Obsidian Trade at San Lorenzo Tenochtitlan, Mexico

Analysis of obsidian artifacts emphasizes the role of trade in the rise of Olmec civilization.

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The Olmec civilization is now recognized as the earliest complex culture in Mesoamerica, if not in the entire pre-Columbian New World. This civilization is pristine, in the sense of having been the first to appear in the area and of having developed its major traits in virtual isolation. In this way, it is comparable to pristine civilizations of the Old World, such as the Shang in China or the Sumerian in Mesopotamia. Archeological excavations and radiocarbon dating have shown that the Olmec civilization flourished in the hot, wet lowlands of the Mexican Gulf Coast, from about 1150 to 400 B.C., many centuries before the appearance of other complex cultures in Mesoamerica.

Perhaps one of the most significant facets of the rise and evolution of a pristine civilization is its trade and procurement systems. These systems are revealed either by the identification of manufactured articles that are typical of other sites, or by the identification of raw materials from sources that have unique chemical or physical properties.

In Mesoamerica, as in the Mediterranean and Near East, obsidian trade prospered. Dixon, Cann, and Renfrew (*1*) have used the concentrations of trace elements in obsidian to determine sources in the latter two areas. Obsidian trade, if it is significant, acts as an indicator of general trade and procurement during a particular time.

The importance of obsidian for the economy of ancient Mesoamerican peoples was probably similar in magnitude to that of steel for the economies of modern industrial nations, for the Mesoamerican peoples manufactured most of their tools and weapons either from or with obsidian and no doubt considered it a necessity for existence. Because the overwhelming majority of nonceramic artifacts in Mesoamerican sites are made from obsidian, it has become obvious (*2*) that an analysis of the sources of obsidian should indeed throw great light upon ancient trade and procurement systems in Mesoamerica.

The oldest Olmec site so far recognized is San Lorenzo Tenochtitlan, which is actually a complex of three sites in southern Veracruz, Mexico, near the middle reaches of the Coatzacoalcos River. Three field seasons of work conducted by Yale University and the Instituto Nacional de Antropología e Historia (*3*) have demonstrated that the San Lorenzo site itself, a partially man-made plateau lying about 50 meters above the surrounding plains, may well represent the oldest civilized community in Mesoamerica. During its apogee, which was in the San Lorenzo phase (1150 to 900 B.C.), almost all of the famous Colossal Heads and other gigantic basalt sculptures were carved.

The large number of obsidian artifacts recovered at the San Lorenzo site (7747 pieces from unmixed deposits) indicates the importance of obsidian in the inhabitants' economy. Distinctive identifying criteria, especially the concentration of trace elements in obsidian, can be used to assess a population's changing patterns of obsidian acquisition.

Obsidian does not occur naturally in the Olmec "heartland" proper; thus its presence at an Olmec site indicates that it was imported, either through trade or direct procurement. Obsidian was present throughout the long and complex sequence at San Lorenzo Tenochtitlan (*4*), although in differing quantities for each phase. During the first known occupation of the San Lorenzo site (Table 1), in the Ojochi phase (circa 1450 to 1350 B.C.), there are only small, crude flakes in small amounts. The succeeding Bajío (1350 to 1250 B.C.) and Chicharras (1250 to 1150 B.C.) phases show a slight decrease, then increase, in the importation of obsidian. Blades do not occur in any significant amount until the first purely Olmec occupation, which was in the San Lorenzo A subphase (begun by 1150 B.C.). There is a vast increase in the importation of both blades and flakes in the San Lorenzo B subphase, which ended in the partial destruction of San Lorenzo around 900 B.C. There is a definite decrease in importation during the Middle Formative period (Nacaste and Palangana phases), which follow San Lorenzo B. After a long hiatus, during which the area seems to have been essentially abandoned, came the Toltec-influenced Villa Alta phase (circa A.D. 900 to 1200), which marks another great increase in the importation of obsidian.

Obviously, the amount of obsidian obtained by the residents of San Lorenzo Tenochtitlan reflects, in large part, the size of the population at any given time. An even more reliable population index would be the number of metate and mano fragments, since every household had at least one set of maize-grinding stones. Figure 1 shows that population must have been a significant factor; for instance, the peak of obsidian importation during the Formative period was in San Lorenzo B, which also had the peak population, as determined by the number of manos and metates.

