23. Raw Materials and Sources

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Archaeologists have recently begun paying greater attention to the raw materials from which artifacts were manufactured. Although "trade artifacts" have long been identified and used for general hypotheses concerning interregional "influences," today artifacts can be scientifically analyzed and sources of their raw materials specifically defined. While these analyses are clearly superior to earlier visual comparisons between artifact composition and source material, scientific characterization is not a Rosetta stone. Characterization provides source data on only a small percentage of the actual (as opposed to the archaeological) cultural inventory. It thus does not serve as a means of documenting entire interaction networks. Nevertheless, it is of substantial value and has contributed greatly to our understanding of some segments of the archaeological record, and has frequently documented that which had previously been conjecture in the realm of trade and exchange.

The Chalcatzingo Project placed special importance upon raw material characterization since both Kenneth Hirth (1978a) and I (Grove 1968c) felt that trade/exchange may have been a significant factor, if not the *raison d'être*, for Chalcatzingo's growth and importance. The results of the characterization studies have been inconclusive in this regard, as perhaps should have been expected. While they demonstrate that Chalcatzingo received raw materials and/or artifacts from other regions, the total data do not elucidate the strength or significance of these inputs, and much remains to be inferred. In fact, the characterization is perhaps most valuable at the local level, where it demonstrates Chalcatzingo's exploitation of resources within the valley.

The exploitation of certain local raw materials which are rare in other regions suggests that Chalcatzingo may have acted as a distributor of these materials to other regions. An intermediary role in the exchange of materials between other regions is also possible. Yet both roles, distributor and intermediary, are difficult to ascertain from the Chalcatzingo data alone, and characterization studies are generally lacking at sites which might have been recipients.

This chapter discusses seven materials found at Chalcatzingo: iron ore, obsidian, greenstone, kaolin, lime, chert, and granodiorite (*cantera*). All of these except kaolin occur in both raw and manufactured states at the site. A generalized map locating the sources of most of these materials in the Río Amatzinac Valley is provided (Fig. 23.1).

IRON ORE

Unworked iron ore fragments as well as worked and polished pieces were recovered at Chalcatzingo from both the surface and excavations. Of the eighty specimens of ore found, only four show any purposeful alteration. In each instance the alteration is present as a relatively roughly ground flat surface. The coarseness of the grinding suggests it was for the purpose of making powder, presumably for use as pigment. The grinding does not seem to be related to the manufacture of polished iron ore artifacts. In addition to the unworked and coarsely ground pieces, thirteen mirrors, including one complete concave mirror found in association with a high-ranking burial (no. 40), were recovered (see below and Chapter 16). Source analyses performed on both the unworked and the polished ore pieces reveal that almost all of the former derive from a local source, while the polished specimens seem to be manufactured only from non-local ores.

Distribution of raw iron ore and polished mirror fragments across the site is non-random. As can be seen in Table 23.1, 58 percent of the raw ore was recovered in the excavations of PC Structures 1 and 2 and T-24. Six raw ore pieces were also recovered from the surface of T-31, suggesting that this unexcavated site area may also have had a significant relationship to iron ore use. Polished mirrors occurred in greatest abundance in the Plaza Central excavations but were also found on T-27, N-5, and S-39, as well as in Cave 1. No raw ore was recovered in these last four excavation areas. Polished iron mirrors usually do not derive from the same contexts or areas which possess the unworked or coarsely ground ore.

Analyses

The most thorough and up-to-date analysis of Mesoamerican iron ore artifacts is currently the work carried out in the Valley of Oaxaca by Jane Pires-Ferreira (1975; 1976b) using Mössbauer spectroscopy (Evans 1975). Through an extensive survey of potential sources in the Valley of Oaxaca and Tehuantepec area, fifty-four sources were sampled, and these provided a base against which to compare raw and worked iron ores being uncovered by the research of Kent Flannery and his associates in the Valley of Oaxaca.

Pires-Ferreira (1975:48–57) has classified and labeled the Oaxacan sources according to their primary composition as follows: Group I, magnetite; Group II, hematite; Group III, ilmenite; and Group IV, mixed magnetite and ilmenite. Groups are frequently subdivided with letter affixes (e.g., I-A, I-B). Some of these groups are relevant to our analyses (below).

The Mössbauer spectroscopy of the Oaxacan samples was conducted by B. J. Evans of the University of Michigan (Evans 1975). For the sake of comparability and consistency in results, Evans consented to run a quantity of the Chalcatzingo samples. Originally fifty-three pieces of iron ore (including four with ground surfaces) and seven mirror fragments were analyzed. Later an additional five samples from a possible source in the Río Amatzinac Valley were analyzed (see below).

The analysis of the Chalcatzingo raw ore samples yielded six distinct clusters. These we have labeled Groups A–F to clearly distinguish them in our discussions from the Oaxacan groups. The comments on the six Chalcatzingo groups are primarily those of Evans (personal communication). On-site distribution of these groups is given in Table 23.1. *Group A.* These are hemomagnetites, in which magnetite is the major phase and hematite is present only in minor amounts (Fig. 23.2). They are not derived from the Oaxacan Group V source and are only grossly similar to artifacts from Oaxacan Group I-A. Thus, they do not appear to be from Oaxacan sources. Of the fifty-three samples analyzed from Chalcatzingo, fourteen (26 percent) are Group A. *Group B.* These are magnetite-hematite ores in which the ratio of magnetite to hematite is approximately 2 : 1 (Fig. 23.3). They are similar to Oaxacan Group V ores but also different enough to determine that the Chalcatzingo samples are not from Group V sources. Eighteen specimens (34 percent) of the sample analyzed belong to this group. *Group C.* This group has a hematite to magnetite ratio of about 1 : 4 (Fig. 23.4). While the six samples (11 percent) constituting this group are similar to the Group I-A archaeological samples from San José Mogote, Oaxaca, the Chalcatzingo specimens are not from that Oaxacan source. *Group D.* The solitary specimen from this group is ilmenite (Fig. 23.5) and has a possible match with Pires-Ferreira's Group III-A, a Oaxacan group with no known source (defined solely on the basis of artifacts). Mirrors from La Venta, Arroyo Pesquero, and San Lorenzo likewise match this unknown source (Pires-Ferreira 1975: Table 15). The Chalcatzingo specimen is from T-24, one of the excavated terraces with abundant iron ore fragments. *Group E.* These five specimens (9 percent) contain less than 2 percent iron, although they may be metallic ores. *Group F.* Similar to Oaxacan Group II, these nine (17 percent) hematite specimens (Fig. 23.6) have a qualitatively different character from Oaxacan source ores, and thus a match is doubtful.

