CHAPTER 9

VESUVIANITE-GROSSULAR ACQUISITION NETWORKS

CHAPTER INTRODUCTION: HARAPPAN "JADE"

In this chapter, I examine a distinctive translucent green to yellowish-green rock that has been recovered at Harappa in the form of beads, amulets and manufacturing debris (Figure 9.1). The Italian researchers Vidale and Bianchetti (1997) analyzed three of the debris fragments using X-ray diffraction (XRD) and determined them to be composed of a mixture of the minerals vesuvianite and grossular garnet (called here "vesuvianite-grossular"). They went on to suggest that translucent green beads from Mohenjo-daro (Figure 9.2 *top*), which were previously identified as "a peculiar form of jade" (Coulson 1931: 542), may actually be composed of this variety of stone. Reports of "jade" beads from early excavations at Harappa (Beck 1940: 402) and Mohenjo-daro (Mackay 1931c: 519, Mackay 1938: 498, 527), have led some scholars to suggest (Allchin and Allchin 1982: 186; Mackay 1948: 83) that long-distance exchange networks existed between the Indus region and distant parts of Asia where gem-quality nephrite (western China) or jadeite (Myanmar) can be found. Vidale and Bianchetti's identification of vesuvianite-grossular – a rock that greatly resembles jade and has several of the same mineralogical characteristics, casts doubt on those interpretation. More recently, the Italian team hypothesized (Vidale and Bianchetti 1999) that this stone may have even been a long-distance export from the Indus Civilization to consumers in Mesopotamia region.

I begin this chapter with an overview of the mineralogy of vesuvianite-grossular followed by an account of the effort to identify and characterize artifacts composed of it at Harappa. After that, the possibility that past researchers misidentified this rock as the mineral jadeite is explored. Next, I review the potential sources of this stone in South Asia and present the results of an INAA study in which samples from three of those sources were compared with artifacts from Harappa and Mohenjo-daro. I then consider Vidale and Bianchetti's hypothesis that vesuvianite-grossular may have been an export from the Indus region to Mesopotamia. In the concluding section, I explore the spatial and temporal distribution of vesuvianite-grossular at Harappa and discuss what appears to be its close association with "Ernestite," which is only material in the assemblage from which drills capable of perforating it could have been made. All sites, geologic sources and geographic regions mentioned in this chapter are identified on figures 9.7 and 9.8.

THE MINERALOGY OF VESUVIANITE-GROSSULAR

The translucent green-colored stone that is the subject of this chapter is a rock composed primarily of two distinct minerals: vesuvianite and grossular garnet. In order to best understand the particular nature of this material and how it was used at Harappa, it is useful to be aware of each mineral's individual properties and variability.

<u>Vesuvianite</u> is a rock-forming silicate mineral first described in blocks of metamorphosed limestone on the slopes of Mt. Vesuvius (Pough 1988: 281). Its exact chemistry, structure and even official designation (which has alternated between vesuvianite and

idocrase several times in recent decades) are subject to continued debate (Allen 1985: 2). Several chemical formulae have been proposed over the years (Groat *et al.* 1992: Table 2). The most recent edition of *An Introduction to the Rock-Forming Minerals* (Deer *et al.* 1992) lists it as Ca_{19} (Al, Fe)$_{10}$ (Mg, Fe)$_3$ $[Si_2O_7]_4$ $[SiO_4]_{10}$ $(O,OH,F)_{10}$. Published specific gravity (SG) values of pure vesuvianite range from 3.32 to 3.5 and its hardness is reported to fall between 6 and 7 on Mohs' scale (Deer *et al.* 1992: 47; Pough 1988: 280; Read 1979: 375). Vesuvianite is transparent to translucent and its color can range from yellow, green, to brown, with rare occurrences of red or blue (Deer *et al.* 1992: 47). The mineral most commonly occurs in areas resulting from the contact metamorphism of calc-silicate rocks (skarns), the metasomatic alteration of ultramafic rocks that results in rodingites (rodingitization – discussed on the next page) or, more rarely, in metasomatically altered alkali syenites (Allen 1985: 147-155). Pure vesuvianite is not a commonly used gemstone today, although it is known to occur both as "gemmy" pyramidal crystals and in a massive form that sometimes resembles jade (Pough 1988: 280-81).

Grossular is a member of the garnet group and has a chemical formula of $Ca_3Al_2Si_3O_{12}$ (Deer *et al.* 1992: 31). Like vesuvianite, it is a variable mineral. Published SG values range between 3.57 to 3.73 and its hardness may run from 6 up to 7.5 (Manson and Stockton 1982: Table 1). Pure grossular is colorless (ibid.: 207) but gem varieties have two distinct color trends: a yellow to orange to red-brown range called "hessonites" and a light yellow-green to dark green range called "tsavorites" (ibid.; Hansen 1986: xii). The mineral is transparent to translucent and occurs both as a crystal and in a massive form. Massive green grossulars from Africa and Pakistan are used jade simulants by jewellers in both countries (Qaiser *et al.* 1970: 735; Rothstein 1983: 611-13). Also like vesuvianite, grossular garnet forms in both regionally metamorphosed calc-silicate rocks and ultramafic rocks (most notably ophiolite sequences) that have undergone a metasomatic conversion sometimes called *rodingization* (Deer *et al.* 1992: 44; Hansen1986: xiii).

Although of different mineral families, the crystal structures of vesuvianite and grossular garnet are very similar (Groat *et al.* 1992: 22), with certain aspects being nearly identical in both (Deer *et al.* 1992: 47). The *c* axis of tetragonal vesuvianite is approximately equal to the length of the cubic edge of grossular (Allen 1985: 10). Thus, vesuvianite and grossular garnet, which form under similar conditions, frequently occur together. The term "californite" is informally used to describe a massive rock composed of vesuvianite and grossular garnet that may resemble jade (Rothstein 1983: 606) and which has a density of between 3.25 and 3.35 (Webster 1975: 232). It appears to be this co-occurring variety (which can grade in a single deposit from predominantly grossular to predominantly vesuvianite – Anderson 1966: 119) that is found at Harappa.

CHARACTERIZATION AND IDENTIFICATION OF VESUVIANITE-GROSSULAR AT HARAPPA

There are several varieties of rocks and minerals such as serpentine, nephrite "jade," jadeite "jade," periodote and green quartz, for which vesuvianite-grossular may be mistaken. In fact, the three fragments from Harappa that Vidale and Bianchetti (1997) identified were originally classified as serpentine, as were most translucent green-colored varieties of stone encountered during HARP operations up to that point. For this reason, it was considered essential to reexamine all artifacts of this description recovered at the site. This was done in two stages. For the first, a set of 26 translucent green-colored debris fragments was assembled for an initial

Figure 9.1 Vesuvianite-grossular garnet artifacts from Harappa.

round of mineralogical characterization involving XRD analysis and specific gravity (SG) testing. All samples were surface finds chosen to represent the full range of hues and material qualities (based on degree of internal fracturing) present in the sub-assemblage. XRD results and specific gravity determinations on these 26 have already been listed in Appendix 4.1. Seven of the samples underwent supplementary characterization using electron microprobe analysis (EMPA) – the details of which are provided in Appendix 9.1. For comparative purposes, five samples from two vesuvianite-grossular sources in Pakistan (described later in the chapter) were also analyzed (using XRD and EMPA) with the group. Informed by the results of these initial studies, the second stage of reexamination involved SG testing of all green-colored stone artifacts (translucent or otherwise) recovered at Harappa weighing 0.5 grams or more.

XRD analysis of the initial group of 26 archaeological samples revealed that, in every case but one (H94/4999-213, which turned out to be a flake of green-colored quartz), the fragments were composed

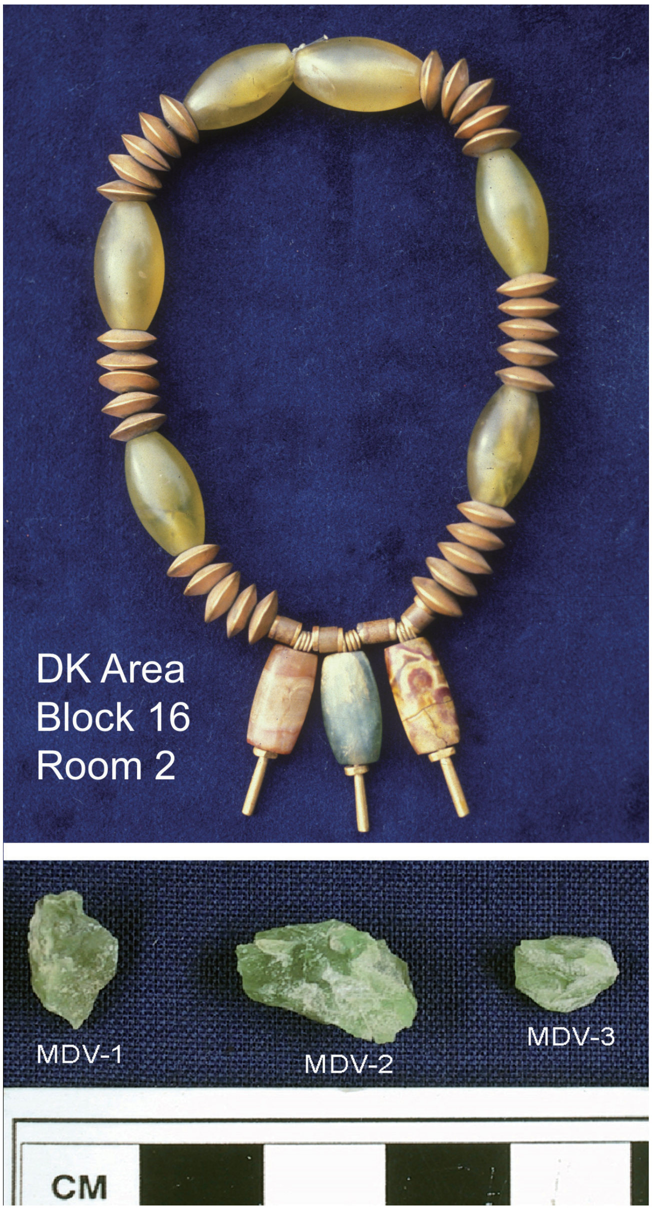

Figure 9.2 Vesuvianite-grossular garnet artifacts from Mohenjo-Daro.

of either vesuvianite or grossular, or some mixture of both. Although it is not impossible that three distinct rocks and minerals (vesuvianite, grossular garnet and co-occurring vesuvianite-grossular) are represented among the samples, I consider it more likely that they all are fragments of the type of massive, heterogeneous vesuvianite-grossular rock sometimes called "californite." Chlorite (variety clinochlore) – a common constituent and/or weathering product of ferromagnesium rocks and minerals (Deer *et al.* 1992: 340), was also detected (either by XRD or EMPA) in approximately half of the samples analyzed and was the primary component in two of them.