By dividing the number of obsidian artifacts—blades, flakes, or the total—by the total number of metates and manos for each phase, it should be possible to arrive at a rough estimate of the household consumption of obsidian. Figure 2 shows that, with the exception of the aberrant Ojochi phase (the conclusions about which are probably distorted by the small sizes of the samples), there was a net increase in the amount of obsidian used by the households of San Lorenzo Tenochtitlan throughout all of the phases, particularly throughout the Formative period. This may be an indication of the gradual rise in prosperity, or "buying power," of the individual in this part of Mesoamerica; if so, the highest level of prosperity was

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attained by Villa Alta times, in the Early Post-Classic Period. The ability of the local inhabitants to obtain finished obsidian artifacts rather than crude flakes also rose and fell. Because we recovered only 11 definite blade cores, it can be assumed that the majority of the 2796 blades Coe found had been imported as finished products into San Lorenzo Tenochtitlan; thus their presence is a good index to native buying power.

Sampling and Analysis

Obsidian is a volcanic glass that is chemically similar to granite. Obsidian deposits in Mesoamerica (with the possible exception of Guerrero) occur principally in the east-west volcanic cordillera of central Mexico and the highlands of Guatemala. Twenty-five of the sources of obsidian in Mexico and Guatemala were sampled by Cobean in 1969 (Fig. 3).

In the process of collecting samples from the obsidian sources, the entire source area was investigated wherever possible. However, a number of sources, such as Pachuca and the Ixtepeque Volcano, are so extensive that only a small fraction of their vast quantities of obsidian could be surveyed during the same time available. At least three samples were taken from different sections of each source, the weights of the samples varying between 5 and 300 grams.

We selected from the collection recovered at San Lorenzo Tenochtitlan those artifacts within each cultural phase that represented the widest possible differences in color and in surface appearance, in the hopes of thereby obtaining samples from most or all of the obsidian sources used during each phase. We also took great care to select obsidian artifacts from only those archeological deposits that were as free as possible of admixture with materials that had been deposited in earlier occupations of the site.

In one case, for the San Lorenzo A phase, a random sampling was made in addition to the selective sampling based on physical characteristics. The complete contents of one bag, 37 flakes and blades recovered from the same excavation unit in a midden, were analyzed with the aim of providing a statistical picture of obsidian procurement by a particular Olmec household at one point in time.

The obsidian samples were ground and then made into pellets at 25 tons per square inch (6.5 square centimeters). Concentrations of iron, manganese, rubidium, strontium, and zirconium were determined by x-ray emission spectroscopy without the use of matrix corrections, inasmuch as the narrow range of the concentration of major elements in the obsidians was adequately simulated by the U.S. Geological Survey standard granite G-1. The use of strip chart recordings speeded the method and gave a standard deviation of 10 percent. Each obsidian sample was analyzed in duplicate. In addition, 25 of the samples were analyzed in duplicate for manganese and sodium by neutron activation (*5*), which gave a standard deviation of 2 percent. This procedure allowed a finer discrimination where necessary.

Results

The most significant elements in identifying compositional groups are rubidium and zirconium. Figure 4 is a scatter diagram of the artifacts on a zirconium-rubidium plot. Of the 25 sources of obsidian sampled, only eight appear to be represented in the artifacts at San Lorenzo Tenochtitlan. The artifacts that did not come from any one of the eight sources appear to cluster around five to seven other sources, from which we did not take samples. Approximately 83 percent (by weight) of the artifacts we analyzed are from the eight identified sources. The obsidians from each are distinguishable by their appearance, flaking characteristics, and concentrations of trace elements (Table 2).

Table 1. Obsidian sources utilized during each phase at San Lorenzo Tenochtitlan. (Group A, Group B, and so on are compositional groups from unknown sources. Superscripts: 1, projectile point; 2, knife or knife-scraper; 3, graver; 4, flake core; 5, blade core; and 6, nodule.)

