for the khaki-colored matrix to ≈ 3.2 for the brown-black portion). At Harappa and other Indus sites where it has been identified, such as Mohenjo-daro, Chanhu-daro and Dholavira, "Ernestite" was fashioned into small constricted cylindrical drills, which were used by beadmakers to perforate hard materials (namely microcrystalline silicates and vesuvianite-grossular). Using XRD and EMPA, Kenoyer and Vidale (1992) characterized it as an unknown variety of metamorphic rock composed of quartz, sillimanite-mullite and hematite-titanium oxide phases (ibid.: 506-507). Recently, however, I have conducted a series of follow-up analyses that instead suggest "Ernestite" is a type of *indurated tonstein flint* clay that has been deliberately heated to produce or enhance properties that made it a highly effective material for drilling hard stone beads. In Appendix 4.5, I provide full details on how I came to those conclusions and discuss the possible geologic sources from which Harappans may have acquired the original raw material.

The utilization of "Ernestite" at Harappa was limited in space and time. All but a handful of the roughly 75 drills, drill rough-outs and debris fragments found to date come from the conjoined area of mounds E-ET. Most of those that do not were found in Harappan period dump debris or surface contexts away from the site's main habitation areas. Thirty-eight of the 40 "Ernestite" artifacts recovered from secure contexts came from Period 3C levels while the remaining two were from Period 3B strata. Interestingly, these temporal and spatial patterns seem to closely mirror those for vesuvianite-grossular – a rock that can have a Mohs hardness greater than 7 depending on its grossular content. It is probably no coincidence that stone of that variety is mostly found *when* and *where* beadmakers were also using "Ernestite" because "Ernestite" was the only material available from which drills capable of perforating it could be made (this association is discussed further in Chapter 9). Diamond was not available at this time and the microcrystalline silicate drill bits that Harappans used for other types of stone would have would have been wholly ineffective (explained in Appendix 4.5) on vesuvianite-grossular as well as the long style of carnelian beads. "Ernestite" drills represented a major technological innovation.

Amazonite

The variety of the feldspar mineral *microcline* (potassium aluminum silicate) known as *amazonite* is easily recognized by its prominent cleavage face in combination with its characteristic white-green to blue-green appearance. Despite being one of the less abundant minerals at Harappa, examples have been recovered on each major habitation area at the site except Mound E and from every occupational phase except Period 3A. A selection of amazonite beads and manufacturing debris can be seen in Figure 4.4 I.

Amazonite, sometimes referred to in the literature as "green microcline," occurs in *pegmatites* (Deer *et al* 1992: 425-426). Pegmatites are zone of unusually coarse-grained igneous rocks that are important sources of rare elements and semi-precious minerals (including several in Harappa's assemblage). Early researchers speculated that amazonite artifacts from Mohenjo-daro may have come from a source in the Nilgiris Range of southern India (Pascoe 1931: 678; Mackay 1938: 500). However, this purported occurrence was long ago shown to probably not exist (Gordon 1935, 1936). Confirmed sources of gem-quality green microcline closer to the Indus region and Harappa include those found in the pegmatites of Pakistan's Northern Areas (Kazmi 1995b: 289). Perhaps the most likely source, however, lies in northern Gujarat. There, green microcline occurs in granite pegmatites southeast of Palanpur near the village of Derol (Foote 1898: 22) and amazonite pebbles originating from those rocks can be found in the bed of the adjacent Sabarmati River (ibid.: 29). On a loess terrace not far from this location, geologists R.B. Foote reported a prehistoric site where he recovered chert tools in association with amazonite fragments (Foote 1916: 142-143). Around 125 km southwest of this source area lays the Harappan site of Nagwada. Excavators there found chert drills and the abundant remains of amazonite beads in "different stages of manufacture" (Hegde *et al*. 1988: 58). Hundreds of amazonite debris fragments and beads in different stages of manufacture are present in the assemblage of excavated stone at Dholavira (*personal observations* 2007-2008).

"Ochre" minerals

Several dozen examples of "ochre" minerals have been excavated at Harappa. The most common one is *hematite* – iron oxide (Figure 4.4 J). Appendix 4.2 K is a representative XRD scan of this mineral. A related hydrated iron oxide – *goethite* has also been positively identified (Appendix 4.2 L). Ochres such as these have a long history of use as mineral pigments in

South Asia (O.P. Agrawal 1999). Harappans certainly employed them when decorating ceramics (Dales and Kenoyer 1986a: 64) if not for other purposes.

Ochre minerals have been recovered from every mound at Harappa and from every one its occupational phases. Geologic occurrences exist across the Greater Indus region. Large and varied deposits of ochre are found in Jammu (Indian Bureau of Mines 2001: 27-29), the northern Punjab (Bender 1995b: 269), Balochistan (Ahmad 1975: 129), Sindh (Ahmad 1993: 18), western Rajasthan (Geological Survey of India 2001b: 88) and Gujarat (Merh 1995: 173). Residents of Harappa, however, would only have needed to travel 120 to 150 km north to find ample supplies. Red, yellow and green colored oxides of iron are found at numerous locations in the Kirana Hills and are mined today for use in the local paint industry (Butt *et al*. 1993: 8; Shah 1973: 10-11).

Lead minerals

Over half of the 35 lead artifacts found at Harappa are in the form of raw, unadulterated lead ore. Ore fragments (Figure 4.4 K) composed of galena (lead sulfide), galena with stibnite (antimony sulfide), cerussite (lead carbonate) with anglesite (lead sulfate) and massicot (lead oxide) have been identified using XRD (Appendix 4.2 M, N, & O). A variety of lead objects, residues and slags make up the rest of this sub-assemblage. A small lead rod was found to be partially composed of *wulfenite* (lead molybdate) and graphite (for details on this artifact including its XRD scan see Figure 12.21 in Chapter 12). With the exception of a single galena fragment from Ravi Phase levels on Mound AB, all of the lead artifacts excavated from secure contexts date to periods 3B or 3C. In Chapter 12, I discuss potential lead sources and investigate the probable geologic provenience of these artifacts.

Serpentine

The term *serpentine* refers to a group of hydrous magnesium silicate minerals (lizardite, antigorite and chrysotile) that form due to hydrothermal alteration of ultramafic rocks such as peridotites (Deer *et al*. 1992: 344-352). These minerals have highly variable macroscopic characteristics. They may be opaque or translucent, come in colors ranging from white to green to black and can have either a uniform appearance or one with a mottled or winding (hence the name) pseudomorphic texture (ibid.). For many years, most green-colored translucent varieties of stone encountered at Harappa were believed to be serpentine. However, when all stones classified as such were examined in early 2003 using specific gravity (SG) testing, it was discovered that most were too dense to be serpentine and so they were reclassified as vesuvianite-grossular (serpentines have a SG of approximately 2.6 while vesuvianite-grossular ranges from ≈ 3.0 to 3.5). Only around thirty finished objects or fragments of stone from Harappa are now thought to be serpentine. A selection of these may be seen in Figure 4.4 L. Several of the fragments were examined using XRD and found to be composed of either *lizardite* or *clinochrysotile* (see Appendix 4.2 P and 4.2 Q for a representative scan). Also using XRD, Vidale and Bianchetti (1997) had previously identified a lizardite bead at Mohenjo-daro.