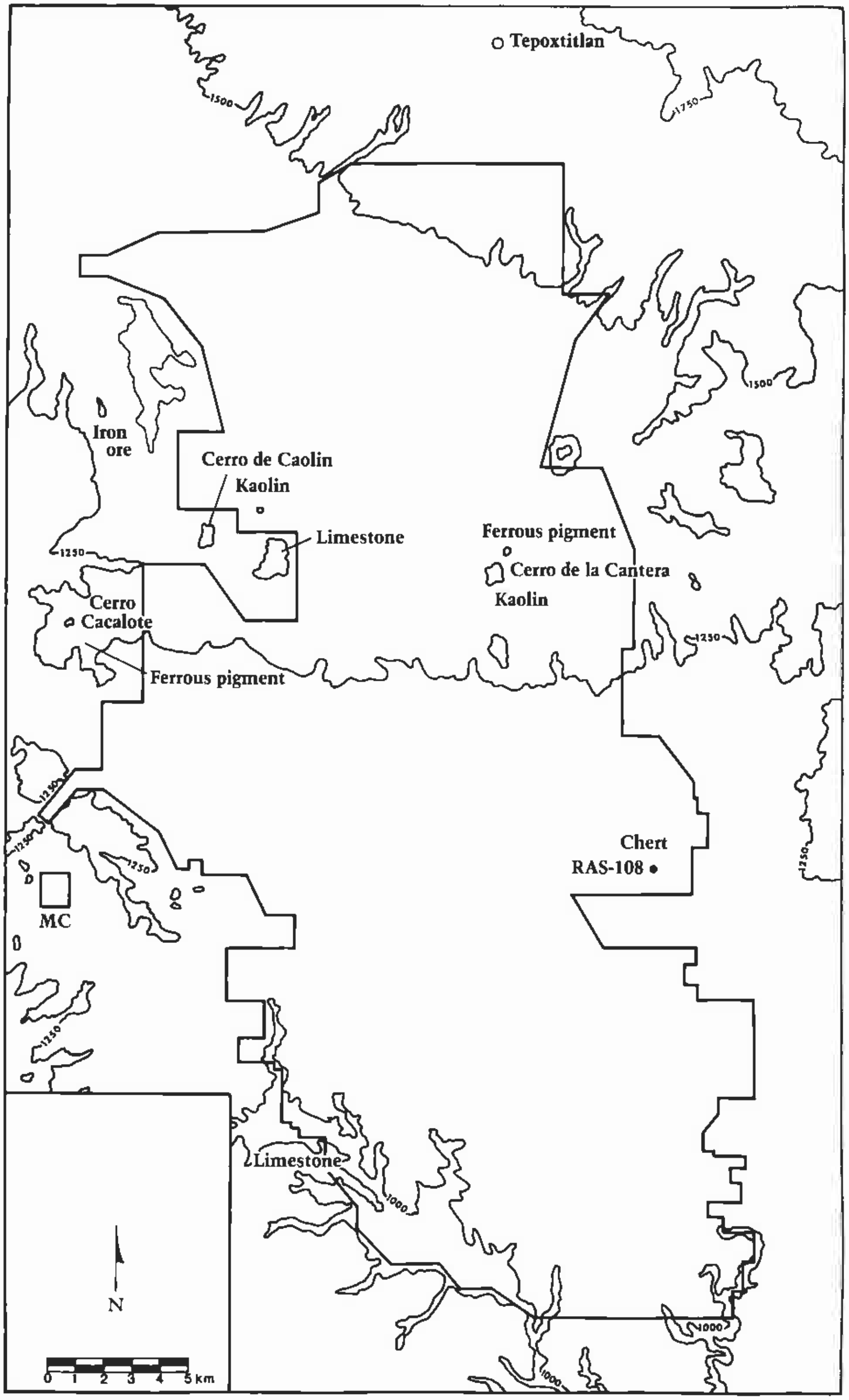

Figure 23.1. Amatzinac Valley, showing locations of mineral resources.

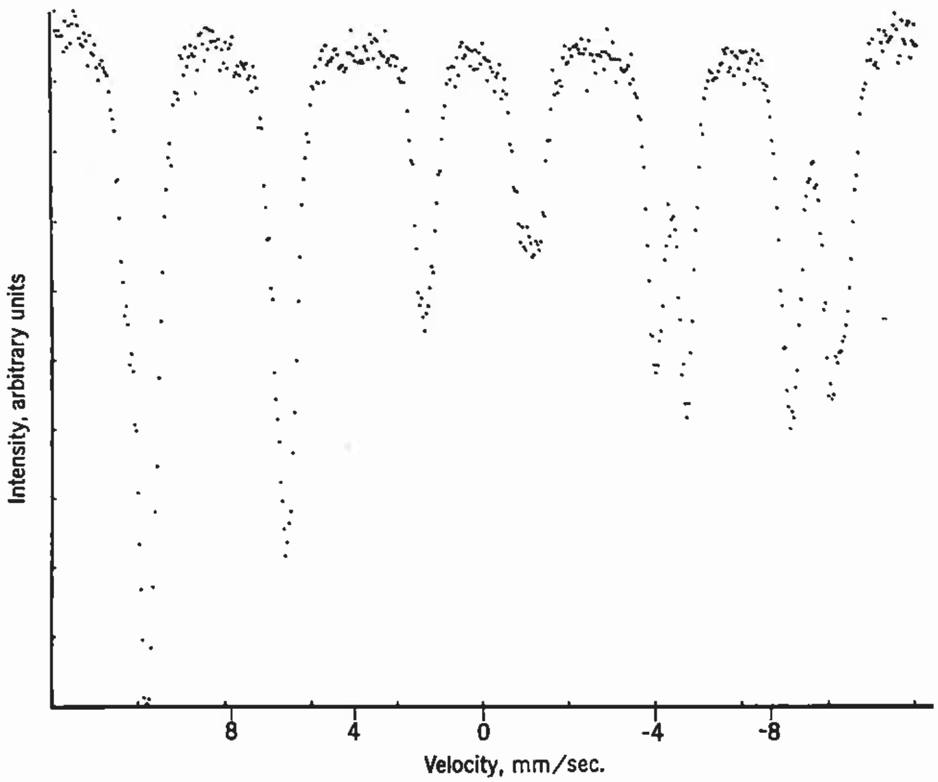

Figure 23.2. Iron ore spectrum, Group A.

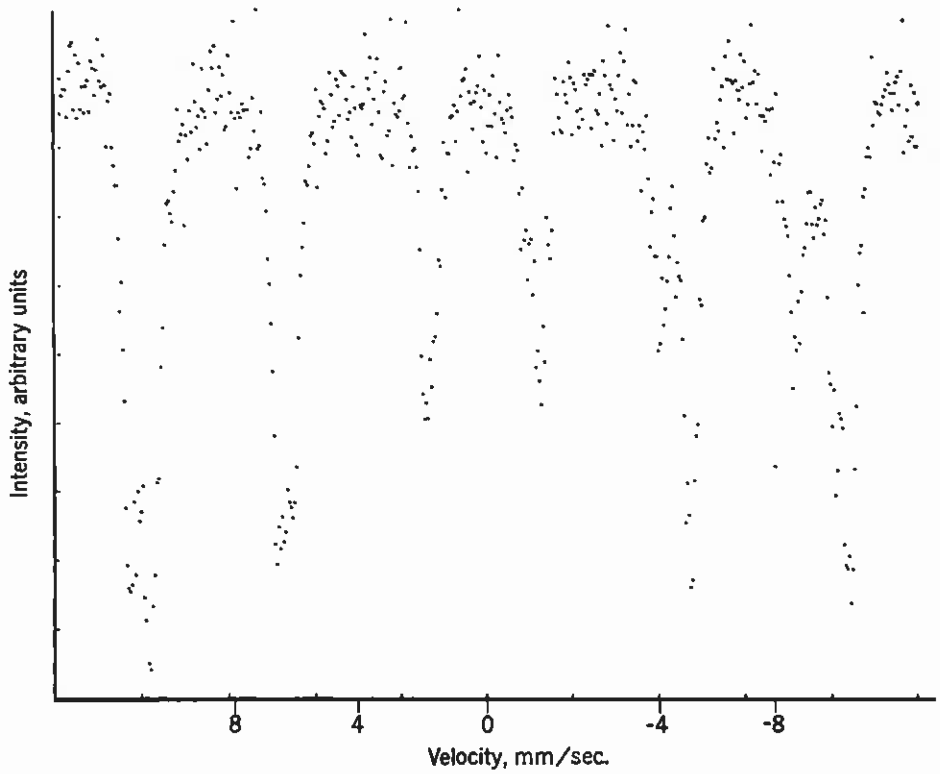

Figure 23.3. Iron ore spectrum, Group B.