To best conceptualize the range of compositional variability in the vesuvianite-grossular sub-assemblage at Harappa, recall Appendix 4.2 F – a composite of four of the XRD scans of debris fragments. The top scan (H2000/9999-91) shows a fragment that appears to be composed entirely of grossular garnet. However, EMPA scans of this sample showed that vesuvianite and chlorite, in amounts undetectable by XRD, was also present in the stone. Below this is a sample (H94/5106-8) that contains a secondary phase of vesuvianite, although still being primarily (as determined by peak intensity) composed of grossular. The third scan from the top (H90/3220-

4) shows a material that is primarily vesuvianite with a very minor phase of chlorite. The bottom scan (H94/5310-36) shows a fragment composed primarily of chlorite with a secondary phase of vesuvianite. Sample H94/5310-36, which is a highly fractured, cloudy pale-green flake, perhaps represents the unusable weathered exterior that was discarded during the processing of a vesuvianite-grossular blocklet. Most finished and unfinished vesuvianite-grossular ornaments recovered at Harappa are composed of clearer stone that contains substantially fewer fractures. The five geologic samples that were examined along with the initial group (Appendix 9.1) exhibit the same mineralogical variability and are more or less identical in appearance to vesuvianite-grossular artifacts from Harappa.

Specific gravity determinations were made on all 26 archaeological fragments (these are listed with the samples in Appendix 4.1) and the five geologic samples (listed with those samples in Appendix 9.1). Although the overall density range of vesuvianite-grossular appears extremely wide (from just under SG 3.0 to over 3.5), it must be remembered that it is a heterogeneous rock, rather than a pure mineral, that has been tested. When density values are considered together with the primary and secondary mineral phases of each sample an important trend is revealed (Figure 9.3). With the exception of the single fragment that turned out to be green quartz, the samples with the lowest SG are those in which chlorite is the primary component. The bulk of the samples are composed mainly of vesuvianite with occasional secondary components of grossular and/or chlorite. The samples having the highest SG values are those with grossular as their primary component. I show below that this trend from low density chlorite-dominated stone to high-density grossular-dominated stone is, to a certain degree, mirrored in the discard patterns of vesuvianite-grossular artifacts.

With an understanding of vesuvianite-grossular variability informed by the results of the initial XRD, EMPA and SG studies, all green-colored stone beads, pendants and ornament manufacturing debris fragments recovered at Harappa since 1986, as well as those from previous excavations on display in the Harappa Museum and its reserve collection, were re-examined during the 2003 field season. Many rock and mineral varieties, such as tourmaline, amazonite (microcline), malachite, turquoise, fluorite and green varieties of steatite, were easily distinguishable from vesuvianite-grossular based on their hardness, texture and/or crystal habit. Most green-colored artifacts composed of quartz (bloodstone, moss agate, green jasper) or opaque varieties of serpentine were likewise distinguished without difficulty. If there was any uncertainty at all, the low density of quartz (2.6) and serpentine (2.5 to 2.7) as compared to vesuvianite-grossular (≈ 3.0 to over 3.5) made definitive differentiation possible as the SG of most artifacts was tested. Density determinations could not be made on artifacts under 0.5 grams due to the inaccuracy of the SG balance below that weight. Thus, fragments of "micro-debitage" had to be identified based solely on their macroscopic properties. Ultimately, 543 artifacts from Harappa (including Vidale and Bianchetti's 3 samples and the 25 fragments characterized using XRD/EMPA) were classified (or re-classified) as vesuvianite-grossular.

Interestingly, when vesuvianite-grossular manufacturing debris, unfinished beads and finished ornaments are considered separately, their average densities are somewhat different (Figure 9.4). The mean SG of the 161 weighed fragments of vesuvianite-grossular ornament manufacturing debris is 3.28. The mean of the 11 unfinished beads is 3.35 and the mean of the 10 finished ornaments is 3.31. Although the density discrepancies might be due to small numbers of finished and unfinished items considered, it may also be indicative of a pattern relating to the use and discard of this type of stone. The lower average density overall for manufacturing debris could reflect the intentional discard of more fractured and weathered stone. Such material tends to have a higher content of chlorite (a mineral with an average density of around 2.65) and so would naturally have a lower SG than less fractured/weathered forms of vesuvianite-grossular. Conversely, the high mean density for unfinished vesuvianite-grossular beads may indicate that the stone becomes more difficult to work as its grossular content increases. Recall that grossular can have a hardness of up to Mohs 7.5 while the hardest drills used by Harappans (made of microcrystalline silicate or "Ernestite") were only around 7. Thus, partially perforated bead blanks (such as the one pictured in Figure 9.5) were likely discarded because their high grossular contents (indicated here by their high densities) rendered them undrillable.

IS VESUVIANITE-GROSSULAR HARAPPAN "JADE"?

In an appendix to his report on beads excavated at Harappa, Beck listed (1940) five examples composed of "jadeite." Beads said to be made of the same mineral were also reported among jewelry hoards discovered in the later levels of Mohenjo-daro's DK (Mackay 1931c: 519, Marshall 1931b: Plate CXLVIII a) and HR areas (Marshall 1931b: Plate CL; Sahni 1931a: 194). That these artifacts were genuine "jade" (either the mineral jadeite or the rock nephrite) has long been taken for granted by scholars (Chakrabarti 1990: 142; Lahiri 1992: 78-79; Mackay 1938: 498; Piggott 1950: 174; Ratnagar 2004: 149; Wheeler 1968: 80) who point to the supposed presence of that stone as evidence for Harappan long-distance trade with peoples in source areas external to the Greater Indus region – namely in Central and/or East Asia. Vidale and Bianchetti have suggested (1997) that the "jade" beads reported from early excavations at Harappa and Mohenjo-daro may actually be composed of vesuvianite-grossular. In this section, I evaluate that possibility.

Some of the supposed "jade" beads from those early excavations are pictured at the beginning of this chapter. HM5339 in Figure 9.1 is from the Harappa Museum collection. Horace Beck did not provide details in his report as to how he came to the conclusion that beads like this one were composed of "true jadeite" (1940: 402). He did, however, note that they seemed to be "unusually transparent" for jade (ibid.). A portion of a necklace with "jade" beads from the DK Area hoard at Mohenjo-daro is pictured in Figure 9.2, *top image*. A.L. Coulson of the Geological Survey of India employed a variety of basic mineralogical tests in the analysis of these artifacts and others like them (Coulson 1931: 538-42). The density of the 23 examples he studied ranged from 3.225 to 3.395, with an average of 3.34. The hardness of two of those beads was judged to be 7.5 and the refractive index (RI) of one determined to be 1.651 ± .002. Like Beck, Coulson noted that the green to yellowish-green material seemed to be "more translucent than most varieties of jade" (ibid.: 542) and twice referred to it (ibid.: 539, 542) as a "peculiar" form of that stone. The finished condition of the ornaments obscured the stone's fracture and texture – characteristics that could have provided additional clues as to its identity.

Given the limited information that Coulson and Beck were able to glean from the beads they examined, the conclusion that they were made from jadeite is understandable. The shade of green the stone exhibits is reminiscent of that mineral and, although somewhat rare, highly translucent varieties (such as *Imperial Green Jadeite*) are known to occur (Levy and Scott-Clark 2001). Moreover, the measured SG and RI values of the Mohenjo-daro beads were consistent both with published values for jadeite and those of the jade specimens that Coulson examined in the Geological Survey of India's collections (particularly those from Burma). There are, nonetheless, several reasons to believe that the beads in question were misidentified and are actually

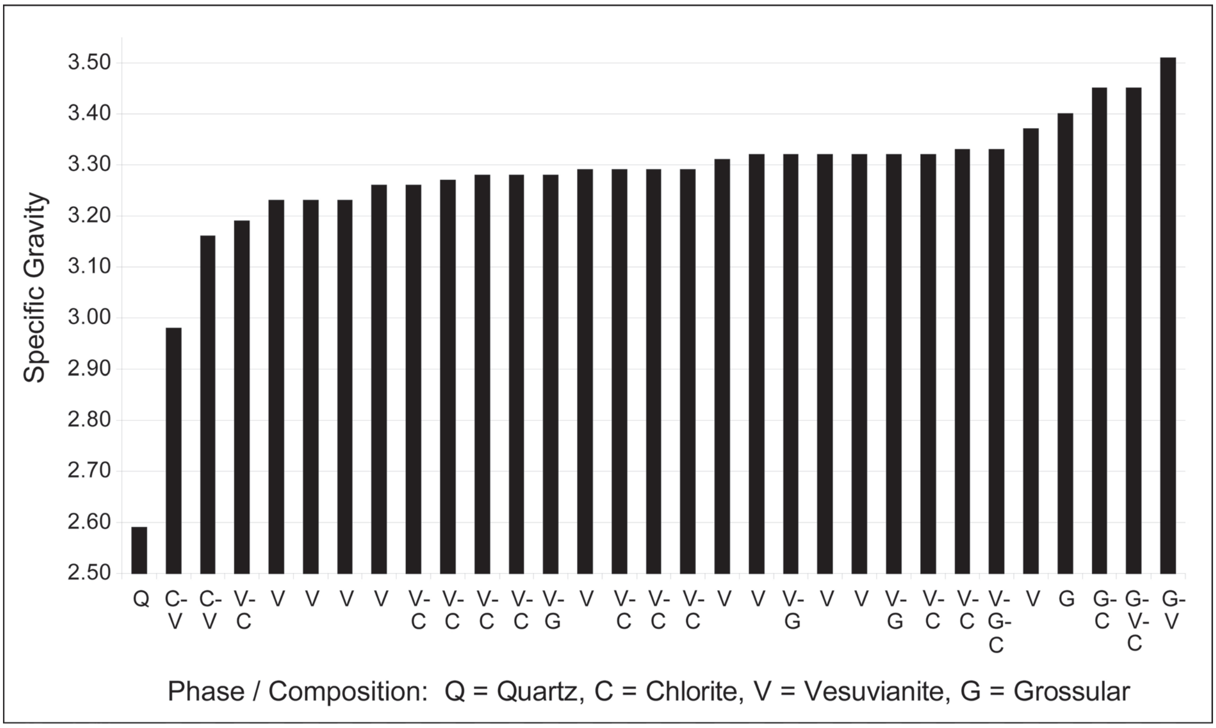

Figure 9.3 Specific gravity and composition of 31 translucent green-stones (26 debris fragments from Harappa and five geologic samples).

composed of vesuvianite-grossular.