Phase	Sources (No.)	Flakes	Blades	Other
Ojochi	3,* *4*†	Guadalupe Victoria Pico de Orizaba El Chayal *Group C'*‡		
Bajío	3, *4*	Guadalupe Victoria Pico de Orizaba Group D *El Chayal*		
Chicharras	3	Guadalupe Victoria El Chayal Teotihuacan		
San Lorenzo A	5	Guadalupe Victoria El Chayal Group A Group E	Teotihuacan Group A Group E	Guadalupe Victoria[2] Teotihuacan[1] Group A[1]
San Lorenzo B	8, *11*	El Chayal Ixtepeque Volcano Pachuca Group B *Group E*	Guadalupe Victoria Teotihuacan Group B Group E *Pachuca* *Ixtepeque Volcano* *El Paraiso* *Group C'*	Guadalupe Victoria[2] El Chayal [1,2,5] Ixtepeque Volcano[1,6] Group A' [1,2] *El Paraiso*[1] *Altotonga*[1,5]
Nacaste	9, *10*	Guadalupe Victoria El Chayal Ixtepeque Volcano Group A *Teotihuacan* *Group C*	Pachuca Teotihuacan El Paraiso Group C' *Altotonga*	Altotonga[1] *Guadalupe Victoria*[3] *Ixtepeque Volcano*[1]
Palangana	6, *8*	El Chayal *Guadalupe Victoria*	Teotihuacan El Paraiso Group A' Group C' *Altotonga*	Guadalupe Victoria[4] El Paraiso[1] *Pico de Orizaba*[3]
Villa Alta	8, *10*	Guadalupe Victoria Pachuca Group B El Paraiso *El Chayal*	Pachuca Teotihuacan Group A Group C *Group B* *El Paraiso*	Pachuca[1,3] Teotihuacan[2,3] El Paraiso[3] Group C [3] Group C' [1,3,5] Group A[5] *Pico de Orizaba*[5] *El Paraiso*[5]

* Unitalicized number includes only sources with highly probable identifications. † Italicized number includes tenuous as well as highly probable identifications. ‡ Italicized words indicate a tenuous correlation between the artifact and the given group.

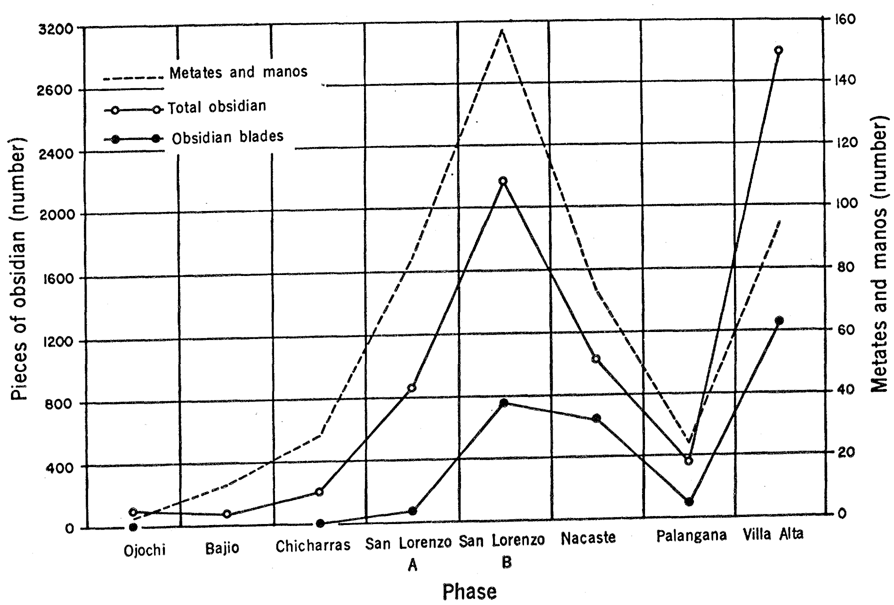

Fig. 1. Occurrence of obsidian artifacts and maize-grinding stones (metates and manos) at San Lorenzo Tenochtitlan, by phase.