Sources

It was not necessary to look outside of the Río Amatzinac Valley area for possible iron ore sources. The valley has long been known as an important source of iron-rich rock. According to Alfonso Luis Velasco (1890:90), the first Spanish iron smelter in Mexico was established at Tepoxtitlan (La Ferrería) near Zacualpan in the northern valley. At least some of the ore for this operation was mined from the hills forming the southwest border of the valley, particularly the Cerro Cacalote. Pit type mines on the Cerro Cacalote were sampled, the material collected consisting of powdered iron oxides rather than solid ore. The bulletin of the Instituto Geológico de México (1923a:216; 1923b:92) also lists hematite and magnetite as occurring near Xalostoc.

Carl Fries (1966) identified a ferrous-rich area near Chalcatzingo. This locale, in the barranca of the Río Amatzinac northwest of Tetla, gives indications of having been lightly mined by the excavation of a shallow cave along a section of the iron-rich sedimentary strata. This "mine," presumed to have been prehispanic due to the presence of Middle Postclassic sherds, would have produced red sediments suitable only for pigment.

At the time of Evans' analysis of the iron ore pieces found on the site, the sources mentioned above either had not been found or had not yielded solid ore samples. Following the analyses, which lacked close similarities to Oaxacan sources, we began a serious attempt to locate the published sources in the western valley. Aside from the pit-like mines on the Cerro Cacalote and the small cave-like feature in the barranca behind Tetla, no other vestiges of prehispanic or colonial mining were found. Ultimately, a hillside between Atotonilco and Xalostoc was surveyed and discovered to have numerous iron ore chunks scattered over the surface. These ore fragments were visually identical to those recovered at Chalcatzingo.

Five samples from this locale were analyzed by Evans. Four were surface specimens taken from widely scattered parts of the hillside (to present a representative sample, if such was possible). The fifth sample came from a modern shallow mine near the top of the hill. Visually this last sample was substantially different from the four surface specimens submitted for testing.

The analysis showed samples 1, 2,

and 3 to be hemomagnetites and good matches to the Chalcatzingo Group A specimens (Fig. 23.7). Sample 4 is magnetite-hematite and matches well with Group B ores (Fig. 23.8). Because minor mining activities have been carried out in the area for a long period of time, it is possible that the surface samples represent spill from loads being carried from other areas of the hill. However, there seems little doubt that this area is the source for both Group A and B specimens, 60 percent of the Chalcatzingo sample analyzed.

Sample 5 is very complex in terms of iron phases present and has no matches with any analyzed archaeological materials.

Mirrors

Seven of the thirteen polished mirrors from Chalcatzingo were analyzed. None are manufactured from Group A or B materials, and all are attributed to imported ores. (See Chapter 16 for provenience of these specimens.) *Mirror M-1.* This complete concave mirror (Fig. 16.22*a*) is unusual, for it consists primarily of high-purity magnetite along with a small amount of some other iron-containing phase which may be an iron sulfide. Evans (personal communication) notes that it is the first time he has seen that kind of spectrum (Fig. 23.9). More unusual is the fact that none of the large mirrors tested for Pires-Ferreira (1975: 48–65) have such a high magnetite content. They are normally ilmenite. There is no match to any known source.

Mirror M-2. This fragment is composed exclusively of ilmenite, and its spectrum is identical to the single ilmenite Group D specimen found on T-24. It is also similar to Oaxaca Group III-A, but the match is not perfect. The presence on T-24 of unworked ilmenite ore and a mirror fragment from the same source suggests that the mirror was not necessarily imported as a finished product but could have been manufactured locally from imported ore. Artifactual evidence of mirror manufacturing (numerous small worked and unworked fragments) such as occurs at San José Mogote, Oaxaca (Flannery et al. 1970), does not occur in excavations or as surface scatter at Chalcatzingo. *Mirrors M-3, M-7, and M-9.* These fragments are made from high-purity hematite ores and are closely similar to our Group F ores. Group F, as stated earlier, is similar but probably not related to Oaxaca

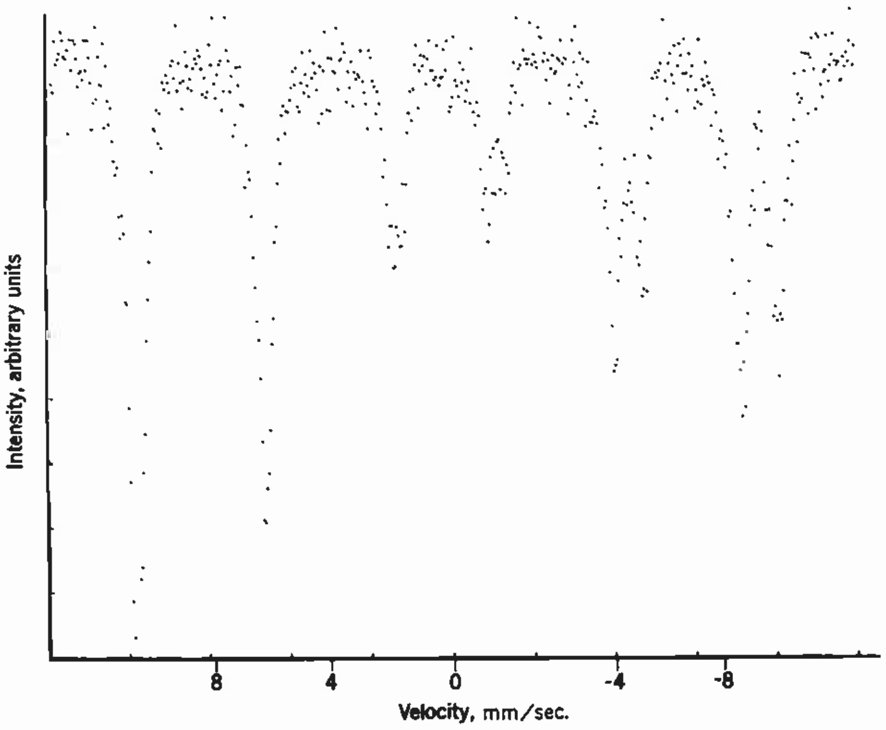

Figure 23.4. Iron ore spectrum, Group C.

