Reports

Olmec Civilization, Veracruz, Mexico: Dating of the San Lorenzo Phase

Abstract. *Archeological excavations at San Lorenzo Tenochtitlan, Veracruz, show that the Olmec sculptures of this zone are associated with the San Lorenzo phase, which can be placed in the Early Formative period (1500–800 B.C.) on the basis of ceramic comparisons. Five of six radiocarbon dates for the San Lorenzo phase fall within the 1200–900 B.C. span. The San Lorenzo phase therefore marks the beginning of Olmec civilization, and the sites forming the San Lorenzo Tenochtitlan group represent the oldest civilized communities known in Mexico or Central America.*

The Olmec civilization of Mexico was discovered by Stirling, who excavated several sites in southern Veracruz and Tabasco between 1939 and 1946. The size of great Olmec ceremonial centers like La Venta, the gigantic proportions of some Olmec sculpture, and the sophistication and delicacy of the art style have convinced some scholars, mainly Mayanists, that this civilization could not be older than that of the Maya. On the other hand, Stirling and certain Mexican archeologists—principally Caso and Covarrubias—have claimed the Olmec civilization to be the oldest in all of Mesoamerica (*1*). This claim was substantiated by the excavations carried out at La Venta in 1955 by the University of California; a number of radiocarbon dates from that ancient center showed that La Venta was constructed and occupied from about 800 B.C. through 400 B.C., roughly contemporary with what has been called the Middle Formative period. It predates the earliest Maya civilization by several centuries (*2*).

The first of three seasons of field work at the Olmec sites collectively known as San Lorenzo Tenochtitlan (Fig. 1), in southern Veracruz, was begun in January 1966. The aims of this project are (i) to discover the origin and nature of Olmec civilization in this zone, (ii) to provide a means of dating the Olmec monuments, and (iii) to throw light on ancient human ecology and agricultural practices in the humid tropics.

We know of only three major archeological sites in the zone. Tenochtitlan is the largest and is located just to the south of the bank of the Río Chiquito, an arm of the Río Coatzacoalcos; the site has long mounds arranged in linear fashion like La Venta. San Lorenzo is much smaller, with fewer and lower mounds, and is placed on a much dissected plateau about 2.5 km south of Tenochtitlan. The third, Potrero Nuevo, is the smallest and lies some 3 km south-southeast of San Lorenzo. All three were explored by Stirling and Drucker in 1946 (*3*); the collections from these excavations are only now being studied at Yale (*4*). Most importantly, they brought to light a large number of fine Olmec sculptures, including the largest colossal heads yet discovered—enormous, freestanding, basalt sculptures believed to be portraits of Olmec lords. San Lorenzo alone produced 15 monuments, most of which were found in, or on the slopes of, ravines which cut into the plateau.

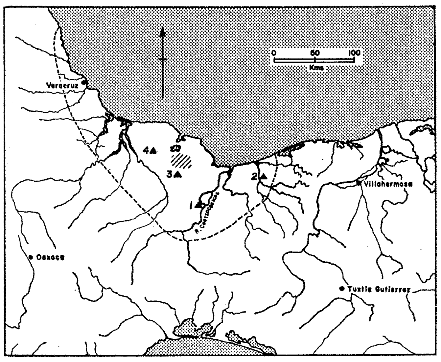

Fig. 1. Important Olmec sites of southern Veracruz and Tabasco. *1*, San Lorenzo Tenochtitlan; *2*, La Venta; *3*, Laguna de los Cerros; *4*, Tres Zapotes. The broken line encloses the Olmec "heartland" in which large-scale stone monuments are found. The source of the basalt used in the San Lorenzo Tenochtitlan sculptures is indicated by hatching.

Several additional monuments were found in the intervening years. In 1966 we excavated three more at San Lorenzo in an attempt to establish the stratigraphic record, that is, to associate the sculptures with a cultural phase which could be dated by normal methods, such as cultural comparison and radiocarbon analysis. Monument 19 was deeply buried on the edge of a precipitous ravine on the southeast side of San Lorenzo, and proved to be a badly damaged head. Monument 20, sunk deep into the ground on the northwest edge of the site, is a large "altar," with a figure sitting in a niche and holding a werehjaguar baby. The monument was definitely correlated with strata and pits rich in potsherds and figurines. Monument 21 was discovered with one of its corners protruding from the surface at the head of a small ravine. On excavation, it proved to be a rectangular block of stone with the back hollowed out; the obverse shows a relief of a running animal, perhaps a jaguar or coyote. It had been placed facedown over an offering of seven stone celts and blanks for celts, all of serpentine, along with large fragments of pottery vessels and charcoal. The "destruction" of the San Lorenzo monuments was not a haphazard affair but was carefully planned, with a good deal of ritual activity. When was this carried out and by whom? We have at least a partial answer to the first of these questions.