Obsidian from the Guadalupe Victoria–Pico de Orizaba area is the only obsidian we found to have zirconium present in trace amounts (< 50 parts per million); it also has distinctive banding. Obsidian from the Pachuca area has more than 600 parts of zirconium per million and a unique green color. Ixtepeque obsidian is distinguished from Teotihuacan obsidian by the concentrations of zirconium and rubidium alone, while the concentrations of manganese and strontium present further differentiate Teotihuacan, El Chayal, and El Paraiso obsidians. Obsidian from Altotonga correlates well with some of the artifacts on the basis of rubidium, strontium, and manganese concentrations, although the concentration of zirconium in the artifacts is in the upper end of the range from that source. This correlation is, thus, less definite than the correlations between the other artifacts and their respective sources. Obsidian from San Bartolomé, Guatemala, was found, on the basis of x-ray fluorescence,

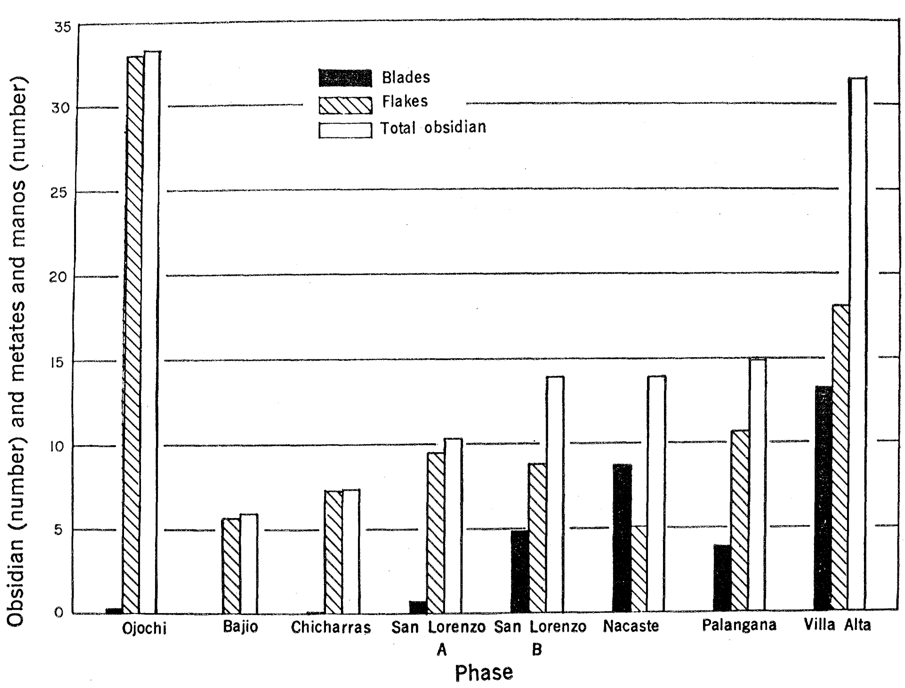

Fig. 2. Ratio of obsidian to metates and manos at San Lorenzo Tenochtitlan. This is by numbers of artifacts, rather than by weight.

to have a composition similar to that of Teotihuacan obsidian, but the high ratios of manganese and sodium in these samples, as determined by neutron activation, allowed us to distinguish between them (the average ratios are 0.0120 and 0.0156, respectively, with no overlap).

A more detailed description of the eight sources follows.

Guadalupe Victoria, Puebla (M-F1, M-F2), and Pico de Orizaba, Veracruz (M-F3): These sources are the products of the Orizaba Volcano, and they lie on its west and east flanks, respectively. The Orizaba Volcano was probably the most important source of obsidian in Mesoamerica during the Formative period, and was in use shortly after 6500 B.C. We have determined that an obsidian point of the Midland type, ascribed to the El Riego phase in Tehuacan, is of the same compositional group as obsidian from the Orizaba Volcano; we thus conclude that Orizaba obsidian was being used shortly after 6500 B.C. Typically, Guadalupe Victoria and Pico de Orizaba obsidian is banded with grey and has a rather irregular surface because of many small inclusions, which give it a poor flaking quality (although the Pico de Orizaba samples appear to be less opaque). Because of their uneven texture, these obsidians are probably unsuitable for making prismatic blades. Only one blade was identified with this source.

Altotonga, Veracruz (M-F4): This is the second closest known source of obsidian to San Lorenzo Tenochtitlan. It lies about 50 kilometers northwest of Jalapa. In a ravine 1 kilometer north of the small town of Altotonga, there are large nodules of dark, translucent obsidian, which are associated with volcanic ash formations. This obsidian has a smooth texture and appears to be of good working quality.