Serpentine artifacts have been found on every mound at Harappa and from secure stratagraphic contexts representing periods 2, 3A, 3B and 3C. Stone of this variety occurs at many locations around the Greater Indus region, especially in the ultramafic ophiolite sequences found along its northern and western margins (Asrarullah *et al*. 1979; Kazmi 1995b: 286). Bead and amulets composed of serpentine varieties that closely resemble those found at Harappa are made today at the shrine of Shah Biwal Noorani in the southern Las Bela district of southern Balochistan (*personal observation*). The craftsmen working there confirmed that those varieties come from occurrences in the nearby ultramafic rocks of the Las Bela ophiolite. Identical looking serpentine minerals are found closer to Harappa itself in ophiolite sequences located in the Zhob district of Balochistan, North Waziristan, the Dargai area of the NWFP and the Gilgit-Skardu region of the Pakistan's Northern Areas (Awan 1987; Kazmi 1995b: 286; *personal observations*). Serpentine occurrences in central Rajasthan (Sen Gupta 1937) should also be considered as potential sources.

MISCELLANEOUS ROCK AND MINERAL VARIETIES

Rock and mineral types for which ten or fewer examples have been recovered at Harappa are termed *miscellaneous* varieties (Figure 4.7). Although collectively these artifacts make up a mere 0.12% of the assemblage, they are as important as any of the more abundant materials in it because of the information they provide on the scope and diversity of Harappa's rock and mineral acquisition networks. The miscellaneous varieties are presented below in alphabetical order.

Almandine garnet

Almandine (iron aluminum silicate) is a dense (SG ≈ 4.3), dark red variety of garnet that occurs in thermally metamorphosed pelitic rocks (Deer *et al*. 1992: 31-46). A single battered fragment of an almandine garnet crystal (Figure 4.7 A) was found in Period 1 levels on the northern side of Mound AB. Another example came from disturbed sub-surface levels on Mound E. Using specific gravity testing, these artifacts were easily distinguished from similar looking but less dense (SG ≈ 3.6) pyrope garnet.

The garnets from Harappa might have come from any of several locations. Almandine is but one of the many varieties mined in garnet-rich Rajasthan today (Kanranth 2000: 200; Sethi 1966: 34-36). To the north of Harappa, gem quality almandine garnet is found in the Neelum Valley of Kashmir (Jan *et al*. 1995) and in various parts of the NWFP and Northern Areas of Pakistan (Kazmi 1995b: 289).

Almandine garnet is a hard stone (Mohs 7.25 to 7.5). Drilling this stone would have been impossible or at least very difficult with the tools Harappans possessed (although small beads could be made by "pecking" or chipping a hole through them). The Ravi Phase fragment could definitely not have been perforated using the chert and jasper (Mohs ≈ 7) tools available at that time. Even "ernestite" drills may have been largely ineffective. Blanche Barthélémy de Saizieu suggested (2003: 29) that hardness was the reason why garnet was infrequently used to make beads at the Neolithic site of Mehrgarh, in Balochistan. This may also account for why so little of this material is found at Harappa.

Calcite

Artifacts made of *calcite* (calcium carbonate) are rare at Harappa. The few calcite crystals (easily distinguished from naturally occurring pedogenic calcium carbonate nodules) that have been identified (Appendix 4.2 R) could have come from any of the geologic formations surrounding the Upper Indus Basin. In 1990 a small, complete stone ring (Figure 4.7 B) was found by one of the local workmen at Harappa while walking across the site. It appears to be composed of *travertine*, or onyx marble (a form of calcite) and looks remarkably like the ornamental stone that is quarried on a large scale today in the Chagai Hills of Balochistan (Ahmad 1975: 124-128).

Fluorite

A light aqua-green-colored stone fragment was found in Period 3C levels of Trench 11 on Mound E while a similar looking material within a matrix of milky white crystalline stone (Figure 4.7 C) was recovered in disturbed strata nearby. The XRD results (Appendix 4.2 S) indicated that both were examples of *fluorite* (calcium fluoride) – a mineral with a history of use both as a flux for lowering the melting

Figure 4.7 Miscellaneous rock and mineral varieties at Harappa.

A. Almandine garnet **B**. Calcite (*travertine*) **C**. Fluorite

D. Fossils **E**. Kaolinite claystone **F**. Mica

G. Nephrite **H**. Prehnite **I**. Sulfur **J**. Tourmaline **K**. Turquoise

point of metals (its name derives from the Latin word *fluo* – "to flow") and as an ornamental stone (Deer et a. 1992: 673; Rapp 2002: 114). A broken aqua green colored bead found on the site's surface by one of the workmen had a specific gravity of 3.1 – exactly that of fluorite.

Fluorite is an extremely variable mineral both in terms of its appearance and the types of geologic environments that it forms in (Deer et a. 1992: 672-675). The artifacts from Harappa might have come from any number of regions except, importantly, some of those closest to it. No occurrences have been reported from the Salt Range, Sulaiman Range or Kirana Hills regions. Fluorite can be found in areas farther north of Harappa such as Dir and Hazara in the NWFP (Ahmad 1969: 81, Kazmi 1995b: 289), Ladakh (Waza *et al.* 1977) and Himachal Pradesh (Rawat 1983). To the west-southwest of Harappa in Balochistan, there are "trivial showings" in the northern Zhob District (Kazmi and Jan 1997: 468) while a rich cluster of occurrences is found in the northern Koh-i-Maran Range in the Kalat District (Mohsin and Sarwar 1980). Far to the south, the Amba Dongar fluorite deposit of eastern Gujarat is the largest in the Subcontinent (Balasubramaniam and Vekaria 1980). Finally, occurrences of this mineral are reported in various districts along the length of the Aravalli Range of Rajasthan (Geological Survey of India 2001b: 61-63).

Fossils

Several fossils have been found at Harappa including two large disc-shaped foraminiferans known as *nummulites*. The nummulite on the right hand side of Figure 4.7 D was found in the Period 3C Harappan dump debris that associated with the cemetery area. The one on the left side was found in Period 4 levels on Mound AB. Fossils of this type can be found in Eocene formations of both the Sulaiman and Salt Ranges (Ashrafuddin and Farooqui 2002; *personal observations*).

Kaolinite claystone

A tiny reddish-colored bead (Figure 4.7 E) was discovered in a small pot buried within a Late Harappa Phase (Period 5) house floor on the north side of Mound AB. Non-destructive XRD and VP-SEM analyses (detailed in Appendix 4.6) found it to be primarily composed of *kaolinite* (aluminum silicate hydroxide) with a minor phase of hematite. The raw material is probably best described as a hematitic kaolinite claystone or clayrock. Such stone is not particularly uncommon and is often, though not exclusively, found in association with coal or iron deposits (Loughnan 1978). The rock from which the bead was made could have come from many different regions. In the Hazara District of the NWFP "hematitic claystone layers " have been reported (Klinger *et al* 1963: 101). Further south, claystone beds and clasts, some of which are red, are also present in the Warcha Formation of the Salt Range (Ghazi and Mountney 2009).