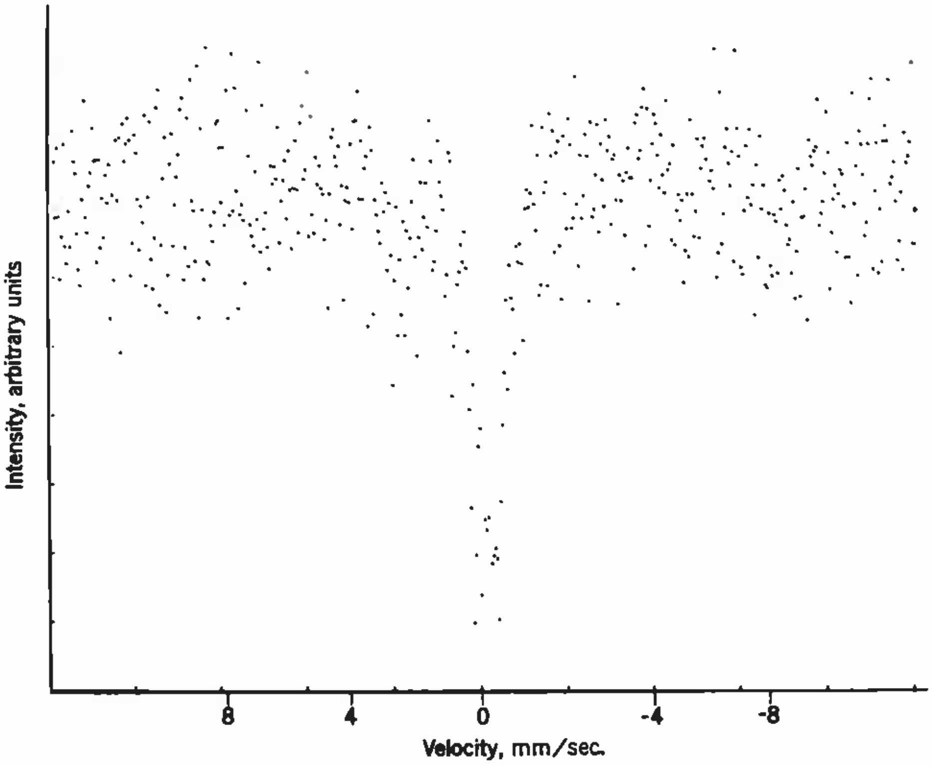

Figure 23.5. Iron ore spectrum, Group D.

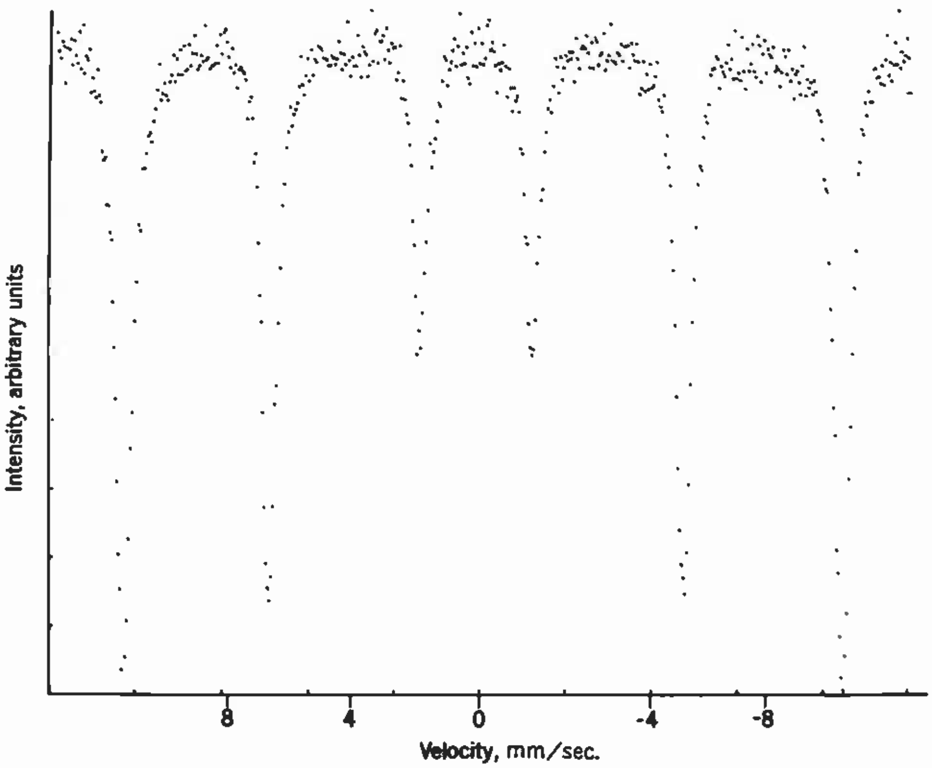

Figure 23.6. Iron ore spectrum, Group F.

Group II. Group F ore specimens have the widest and most varied distribution on the site (Table 23.1). Their source is still undetermined. If the presence of polished and unworked fragments from the same ore source can be taken as evidence of workshop activity (e.g., Mirror M-2), then these data suggest that such activity took place at Chalcatzingo, apparently with non-local iron ores.

However, it is again worth noting that while Group F unworked ore pieces occur at eight different contexts at Chalcatzingo, those same contexts did not yield any polished fragments or other debris which might be expected if individual houses (the context of most specimens) also functioned as mirror workshops. There are other explanations for imported ore fragments in house contexts, including the possible use of the ore for grinding into pigments, or the storage of iron ores in the houses as part of an exchange system participated in by the site's occupants. *Mirrors M-5 and M-8.* These consist exclusively of magnetite, although not as pure as the magnetites found in some Oaxacan mirrors (Evans, personal communication). According to Evans, these two mirror fragments are a "perfect match" to Oaxaca Group I-A, the Loma de la Visnagra source near the north end of the Valley of Oaxaca (Pires-Ferreira 1975:49–54, Table 11). One other Morelos mirror fragment is also known to derive from this source (ibid.:Table 11). It is presumed on the basis of present data that these mirrors were imported into Morelos in an already manufactured form.

Table 23.2 summarizes the identification of ore sources for the analyzed Chalcatzingo mirrors.

OBSIDIAN

Nearly every level of every unit excavated at Chalcatzingo yielded obsidian chips, blades, or small chunks (Chapter 18). Literally thousands of pieces were recovered. In addition, excavations of T-37 uncovered a Cantera phase dump of obsidian debris which yielded over 28,000 pieces (Chapter 19). Because only a limited quantity of the total sample could be source analyzed, a sampling decision had to be made to provide a test sample covering adequate chronological and spatial distributions as well as providing representation of the possible range of sources. My decision was to take, where possible, non-random, selective samples from floor area contexts of most house structures and, where such contexts were not available for certain phases, to take non-random samples from units pertaining to that phase. These non-random samples, which consisted of three to five obsidian pieces from each major unit, were selected visually for what appeared to be different types of obsidian (cloudy, clear, banded, black, etc.).

In addition, a random sample of twenty-five pieces was collected from the T-37 obsidian dump. Further small samples from Late Formative T-27, Telixtac, and Huazulco materials (see Chapter 22), the Tetla Postclassic house (Chapter 25), and comparative Early Formative samples from San Pablo and Nexpa (Grove 1974b) were submitted for analysis. Our analysis comprised a total of ninety pieces of obsidian.