Teotihuacan (M-E4, M-E5): The Arroyo de Estetes on the eastern edge of the Valley of Teotihuacan is the source of the Río San Juan, and in its arroyo an obsidian flow is exposed. It consists of "staircase" formations of black obsidian flows sandwiched between layers of red ash and lava. Cobbles of grey obsidian were found among the exposures of black obsidian. This material has matte bands in reflected light.

Pachuca sources: The obsidian mines in the Sierra de las Navajas north of Pachuca, Hidalgo, were first described by Holmes and recently by Spence and Parsons and by Charleton (*6*). The two localities sampled are Cruz del Milagro (M-E8, M-E9) and El Ocote (M-E10, M-E11), which produce the bottle-green obsidian for which the Pachuca sources are famous. However, in addition to this color, a darker and coarser green was also found.

El Paraiso, Querétaro M-D2): The correlations between artifacts and obsidian from this locality are based on samples from a source about 10 kilometers north of the highway between the city of Querétaro and San Juan del Río, on a ranch near the village of El Paraiso. It is a fine, black obsidian and occurs in outcrops of thin bands separated by layers of ash.

El Chayal, Guatemala (G-C1): This is certainly Guatemala's major source

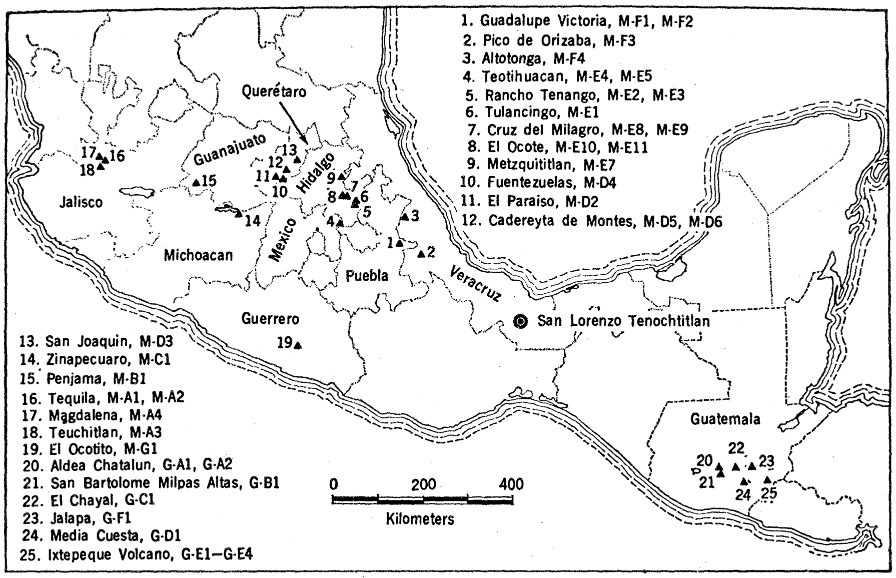

Fig. 3. Mexican and Guatemalan sources of obsidian, sampled during the 1969 and 1970 surveys.

Table 2. Range of the concentrations of trace elements in obsidian groups. (The distinctions between groups A and A′ and between groups C and C′ may be arbitrary, but, in each case, besides the differences in concentration of trace elements, there are consistent differences in color and texture.)