Mica

Small sheets of mica (Figure 4.7 F) have been found in Period 3C levels and surface deposits on Mound E, Period 3C levels beneath the Mughal Sarai south of Mound E and in the Period 3C dump debris associated with the cemetery area. These were possibly related to gold-smithing or may have been used for medicinal purposes (Kenoyer 2006 *personal communication*). X-ray diffraction analysis indicates (Appendix 4.2 T) that these artifacts are of the mica variety *muscovite* (potassium aluminum silicate hydroxide fluoride). This mineral occurs in a wide range of metamorphic environments but is most common in granite pegmatites (Deer *et al* 1992: 292-293). Muscovite bearing pegmatites are found west and north of Harappa in Himachal Pradesh (Director – Punjab, Haryana and Himachal Pradesh Circle – Geological Survey of India 1971: 32), Kashmir (Ahmad 1981: 23) and the Peshawar and Hazara Divisions of the NWFP (Bender 1995b: 269). Of the many mica deposits found throughout Rajasthan (Geological Survey of India 2001b: 86-87), those in the northern Aravallis (Geological Survey of India 1989b: 32) would have been most accessible to Harappan peoples living on the plains of the upper Indus Basin.

Nephrite jade

A semi-translucent, spinach-green colored truncated conical amulet (H88/182-14) with a high-polish (Figure 4.7 G) was recovered in a cemetery area debris layer above a burial pit dated to Period 3B. Non-destructive XRD and VP-SEM analysis (Appendix 4.7) revealed that this object is composed of *nephrite*. Nephrite is a metamorphic rock (a calcium magnesium iron silicate hydeoxide in the tremolite-actinolite series) that, along with the metamorphic mineral *jadeite* (sodium aluminium iron silicate), is, by widely accepted convention, one of the mineralogically genuine varieties of *jade* (Twilley 1992). The presence of nephrite jade at Harappa *could* mean that some form of long-distance trade existed with the well-known nephrite source area along the Karakash River near Khotan (Hetain) in the western Chinese province of Xinjiang (Tosi 1977). However, there are closer occurrences of this stone. Using XRD, Oxford University geologist B.C.M. Butler confirmed (Butler 1963a, 1963b) that cobbles he collected in the Teri Toi River of Kohat, NWFP were nephrite. One of the cobbles he described would seem to be visually and mineralogically identical to the Harappan amulet (see Appendix 4.7 for full details).

Prehnite

Fragments of *prehnite* – a pale green mineral with a vitreous luster (Figure 4.7 H), have been recovered from Period 3C levels on Mound ET and directly identified using XRD (Appendix 4.2 U). Prehnite (calcium aluminum silicate hydroxide) most commonly forms either as a secondary hydrothermal mineral within cavities in basaltic rocks or as a primary mineral in contact metamorphosed impure limestones (Deer *et al*. 1991: 386). Those occurrences found in the Deccan Traps are examples of the former mode of formation (Wise and Moller 1990). In the latter instance, it may be found in association with vesuvianite-grossular - as it is in the ophiolite sequence near Muslimbaugh (formerly Hindubaugh) in the Zhob District, Balochistan (Bilgrami and Howie 1960). Prehnite has also been reported in or near other South Asian ophiolite sequences including those of Las Bela (Vredenburg 1904) and Waziristan (Badshah *et al*. 1997).

Sulfur

A small bright yellow stone fragment (Figure 4.7 I) recovered from a disturbed context on Mound ET was identified using XRD as pure *sulfur* (Appendix 4.2 V). The nearest occurrences of this mineral to Harappa, although very minor in size, would have been in the Salt Range, beginning 225 km north of the site (*personal observations*). Substantially larger sulfur deposits are found in Balochistan at Sanni in the Kalat District and Koh-i-Sultan in the Chagai Hills (Ahmad 1963).

Tourmaline

A fragment of green *tourmaline* – identifiable by its hexagonal structure, vertically striated exterior and glassy fracture (Figure 4.7 J) – was found in disturbed strata within Trench 53, located between mounds AB and E. Minerals in the tourmaline group typically occur in granite pegmatites and can be found in colors ranging from opaque black to blue, green, red or clear (Deer *et al*. 1992: 130-137). Although tourmaline occurs widely across Rajasthan (Rajasthan Mineral Bulletin 1997a: 14), green varieties have not been reported. Gem-quality tourmalines of that color can be found at several localities in Pakistan's Northern Areas, as well as the Neelum Valley and Padar area of Kashmir (Jan *et al*. 1995; Kazmi and Jan 1997: 476; Mehta 1957: 62; Wadia 1975: 459).

Turquoise

Turquoise artifacts are found at Harappa in the form of beads and unworked fragments. One of the beads was recovered within a coffin burial dated to Period 3B and two fragments came from Period 3C levels. The remaining half dozen artifacts are from disturbed strata that were very likely derived from Period 3C or later levels. Despite being few in number, turquoise artifacts have been found on each major mound at the site.

Turquoise (hydrated copper aluminum phosphate) typically forms in arid environments as water peculates down through aluminum-rich rocks in the presence of copper (King 2002: 113). The color of this mineral can range from sky blue to apple green and it often patterned with patches or web-like seams of darker materials. There are several rocks and minerals, such as *azurite*, *lazulite*, *variscite*, *chrysocolla* and copper-stained chalcedony, which may resemble turquoise to the extent that they are mistaken for it or intentionally used as simulants for lapidary purposes (King 2002: 112; Pogue 1915: 131-133). Using XRD, two fragments from Harappa (Figure 4.7 K) were directly identified as true (mineralogically genuine) turquoise (see Appendix 4.2 W for a representative scan).

The existence of true turquoise deposits in South Asia has long been doubted (Bauer 1904: 397; Laufer 1913: 1-5). Occurrences reported in west-central Rajasthan near Ajmer and Ramgarh are now thought to "blue copper ore" or *azurite* – a hydrated copper carbonate (Iyer 1961: 72-73). More recently Jean-François Jarrige and Usman Hassan (1989: 160) reported the existence of old turquoise mining pits near Dalbandin in the Chagai Hills of western Balochistan. A sample of a blue-green turquoise-like material personally collected from that location by Jarrige was provided for this study and analyzed using XRD. The results of that scan (Appendix 4.2 X) indicate that the material is *not* turquoise but, rather, a stone composed mainly of quartz with a secondary phase(s) that suggests copper staining. The quartz content of this sample was further confirmed by placing a piece of it in hydrochloric acid. Turquoise will dissolve in acid (Pough 1989: 209) and the silica-rich Chagai sample did not. Chrysocolla (a hydrated copper silicate with a bright blue-green color) can become impregnated with silica and "may be confused with turquoise" (Poque 1915: 132). Jarrige's sample is, therefore, probably best characterized as "agatized" chrysocolla. E.W. Vredenburg encountered "turquoise blue" chrysocolla of this kind at multiple locations during his geologic survey of the western Balochistan region (Vredenburg 1901: 291-293). The Chagai Hills are certainly the type of geologic environment where turquoise *could* form and there are other mentions of the stone's occurrence there (e.g., Kazmi 1995b: 289). However, no conclusive studies have yet been published and so it is not considered as a potential source area at this time.