In approaching the trace element characterization of Chalcatzingo's obsidian artifacts, we were aware that a great variety of methods had been utilized in previous analyses of Mesoamerican obsidian, and the results of such studies were therefore not always comparable. To date, three major analytical techniques have been used. The obsidian from San Lorenzo was analyzed with optical spectroscopy (Cobean et al. 1971). Berkeley researchers used both X-ray fluorescence (Jack and Heizer 1968; J. Weaver and Stross 1965) and neutron activation (Stross et al. 1968) in analyzing obsidian from a number of Mesoamerican sites, and Pires-Ferreira (1975; 1976a) likewise used neutron activation for the obsidian recovered by Flannery's Human Ecology Project in the Valley of Oaxaca. Neutron activation appears to be becoming the most popular analytical technique, and this method was chosen for our analysis.

One major problem which had to be faced in planning the Chalcatzingo analysis lay in the number of elements to be selected for the final characterization. While other analyses had tested for up to sixteen chemical elements, only two, three, or four elements were ultimately used for source identification and comparison. The elements most frequently selected were iron (Fe), manganese (Mn), sodium (Na), rubidium (Rb), strontium (Sr), zirconium (Zr), and yttrium (Y). Pires-Ferreira's analysis of Oaxacan obsidian artifacts used only Na and Mn. More commonly, three elements—Rb, Sr, and Zr—were tested and plotted upon a tri-pole graph (e.g., Jack and Heizer 1968; Stross et al. 1968). The use of a limited number of elements obviously lends itself to simple graphs for the identification of clustering.

Another source of variability among obsidian characterization studies lies in the manner in which the quantity of each element in a sample is expressed: percentages (Pires-Ferreira 1975; 1976a), counts per second over background (Stross et al. 1968), or parts per million (Cobean et al. 1971). Compounding this problem is the use of different calibration standards. The result is a series of site-specific analyses which are not readily comparable. Thus, as we approached our analysis of the Chalcatzingo obsidian, there was no standard methodology, reporting procedure, or standardized source data to draw upon. Our solution to this last problem was to conduct our own characterization of source material.

Source materials were made available by Thomas Charlton and Robert Zeitlin (Table 23.3). Although highland Guatemalan sources were included among the samples provided, we restricted our analysis to the central Mexican samples, since previous studies (Cobean et al. 1971; Pires-Ferreira 1975; 1976a) strongly indicated that the expected exploitation pattern would be of only central Mexican sources. The results bear out that assumption. Among the eighteen sources tested were Otumba (the so-called Teotihuacan Valley–Barranca de los Estetes source), Paredon (a source north of Teotihuacan recently rediscovered by Charlton), and Guadalupe Victoria, Puebla. This last source, on the lower slopes of Orizaba Volcano, is known to have been an important contributor of obsidian to the Gulf Coast Olmec center of San Lorenzo (Cobean et al. 1971).

Neutron activation analyses were carried out on the Chalcatzingo samples by Philip Hopke of the Environmental Research Laboratory of the University of Illinois. Thirty different chemical elements were recorded. The analytical methods followed are discussed by Charlton, Grove, and Hopke (1978). Because we did not want to restrict ourselves initially by using only a few elements to compare site samples to source samples, computer programs for discriminate cluster analyses using four different dissimilarity matrices and seven possible clustering criteria were carried out for twenty-seven of the thirty chemical elements. We then eliminated some elements which appeared insignificant, and carried out additional computer runs with eight and later with four elements. We constantly checked the clusters provided by the computer against our own observations of possible patterns. The results were generally consistent and definitely surprising. All of the programs clearly identified a significant portion of the Chalcatzingo samples as coming from the Paredon source.

Although the Chalcatzingo obsidian characterization study was the first to utilize samples from the rediscovered Paredon source, previous studies had not

***Table 23.1.* On-Site Distribution of Iron Ore Groups (Excavation and Surface Specimens Excluding Mirrors)**

	Group						
Provenience	*A*	*B*	*C*	*D*	*E*	*F*	*Unanalyzed*
PC Str. 1	5	7	1			1	6
PC Str. 2	3	5	1		2	1	2
PC Str. 6					1		3
PC other							2
T-4	1					1	3
T-6							1
T-7		1					
T-11		1					
T-15					1	1	
T-19	1						
T-20	1					1	
T-23	1					1	1
T-24	2		2	1	1	1	5
T-25		2	1				2
T-31		1	1			2	2
Cave 4		1					

***Table 23.2.* Iron Ore Mirrors and Sources**

Chalcatzingo Group F	*Oaxaca Group I-A*	*Oaxaca Group III-A / Chalcatzingo Group D*	*Source Unknown*	*Unanalyzed*
M-3	M-5	M-2	M-1	M-4
M-7	M-8			M-6
M-9				M-10
				M-11
				M-12
				M-13

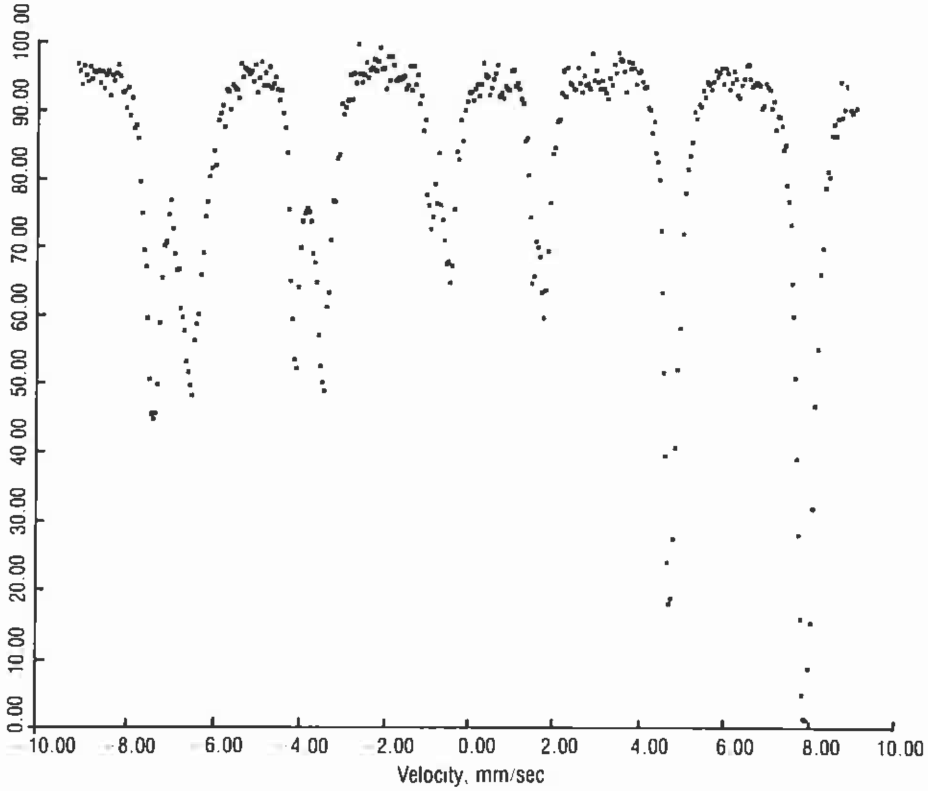

Figure 23.7. Iron ore spectrum, Source Sample 1 (matches Group A).