To begin with, the co-occurring variety of vesuvianite and grossular garnet has a very "jade-like character and may pass for the genuine material, especially" since it and jadeite have *overlapping* specific gravity values (Webster 1975: 232). So, although it is the case the densities of the beads Coulson tested from Mohenjo-daro all fell within (or very near) the density range of jadeite (SG 3.24 to 3.43 – Deer *et al*. 1992: 192), they were also equally consistent with the density range of vesuvianite-grossular. Another important point to observe is that Coulson's estimated hardness of the "jade" beads was Mohs 7.5. That value is much more characteristic of a stone containing grossular than it is of jadeite, which has a *maximum* hardness of Mohs 7 (Schumann 1977: 154) and is usually more around Mohs 6 (Deer *et al*. 1992: 192). Finally, vesuvianite-grossular is sold as "jade" in the bazaars Pakistan today. I have analyzed samples purchased in both Peshawar (Figure 9.6) and Quetta that are mineralogically analogous to artifacts composed of that stone at Harappa. Perhaps most significantly, the visual appearance of this material is *identical* to the "jade" beads in question. Given this and the other physical characteristics that those beads exhibit, I find it far more probable that they were made from vesuvianite-grossular rather some "peculiar" form of jadeite.

Of course, nothing presented above definitively proves that the so-called "jadeite" beads from early excavations at Indus Civilization cities are actually made from vesuvianite-grossular. In order to do that it would be necessary to directly test them. However, I can state that I know of no other variety of rock or mineral (including genuine jadeite) that accounts for the appearance and reported properties of those beads more satisfactorily than vesuvianite-grossular. I can also report that this stone has now been positively identified at Mohenjo-daro (Appendix 9.2). Six small translucent green stone fragments (three of which are pictured in Figure 9.2, *bottom image*) were provided to me by Dr. Massimo Vidale, who collected them from the site's "Moneer" Area (Vidale 1987a, 1990) during the IsMEO-Aachen University project (Jansen

Figure 9.4 Specific gravity range and mean of different types of vesuvianite-grossular artifacts from Harappa

Artifact type	*amount*	*SG range*	*mean SG*
Unweighed "micro-debitage"	361	n/a	n/a
Weighed debris fragments	161	2.98 to 3.52	3.28
Unfinished beads	10	3.30 to 3.50	3.35
Finished ornaments	11	3.32 to 3.45	3.31

and Urban 1984). These samples are mineralogically analogous to vesuvianite-grossular debris fragments found at Harappa.

WHERE DID THE VESUVIANITE-GROSSULAR ACQUIRED BY HARAPPANS COME FROM?

In this section, I attempt to shed light on the question of where Indus Civilization craftspeople obtained the massive variety of vesuvianite-grossular that they used to make beads and amulets. I first examine potential sources of that stone in India and Pakistan. While doing this brief mention is also made of certain geologic occurrences that I do *not* consider to be potential sources, either because they are too distant (those in far eastern India for example) or because the nature of the stone found at those locations is not the same as the material used by Harappans. After reviewing both potential and unlikely sources, I present the results of an INAA study in which vesuvianite-grossular samples collected from three occurrences in three different regions – Rajasthan, Balochistan and the FATA, were compared to fragments of that stone recovered from Harappa and Mohenjo-daro. All archaeological sites, geologic occurrences and geographic regions discussed in this section are identified on figures 9.7 and 9.8.

Potential vesuvianite-grossular sources in India

Scholars studying vesuvianite-grossular artifacts found at sites in both South Asia (Vidale and Bianchetti 1997: 951-52) and West Asia (Sax 1991: 113) have pointed to the Indian state of Rajasthan as a possible source of that stone. Although the region is indeed rich in many varieties of garnet (Geological Survey of India 2001b: 64-65), grossular garnet (green or otherwise) has not yet been reported in the geologic literature as occurring there. Vesuvianite, on the other hand, is known (although not particularly well) from several places in Rajasthan. Middlemiss (1921: 20) made an oblique reference to a sample of vesuvianite in the Tonk Museum, which was said to be from a quarry near Rer in the eastern part of the state. However, no other information was provided on either the sample (its color, to crystal habit, etc.) or its source. Vesuvianite is mentioned as a mineral associated with skarn rocks round Kararavav in the Pali District of southwestern Rajasthan (Rathore 1991). Although no further details were given regarding that occurrence, it is likely related to another one nearby within Kumbhalgarh Forest Reserve in the adjacent Rajsamand district, which I first learned about in 2003.

In March of that year, while visiting with a jeweler in Udaipur, Rajasthan, I was shown a string of semi-translucent green beads (Figure 9.9) along with the raw stone from which they were made. The green hue of the beads was somewhat deeper than the typical vesuvianite-grossular artifact from Harappa

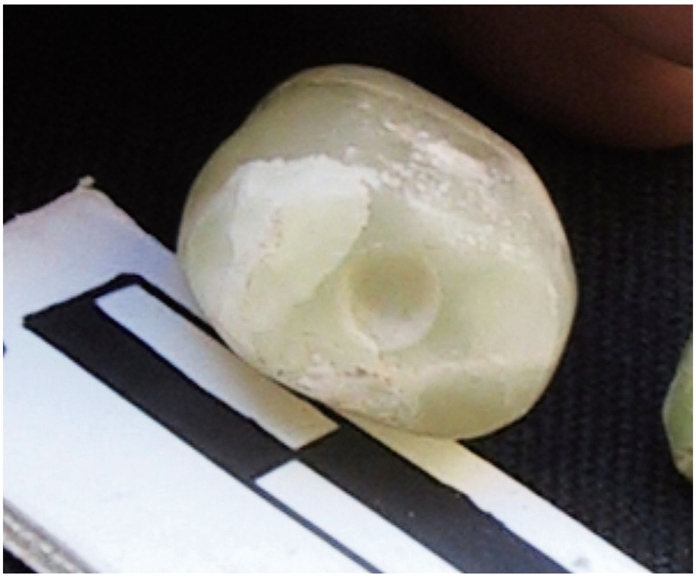

Figure 9.5 Unfinished vesuvianite-grossular bead H96/7106-6 (SG = 3.50).

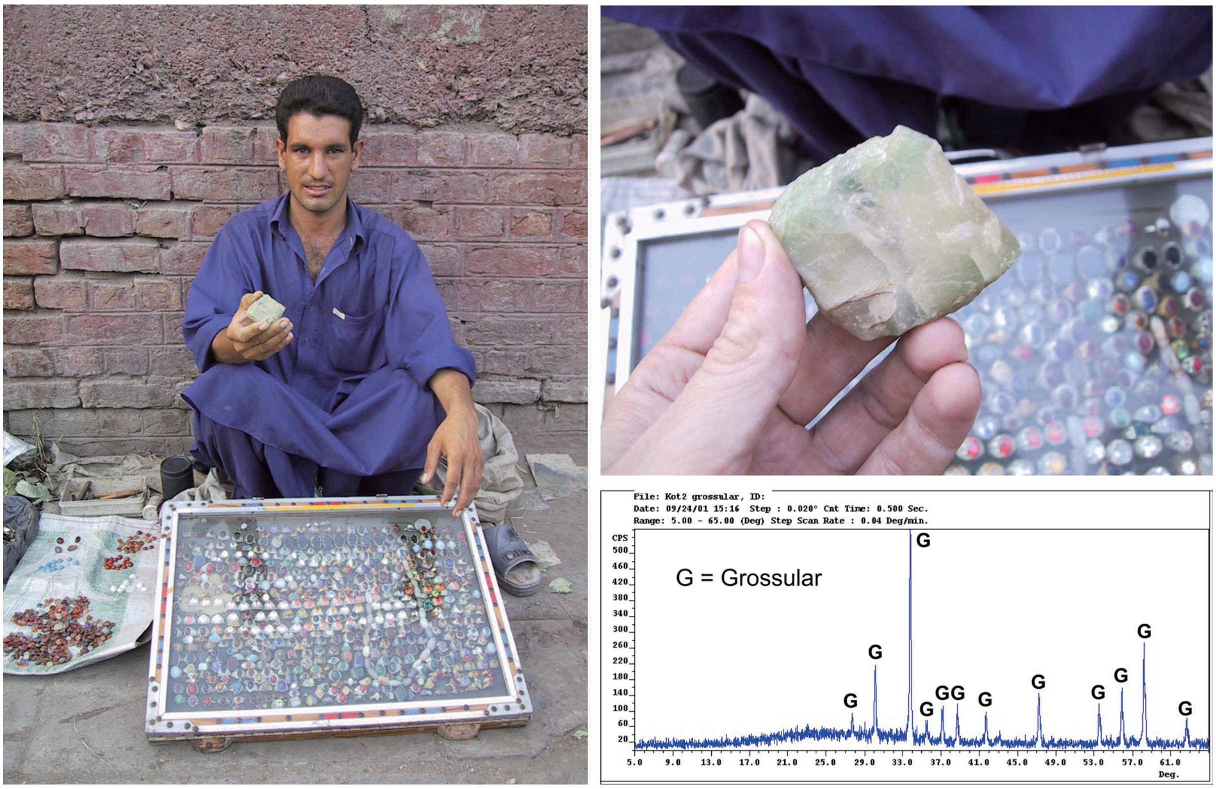

Figure 9.6 Johri in Peshawar, Pakistan selling raw "jade" (said to be from Sakhakot-Qila) that was later identified at grossular garnet.

but the stone, although highly fractured, was massive, compact and seemed to be fairly dense, which was much more like vesuvianite-grossular than other locally available green stones such as serpentine or aventurine quartz. I arranged to meet the man from whom the jeweler purchased the stone. That man was unwilling to either take me to the stone's source or give me much information about its location except to say that it was "in the forest." I was, however, able to acquire many samples (Figure 9.10). A few weeks later I related this story to N.K. Sood, Director–Geological Survey of India at Jaipur. Although he