Turquoise then is the only rock and mineral variety in Harappa's assemblage other than lapis lazuli that, apparently, cannot be found in South Asia proper (considered here to be the area encompassed by modern India and Pakistan). This makes it an excellent indicator of the extent of long-distance trade networks external to the Greater Indus region. It is unlikely that Harappan turquoise trade networks extended all the way to deposits in Egypt (Hussein *et al*. 1995) or central China (Qi *et al*. 1998; Qian and Xu 1993) simply because there were much closer sources of that material. Perhaps the best known of these are the famous mines at Nishapur and Damghan in northeastern Iran (Khorassani and Abedini 1976; Manutchehr-Danai 1977). Maurizio Tosi (1974b), however, suggests that those sources may not have been exploited during the third millennium BC and instead points to deposits in Uzbekistan's Kyzyl Kum desert (Klyavin 1974) that were clearly being worked at that time as the likely source of the many turquoise artifacts found at Helmand Tradition sites of Shahr-i-Sokhta and Mundigak (Bulgarelli 1981; Jarrige and Tosi 1981). Material from the Kyzyl Kum deposits and perhaps other Central Asian sources like the one in the Akturpak region near the Ferghana Valley (Turesebekov and Meshchaninov 1983), could have entered Indus trade networks indirectly via Harappan interaction with the turquoise-using Helmand Tradition cultures. On the other hand, turquoise artifacts are found at the Harappan site of Shortughaï in northern Afghanistan (Francfort 1989: 145). At least some material from Central Asian sources may have entered Indus acquisition networks via that region. Lastly, the turquoise deposits of Tibet (Pogue 1915: 42) must be considered as potential sources. Occurrences in the western part of that region are the closest ones to Harappa and there is clear evidence that connections existed between cultures of the northern Subcontinent and those of the Tibetan Plateau and beyond during the third millennium BC (Fairservis 1975: 312-218; Stacul 1992, 1994; Xu 1991).

MATERIAL VARIETIES AT HARAPPA KNOWN ONLY FROM PREVIOUS EXCAVATIONS

Several materials were found during earlier excavations at Harappa that have not been encountered again in the over two decades of work there by the HARP. For this reason, they were not considered when calculating the proportions of the different varieties making up the site's rock and mineral assemblage. Relatively few examples of these materials are recorded in Vats' 1940 site report and so, more than likely, they would have fallen into the miscellaneous category. It is, nevertheless, important to discuss them here in order to fully illustrate the range of rocks and minerals in use at Harappa and to thoroughly assess the extent and possible directions of acquisition routes.

Silver

No artifacts made entirely of silver have, as of yet, been recovered during HARP operations, although gold sheeting wrapped around what may be a silver wire has been found as well as a small lump in which gold and silver have been cold hammered together. A small number of artifacts from mounds AB and F made entirely of silver (a vase, a broach, a bangle, two bosses and various beads) are recorded in Vats' 1940 excavation report. The apparent scarceness of this precious metal at Harappa, rather than being indicative of its limited of use there, may largely be due to factors relating to its preservation (or rather lack of) in the saline, moisture-laden soil of the site. Silver, in contrast to gold, is oxidizable and much more water-soluble (Guilbert and Park 1986: 744). Under certain burial conditions it is subject to "complete disintegration through severe internal corrosion and embrittlement" (Drayman-Weisser 1992: 192). Thus, many of the objects made of this material that escaped recycling four millennia ago at Harappa may have since degraded to the point that little or no trace has been left behind (especially small ornaments and tiny fragments). Still, we have been able to glean from the discovery of jewelry hoards and individual finds at numerous other settlements, both large and small, across the Greater Indus region that silver was an important and widely traded metal during the Harappan Period (for details on these see Ratnagar 2004: 197 or Lahiri 1992). In Chapter 12, I present the results of compositional and geologic provenience studies of silver artifacts from several of those other sites. Here, I make a few remarks regarding how Harappans may have acquired this metal and from where.

Silver in its native state is quite rare, much more so than native gold (Dana 1957: 404). For this reason, it is thought that the majority of this metal used throughout history was won by the *cupellation* (refinement through the oxidation of base metals) of *argentiferous* (silver-rich) lead ores (Rapp 2002: 147). A number of scholars have suggested that Harappan silver probably was derived in that way (Asthana 1993: 276; Biwas 1996: 329; Mackay 1931c: 524; Ratnagar 2004: 193; Sana Ullah in Mackay 1938: 599). A lead ore body may be considered viably argentiferous if it contains more than ten parts per million (10 ppm) silver (Craddock 1995: 211). Such deposits are found at multiple locations across northwestern South Asia (I discuss these, along with the other lead deposits of the Greater Indus region, in Chapter 12). In addition, small amounts of lead were detected in analyses of silver artifacts from Mohenjo-daro (Hamid, Sana Ullah in Mackay 1938: 478, 599) and Lothal (Lal 1985: 656), which *might* indicate that the metal used to make those objects was derived from a lead ore rather than native silver.

It is worth pointing out that ores such as chalcopyrite and chalcocite can also be argentiferous (Craddock 1995: 232; Dana 1941: 402; Gregg 1934) and, therefore, the possibility exists that at least some of the silver found at Indus Civilization sites may have been a byproduct of copper production. In fact, in the analyses of silver artifacts from Mohenjo-daro and Lothal cited above, copper was detected in much greater amounts (from 2.67% up to 7.87%) than was lead (from 0.42% to 1.64%). Copper (and for that matter lead) could have been deliberately added during the manufacture of those objects (Bhardwaj 1989: 327), but this is by no means certain. What is certain is that Harappans were heavy consumers of copper and that silver is currently being recovered from argentiferous copper deposits in two regions that may have been exploited in the late-prehistoric era – the Khetri copper belt of northern Rajasthan (Rao *et al*. 1997) and the Saindak copper prospect of western Balochistan (Mining Magazine 2001; Wolf 1974).

Arsenical minerals: Löllingite and Orpiment

Two arsenical minerals were recovered from Harappan Period levels on Mound F during excavations in the 1920s. A "black lump" found in Vats' Trench I was identified by Sana Ullah (in Vats 1940: 90) as *löllingite* (iron arsenide). Specimens of this material were also recovered at Mohenjo-daro (Pascoe 1931: 684-685, 690). Löllingite is a relatively uncommon mineral that can form both in sulphide deposits and pegmatites. Occurrences of the latter type are reported in association with gem-quality tourmalines in the Stak Valley of Pakistan's Northern Areas (Laurs *et al*. 1998) and in the gold-bearing Dhawar schists of the Gulbarga District, Karnataka (Mahadevan and Krishna Murthy 1945). In the Banswara District of southeast Rajasthan, native gold occurs with löllingite and arsenopyrite at Bhukia (Golani *et al*. 1999).

In Vats' Trench V, a small lump of *orpiment*, or arsenic sulphide, was recovered (Vats 1940: 468). This substance may have been used to alloy copper (although Kenoyer and Miller 1999 consider this unlikely), as a yellow pigment (O.P. Agrawal 1999: 191) or even for medicinal purposes (Treleaven *et al*. 1993; Watt 1885: 321). Orpiment, like löllingite, is not a common mineral. In Pakistan, it is mined in Chitral and small amounts are found at a few other locations in the north of the country (Ahmad 1969: 4-5; Shams 1995b: 255). "Minor occurrences" and "scattered fragments" are reported in the Zanskar and Kumaon regions of the Himalayas (Chatterjee 1963a: 12; Krishnaswamy 1979: 55).

Fuller's Earth

During the 1924-25 excavation season at Harappa, a wide (≈ 3.5 m) but shallow (≈ 55 cm) depression was encountered among a group of houses in the central part of Mound AB (Vats 1940: 154). Lining the depression was a "filmy coating of bluish green earth with a soft, soapy feel," which was later identified by Sana Ullah (ibid.) as *Fuller's Earth* or, as it is known in this part of South Asia, *Multani Mitti* (Multan Earth). Fuller's Earth is a type of highly absorbent calcium montmorillonite clay that has been used throughout history as a substance for cleaning textiles (Robertson 1986). The designation "Fuller" refers not to a person but to an occupation – one who scours, or *fulls*, cloth to make it clean (Aronson 1996). Evidence that suggests some sort of washing activity may have taken place at the location at Harappa where this soapy material was found. The depression, or "reservoir" as it is noted on the trench plan (Vats 1940: Plate XXXII), which the Fuller's Earth was lining is situated in an area, perhaps a courtyard, where water was clearly being used and controlled – there are brick-on-edge platforms nearby, a water chute and several drains including a long one that would have carried waste water away from the area.