Source—artifact group	Specimens		Range of concentration (parts per million)			
	Source (No.)	Artifact (No.)	Zirconium	Rubidium	Strontium	Manganese
			San Lorenzo artifacts and identified sources			
Guadalupe Victoria, Puebla	5	62	30– 50*	95–130	60– 90	720–1130
Pico de Orizaba, Veracruz	1	2	30– 50*	125–135	30– 50*	~930
Pachuca, Hidalgo	7	13	600–870	175–210	n.d.†	1275–1625
Ixtepeque Volcano, Guatemala	7	12	130–185	95–120	140–170	580– 770
Teotihuacan, Mexico	5	18	115–160	120–150	120–150	535– 675
El Chayal, Guatemala	3	27	100–135	145–190	135–170	840–1130
El Paraiso, Querétaro	3	14	85–130	140–195	n.d.	220– 275
Altotonga, Veracruz	3	7	120–175	155–185	30– 50*	360– 420
			San Lorenzo artifacts with unknown sources			
Group A	0	10	160–195	175–190	n.d.	520– 590
Group A′	0	4	180–190	200–205	n.d.	510– 520
Group B	0	4	95–100	105–120	n.d.	290– 350
Group C	0	10	140–165	130–150	30– 50*	335– 375
Group C′	0	12	150–175	150–175	30– 50*	335– 375
Group D	0	1	30– 50*	100	n.d.	495
Group E	0	5	140–165	155–170	n.d.	520– 610
			Sampled sources not recognized at San Lorenzo			
Rancho Tenango, Hidalgo/ Tulancingo, Hidalgo	2/2	0/0	485–650	130–145	30– 50*	565– 580
Metzquititlan, Hidalgo	2	0	175–180	285–300	30– 50*	205
Fuentezuelas, Querétaro	2	0	70– 80	220–225	n.d.	375
Cadereyta de Montes, Querétaro	2	0	580	180	n.d.	390
San Joaquin, Querétaro	2	0	510	255	n.d.	350
Zinapécuaro, Michoacan	2	0	90	200–210	n.d.	260
Pénjamo, Guanajuato	2	0	470–630	170–190	n.d.	510
Tequila, Jalisco	2	0	200–225	115–125	55– 60	480
Magdalena, Jalisco	2	0	195–230	160–180	n.d.	630– 650
Teuchitlan, Jalisco	2	0	265–460	185–195	n.d.	480
El Ocotito, Guerrero	2	0	100–125	150–170	30– 50*	260
Aldea Chatalun, Guatemala	2	0	110–125	120–130	180–200	650– 680
San Bartolomé Milpas Altas, Guatemala	2	0	120–145	140–145	120–130	660– 750
Jalapa, Guatemala	2	0	120–125	165–180	180	670
Media Cuesta, Guatemala	2	0	130–150	125–135	160–175	710

* Estimated. † n.d., Not detectable (level of detection ~ 30 parts per million).

of obsidian. It is located on a small hill 25 kilometers northeast of Guatemala City (7). A road has been cut through part of this hill, exposing quantities of black and grey-striped obsidian nodules. This source ranks with the Pachuca mines as one of the greatest obsidian workshops in the New World.

Ixtepeque Volcano, Guatemala (G-E1 through G-E4): Huge quantities of grey-striped, solid grey, and solid black obsidian, as well as minor quantities of mottled red material, have been produced by this volcano. Extensive workshop areas have been reported (8) in the nearby ruins of Papalhuapa.

The artifacts not clearly associated with one of these eight sources cluster into five to seven other compositional groups. On the assumption that these groups represent sources that were not sampled in this study, we use them in discussing the variety and changes of sources of obsidian found at San Lorenzo Tenochtitlan. These are designated A, A′, B, C, C′, D, and E.

Discussion

Olmec civilization at San Lorenzo Tenochtitlan emerged, matured, and then abruptly collapsed (or was destroyed) over a period of 5½ centuries, from the Ojochi through the San Lorenzo B phases. Various aspects of these cultural processes and events are reflected in the patterns of obsidian trade during this period. The number of sources being exploited during each phase (Table 1) greatly increased between the Ojochi phase (four sources) and the San Lorenzo B subphase (probably 11 sources). It is especially significant that most of this increase in trade took place between the San Lorenzo A subphase (five sources) and the San Lorenzo B subphase. The great expansion of the obsidian trade at this point, along with certain other cultural traits that distinguish the San Lorenzo B from the San Lorenzo A subphase, indicates that certain major changes had occurred in the magnitude or the structure, or both, of the Olmec cultural sphere.

The patterns of obsidian trade show that the Olmec peoples were constantly establishing new commercial relationships with peoples in other areas of Mesoamerica. The importation of obsidian from El Chayal, Guatemala, as early as the Ojochi phase and from Teotihuacan by Chicharras times is especially interesting because it took place several centuries earlier than any known occupations of these source areas, both of which eventually became the centers of great civilizations.