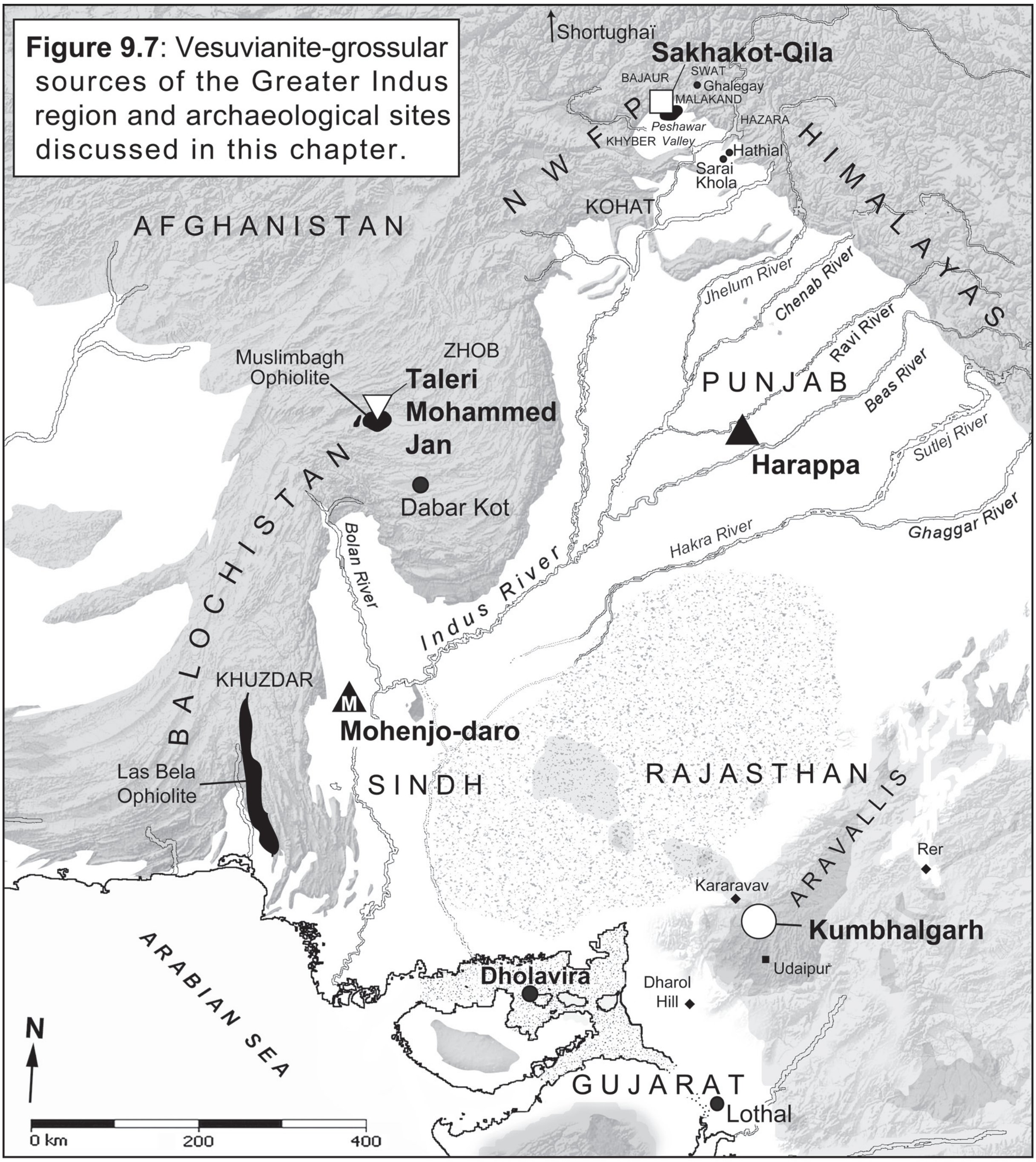

Figure 9.7: Vesuvianite-grossular sources of the Greater Indus region and archaeological sites discussed in this chapter.

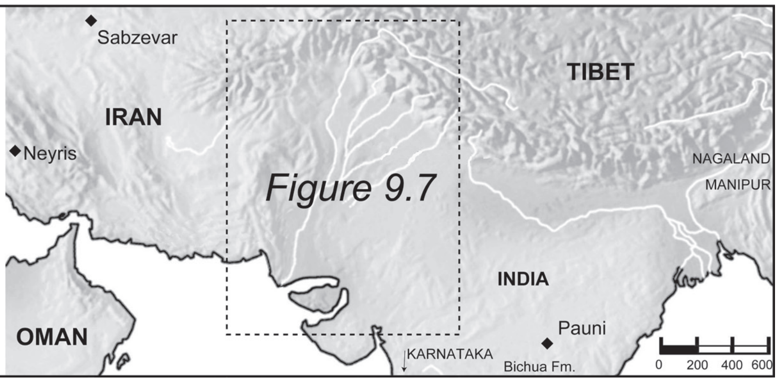

Figure 9.8: Occurences of vesuvianite, grossular, or both outside of the greater Indus region.

Figure 9.9 A string of Kumbalgarh vesuvianite beads purchased in Udaipur, Rajasthan.

Figure 9.10 Masses of Kumbalgarh vesuvianite purchased from a stone merchant near Udaipur.

was not certain at the time of the stone's composition, he was able to confirm that it could be found in Kumbhalgarh Forest Reserve, Rajsamand District of southern Rajasthan. He said that Bhil tribesmen in the area were mining the stone and showed me a sample of that material that they had provided to him. It appeared to be identical in every way to the samples that I had acquired from the stone merchant living near Udaipur.

I analyzed the Kumbhalgarh stone using XRD upon my return to Madison and found it to be pure vesuvianite (Appendix 9.3). Although there was no indication of grossular or chlorite in the XRD peak profile of the single sample that I studied, the same is actually true of many of the debris fragments analyzed from Harappa. As I noted above, the appearance of the Kumbhalgarh stone is slightly different than typical Harappan vesuvianite-grossular. Still, among the flakes at Harappa there are a few deeper green and highly fractured examples. That such material was sometimes used to make ornaments is evident from the truncated conical amulet numbered H90-3037-36, which is pictured in Figure 9.1. Therefore, Kumbhalgarh Forest could be a potential source of this stone.

Elsewhere in India, green garnet occurs at several locations in Karnataka (Parthasarathy *et al*. 1999; Viswanathiah *et al* 1979; Somasekar and Naganna 1966) but it is of the uvarovite garnet variety. Grossular garnet and vesuvianite are found together (but only as small grains) in the calc-schists of the Bichua formation of central India (West and Sharma 1989: 497). A showing of vesuvianite was reported from a chromite mine in the Pauni ultramafics of Maharashtra but no information was given as to its color (Mahajan and Singh 1984: 11). Vesuvianite and vesuvianite-grossular occur in veins a few inches across at Dharol Hill in northeast Gujarat (Middlemiss 1921: 20-21). The material at this location is described as translucent to transparent brown, however.

Translucent green vesuvianite-grossular can be found near the border Myanmar border in the far eastern part of India. Rodingitized volcanic dykes in ophiolitic rock in the states of Manipur (Shukla 1989) and Nagaland (Ghose *et al*. 1986) are reported to contain large masses of this material. Although it is not impossible that massive vesuvianite-grossular from these distant sources found its way to Harappa (over 2200 km away), there were much closer sources in regions that today are within modern Pakistan.

Potential vesuvianite-grossular sources in Pakistan

There are three regions in Pakistan where vesuvianite or vesuvianite-grossular has been positively identified: the FATA, northern Balochistan and southern Balochistan

Massive varieties of translucent green vesuvianite-grossular occur at several places in the bordering Malakand, Mohmand and Bajaur Agencies of the FATA (Kazmi 1995b: 286; Kazmi and Jan 1997: 477). Volcanic dykes running through the Sakhakot-Qila ophiolite, which is located on the northwestern fringe of the Peshawar Valley along the Malakand-Mohmand border, contain extensive lenses of massive vesuvianite-grossular with occasional chlorite impurities and inclusions of chromite and magnetite (Qaiser *et al*. 1970, 1972; Ahmed 1987a, 1988a, 1988b). Qaiser and others (1970: 735) noted that stone from this area “has been sold locally as ‘jade’.” Samples from this source (Figure 9.11) were obtained in the Peshawar bazaar and provided by the late Dr. Syed Hamidullah of the Center of Excellence in Geology, University of Peshawar.

Near the village of Taleri Mohammed Jan in the Zhob District of northern Balochistan, the metasomatic alteration of a dolerite dyke in the Muslimbagh ophiolite resulted in the formation of vesuvianite, grossular and clinochlore (Bilgrami and Howie 1960, Bilgrami 1960, Bilgrami 1963: 1176-77). In May of 2001, I visited this occurrence (Figure 9.12) with Dr. Khalid Mahmood of the Center of Excellence in Mineralogy, University of Balochistan, Quetta. We collected samples from an area of rodingite bearing a vein of translucent, but highly fractured green vesuvianite-grossular. Although no evidence of ancient mining was observed here, the massive talus-like debris field surrounding the source suggested an extended and/or intensive period of exploitation. Local residents reported that during the British Era much larger masses of material could be found at this location. Kazmi noted (1995b: 286) that vesuvianite had recently reappeared in the bazaars Quetta indicating the possibility that local tribesmen had discovered a new source. I obtained several additional samples of massive vesuvianite-grossular in Liaqat Bazaar, Quetta during the spring of 2001, which were said to be from a new source in

Figure 9.11 Samples of vesuvianite-grossular from the Sakhakot-Qila ophiolite, Malakand-Mohmand agencies, FATA.

the Muslimbagh ophiolite.

Translucent green crystals occurring in the northern part of the Las Bela ophiolite in the Khuzdar District, southern Balochistan were identified using XRD as vesuvianite by Armbruster and Gnos (2000: 112). The crystals were, however, all less than 1 mm in size. Although no massive bodies of vesuvianite-grossular have yet been reported in this area, the geology of the region (rodingization of calcium-rich rock) is such that they could exist.

An INAA comparison of vesuvianite-grossular artifacts to samples from three sources

Ten vesuvianite-grossular artifacts – seven debris fragments from Harappa and three from Mohenjo-daro – were compared to samples from three potential geologic sources (Sakhakot-Qila, Taleri Mohammed Jan and Kumbhalgarh Forest) in South Asia using INAA-derived elemental data, canonical discriminant analysis (CDA) and cluster analysis (CA). Details relating to sample preparation, INAA and data evaluation using CDA and CA have already been discussed in Chapter 3. The INAA results for the artifacts are listed in Appendix 9.4 and those for the geologic sources can be found in appendices 9.5 and 9.6.

Although the seven vesuvianite-grossular artifacts from Harappa in the comparative set (pictured in the bottom image of Figure 9.1) represent a mere 1.3% of the sub-assemblage of that rock variety, they were carefully selected to be as spatially and temporally representative as possible (see columns two through four of Appendix 9.4 for information on their Period, Mound and Trench associations). All are from stratigraphically secure contexts (together they represent around 4% of the 180 vesuvianite-grossular artifacts from such contexts). There is at least one example in the set from each chronological phase in which this variety of stone has been recovered (periods 1, 3B, 3C and 5). As only one vesuvianite-grossular flake each was found in periods 1 and 5 levels, and only four flakes are associated with Period 3B levels, the analysis of these artifacts represent a 100%, 100% and 25% (respectively) sample of those chronological sub-assemblages. Each of the four major mounded areas at the site is represented in the set by at least one artifact.