Sana Ullah inferred "that this earth was imported" (in Vats 1940: 154) and he was certainly correct as there would have been no local sources for this variety of clay. The most extensive deposits of Fuller's Earth in northwestern South Asia occur in Sindh, especially in the Lakhi Range and the Rohri Hills area between Sukkur and Kot Diji (Ahmad 1969: 67; Shah 1977: 115). Numerous occurrences may also be found throughout the west and northwestern portions of Rajasthan (Department of Mines and Geology 1989: 81-82; Pareek 1984: 71). The deposits nearest to Harappa, however, are found just over 200 km directly west of the site in the Rakhi Nala and Taunsa areas of the Sulaiman Range piedmont (Hassan *et al.* 1995: 31-32; Shah 1977: 115; Yusaf *et al.* 1989).

SPATIAL AND TEMPORAL ASPECTS OF HARAPPA'S ROCK AND MINERAL ASSEMBLAGE

Now that Harappa's rock and mineral assemblage has been presented in all of its diversity, it is possible to take a step back and examine it on a broad-scale, as a single entity, composed of many different and potentially variable "elements." These "elements" are the major, minor and miscellaneous rock and mineral varieties that have been defined and described in this chapter. In this section, I am mainly concerned with which of them are present or absent in a particular chronological phase and/or on one of the major habitation areas at the site. Much more detailed examinations of select varieties take place in the eight chapters that follow this one. The purpose here is to determine if the suite of rocks and minerals acquired and used by Harappans, *as a whole*, varied from period to period and from mound to mound. If it did, then how does that inform the three lines of inquiry that were outlined in Chapter 1? Before addressing those questions, however, it is necessary to consider the following issue: To what degree is any evident variation in the composition of the rock and mineral assemblage a reflection of the actual behaviors of Harappans living in different periods and/or parts of the site, as opposed to being due to other factors, such as the physical constraints of the site and the research strategies of the excavators? In order to evaluate this, it had to be taken into account how the assemblage, as a set of deliberately recovered archaeological remains, was distributed across space and time at Harappa. The first task was to determine the spatial and temporal contexts of the artifacts making up Harappa's rock and mineral assemblage.

Contextualizing the rock and mineral assemblage

In order to determine the spatial and temporal contexts of the artifacts making up Harappa's rock and mineral assemblage, a list of every excavation/survey unit (known as a "lot") that contained one or more stone or metal objects was first compiled using the tabulation database. Excavation field books and stratigraphic section drawings were then consulted. Those lots associated with stratigraphic contexts that were not secure (surface, sub-surface rubble, the fill inside of brick-robber trenches, root holes, animal burrows, etc.) were flagged. The remaining ones were synchronized with unpublished lists of lot chronological associations already worked out by Drs. J. Mark Kenoyer and Richard Meadow for certain phases and areas of the site. Using the field books and section drawings, Dr. Kenoyer and I went then through the entire list again, lot by lot, to confirm associations. The stratigraphy of Harappa is highly complex and contextual data in the tables below should be considered provisional until a final version is published by the HARP directors.

The spatial and temporal distribution of the rock and mineral assemblage

The physical locations where rock and mineral artifacts are found at Harappa reflect the behaviors of its prehistoric inhabitants as well as various other site formation processes (some cultural, some not) that have acted upon them. The way in which the assemblage that is available for study is spatially and temporally distributed, however, is a function of both the physical aspects of the site as well as the strategies of the researchers who recovered the artifacts. For

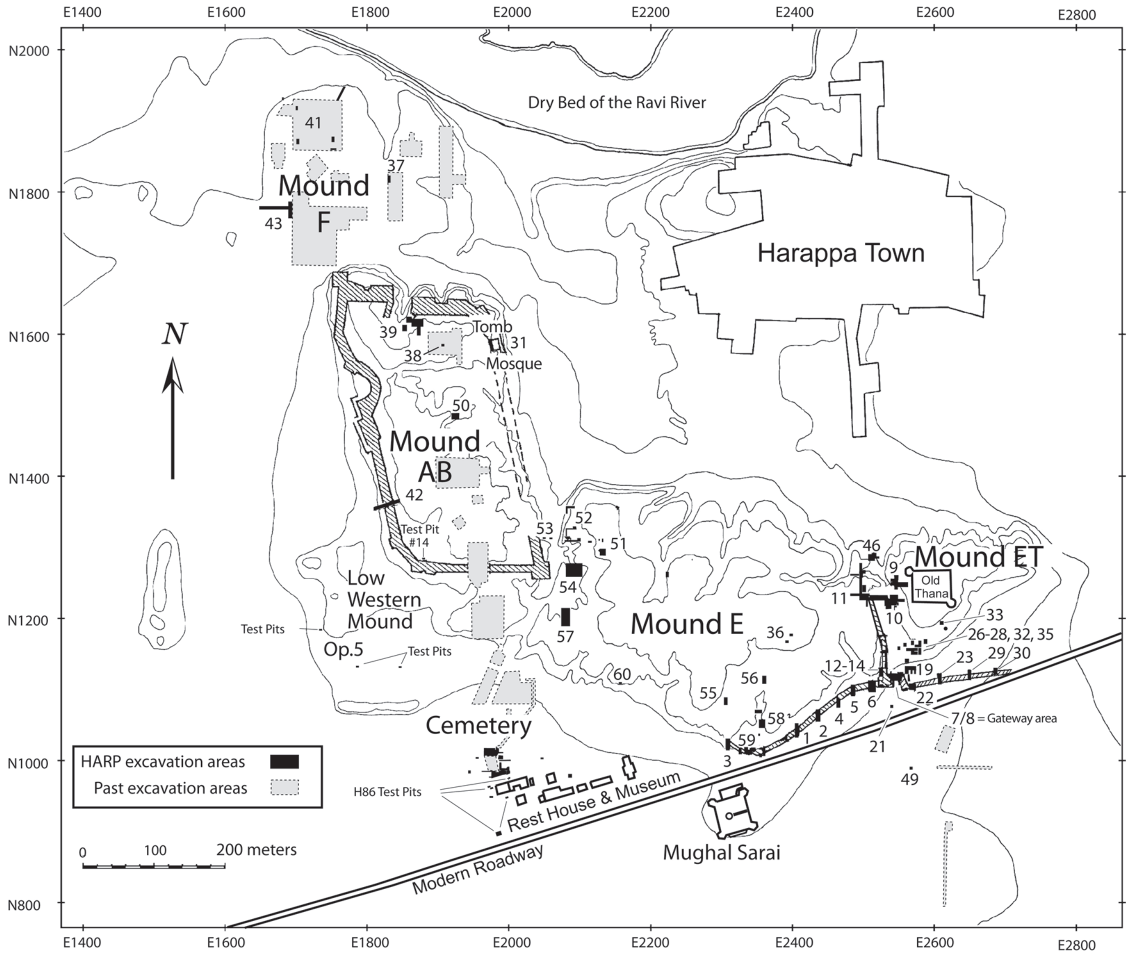


Figure 4.8 Harappa site plan with numbered trenches and excavation areas where rock or mineral artifacts have been recovered.

various reasons, some time periods and areas at Harappa are better represented in the assemblage than others. It is vitally important to be mindful of this when comparing sub-assemblages from different parts of the site and from different phases.