The last line in Table 3 tabulates the number of new obsidian sources that appears in each phase of the archeological sequence, while the other lines record the net gains and losses of sources throughout these phases. The striking expansion of obsidian trade in the San Lorenzo B subphase could have been the result of several cultural processes. It is still uncertain whether the Olmecs developed an empire controlling extensive areas in Mesoamerica outside their heartland on the Gulf Coast; however, the sharp rise in trade and the general elaboration of Olmec civilization during the San Lorenzo B subphase may well have been associated with an empire. Recent archeological research (9) has shown that during the Formative period there were strong Olmec influences, and even Olmec trade objects, at many cultural centers beyond the heartland. It has been suggested (10) that these influences could have been the result of expeditions or colonization by Olmec merchant-warriors similar to the Aztec *pochteca*.

Our data clearly support the hypothesis that trade played a major role in the expansion of Olmec influence in Mesoamerica, whether or not military con-

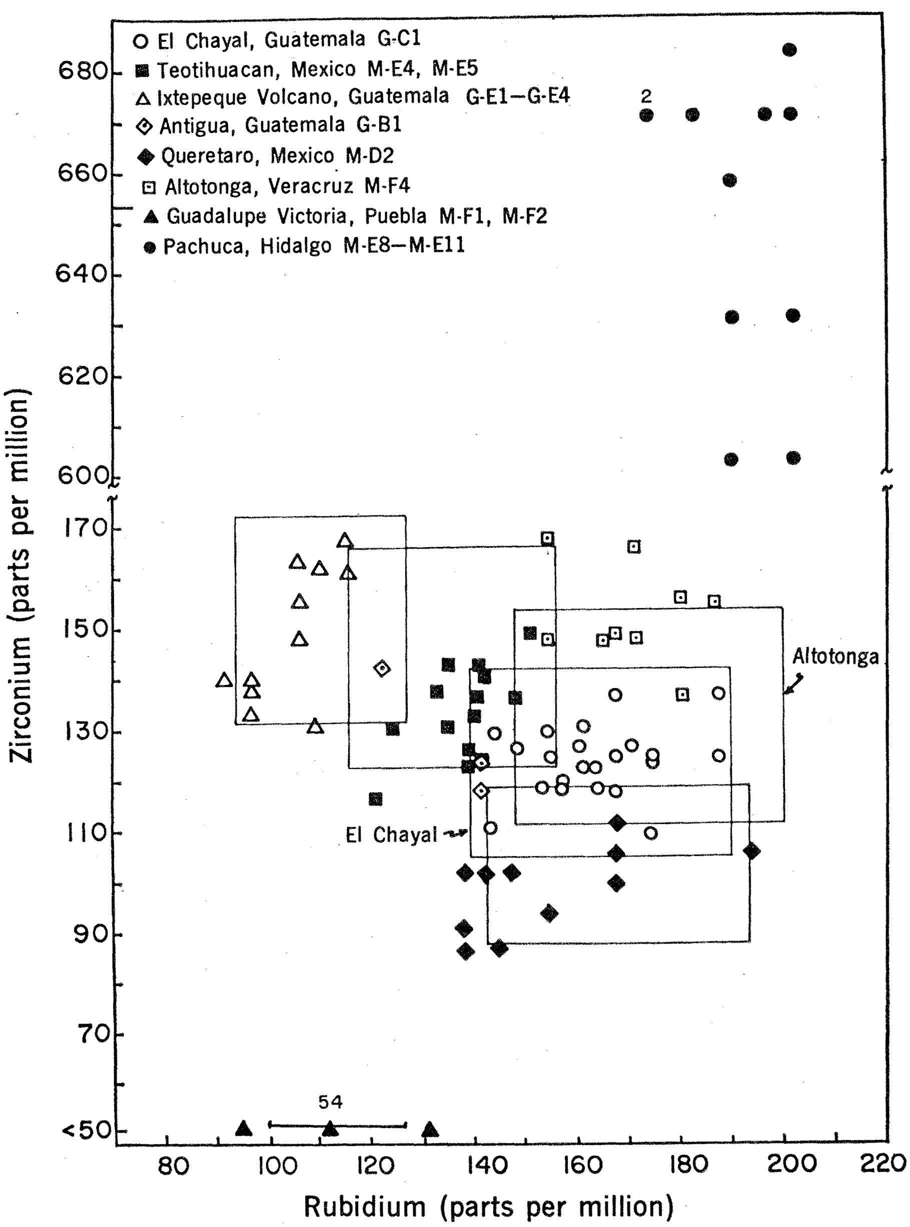

Fig. 4. Zirconium-rubidium plot of obsidian sources and correlated artifacts from San Lorenzo Tenochtitlan. The rectangles were constructed to represent a 15 percent variation in the mean composition of the source materials.