The three vesuvianite-grossular artifacts from Mohenjo-daro (pictured in Figure 9.1, *bottom image*) were provided by Dr. Massimo Vidale. All are surface finds that he collected during his research on lapidary craft industries at the site's "Moneer" Area (Vidale 1987a, 1990). The three artifacts (MDV-1, MDV-2 and MDV-3) are from among the six flakes I previously analyzed using XRD (Appendix 9.2).

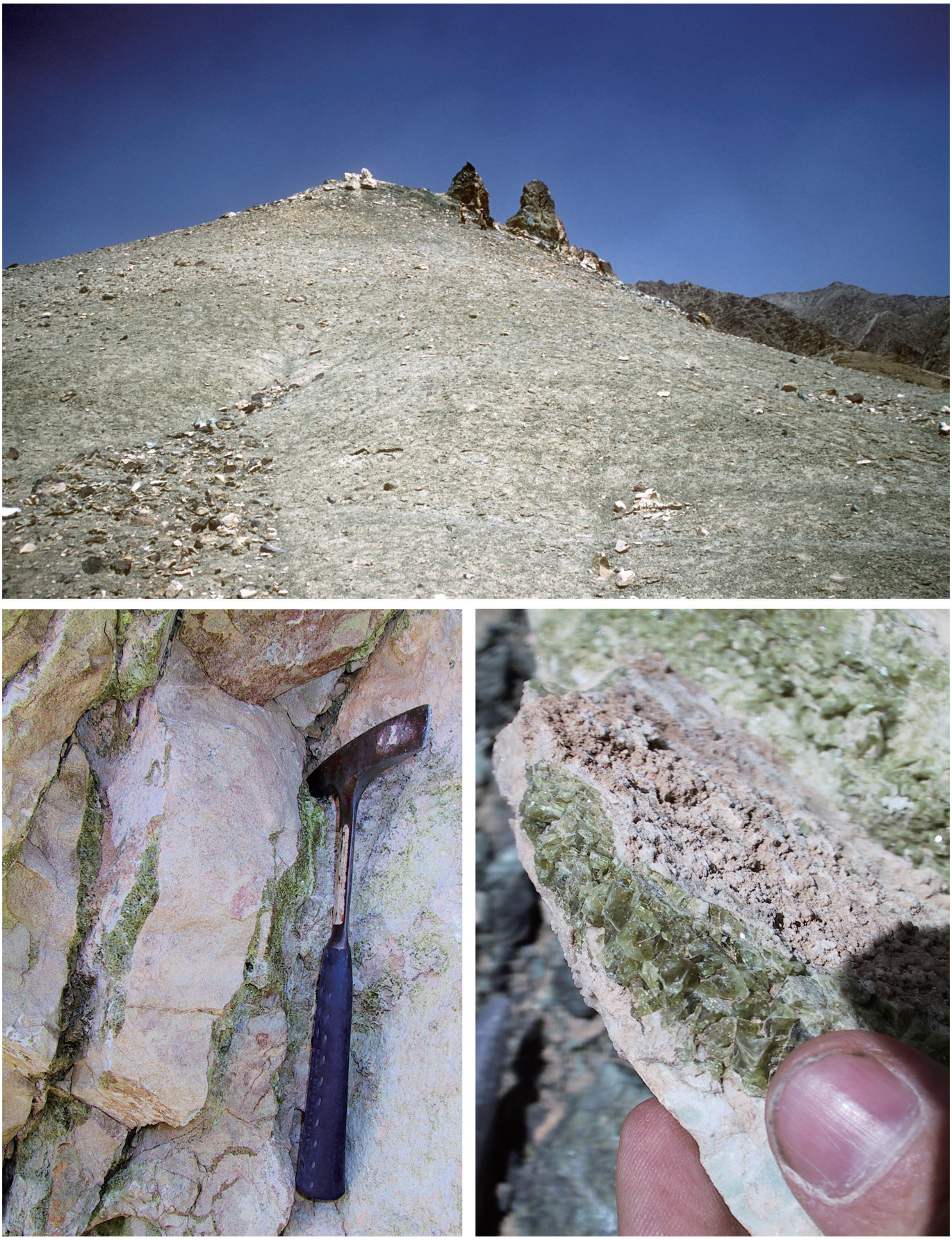

Figure 9.12 Top - The rodingite outcrop and talus slope of the vesuvianite-grossular occurrence at Taleri Mohammed Jan, Zhob District, Baluchistan. Bottom - Veins of fractured vesuvianite-grossular at Taleri Mohammed Jan.

Twenty-two samples from three vesuvianite-grossular sources comprise the set of geologic comparative material. Six are from rodingite veins in the Sakhakot-Qila ophiolite, Malakand/Mohmand agencies, FATA. Nine are from Taleri Mohammed Jan, Zhob District, Balochistan. Seven are from the reported vesuvianite occurrence in Kumbhalgarh Forest, Rajsamand District, Rajasthan.

INAA of the comparative set yielded 13 elements (Al, Ce, Co, Cr, Eu, Fe, Mn, Na, Sc, Sm, Sr, U and V) suitable for multivariate statistical analysis. These data were first examined using CDA. (Appendix 9.7 lists the standardized [canonical] discriminant function coefficients for that figure). Outstanding separation between the three geologic sources was achieved (Figure 9.13 *top*). Application of the leave-one-out classification function resulted in a 100% grouped sample cross-validation success rate, which indicates that the three sources are also highly distinct statistically. When the artifacts were plotted as ungrouped cases in relation to the geologic samples (Figure 9.13 *bottom*), the predicted group membership for eight of ten was the Sakhakot-Qila source. Two artifacts – one from Period 3C at Harappa (H94/4898-83) and one from Mohenjo-daro (MDV-3) were predicted to belong to the Taleri Mohammad Jan source (both artifacts are labeled on the bottom plot of Figure 9.13).

The vesuvianite-grossular artifact and source sample data were also examined using hierarchical cluster analysis. Multiple clustering strategies were employed. Figure 9.14 is a dendrogram generated using Ward's method. Six alternate strategies can be seen in Appendix 9.8. All produced dendrograms that were remarkably similar. With regard to the geologic sources, the Kumbhalgarh Forest samples (Raj-K) always formed a cluster that was completely distinct from the other two geologic sources examined. Those two – Sakhakot-Qila (FATA-SQ) and Taleri Mohammad Jan (BZ-TMJ), together formed a second larger cluster indicating that, geochemically, they were much more similar to one another. This is not altogether surprising as they are both associated with the ophiolite formations that are found intermittently along the northern and western margin of the Indus Basin. Within that second large cluster, however, the Sakhakot-Qila and Taleri Mohammad Jan sources either overlap minimally or, depending on the clustering strategy used, not at all.

Turning to the artifacts, once again, none even remotely resemble the Kumbhalgarh source. An examination of the dendrograms indicates that the same four artifacts consistently group closely with the either the Sakhakot-Qila or Taleri Mohammad Jan sources. Sample H94/4898-83 groups closely with the Taleri Mohammad Jan samples while H98/8908-8, H99/9730-11 and MDV-3 groups with those from Sakhakot-Qila. (note that CDA had previously assigned MDV-3 to the Taleri Mohammad Jan source). The six remaining artifacts consistently grouped together to form a cluster that, although clearly more closely related to those two sources than to the Kumbhalgarh source, is still very distinct in itself. This suggests that these artifacts may be from a fourth vesuvianite-grossular source that is not represented among the geologic sample set. As previously indicated by CDA, the artifacts forming that cluster are statistically more closely related to the Sakhakot-Qila source than they are to the Taleri Mohammad Jan source. It is probable, therefore, the unknown source is one of the several as yet of un-sampled vesuvianite-grossular deposits reported to exist in the Mohmand or Bajaur agencies of the FATA.

In conclusion to this section, the ten vesuvianite-grossular artifacts from Harappa and Mohenjo-daro analyzed for this study almost certainly came from an occurrence located along the northwestern margin of the Greater Indus region rather than from Rajasthan. Most seem to have been derived from an FATA source but a few may have come from one in northern Balochistan. Although no Indus Civilization settlements can be found in the immediate vicinity of either source, both lie along what may have been major trade and communication routes during the third millennium BC. Harappans might have passed through or near the Malakand or Mohmand areas of the FATA on their way to and from the outpost of Shortughaï in northern Afghanistan. Taleri Mohammad Jan lies at the southern end of the

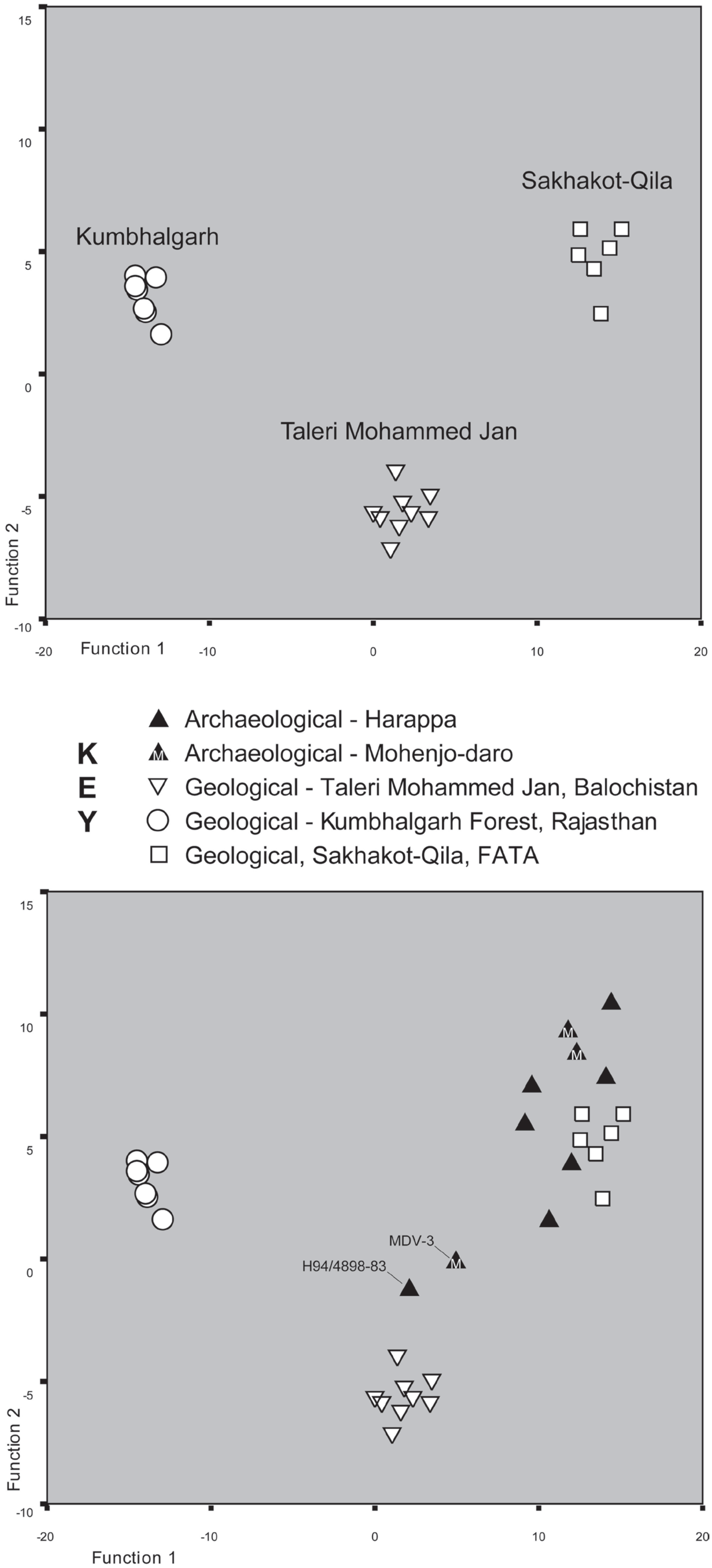

Figure 9.13 Comparison of samples from three vesuvianite-grossular sources and ten vesuvianite-grossular artifacts using canonical discriminant analysis.