On the preceding page is the site plan of Harappa (Figure 4.8). Marked in black and labeled by trench, operation (Op.) or test pit (TP) number are the HARP excavation areas in which rock and mineral artifacts have been recovered. This basically includes all but a handful of the trenches (mostly small test pits) that have been placed at the site by the HARP. The areas of Harappa excavated by past researchers are marked with gray shapes. Figure 4.9 is a table showing how the rock and mineral assemblage recovered during HARP operations is distributed among the major areas of the site. Since the project commenced in 1986, much of the research emphasis has focused on those parts of Harappa that had not been examined during previous excavation projects – namely, mounds E and ET. Nearly every season has seen large-scale excavations conducted in those areas. Although test pits, small trenches and surveys were made in all parts of the site during the early years of the project, it was not until the mid-1990s that large-scale excavations began on Mound AB and not until the later-1990s that they started on Mound F. As a consequence, most of the rock and mineral artifacts recovered over the past two decades – fully two-thirds of the site's entire assemblage, comes from the conjoined area of mounds E and ET. Mounds AB and F together comprise roughly half of Harappa's main habitation area but are represented by only around one-quarter of the total assemblage.

Figure 4.9 Distribution of Harappa's rock and mineral artifact assemblage among the major areas of the site (based on all 56,350 artifacts).

location	*percentage*
Mound AB	19.54%
Mound E	40.14%
Mound ET	26.51%
Mound F	6.73%
Mughal Sarai	0.31%
Other* (cemetery, dumps, misc. finds, off-mound survey)	6.76%

Figure 4.10 Distribution of the rock and mineral assemblage through each chronological phase and by excavation areas. Percentages based upon number of artifacts from secure contexts (total n = 32,365) and number of excavation lots containing stone artifacts (total n = 3024). Excavation areas list by Trench number or abbreviation (C = Cemetery, S = Sarai, TP = test pit).

	by artifact	*by lot*	*Trench / excavation area*
Period 1	11.59%	5.39%	39
Period 2	7.95%	9.33%	1, 2, 11, 39, 42, 52, 58
Period 3A	6.10%	4.66%	1, 2, 10, 11, 21, 39, 42, 52, 54, 58, 59, C
Period 3B	10.88%	19.84%	1, 9, 10, 11, 21, 22, 37, 39, 42, 49, 52, 54, 56, 57, 58, C, TP-14
Period 3C	62.81%	59.95%	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 19, 21, 22, 23, 27, 28, 31, 32, 33, 35, 36, 37, 39, 41, 42, 43, 46, 50, 51, 52, 54, 55, 56, 58, 59, 60, C, S, TP-H86, TP-Op.5
Period 4	0.17%	0.40%	38, 43
Period 5	0.49%	0.43%	38

Figure 4.10 is a table showing how Harappa's rock and mineral assemblage is distributed among site's the periods and sub-periods. Distribution was calculated in two different ways: 1) Of the over 56,000 artifacts making up the rock and mineral assemblage, exactly 32,365 are from chronologically secure contexts. The percentages in the second column of the figure were calculated based on the total number of stone artifacts from secure contexts that are found in each period. 2) Of the approximately 10,000 excavation

Figure 4.11 Temporal and spatial distribution of Harappa's rock and mineral assemblage. Percentages calculated by the number of artifacts recovered from secure contexts in walled mounds only (cemetery/off-mound artifacts excluded).

	Period 1	*Period 2*	*Period 3A*	*Period 3B*	*Period 3C*	*Period 4*	*Period 5*
Mound AB	100%	84.06%	54.30%	6.20%	5.24%	96.36%	100%
Mound E	not excavated	12.52%	43.02%	53.89%	39.02%	not excavated	not excavated
Mound ET	not present	3.42%	2.68%	35.54%	40.36%	not excavated	not excavated
Mound F	not present	not present	not present	4.36%	15.38%	3.64%	not excavated

or survey units (lots) that have been assigned to date, around 4000 contained at least one stone or metal artifact. About three-quarters (n = 3024) of those lots represent chronologically secure strata. The percentages in the third column of the figure were calculated based upon the number of individual lots containing stone within each period.

Both methods of calculation result in overall similar distribution patterns. It is at once evident that stone artifacts belonging to Period 3C dominate the dateable assemblage (comprising around 60% of the total). This is not at all surprising as most of the Harappa's surface area consists of strata belonging to that sub-period and therefore nearly every excavation trench placed at the site encountered those levels. Stone from earlier periods was recovered in only a limited number of trenches. The fourth column of Figure 4.10, which shows the numbered trenches and/or other excavation areas that are associated with each chronological phase, quite clearly illustrates phenomenon. The considerably smaller percentages for the others periods is due to either their comparatively limited exposure (periods prior to 3C) or lack of preservation (periods after 3C). It may seem counterintuitive that the Period 3A assemblage is smaller than the even more deeply buried periods 1 and 2. However, this is due to the fact that most (or all in the case of Period 1) of the stone artifacts representing the initial two chronological phases at Harappa come from the large-scale exposures of Trench 39, which was placed at a point on the northern edge of Mound AB where the overburden of later levels was minimal. Substantially fewer Period 3 artifacts were recovered in that particular large trench than would normally be expected when exposing an area of Early Harappan levels of that size. Although Period 3A levels were reached in many more trenches, the areas actually exposed in each were very small.

Figure 4.11 details the temporal and spatial distribution of the rock and mineral assemblage among the main mounds at Harappa. Because one of the aims of this study is to compare acquisition and use patterns between parts of the site that may have been controlled by different social/political groups, the roughly seven percent of the assemblage that comes from cemetery and off-mound contexts, which cannot realistically be associated with one or another group, was excluded from the calculations for this particular table. With the focus on just the four main walled areas, the equities and, mostly, disparities in how the assemblage is distributed among them during the various periods become quite clear. Although there is evidence for a Ravi Phase occupation in the area of what is the northwest corner of Mound E, all of the stone representing Period 1 presently comes from Mound AB. Similarly, evidence for a Late Harappan Phase occupation exists over large parts of the site but the only stone from secure Period 5 levels comes from a small area on Mound AB. Period 3A has the most equitable distribution of rock and mineral artifacts between the two largest habitation areas at Harappa (54% for AB vs. 43% for E) but, aside from Period 4/5, the smallest sized sub-assemblage of any phase (refer back to Figure 4.10). The largest rock and mineral sub-assemblage dates to Period 3C, but nearly 80% of it comes from the conjoined area of mounds E-ET. Artifacts from those mounds comprise nearly 90% of the sub-assemblage for Period 3B.