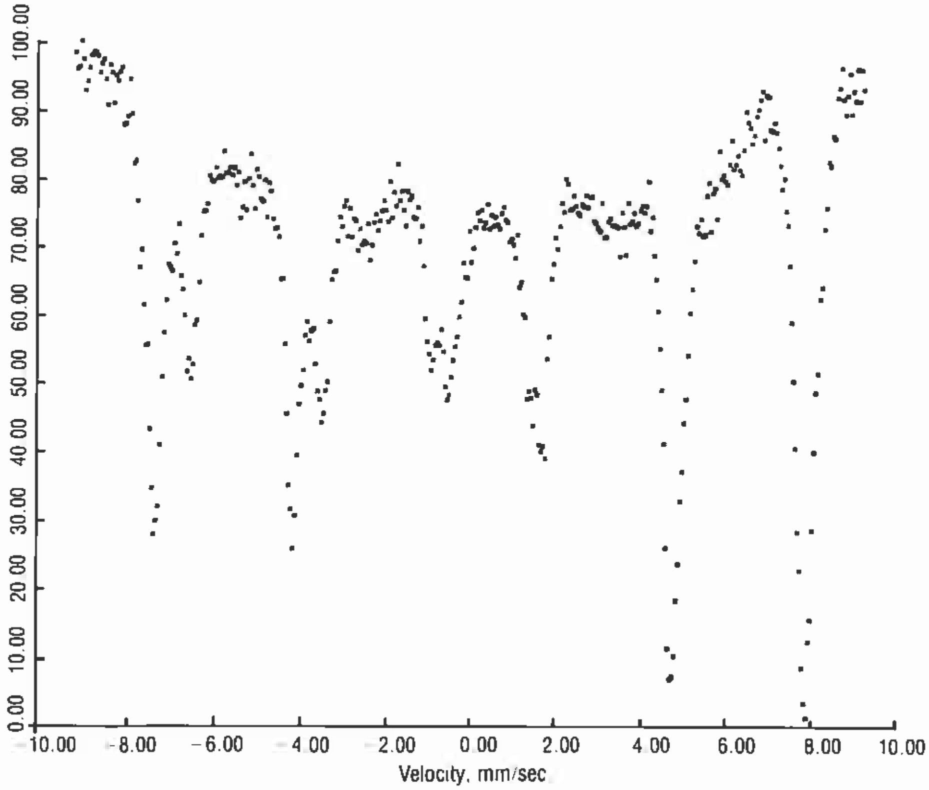

Figure 23.8. Iron ore spectrum, Source Sample 4 (matches Group B).

set apart an "unidentified" source among their samples. Table 23.4 demonstrates that distinguishing between Otumba and Paredon obsidian is virtually impossible with the elements commonly used in obsidian analyses: Mn, Na, Rb, Sr, and Zr. The elements which serve to differentiate these two sources are barium (Ba), lanthanum (La), and arsenic (As). Thus, obsidian from archaeological contexts in Oaxaca and the Gulf Coast previously identified as from the Teotihuacan Valley (Otumba) source probably includes Paredon obsidian as well.

The fact that our analysis was able to separate Otumba and Paredon sources is significant because all of the obsidian tested from the Early and Middle Formative levels at Chalcatzingo originated at these two sources. The Guadalupe Victoria source, so important in the Gulf Coast lowlands, is unrepresented, and logically so. If obsidian exchange is viewed in terms of "cost efficiency" for handling and transportation, then sources nearest to the site should show the greatest amount of exploitation, and at Chalcatzingo this seems very clearly to be the case. In fact, because Otumba is nearer to Chalcatzingo than Paredon, it should be expected that Otumba obsidian would constitute the larger percentage of the sample, and the data show exactly this. Otumba obsidian makes up 68 percent of the random sample from the T-37 Cantera phase obsidian trash dump, while Paredon contributed 32 percent. Only two Pachuca green specimens, a type common during the Classic period, occur in the Cantera phase materials tested.

Amate phase, Barranca phase, Late Formative, and Middle Postclassic samples, as well as those from the valley sites of Huazulco and Telixtac and Nexpa–San Pablo in central Morelos, were selectively chosen. With the exception of the Middle Postclassic specimens, all sample groups contained both Otumba and Paredon obsidian. The Middle Postclassic sample, from the floor of the Tetla house (Chapter 25), contained four Otumba specimens and one piece of Pachuca green obsidian. Because these samples were selective, their percentage distribution is meaningless.

From the data gathered during this analysis it is clear that Formative period Chalcatzingo received obsidian from two sources almost exclusively, Paredon and Otumba. The minimal data from Telixtac, Huazulco, Nexpa, and San Pablo suggest that those sites likewise received obsidian originating from the same two sources. The exclusivity of Otumba and Paredon sources in Morelos during the Formative, together with the proximity of those two sources to each other, suggests that the obsidian was probably pooled prior to its arrival in Morelos. This pooling, I presume, was carried out by a Valley of Mexico community acting as intermediary. If two separate exchange systems, one tied to each source, had been in operation, greater intraregional variation and stronger ties of one site to one source might be expected. Such is not the case.

My undocumented observation is that Chalcatzingo has a greater quantity of surface obsidian debris than have other Middle Formative sites in the Río Amatzinac Valley. This observation, together with the presence of a workshop, suggests that the site was probably a redistribution center for both worked and unworked obsidian in the valley (and perhaps an intermediary in obsidian exchange over greater distances). However, until further work is carried out, this remains simply conjecture.

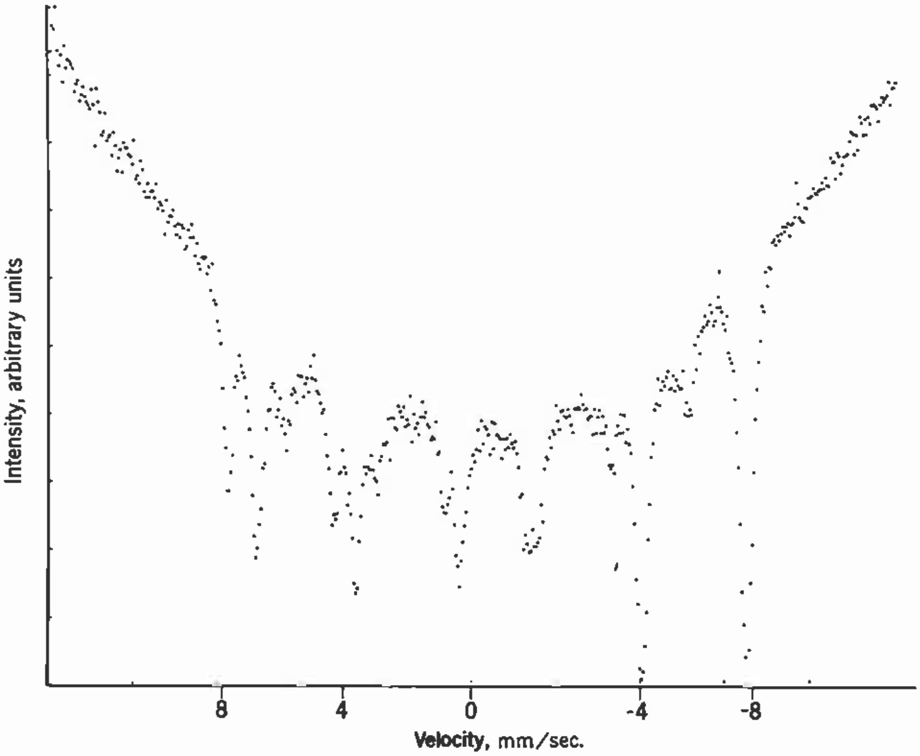

Figure 23.9. Iron ore spectrum, Burial 40 concave mirror.