Zhob Valley (an important route through northern Balochistan today) and is around 130 km northwest of the Indus Civilization settlement of Dabar Kot.

WAS VESUVIANITE-GROSSULAR EXPORTED TO MESOPOTAMIA FROM THE GREATER INDUS REGION?

In reference to reports of artifacts made of vesuvianite-grossular at third millennium BC sites in Mesopotamia, Vidale and Bianchetti (1999) hypothesized that this variety of stone may have been exported to that region from South Asia. Earlier, Margaret Sax (1991) had made a similar suggestion with regard to first millennium B.C Mesopotamian cylinder seals composed of the same material. In this section, I first briefly discuss the possibility that Harappans exported vesuvianite-grossular west of the Greater Indus region. I then review potential sources of that stone that, as compared to those in South Asia, may have been more accessible to consumers in western Asia.

There is no reason why vesuvianite-grossular (or any other material for that matter) could not have been traded from South Asia to the Mesopotamia region during the third millennium B.C or later. As previously noted, green stone fragments and beads visually identical to the vesuvianite-grossular artifacts positively identified at Harappa and Mohenjo-daro are present in collections from the Indus Civilization city of Dholavira in northern Gujarat (*personal observation*). From there and other southern coastal settlements, this stone could have easily been transported to consumers in West Asia via maritime trade routes, which were clearly active at this time (Possehl 1997a). Overland exchange could have taken place via any number of pathways (many of which are outlined in Chakrabarti 1990 and in Ratnagar 2004). Vesuvianite-grossular might very well have been moved along the same routes through which "inter-cultural" style chlorite vessels were traded from highland Iran to inland settlements across a broad area extending from the Indus Valley to West Asia (Kohl 1975; Lamberg-Karlovsky 1993). Indus Civilization peoples clearly had the capability and connections necessary to export this valuable stone to consumers the west. The pertinent question now is whether or not Mesopotamian consumers had access to alternate sources of vesuvianite-grossular.

A review of the geologic literature reveals numerous potential vesuvianite-grossular sources that, as compared to those of northwestern South Asia, would have been closer to consumers in Mesopotamia. A massive occurrence of this stone is reported (Alberti *et al*. 1976) in rodingitized rock in the Sabzevar ophiolite, Khorassan Province, northeastern Iran (see Figure 9.8). Nearer to the Mesopotamian heartland (not pictured on Figure 9.8) is a vesuvianite-grossular source in the Neyriz Ophiolite Complex of the southern Zagros Range, Iran (Adib and Pamic 1979). Stone from that locality might have been acquired through Mesopotamian interaction with the ancient groups inhabiting those resource-rich highlands (Henrickson 1994). The grossular described (Ahmed 2002) in the al-Madhiq region of southwest Arabia is brownish-red in appearance but it is possible that there are sources of green-colored stone elsewhere in western Asia that remain to be identified. Ophiolites containing the skarn rock / rodingite formations in which massive vesuvianite-grossular tends to form are found a various other points along northern Zagros Range and into the highlands of Anatolia (Cogulu 1980; Schandl and Mittwede 2001). A source of the massive green variety could eventually be found in those regions.

Although Harappans could have exported vesuvianite-grossular to Mesopotamia, consumers in that region probably had access to closer sources of the stone. To test Vidale and Bianchetti's hypothesis (1999), it will be necessary to compare Mesopotamian

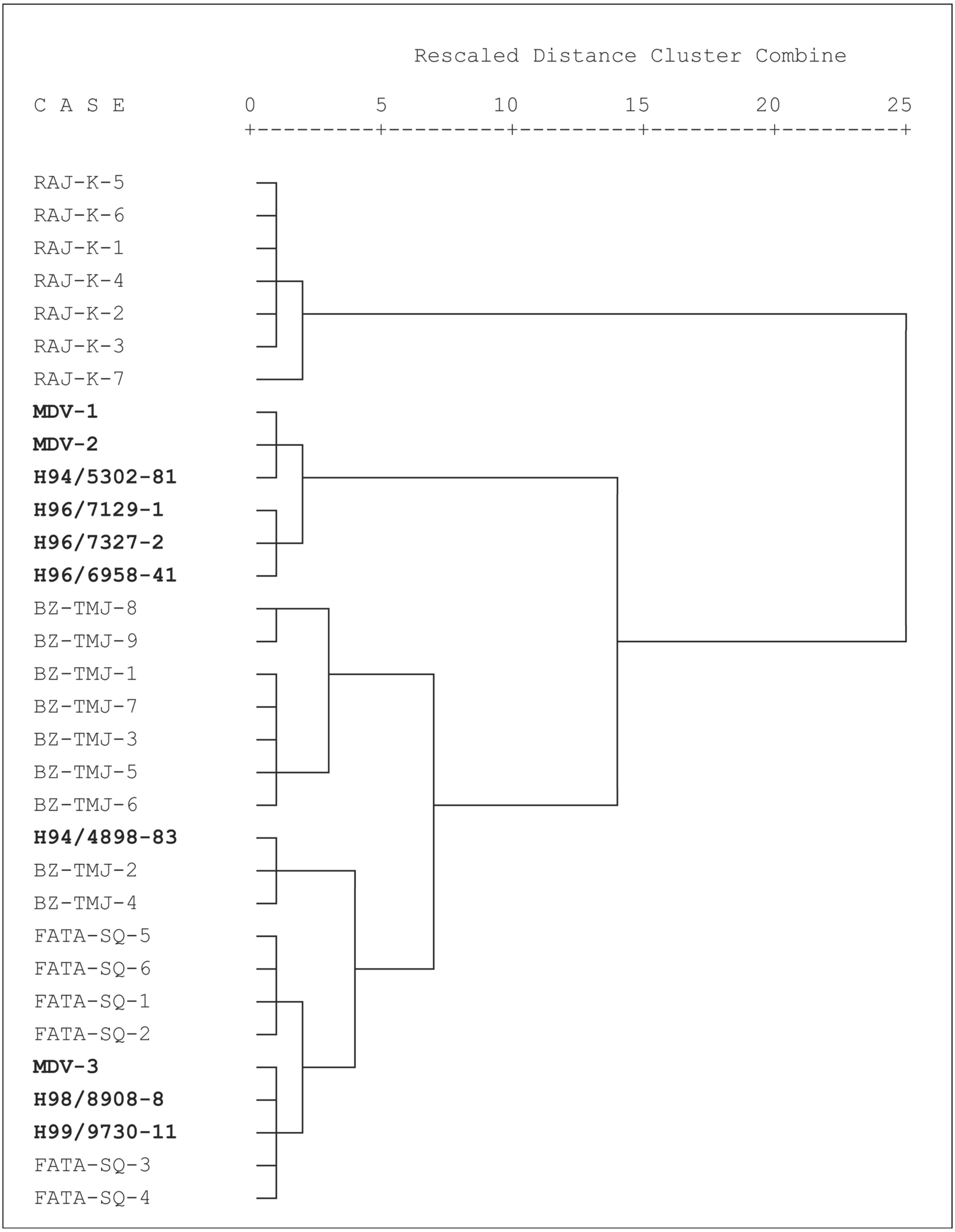

Figure 9.14 Comparison of samples from three vesuvianite-grossular sources and ten vesuvianite-grossular artifacts using hierarchical cluster analysis (Ward's Method).

artifacts with sources analyzed in this chapter and samples collected from West Asian occurrences.

VESUVIANITE-GROSSULAR AT HARAPPA AND ITS ASSOCIATION WITH "ERNESTITE"

In this final section, I examine the spatial and temporal distribution of vesuvianite-grossular artifacts at Harappa and discuss what I believe is an interesting and important association between that material and another variety of rock found at the site – "Ernestite."

The 543 artifacts classified as vesuvianite-grossular at Harappa comprise 0.96 % of the site's entire stone and metal assemblage – just short of the (admittedly arbitrary) 1% value above which I defined materials as major rock or mineral varieties. The only stones used more by bead-makers were steatite and microcrystalline silicates. Vesuvianite-grossular is three times as abundant at Harappa as lapis lazuli, which is a material that has received considerably more attention from scholars (see Appendix 4.4). A similar pattern may exist at Mohenjo-daro. Few lapis lazuli artifacts have been reported at that site but it now appears as if numerous items, such as the beads previously identified as "jade" and rock fragments once thought to be serpentine (Vidale 2000: 42), are composed of vesuvianite-grossular. Whether or not that stone was as widely distributed across the Indus Civilization as lapis lazuli remains to be determined but, as I have already noted, it seems to be present as far south as Dholavira. Although it may eventually be discovered that vesuvianite-grossular artifacts were relatively abundant and widespread, the evidence from Harappa indicates that the stone's use, at least at that site, was rather restricted in space and time.

The numbered trenches and labeled areas on Figure 9.15 indicate those parts of Harappa from which vesuvianite-grossular artifacts have been recovered. The inset pie-chart on that figure shows how this material sub-assemblage was differentially distributed among site's major areas. The first four columns of Figure 9.16 provide a more detailed picture of the sub-assemblage's composition and its distribution among those excavation trenches and survey areas from which it was recovered. Slightly more than 91% of all vesuvianite-grossular artifacts at Harappa came from mounds E and ET (the heaviest concentration is in the area straddling the east-southeast side of mound E and the west-southwest side of mound ET). Fifty-three vesuvianite-grossular artifacts were recovered elsewhere at the site. The majority of those (n = 41) came from off-mound Harappa Period dumps above the cemetery area and the Low Western Mound. A mere five were found on mound AB and only four on Mound F. One flake was found in the area of the Mughal Sarai (just to the south of Mound E). Lastly, there are two beads from the Harappa Museum collection included in the vesuvianite-grossular sub-assemblage. Although their precise context is unknown (they did not possess any identifying numbers), it is not unlikely that they are from among the five "jadeite" beads listed in Beck's report (1940: 413-414), four of which reportedly came from Mound F and one from Mound D (≈ Area J near the Low Western Mound and south of Mound AB).