Stratigraphic cuts were also made in the riverbank at Tenochtitlan, where the present-day Río Chiquito has cut through a deeply stratified succession of village materials, which reach down to almost 6 m below ground level. It was here that Drucker in 1946 found two great stone columns at the deepest level excavated.

All of the pottery and other artifacts from the 1966 season have now been studied. There are only two archeological phases or cultures detectable in the San Lorenzo Tenochtitlan group; they are separated from each other by a very long period of abandonment. The later phase, which we are

Table 1. Dating of samples of wood charcoal from stratified hearths of the San Lorenzo phase, taken from the riverbank cut at Tenochtitlan, Veracruz, Mexico. B.P., before present.

Sample	Source (hearths)			Date
	No.	Level	Cut	
Y-1797	3	10	1	3010 ± 80 B.P. (1060 B.C. ± 80)
Y-1798	1	12	1	3100 ± 140 B.P. (1150 B.C. ± 140)
Y-1799	4	14	1	4100 ± 80 B.P. (2150 B.C. ± 80)
Y-1800	4	18	1	3050 ± 100 B.P. (1100 B.C. ± 100)
Y-1801	1	H	4	3090 ± 80 B.P. (1140 B.C. ± 80)
Y-1802	From hearth series associated with deposits of whole and broken pottery vessels of the San Lorenzo phase			2870 ± 140 B.P. (920 B.C. ± 140)

calling Villa Alta, falls at the very end of the Late Classic period (about A.D. 800–900) and is similar in many ways to the coeval occupation of Tres Zapotes (*5*). Both contain much fine orange-paste ware and hollow, mold-made figurines of Mayoid appearance. It seems probable that much of the mound construction at Tenochtitlan (but not at San Lorenzo) dates to the Villa Alta phase.

But it is the earlier occupation with which we are most concerned, for this is purely Olmec. We have named it the San Lorenzo phase, since that site seems to have been occupied mainly at that time. With the exception of the uppermost meter (belonging to the Villa Alta phase), the village materials exposed in the riverbank below Tenochtitlan were also laid down in San Lorenzo phase. Briefly, the pottery of San Lorenzo is extraordinarily similar to that of the Cuadros phase on the Pacific coast of Guatemala, which has been dated by the radiocarbon method to 1000–850 B.C. (*6*), and to the Chiapa I or Cotorra phase of Chiapas which has a radiocarbon age of 3010 ± 100 years (GRO-774) (*7*). These cultures share such specific features as a preponderance of tecomates (neckless jars), the use of interior finger-punching or dimpling on the walls of these tecomates, plain rocker-stamping, zoned red decoration, and deep bowls with exteriorly bolstered rims. These traits strongly suggest that the Olmec occupation at San Lorenzo Tenochtitlan is concomitant with the Early Formative period (1500–800 B.C.), and probably falls within the latter half of that period.

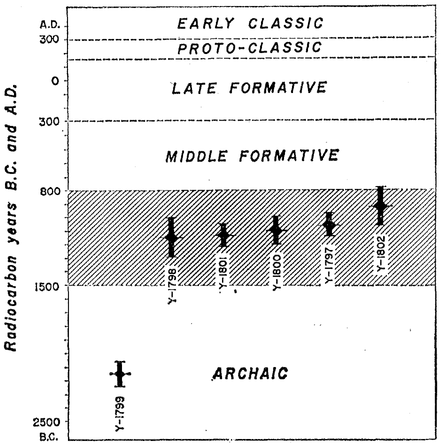

Fig. 2. Radiocarbon dates from the San Lorenzo phase, with 1-sigma deviations. The hatched area indicates the span covered by the Early Formative period.