Table 3. Appearance and disappearance of obsidian sources exploited by San Lorenzo Tenochtitlan throughout all phases. (All data from Table 2 are included.)

Sources	Phase							
	Ojochi	Bajío	Chicharras	San Lorenzo A	San Lorenzo B	Nacaste	Palangana	Villa Alta
Added	4 (initially)	1	1	2	7	2	2	4
Subtracted	—	1	2	0	1	3	4	2
Net gain or loss	—	0	−1	+2	+6	−1	−2	+2
First appearance of new	—	1	1	2	6	1	0	0

quest played its role too. Religion was another important factor in this process, with many trade activities probably taking place in a religious context. Cults centering upon werejaguars and other Olmec deities spread throughout much of Mesoamerica during the Formative period and appear to have provided the foundations for many aspects of later religions in those regions. Significantly, however, most Olmec cult objects, such as the famous carved jades and the iron-ore mirrors, were made from exotic materials that were procured through trade.

Many of the fundamental patterns and processes in the Olmec economic system cannot be confidently reconstructed at present. For instance, obsidian and other foreign commodities might have been brought to San Lorenzo in several ways. The most likely of these are (i) expeditions in which the Olmecs themselves went to the sources, mined the obsidian, and transported it back to their centers; (ii) ordinary trade, in which the Olmecs exchanged local raw material or manufactured goods for obsidian; and (iii) ritual exchange, in which the Olmecs traded goods or services having mainly religious or symbolic value (but also possessing important economic functions) for obsidian supplied by outside peoples.

The great distance between San Lorenzo Tenochtitlan and most of the obsidian sources makes it highly unlikely that the inhabitants acquired the bulk of their obsidian through mining expeditions. The sources in Guatemala and Hidalgo are more than 800 kilometers by air from San Lorenzo Tenochtitlan and much further by foot or canoe. Thus, the Olmecs must have participated in a trade network with peoples who supplied them with obsidian and other exotic materials. This may have been a ritual exchange system along the lines of the famous *kula* ring of the Trobriand Islands.

Obsidian is the only major, long-distance trade material in the Olmec occupation of San Lorenzo Tenochtitlan that we have been able to associate with specific sources. Petrographic analysis (*11*) shows that basalt for sculptures and for metates and manos was brought in from the Tuxtla Mountains 80 kilometers away, a considerable feat considering that some of the Olmec monuments weigh over 20 tons (18,144 kilograms). While no trade pottery has been found, a wide variety of other exotic goods has; for example, mirrors and beads, possibly of Oaxaca origin, made of polished magnetite, ilmenite, and hematite. Besides the expansion of the obsidian trade in the San Lorenzo B subphase, there was a dramatic increase in the amount of serpentine and flint being imported. Clay figurines of nonlocal design also appear, including some with features vaguely reminiscent of heads from the Valley of Mexico. Other imports in the San Lorenzo phase include fish (red snapper) and bitumen from the coast, along with mica and schist.

Evidence of the kinds of goods that the Olmecs might have exchanged for foreign materials is very incomplete. Workshops engaged in the manufacture of ear spools and beads from serpentine, schist, and other exotic stones were operating in San Lorenzo times. Many of the items exported from San Lorenzo Tenochtitlan, however, must have been ceremonial or prestige objects, such as pottery decorated with Olmec religious motifs, or large, hollow, baby-faced figurines; significantly, these items appear in the rubbish at San Lorenzo Tenochtitlan, whereas in the highland sites of Tlatilco and Las Bocas they were used as grave furniture.

The analysis of obsidian artifacts used during the Formative period in a number of Mesoamerican settlements that show Olmec influences should provide considerably more information on the role of trade in the initial emergence of the Olmec civilization and in the subsequent rise of other Mesoamerican civilizations.

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