Three hundred sixty-three (or approximately two-thirds) of the 543 vesuvianite-grossular artifacts at Harappa are from surface or disturbed deposits. Of the remaining 180 artifacts recovered from stratigraphically secure deposits (see Figure 9.17 *third row*), all but six come from Period 3C levels. Four were recovered in Period 3B levels. A single flake was found in Ravi Phase (Period 1) levels (Trench 39, Mound AB). Although the flake appears to be from a secure excavation lot, there is a possibility that it is a later phase artifact that was re-deposited by rodent action, which is common in those levels (although great care is taken to identify such disturbances). Another individual flake of vesuvianite-grossular

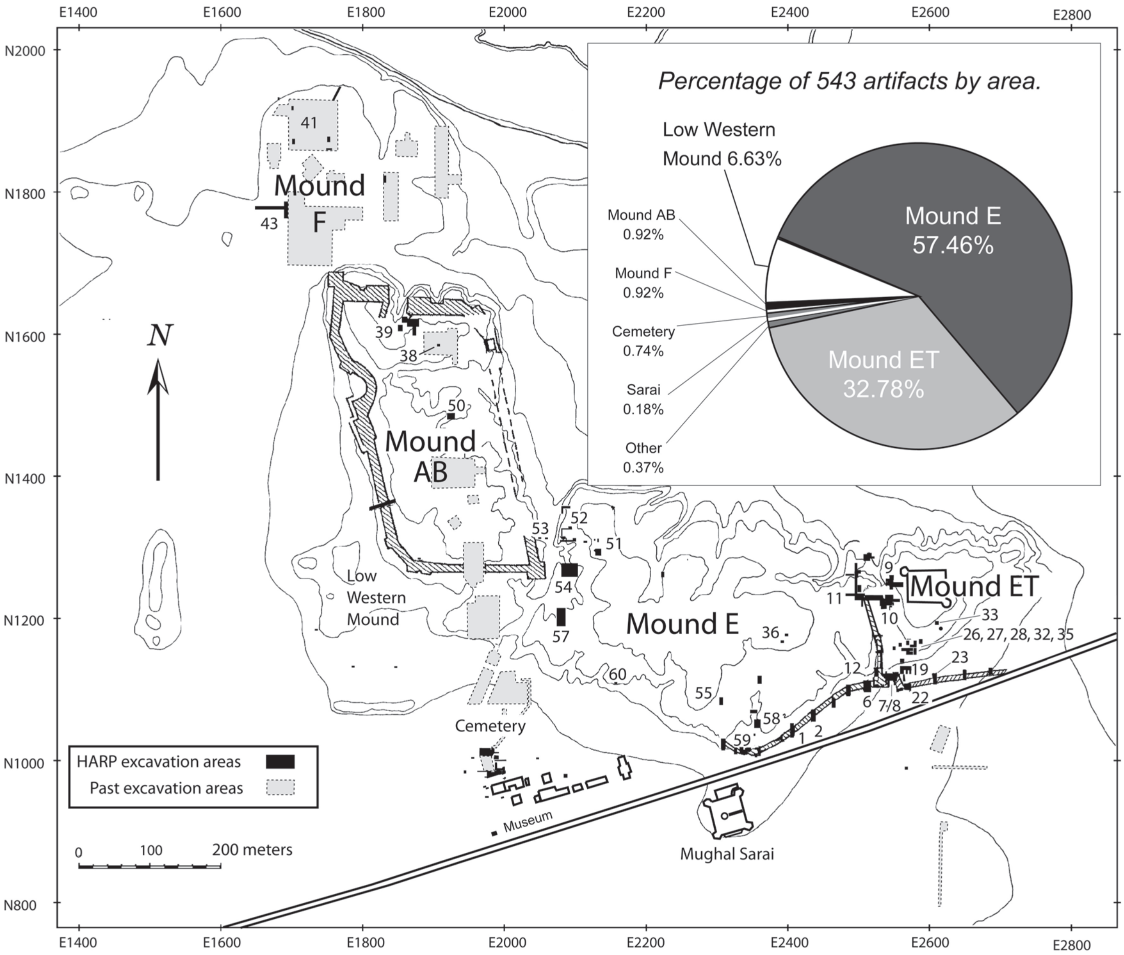

Figure 9.15 Vesuvianite-grossular artifact distribution at Harappa.
Vesuvianite-grossular artifacts have been recovered in all trenches and areas labeled on this site plan.

was found on the floor of a Late Harappan (Period 5) structure (Trench 38, Mound AB). It is possible that this artifact was initially deposited there during Period 5. However, not far away was found a small pot containing mixed beads, amulets, stone fragments and metal scraps (Meadow *et al* 1996: 5-6, figures 34-36). This find is thought to probably represent the cache of some Late Harappan person who gathered miscellaneous objects from the surface of the site during that period (ibid.: 6; Kenoyer *personal communication*). The vesuvianite-grossular flake found nearby might, therefore, be a loose item from an earlier phase that was collected and brought to this location.

When the spatial and temporal distributions of vesuvianite-grossular artifacts at Harappa are considered together, we see that the four examples from Period 3B levels were all recovered on mounds E and ET (in trenches 9, 10 and 11). Nearly 98% of all examples from Period 3C (170 of 174) also come from those two conjoined mounds. The four artifacts from that period that do not, were recovered on Mound F (n = 3 in trenches 41 and 43) and beneath the Mughal Sarai (n = 1). The two remaining vesuvianite-grossular artifacts of the 180 from secure contexts are the individual flakes from periods 1 and 5 on Mound AB discussed in the preceding paragraph.

I have provided this detailed discussion of the spatial and temporal breakdown of Harappa's vesuvianite-grossular sub-assemblage because I wish to highlight what I believe to be two *genuine* patterns (see Appendix 9.9) related to the use of this stone at the site. Firstly, it appears that Harappan beadmakers probably only used vesuvianite-grossular to create

Figure 9.16 Spatial distribution of all vesuvianite-grossular and "Ernestite" artifacts at Harappa

Vesuvianite-Grossular (n = 543)					**"Ernestite"** (n = 75)		
debris	*unfinished beads*	*finished beads*	*amulets*	**Mound E-ET**	*drills*	*blocklets / blanks*	*debris*
2				Trench 1	1		
3				Trench 2			
1				Trench 6			
1				Trench 7	1		
2				Trench 8			
1				Trench 9			
10	1			Trench 10	1		3
2				Trench 11	1	1	2
2				Trench 12			
24				Trench 19	1		
2				Trench 22	1		
7				Trench 23			
13				Trench 26			
37	1			Trench 27	3		5
31	1	1		Trench 28	7	1	4
8				Trench 32	2		
1				Trench 33			
3				Trench 35			
235	4			Trench 36	2	3	9
5				Trench 51			
2		1		Trench 52			
1				Trench 53			
5				Trench 54			3
1				Trench 55			
3				Trench 57			1
4			1	Trench 58			
3		1		Trench 59			
		1		Trench 60			
67	1	1		Survey on E/ET	6	1	8
				Mound AB			
1				Trench 38			
3				Trench 39			
	1			Trench 50			
				Survey on AB			4
				Mound F			
	1			Trench 41		1	
3			1	Trench 43			
				Other			
1				Mughal Sarai			
4				Cemetery area		1	1
34		2		Low Western Mound			1
		2		Unknown (Harappa Museum)			
522	*10*	*9*	*2*	*TOTALS*	*26*	*8*	*41*

ornaments during periods 3B and 3C. Secondly, it also seems that this activity was almost exclusively confined mounds E and ET during those periods. Admittedly, these patterns could be due, at least in part, to bias stemming from both excavation strategies and physical aspects of the site (discussed in Chapter 4). Recall Figure 4.11. Almost 90% and 80% of all rock and mineral artifacts representing periods 3B and 3C (respectively) were recovered from mounds E and ET. Those phases are, quite obviously, over-represented in the assemblage of stone and metal artifacts from secure contexts. However, every square meter of Harappa's surface has been surveyed by the HARP and this has provided us with a good and

Figure 9.17 Temporal distribution and shared lot association of all vesuvianite-grossular and “Ernestite” artifacts from stratigraphically secure contexts at Harappa (np = not present).

Period	***1***	***2***	***3A***	***3B***	***3C***	***4/5***	***Shared secure lots (n=11)***
Vesuvianite-Grossular (n = 180 in 77 lots)	1	*np*	*np*	4	174	1	14.3% of secure lots containing vesuvianite-grossular also contain “Ernestite”
"Ernestite" (n = 40 in 34 lots)	*np*	*np*	*np*	2	38	*np*	32.4% of secure lots containing “Ernestite” also contain vesuvianite-grossular

Figure 9.18 Spatial distr bution of all vesuvianite-grossular and “Ernestite” artifacts from non-secure contexts at Harappa.

Mound	***F***	***AB***	***E***	***ET***	***Low Western***	***off-mound / unknown***
vesuvianite-grossular *artifacts* (n = 363)	2	2	212	106	36	5
percent of total	0.55%	0.55%	58.4%	29.2%	9.9%	1.4%
“Ernestite” *artifacts* (n = 35)	1	4	18	11	1	0
percent of total	2.9%	11.4%	51.4%	31.4%	2.9%	0%

representative conception of where major and minor craft activities took place at the site (Kenoyer and Miller 2007; Miller 1994a, 1997, 2000). Figure 9.18 shows the spatial distribution of vesuvianite-grossular artifacts recovered during surveys in combination with those from other non-secure contexts such as brick-robber trenches (this amounts to 363 artifacts in total). The vast majority (87.6%) of such artifacts were found, once again, on mounds E and ET indicating that the most intensive working of that stone took place in that area. Most of the remaining ones (9.9%) came from the Harappan Period dump called the Low Western Mound. If a significant amount of vesuvianite-grossular bead-making activity had taken place on mounds F or AB then the amount of debris recovered from non-secure deposits in those areas should have been far greater than a mere two flakes from each mound.

The spatial patterning of vesuvianite-grossular artifacts at Harappa strongly suggests that the acquisition of that stone and the production of ornaments using it were activities almost exclusively engaged in by residents of mounds E and ET. The reason for this might be because the procurement and distribution of this important resource was something that was closely controlled by individuals or groups living in those areas. On the other hand, it may be the case that, as I will argue shortly, beadmakers in those areas were the only ones who possessed (controlled) the technology needed to perforate this very hard variety of stone. Perhaps both explanations are true.