The Olmec nature of the San Lorenzo phase is revealed by the presence of hollow, baby-faced, pottery figurines (some of which are identical with the large examples from Las Bocas, Puebla) (*8*), and by the deep excising of the typically Olmec jaguar-paw-wing motif on pottery vessels (*9*). But, apart from this, the monuments which we excavated at the San Lorenzo site are all unquestionably associated with offerings and debris of the San Lorenzo phase alone. Stone monuments cannot be directly dated by the radiocarbon method, but the associated culture can be. Six wood charcoal samples from stratified hearths of the San Lorenzo phase, all from the riverbank cut at Tenochtitlan, have now been analyzed at the Yale Radiocarbon Laboratory (Table 1). These dates show a high degree of internal consistency, with the exception of Y-1799 which may well be contaminated with pieces of asphalt (of which lumps appeared in every one of our excavations) and should thus be disregarded (*10*). Converting these figures into radiocarbon years of our calendar (by subtracting them from A.D. 1950), there is a high degree of probability that the radiocarbon date of the San Lorenzo phase—and the famous Olmec monuments of the zone—lies between 1200 and 900 B.C. (Fig. 2); this date confirms our pottery analysis which suggested an Early Formative placement. Of course, if one is to consider the "true" age for the San Lorenzo phase (which must be done when comparing the C^{14} dates with time scales based upon other methods), then a correction must be made for the estimated fluctuations of the C^{14} activity of atmospheric CO_2 with time (*11*). In this case, the "true" sample age of Y-1801 might be on the order of about 3300 years B.P. (1350 B.C.).

Therefore, the Olmec monumental style of the San Lorenzo Tenochtitlan group cannot be later than 900 or 800 B.C. This date reverses the usual scheme and puts San Lorenzo at the beginning, not the end, of the Olmec development. We have, therefore, found the oldest civilized communities thus far known in Mesoamerica. Nonetheless, by pushing back the earliest Olmec civilization to such an early date—to a time when there was little else but simple village cultures in the rest of Mexico and Central America—the lack of antecedents is an embarrassing problem. We now have no idea where the Olmec came from who built the mounds and carved the sculptures of San Lorenzo. Whoever they were, these pioneers must have been unusually gifted in engineering as well as art, for it has now been shown that the basalt from which these great monoliths were fashioned came from the slopes of the Cerro Cintepec in the Tuxtla Mountains, far to the northwest of San Lorenzo Tenochtitlan (*12*). They must have been floated on rafts down to the Gulf of Mexico and along the coast to the mouth of the Río Coatzacoalcos, and dragged from the river up to the San Lorenzo plateau with ropes (*13*).

We do not yet know why the San Lorenzo Tenochtitlan group was abandoned near the close of the San Lorenzo phase. We now speculate (i) that there was a transfer of some monuments (the rest being ceremonially abandoned) and presumably leaders to La Venta, which at about 800 B.C. became the new Olmec supreme center; (ii) that there was a simultaneous movement of Olmec groups to the Mexican highlands, particularly to Puebla and Morelos, and across to the Pacific coast of southeastern Mesoamerica; (iii) that La Venta was in turn destroyed or abandoned after 400 B.C.; and (iv) that in the Late Formative period there was the final flicker of a civilization which could now barely be called Olmec at the site of Tres Zapotes.

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9. See illustrations of motif in M. Covarrubias, *Indian Art of Mexico and Central America* (Knopf, New York, 1957), pp. 31–32.
10. There is little possibility that any of the other five radiocarbon samples were so contaminated. First, if they were, it is statistically unlikely that they would form such a uniform group. Second, all charcoal pieces in the samples were very carefully selected for evidence of wood structure. And third, the only sample which did not show such structure was Y-1799, which never should have been submitted. The asphalt occurs in discrete lumps and is usually quite easy to identify; we do not yet know what is was used for, beyond the occasional decoration of figurines.
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13. This would have had to have been during the rainy season (May to November), for at other times of the year there would be too little water in the rivers to have enabled monuments of up to 40 tons to have reached San Lorenzo Tenochtitlan by raft.
14. Research supported by NSF grant GS-715.