It is worth acknowledging that sub-assemblages recovered from different phases and/or mounds at Harappa are not necessarily equally representative samples of the contexts to which they belong. In order to begin to get a truly accurate picture of how representative they may or may not be in relation to each other, it would be necessary to know the total volume of the strata comprising each period (both for the site and for each mound) and compare that to the volume of excavated strata for each period. Calculations of this type have not yet been completed due to the complexity of Harappa's stratigraphy. In spite of that, informed comparisons between sub-assemblages can still be made as long as proper consideration is given to differences among the contexts under examination. For example, nearly 12% of the 32,365 stone or metal artifacts from secure contexts were recovered in a single trench that reached Ravi Phase levels, while roughly 60% of them came from 40 excavation areas that exposed Period 3C contexts (refer back to Figure 4.10). Judging from the temporal distribution pattern alone it might appear that the sub-assemblage for Period 1 at Harappa is not as representative of the Ravi Phase as the one for Period 3C is of that phase. However, the size disparity between these two chronological sub-assemblages is mitigated somewhat when it is recognized that the Ravi Phase occupation (estimated is have been at most 10 ha in area – Kenoyer and Meadow 2000: 56) was much smaller than that of Harappa Phase 3C (estimated to have been 150+ ha – Meadow and Kenoyer 2001: 26). As sets of artifacts belonging to different periods and areas are compared in the following section and throughout this book, every effort is made to similarly consider potential assemblage distribution biases in light of differences in the nature and extent of the temporal and spatial contexts under examination.

Spatial and temporal variations in the rock and mineral assemblage

Having shown how Harappa's rock and mineral assemblage is distributed across the site, potential spatial and/or temporal variation of the "elements" that make it up can be properly examined and evaluated. In Figure 4.12, the major, minor and miscellaneous rock and mineral varieties at Harappa are cross-listed with the contexts in which they occur. Those present in a particular context are identified in the columns using the one or two letter code that signifies the mound or other part of the site where they were recovered. On the bottom row on the figure the total number of varieties present at Harappa in each phase is noted in bold print while the totals from each mound are in parentheses.

At first glance it would appear that, from Period 1 through Period 3C, there is a general trend toward greater diversity in terms of the varieties of rocks and minerals used by Harappans. Fourteen varieties have been recovered in both the Ravi and Kot Diji phases (although not entirely the same ones). Then, after a slight drop in Period 3A, they increase to 19 varieties in Period 3B and by Period 3C at least 22 were being used. The steep drop to 11 in Late Harappa (Period 4/5) levels could be taken as evidence of a dramatic reduction of acquisition networks during that period.

Figure 4.12 Distribution of rock and mineral varieties by period and by mound or other* areas
*(C = Cemetery, S = Sarai)

Variety ↓ / *Context* →	*1*	*2*	*3A*	*3B*	*3C*	*4/5*	*surface / disturbed*
1. Steatite	AB	AB, E, ET	AB, E, ET, C	AB, E, ET, F, C	AB, E, ET, F, C, S	AB, F	AB, E, ET, F, C, S
2. Chert	AB	AB, E, ET	AB, E, ET	AB, E, ET, F, C	AB, E, ET, F, C, S	AB	AB, E, ET, F, C, S
3. Agate-Jasper	AB	AB, E, ET	AB, E, ET, C	AB, E, ET, F, C	AB, E, ET, F, C, S	AB	AB, E, ET, F, C, S
4. Copper	AB	AB, E, ET	AB, E	AB, E, ET, F	AB, E, ET, F, C, S	AB	AB, E, ET, F, S
5. Siliclastic rocks	AB	AB, E	AB, E	AB, E, ET, F, C	AB, E, ET, F, C, S	AB	AB, E, ET, F, C, S
6. Vesuvianite-grossular	AB	x	x	E, ET	AB, E, ET, F, C, S	AB	AB, E, ET, F
7. Igneous-metamorphic	AB	AB, E	AB, E, C	AB, E, ET, F, C	AB, E, ET, F, C, S	AB	AB, E, ET, F, C, S
8. Gypsum	AB	AB	AB, E, ET	AB, E, ET, C	AB, E, ET, F, C, S	x	AB, E, ET, F, S
9. Limestone	x	AB	x	E, ET	AB, E, ET, F, C, S	x	AB, E, ET, F
10. Lapis lazuli	AB	AB, E	AB, E	E, ET, C	AB, E, ET, F, C	AB	AB, E, ET, F
11. Crystalline quartz	x	AB	AB, E	E, ET, F	AB, E, ET, F, C	x	AB, E, ET, F, S
12. Gold	AB	AB, E	AB, E	E, ET, C	E, ET, F, C	x	AB, E, ET, F, C
13. "Ernestite"	x	x	x	ET	E, ET, F, C	x	E, ET
14. Amazonite	AB	AB	x	F, C	AB, ET, F	AB	AB, ET
15. Ochre Minerals	AB	AB, E	E	E	E, ET, F	AB	AB, E, ET
16. Lead	AB	x	x	C	E, ET, F	x	E, ET, F
17. Serpentine	x	x AB	E	AB, E	E, ET, F, C	x	AB, E, ET
18. Almandine garnet	AB	x	x	x	x	x	E
19. Calcite	x	x	x	x	x	x	?
20. Fluorite	x	x	x	x	E	x	E, ?
21. Fossil foramina	x	x	x	x	C	AB	x
22. Kaolinite	x	x	x	x	x	AB	x
23. Mica	x	x	x	x	E, C, S	x	x
24. Nephrite	x	x	x	C	x	x	x
25. Prehnite	x	x	x	x	ET	x	x
26. Sulfur	x	x	x	x	x	x	ET
27. Tourmaline	x	x	x	x	x	x	(AB-E)
28. Turquoise	x	x	x	C	ET, F	x	AB, E
total varieties present	14	14 – AB(14) E(9) ET(4)	12 – AB(10) E(12) ET(4)	19 – AB(8) E(14) ET(13) F(8) C(12)	22 – AB(12) E(18) ET(19) F(17) S(10)	12	23 – AB(17) E(20) ET(18) F(13)

It would also appear that there were synchronic differences in the number of varieties to which residents living on different mounds at Harappa used or had access. Except for Period 2, in all chronological phases for which stone has been recovered in multiple areas of the site there are a greater number of varieties found on conjoined mounds E and ET.

The patterns evident in Figure 4.12 cannot simply be taken at face value, however. When they are considered in relation to figures 4.9 through 4.11, it is clear that there is a direct correlation between the spatial and temporal distribution of the assemblage and its diversity in different periods and areas. Quite simply, those mounds and phases from which the largest sub-assemblages were recovered are also the ones that exhibit the greatest diversity of rock and mineral varieties. Those with the smallest-sized sub-assemblages are the least diverse. So although it might be tempting say that Harappans dwelling on mounds E-ET during Period 3C had access to and were utilizing a much wider range of rocks and minerals than their counterparts in other periods and areas of the site, I do not think that such a statement is tenable. Much of the apparent diversity in that particular period/area is due to the presence of many miscellaneous and lesser abundant minor varieties that are absent in other contexts. However, there was a much greater probability that those rarer materials would be recovered in Period 3C levels on E-ET simply because 60% of the dateable assemblage belongs to that period and 80% of that comes from those mounds. When a similar amount of strata is eventually unearthed for other contexts it is quite probable that many of the scarcer varieties also will be encountered in them. Of course, some of those miscellaneous rocks and minerals actually may have been used for the first time by Harappans dwelling on Mounds E-ET during Period 3C. However, because of the small number of artifacts (all but one of the miscellaneous varieties is represented by three or fewer examples) and the clear bias in the assemblage distribution toward that particular area/period, such an interpretation would be rather tenuous indeed. Convincing evidence for *genuine* variations (i.e., those stemming from the behaviors of Harappans) between sub-assemblages from different spatial and temporal contexts is better sought by examining varieties for which a much greater number of examples have been recovered.