GREENSTONE

Characterization studies of greenstone (jadeite, serpentine, etc.) are still in their infancy, particularly outside of the southern Maya area. Central Mexican greenstone sources remain essentially at the hypothetical level. Data suggest that jadeite may occur near Acatlan, Puebla (Ortega-Gutiérrez 1974), an area which William Foshag (1957:12) notes may have been a source for the antigorite used in some "Olmec" figurines. The chlorite schists of north-central Guerrero may likewise have yielded jadeite (e.g., Coe 1968a:102–103), but little related exploratory field work has been carried out anywhere in the central highlands.

At this time the only recent characterization study relevant to our materials is that of Phil Weigand, Garman Harbottle, and Edward Sayre (1977) on turquoise exchange between the U.S. Southwest and Mesoamerica during the Classic period. A great number of tiny mosaic fragments, apparently turquoise, were found adjacent to the skull of Chalcatzingo Burial 40. Turquoise is rare in Middle Formative archaeological contexts, and characterizations of the Chalcatzingo mosaic pieces would be of substantial interest. However, we attempted no greenstone characterization since without source data such analyses would be of little value.

The Chalcatzingo greenstone artifacts and raw materials were studied by Charlotte Thomson (Chapter 17, Appendix F). She distinguished five categories of greenstone in our sample: jadeite (several types and thus probably several sources), Chalcatzingo mottled jadeite, serpentine, fuchsite, and other (chrysoprase, chalcedony, etc.). All of these are apparently non-local, since geology appropriate to the presence of greenstone does not occur in this area of eastern Morelos. Her analysis concludes that Chalcatzingo and La Venta received their finer-quality greenstones from the same supplier (and the same sources). Current data do not permit any more elaborate conclusions.

Drill cores and partially worked fragments of greenstone indicate that some lapidary activities were carried out at Chalcatzingo. These activities appear to have been minor, however, and were probably only for consumption at the site and within the Río Amatzinac Valley.

KAOLIN

Circumstantial evidence points to kaolin clay (kaolinite) as probably having been a significant local raw material exploited and perhaps exported by Chalcatzingo. The only source of kaolinite in the Morelos–western Puebla area, according to the Instituto Geológico de México (1923a; 1923b), is in the *municipio* of Jonacatepec, Morelos. Chalcatzingo lies just outside the *municipio's* northern boundary, and in fact, the southern slopes of the Cerro Chalcatzingo are within the *municipio.* The presence of kaolinite to the south of the site is confirmed by the biological and mineralogical map of Morelos (Mazari 1921).

Informants mention that kaolin clay from this source or sources was exploited until the Zapatista revolution. It was apparently used as a white colorant for sugar produced by the local haciendas. The revolution wiped out the sugar industry in eastern Morelos, and the kaolin demand apparently died with it. We were able to locate only two people who remembered kaolin mining near Jonacatepec. One man, in his nineties, was too infirm to show us the source he remembered and at the same time insisted that

***Table 23.3.* Obsidian Source Samples Tested**

Contributor	*Contributor's Sample ID No.*	*Source*	*Description*
T. Charlton	5704	Tulancingo, Hgo.	Green-brown, clear
	5705	Pizarrín	Goldish, clear
	5706	Navajas (Nopalillo)	Fine green, clear
	5707-A	Navajas	Gold bands in black obsidian, inclusion dots
	5708	Otumba (Barranca del Muerto)	Cloudy grey (grey caused by tiny bubbles)
	5709	Otumba (TA-79)	Cloudy grey (grey caused by tiny bubbles)
	5710	Otumba (TA-325)	Clear to cloudy with black bands
	5712-1	Paredón	Clear
	5712-2	Paredón	Clear
	5713	Paredón	Clear
	5714	Paredón	Clear, some dot inclusions
R. Zeitlin	MB-1-1	Penjamo, Gto.	Clear
	MC-1-1	Zinapecuaro, Mich.	Cloudy
	MD-2-1	El Paraiso, Qro.	Clear to streaked
	MD-4A-1	Fuentezuelas, Qro.	Clear light grey
	MD-5-1	Cadereyta, Qro.	Ink black
	ME-1-2	Tulancingo, Hgo.	Grey-green
	ME-2-1	Rancho Tenango, Hgo.	Banded green-brown
	ME-6-1	Teotihuacan	Cloudy, streaked
	ME-7-1	Metzquititlan, Hgo.	Dark streaky grey
	ME-8-1	Cruz de Milagro, Pachuca	Goldish
	ME-10Z-7	Huasca, Hgo.	Very black
	ME-11-1	El Ocote, Hgo.	Clear green
	ME-12-1	Otumba	Cloudy, streaked
	MF-1-1	Guadalupe Victoria, Pue.	Cloudy, black dot inclusions
	MF-3-1	Pico de Orizaba, Ver.	Clear, light streaks
	MF-4-1	Altotongo, Ver.	Very dark brown

***Table 23.4.* Neutron Activation Results on Otumba and Paredón Obsidian**

Element	*Otumba Ranges*	*Paredón Ranges*
Na	2.94–3.16	2.92–3.16
Mn	364–386	351–360
Rb	114–133	130–178
Sr	102–211	120–162
Zr	56–105	71–119
Ba	708–909	80–179
Ln	23–30	51–64
As	3–6	11–16

rather than tell us where the "mine" was, he would take us there personally. We made numerous inspections of aerial photographs as well as reconnaissances of the area on foot. We sampled a number of exposures of "*tierra blanca*," but none proved to be kaolinite.

A second informant, working for the state government in Cuernavaca, told us of kaolin mining in the past near the village of Tlayca to the west, across the valley from Chalcatzingo. A hill immediately south of Tlayca is locally termed the Cerro de Caolin (Fig. 23.1). Unfortunately, at the time we went to Tlayca to take samples from exposures and tunnels on the hill, we were prevented from doing so due to an unfavorable local political situation.

At the moment, the value of locating kaolin sources for any reason other than to verify their presence is questionable. Unlike obsidian and iron ores, which can be characterized by trace minerals, kaolin, once fired, apparently cannot. Thus, present analytical techniques do not permit raw kaolin or kaolin ceramics to be associated with specific kaolin sources or analytically compared.

The question arises as to how important kaolin was in the Middle Formative. Amatzinac White sherds from Chalcatzingo were analyzed by X-ray diffraction at the Illinois Geologic Survey. The featureless readings strongly suggest that the slip is kaolin. It was definitely not a carbonate (lime) slip. We tested over 100 Amatzinac White sherds, taken at random from many site locations, with hydrochloric acid, which would have detected a lime carbonate slip, with negative results. "Whitewashed" daub fragments from a Cantera phase structure were also tested with hydrochloric acid, and again the results were negative. This suggests that the white pigment was probably kaolin.