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Shock-Wave Compression and X-Ray Studies of Titanium Dioxide

Abstract. *The Hugoniot of the rutile phase of titanium dioxide has been determined to 1.25 megabars, and data show the existence of a phase change at about 0.33 megabar. The volume decrease associated with this transformation appears to be quite large (approximately 21 percent). Rutile, when recovered from shock-loading in excess of the transformation pressure, is found to be irreversibly transformed to the orthorhombic lead dioxide structure (a distortion of the fluorite structure) with parameters* a, *4.529;* b, *5.464; and* c, *4.905 angstroms and a calculated density of 4.374 grams per cubic centimeter. The new phase reverts to rutile at temperatures above 450°C. It is suggested that the new phase may be another diagnostic indicator of meteorite impact on the earth's surface.*

Rutile, one of the three naturally occurring polymorphs of titanium dioxide, has been studied both with explosive-generated dynamic pressures and by x-ray diffraction at static pressures. The techniques have been described in detail elsewhere (*1*). Dynamic pressure data consist of shock-wave velocities, U_s, measured in the rutile, and the associated shock-particle velocities, U_p, determined from the measured shock strength in a 2024 Al standard and the shock-wave impedance match requirements. The equation of state of the 2024 Al standard needed for this was calculated from the measured 2024 Al Hugoniot

$$U_s = 5.355 \text{ km/sec} + 1.345\ U_p$$

and a Grüneisen ratio, γ, determined from the following relation

$$\rho\gamma = \rho_0\gamma_0 = 6.17 \text{ g/cm}^3$$

where ρ is the density and the subscript 0 refers to standard conditions. Experimental shock-wave velocities are listed in Table 1 together with the particle velocities, pressures, and densities calculated from the Rankine-Hugoniot relationships. These experiments were performed on single crystals cut from boules with unknown orientations, except for two specimens made from naturally occurring polycrystalline samples from Oaxaca, Mexico. No difference in results was observed in the two types of specimens.

The isothermal (25°C) compression of rutile was measured by x-ray diffraction with the use of NaCl for an internal pressure gage (*2*). For this work a new 25°C NaCl isotherm, calculated from Hugoniot data recently measured (*3*) at the Los Alamos Scientific Laboratory, was used for a standard. The compression is not measured with as high precision as we would like because rutile is quite incompressible, with little variation in its lattice parameters. These data, Table 2, are estimated to be valid to less than 1 percent in the ratio between volume and original volume (V/V_0). They are plotted in Fig. 1 with a 25°C isotherm calculated from the Hugoniot:

$$U_s = 6.91 \text{ km/sec} + 1.47\ U_p$$

This Hugoniot was determined from the zero-pressure bulk sound velocity, 6.91 km/sec, computed from measured elastic constants (*4*) and the four low-pressure shock wave data points also plotted in Fig. 1. The x-ray and shock-wave data appear to be in good agreement and are compatible with the initial slope of the calculated isotherm determined from the elastic constants. Data of Clendenen and Drickamer (*5*) have also been plotted in this figure and are, quite obviously, in serious disagreement. They report the onset of a transition at 0.1 megabar (Mb); this is also in contradiction to the pressure-volume (*P-V*) data reported here and to additional static x-ray experiments to pressures of about 0.18 Mb, which also failed to show the existence of a transformation. These particular x-ray experiments were performed without any internal standard for maximum clarity in the films. Pressures were estimated by extrapolating the previously determined compression. We

Table 1. Hugoniot data for TiO_2 (rutile).

ρ_0 (g/cm³)	U_s std. (km/sec)	U_s (km/sec)	U_p (km/sec)	P (Mb)	V/V_0	ρ (g/cm³)
4.25		6.91*	0	0	1.000	
4.25	6.29	7.65	0.50	0.162	0.935	4.54
4.25	6.57	7.87	0.66	0.220	0.916	4.64
4.25	6.62	8.18	0.68	0.234	0.917	4.63
4.25	6.65	7.86	0.71	0.237	0.910	4.67
4.25	7.72	8.30	1.38	0.488	0.833	5.10
4.25	9.18	8.26	2.47	0.869	0.701	6.06
4.25	9.26	8.31	2.52	0.891	0.697	6.10
4.25	9.75	8.33	2.91	1.033	0.650	6.54
4.21†	9.86	8.51	2.98	1.068	0.649	6.49
4.25	10.08	8.74	3.11	1.157	0.644	6.60
4.25	10.10	8.77	3.13	1.165	0.644	6.60
4.25	10.11	8.76	3.13	1.165	0.643	6.61
4.25	10.28	9.06	3.22	1.242	0.644	6.60
4.20†	10.25	8.90	3.25	1.212	0.635	6.61
4.25	10.29	8.94	3.25	1.235	0.637	6.67

*Computed from elastic constants (*4*). †Natural rutile from Oaxaca, Mexico.