The spatial patterning of vesuvianite-grossular artifacts also provides another important line of evidence indicating that a close relationship existed between the peoples living and working on mounds E and ET. Recall that in Chapter 4 I showed that grindingstone source usage patterns in those adjoining areas of the site more or less paralleled one another throughout periods 3B and 3C and in surface collections. Below, I show that the same is true for “Ernestite.” In the next chapter, I present evidence suggesting that peoples in those areas were the exclusive producers and/or users of alabaster bangles during Period 3. Considered together, these comparable synchronic patterns lend support to the interpretation that residents of mounds E and ET were probably a part of the same socio-political entity. When those two areas are regarded as a single mound (E-ET) and compared to the other mounds at Harappa, an affirmative answer is provided to study's third line of inquiry.

The chronological distribution of vesuvianite-grossular artifacts at Harappa clearly shows that the most intensive and, perhaps, exclusive period of acquisition and use of this stone was during the latter part of the Harappa Phase (for reasons already explained, the single flakes found in Ravi and Late Harappan levels *may* be anomalous items that were not originally acquired during those phases). This pattern could indicate that sources were not accessible (either directly or indirectly) to the site's residents prior to that time. Toward the end of the third millennium BC (ca. Period 3C at Harappa), the stone *might* have been acquired indirectly through interaction with Bactria-Margiana Complex (BMAC) peoples of southern Central Asia who were then expanding from that region into the west-northwestern borderlands of South Asia (Hiebert and Lamberg-Karlovsky 1992; Jarrige 1991a) and were evidently present in some capacity at Indus Civilization cities (Meadow 2002; Parpola 2005). As I showed in Chapter 7, the black steatite that was used to carve the small "BMAC-like" wig found in Period 3C levels on Mound F at Harappa appears to be most closely related to steatite occurring in the same geologic formation as one of the vesuvianite-grossular sources examined in this chapter – the Sakhakot-Qila ophiolite. That formation is located on the northern fringe of the Peshawar Valley nearby the Khyber Pass going west into Afghanistan and the Malakand Pass going north into the Swat Valley. If Indus Civilization peoples used these particular passes when traveling to and from the Harappan outpost of Shortughaï in northern Afghanistan then they themselves might have had direct access to vesuvianite-grossular from the Sakhakot-Qila ophiolite.

Regarding the possibility that vesuvianite-grossular sources were not accessible until latter part of the Harappa Phase, I would point out, again referring to Chapter 7, that the site's residents appear to have been acquiring steatite from deposits in the general vicinity (in the Hazara District and the Khyber Agency) of the Sakhakot-Qila area since the Early Harappa Period. Early Harappans had settlements (Sarai Khola and nearby Hathial) near the eastern edge of the Peshawar Valley and, as indicated by finds at Ghalegay Rock Shelter (Stacul 1987), had at least limited interaction (probably via the Malakand Pass) with peoples in the Swat Valley. The single vesuvianite-grossular flake from Period 1 levels at Harappa (which, of those analyzed, is one of the most geochemically analogous to the Sakhakot-Qila source) might, therefore, have actually been acquired at that time. However, it would have been impossible for Ravi Phase beadmakers to perforate a stone of its hardness using the chert and jasper drills that they then possessed. I believe that this technological limitation is one of the main reasons why vesuvianite-grossular really does not appear in Harappa's archaeological record until the latter part of Period 3.

The only material in Harappa's rock and mineral assemblage from which drills capable of perforating vesuvianite-grossular could have been fashioned was "Ernestite" (support for this statement is provided in Appendix 4.5). To date, 75 artifacts composed of that stone (drill bits, worked blocklets / drill blanks and debris) have been recovered. Their spatial distribution is shown in the last three columns of Figure 9.16. In *all* trenches and areas where "Ernestite" artifacts were recovered vesuvianite-grossular artifacts were also found. When association at the level of shared stratigraphically secure excavation lot is considered (Figure 9.17 far right column), we see that in roughly

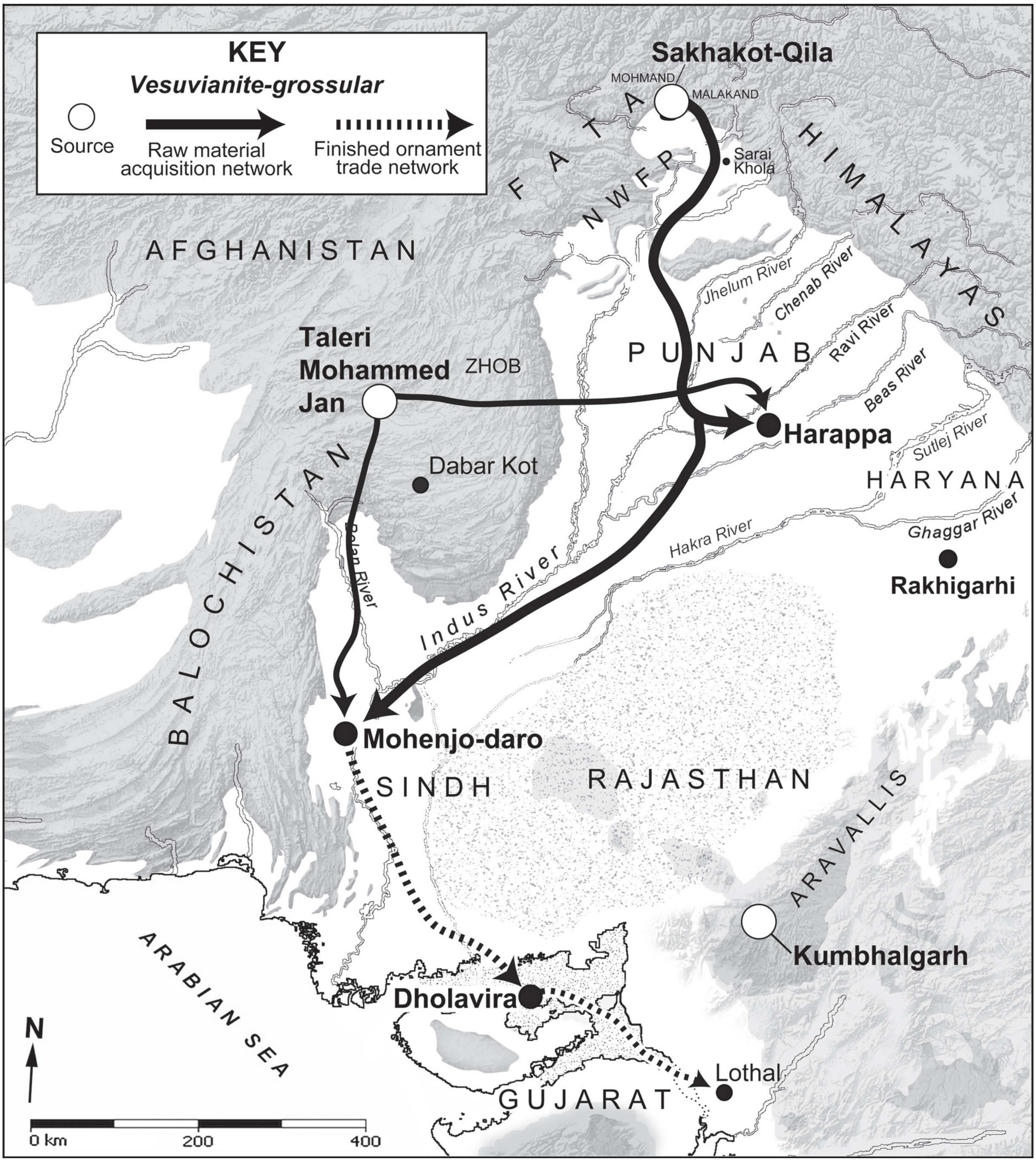

Figure 9.19 Harappan vesuvianite-grossular acquisition and trade networks (provisional).

one out of every three lots (32.4%) in which an "Ernestite" artifact was recovered a vesuvianite-grossular artifact was also present. The 40 "Ernestite" artifacts from secure contexts all come from periods 3B (n = 2) and 3C (n = 38) levels (Figure 9.17 bottom row) on Mound E/ET. Nearly 83% of the 35 examples from non-secure contexts are also from that area (Figure 9.18 bottom row).

The spatial and temporal distribution patterns of "Ernestite" and vesuvianite-grossular artifacts at Harappa are practically mirror images of one another. This is almost certainly no coincidence. Vesuvianite-grossular could not have been drilled without the use of "Ernestite" bits (holes can be "pecked" through that stone to make very small beads but there is no evidence this was done). Harappans might have had access to the regions where vesuvianite-grossular occurred and even knowledge of the stone's existence as early as the Ravi Phase but they did not then possess the technology needed to turn it into finished beads. That each variety of stone appears in the archaeological record at exactly the same time when (ca. periods 3B and 3C) and, largely, in the same places where (Mound E/ET) beadmakers were using the other one should come as no surprise. In Chapter 13, I discuss the implications of the differential distribution of this and other rock varieties at Harappa.

CHAPTER CONCLUSION

As early as the Ravi Phase (Period 1), residents of Harappa acquired vesuvianite-grossular from sources along the northwestern fringe of the Peshawar Valley (today the Mohmand-Malakand regions of the FATA). However, it was not until the middle to late part of the Harappa Phase (periods 3B and 3C) that site residents (mainly those dwelling on mounds E and ET) began to import raw material from that area, as well as from another source in northern Balochistan, in abundance. The reason for this likely has to do the development of a specialized drilling technology that permitted them to make ornaments from this variety of stone, which was much harder than the other rock and mineral varieties they typically used. Bead-makers at Mohenjo-Daro in Sindh evidently began to import vesuvianite-grossular from the FATA and Balochistan to make ornaments during approximately the same period.

I am currently conducting large-scale examinations of the rock and mineral artifact assemblages at the Indus Civilization settlements of Dholavira and Lothal in Gujarat and Rakhigarhi in Haryana. I have not yet encountered vesuvianite-grossular artifacts of any kind among the Rakhigarhi materials. However, finished ornaments composed of high-quality clear, largely fracture-free vesuvianite-grossular have been recorded (and preliminarily confirmed to be that material using specific gravity testing) at both Dholavira and Lothal. Significantly, no flakes or fragments of this stone have yet been observed within the large assemblages of ornament manufacturing waste recovered from those sites. It is, therefore, my provisional conclusion that vesuvianite-grossular ornaments are items that were made mainly or exclusively at Harappa and Mohenjo-Daro. The finest-quality finished examples were then traded to settlements like Dholavira and Lothal. Figure 7.19 is a map depicting these provisional vesuvianite-grossular acquisition and trade networks.

In the next chapter, I examine the acquisition of alabaster – a much more widely available variety of stone that was used to create both small ornaments and, on occasion, very large objects.