The five major rock and mineral varieties at Harappa are present in all of the site's chronological phases. The few spatial contexts where some have not been found (such as the absence of siliciclastic rock artifacts on Mound ET during periods 2 and 3A) are, not surprisingly, those areas where limited exposures have produced extremely small sub-assemblages. Examples almost certainly will be found in those areas when more excavation takes place and, therefore, I believe it can be safely stated that Harappans of all periods and parts of the site probably had access to each of these material varieties. Possible temporal and spatial variations in the use of certain types of each of the major rock and minerals varieties are explored in upcoming chapters.

Many of the minor rock and mineral varieties display clear spatial and temporal variations, some of which are likely genuine, others of which are probably not. The uneven distribution through the assemblage of certain less abundant minor varieties, such as lead and serpentine, likely relates to the same issue of low recovery probability that affects the miscellaneous varieties. Similarly, the absence of nine of the twelve minor varieties from Period 3B contexts on Mound AB is almost certainly a result of sample size (only around 6% of the dateable assemblage from that period belongs from Mound AB – refer to Figure 4.15). Materials like gold, lapis lazuli, gypsum (alabaster), igneous-metamorphic rocks and ochre minerals each seem to have been used in all chronological phases and in most areas of the site. On the other hand, the "Ernestite," vesuvianite-grossular and limestone sub-assemblages are concentrated in

Figure 4.13 Map showing the nearest sources of the major, minor and miscellaneous rock and mineral varieties found at Harappa (numbers and symbols correspond to varieties listed in column one of Figure 4.12).

certain contexts in ways (previously noted in this chapter) and, importantly, *in amounts* that suggest the use of these materials was genuinely variable over time and space at Harappa. Further details relating to the use patterns of these three varieties of stone are featured in the upcoming chapters devoted to them.

INTERPRETATION OF THE ROCK AND MINERAL ASSEMBLAGE'S COMPOSITION AND VARIABILITY

In this final section, I consider the composition and variability of Harappa's rock and assemblage as a whole in relation to the three lines of inquiry outlined in Chapter 1.

Who in the ancient Greater Indus region or beyond were the residents of Harappa interacting with when they acquired rock and mineral resources? What was the extent of those inter-regional relationships/acquisition networks? It was not the purpose of the chapter to make the provenience determinations necessary to link stone and metal artifacts from Harappa to their probable geologic sources. However, much can be still be learned about the possible extent and direction of the acquisition networks in which the site's residents participated by examining where potential raw material sources occur in relation to the site and to each other. Also, the geologic occurrences of at least one material variety – lapis lazuli, are sufficiently restricted enough that it is possible to confidently propose the existence of a specific source-to-site network during the periods in which it is present.

For her study of resource access and inter-regional interaction in the ancient Indus region, Marcia Fentress created a map of northwestern South Asia (Fentress 1976: Map 7) that is useful for conceptualizing distance/direction relationships and possible travel times between major Indus cities on the alluvial plains and the surrounding highland regions where rock and mineral resources occur. On it she placed concentric circles extending outward from Harappa and Mohenjo-daro at intervals of 100, 300 and 500 kilometers. Using the same distance intervals centered just on Harappa, I have created a modified version of that map (Figure 4.13) on which numbers and symbols (corresponding to the varieties listed in the first column of Figure 4.12) are placed that identify the *nearest* locations where each of the rock and mineral varieties (and a few important macroscopically distinct sub-varieties or *types*) recovered at the site can be found. Half of them occur within a 300 km radius (around a 10-day walk in Fentress's estimation) and most of the rest are located within 500 km (≈ 20-day walk). Only for lapis lazuli, turquoise and the carnelian variety of agate would it have been necessary to travel farther than that. Most significantly, all of the nearest sources are located within a broad, semi-circular zone that begins directly west of Harappa in the Sulaiman Range and extends through regions to the north and northeast of the site. It should be stressed that the locations noted are not necessarily the sources that Harappans used (not all are the most accessible or the ones that contain the best quality material). They are the closest, however, and plotting them on the map in this way clearly illustrates how they are concentrated in the highland areas west and north of the upper Indus Basin. In terms of simple site-to-potential-source distance, Harappa is most decidedly oriented in these directions. It is, therefore, quite reasonable to expect that many of the rock and mineral varieties recovered at the site may have been originally derived from sources within this zone. I believe one variety – lapis lazuli, almost certainly was.

In Appendix 4.4, I argue that the Badakhshan area deposits of northern Afghanistan were the sole sources of lapis lazuli for consumers in ancient South Asia. Some degree of interaction between that source region and the Punjab from the fourth through second millenniums BC second is, therefore, indicated by the presence of artifacts made of this stone in every one of the Harappa's chronological phases and sub-phases. Whether or not that interaction was direct or indirect and the route(s) along which it occurred is unclear. During the Early Harappan periods (ca. fourth and early third millenniums BC), residents of Harappa may have acquired lapis lazuli indirectly through long-distance trade with Helmand Tradition peoples, such as those at Shahr-i-Sokhta, who clearly seem to have been involved in its processing and transportation at that time (Tosi 1974a). The presence of Indus Civilization peoples at Shortughaï (Francfort 1989) in northern Afghanistan might well indicate that Harappans had direct access to that material during Period 3 (although the site was actually several hundred kilometers downstream and a few thousand meters below the actual deposits). Regardless of how it was acquired or how much was recovered, lapis lazuli is present throughout the sequence at Harappa and, because it was almost certainly from a source to the north of the site, it opens the possibility that many other rock and mineral resources were also being obtained from sources in that general direction.

How did the patterns of inter-regional interaction/ acquisition exhibited by residents of Harappa change over time? Once again, it was not the intent here to make the provenience determinations necessary to diachronically examine patterns of interaction. Comparing assemblage compositions from period to period, however, gives the impression that, in general, there was not a great deal of change over time in the basic suite of materials used at Harappa. Dilip Chakrabarti's assertion (1998: 51) that there was "hardly any major change" in basic suite of raw material types used by Early Harappan and Harappan peoples basically holds true – at least at Harappa itself. The abundant varieties are present throughout the site's entire sequence while less abundant ones likely vary because of low probability of recovery. Exceptions may be limestone, "Ernestite" and vesuvianite-grossular, the use of which seems to have been most intense during periods 3B and 3C. The reasons for this have been or will be discussed but, suffice to say, I do not think they have to do with newfound access to the regions where those materials occur. Rather, their use likely relates to changing cultural preferences (discussed in Chapter 11 for limestone) or technological innovation (the development of "Ernesite" drills).

Did synchronic variations in patterns of rock and mineral resource acquisition and use exist between groups of people living in different habitation areas at Harappa? It appears that, by and large, people living in all parts of Harappa had access to the same varieties of rocks and minerals. This is not to say that they were acquiring them from the same sources or that they were using them in the same way; only that copper, steatite, chert, alabaster, etc, etc, are pretty much found in all parts of the site. Most instances where a particular material is absent from a mound is likely due to low probability of recovery for less abundant varieties in areas that have not been as extensively excavated. Vesuvianite-grossular and "Ernestite," which are concentrated on mounds E-ET, again seem to be exceptions. This may indicate that access to these particular materials was controlled by the residents of those areas (this issue is returned to again in chapters 9 and 13).

CHAPTER CONCLUSION

Harappa's large and diverse rock and mineral assemblage has been organized and examined on a broad scale. In the next eight chapters, I attempt to identify the inter-regional interaction networks through which specific material varieties were acquired.