In sum, the evidence for kaolin exploitation by Middle Formative Chalcatzingo is circumstantial. Kaolin was apparently used as the slip on the ubiquitous Amatzinac White ceramics, which data suggest were locally manufactured. Kaolin was also apparently used as a pigment for "whitewashing" structures. Chalcatzingo lies close to a kaolin source (or sources) known to have been exploited early in the twentieth century. If Formative period Chalcatzingo residents exploited this local kaolin, as they probably did, then they may have also exchanged kaolin to more distant villages lacking this clay. Although the Instituto Geológico de México (1923a; 1923b) data may be out of date, as of 1923 the source near Chalcatzingo was the only kaolin source listed for Morelos and one of only seven listed in all of central Mexico. If most Middle Formative white wares utilized kaolin slip (a hypothesis remaining to be tested), then the demand for kaolin would have been extensive, while the sources may have been few. Kaolin would have thus been an important commodity in the Middle Formative exchange networks.

CHERT

During the surface reconnaissance which covered almost the entire valley (Chapter 21), a small hill in the south-central valley (RAS-108, Appendix H) was found to be composed primarily of red chert. Numerous chert cores were found here, and red chert is found at many other sites in the valley. This suggests that RAS-108 was an important local chert source. Some of the chert artifacts at Chalcatzingo probably derived from this source, although the color variability among the Chalcatzingo sample suggests the possibility that other unidentified sources were being exploited as well (Chapter 18).

More data are needed on the color variability, quantity, and distribution of the RAS-108 chert within the valley and at sites outside of the area as well in order to determine to what extent Chalcatzingo and other communities were exploiting this source and how this chert was transmitted along exchange networks.

LIME

Limestone outcrops occur in the hills on the west and south flanks of the valley (Fig. 23.1). Some of these sources are commercially exploited today. Our evidence for lime use during the Formative period at Chalcatzingo is quite restricted. Excavations on S-39, the southernmost occupation area, uncovered a thin but somewhat extensive deposit of processed lime underlying Cantera phase vessels and burials (Fig. 4.36). Gravel-sized lime pebbles (also processed by firing) were occasionally found during excavations at other site areas (e.g., the Plaza Central cross-trench, T-9B, T-25), but never in associations which would allow the identification of their function.

There are data which lead us to believe that S-39 may have been a ceramic workshop area (Chapter 16). At the same time, we have no data indicating that lime was used in ceramic manufacturing. Our tests on Amatzinac White slip (above) suggest it is kaolin and not lime. Other slips, such as Laca, remain to be tested.

Lime could have been used in the preparation of corn, although the S-39 deposit is the only large lime concentration uncovered. While there are no substantial data to indicate that corn was processed with lime during the Middle Formative, the flat shallow plates with roughened bases (see the RD ceramic forms, Chapter 13 and Appendix D) may be early *comales* (griddles) which would further imply that tortillas made from processed corn were part of the Chalcatzingo diet.

Evidence for Classic period lime use is more extensive since three lime kilns from this period were found during our excavations (Chapter 24). The lime processed at Chalcatzingo was probably utilized in both maize preparation and the making of stucco. Traces of lime plaster occur on T-3 Structure 1, the round pyramid. The Postclassic hillside shrine also shows extensive use of lime plaster.

Figure 23.10. Boulder on hill with large cut.

Figure 23.11. Boulder on hill showing two cuts.

GRANODIORITE

Chalcatzingo's Formative period free-standing monuments are manufactured from the local granodiorite (*cantera*). While large boulders are abundant on this hillslope and could have been worked into almost any form, mining may have taken place at selected areas on the *cerros*. During the project we encountered an area midway up the southern slopes of the Cerro Chalcatzingo with a large partially worked and grooved slab (MCR-12) and other probable slab fragments nearby. More recent investigations of stone exposures above this area indicate that here the rock has natural lamellar fractures which would produce slabs suitable for stelae, etc., with less reworking necessary than would be required with other rocks. Two large, thick, horizontal-lying boulders in the immediate area had been partially cut through (Figs. 23.10, 23.11). These data indicate that quarrying and initial reworking of some *cantera* took place in this locale. Since we have no evidence for Classic or Postclassic use of large worked slabs, we presume this quarry to have been utilized during the Formative period.

Although there has been hacienda period and recent "mining" of *cantera* boulders at the base of the hill for use elsewhere (Chapter 2), there is no evidence that this was an important prehispanic source of monumental-size stone for the rest of the valley. Other sites in the area did not, to our knowledge, utilize stone stelae or monuments, and utilitarian implements would have been more readily fashioned from river stones easily accessible almost anywhere in the valley.

RESUMEN DEL CAPÍTULO 23

En el proyecto tuvo especial importancia la caracterización de las materias primas de los artefactos como medio para ganar información acerca del comercio e intercambio locales y distantes. Se centra la discursión alrededor de siete tipos de materia prima: mineral de hierro, obsidiana, piedra verde, kaolín, cal, quarzo, y cantera. Los resultados de los análisis probaron ser de valor fundamentalmente para entender la explotación de los recursos minerales dentro del Valle del Río Amatzinac.

La espectroscopía Mössbauer reveló que, de los muchos trozos de mineral de hierro encontrados en Chalcatzingo, la mayoría proviene de un área de recursos situada en la sección poniente del valle. Varios fragmentos de espejo pulido, sin embargo, son iguales a los que provienen de los recursos del Valle de Oaxaca, lo que sugiere que éstos hayan sido importados.

La activación de neutrón se utilizó para buscar la caracterización de elementos en los artefactos de obsidiana del sitio. El análisis indica que la obsidiana del Formativo Temprano y Medio proviene de dos recursos, Otumba y Paredón, ambos situados al nororiente del Valle de México. La información sugiere que la obsidiana probablemente fuera "reunida" antes de llegar a Morelos.

Los artefactos de piedra verde no se sujetaron al análisis de caracterización, por no existir suficientes datos de las áreas de recurso. Toda la piedra verde parece ser de importación en Chalcatzingo. Hay alguna muestra de que el trabajo del tipo blando de piedra verde se realizara en Chalcatzingo, probablemente limitado al consumo dentro del área local.

El kaolín era una materia prima importante utilizada para el engobe de la cerámica Amatzinac Blanco de Chalcatzingo y para blanquear algunas casas. Se conoce un recurso de kaolín cerca del sitio, pero el kaolín es una de las pocas materias primas que por naturaleza no pueden ser actualmente caracterizadas con éxito. Sin embargo, la proximidad de Chalcatzingo a esta importante materia prima implica que el sitio pudo haber jugado un papel importante en la distribución de este material durante el período Formativo Medio en las tierras altas del centro de México.

Se encontró una loma de quarzo al sur del valle (sitio RAS-108). Este material parece haber sido explotado localmente y distribuido por medio de una red de intercambio centralizada aquí, al sur del valle y no en Chalcatzingo.

La piedra caliza se encuentra en las lomas a lo largo del poniente y del sur del valle. La cal procesada se encontró en un contexto del Formativo Medio en Chalcatzingo, pero los usos a los cuales haya sido destinada no han sido determinados. La cal pudo usarse en el procesamiento de maíz, pero no parece haber sido usada como pigmento blanco en la manufactura de cerámica.

La cantera de la localidad sirvió como material para los monumentos con soporte propio encontrados en el sitio. Los trozos de roca se obtenían de los macizos que sobresalen en las laderas del sur del Cerro Chalcatzingo, en donde hay muestra de estos talleres todavía a la vista.