Implications of new petrographic analysis for the Olmec "mother culture" model

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Petrographic analysis of Formative Mexican ceramics by J. B. Stoltman *et al.* (see the companion piece in this issue of PNAS) refutes a recent model of Olmec "one-way" trade. In this paper, we address the model's more fundamental problems of sampling bias, anthropological implausibility, and logical non sequiturs. No bridging argument exists to link motifs on pottery to the social, political, and religious institutions of the Olmec. In addition, the model of unreciprocated exchange is implausible, given everything that the anthropological and ethnohistoric records tell us about non-Western societies of that general sociopolitical level.

ancient Mexico | ethnographic models | reciprocal exchange

Some 3100–2850 radiocarbon years before the present, the societies of central and southern Mexico emerged from egalitarian village life. From the Basin of Mexico on the north to the Chiapas coast on the south, many societies ruled by ambitious hereditary leaders arose (see Figure 1 of ref. 1). These chiefdoms, as evolutionary archaeologists call them, varied greatly in population and degree of complexity. Some, like those in Puebla's Tehuacán Valley, were minimal in nature. Others in the Basin of Mexico, Morelos, and the Valley of Oaxaca had administrative hierarchies of two tiers, with satellite villages encircling larger chiefly centers (2–5). A few, like San Lorenzo in the Olmec region of Veracruz, are considered large enough to have had both secondary and tertiary satellites surrounding a sprawling paramount center (6).

For 50 years, there have been two competing models for the role that these societies played in the development of later Mesoamerican civilization. For most archaeologists, each region is considered to have contributed its share of key elements. Some have argued that because all regions were engaged in exchanges of craft products and raw materials and the leaders of each chiefdom put pressure on their subjects to outdo their neighbors, sociopolitical evolution became rapid (7). For a vocal minority, however, the Olmec are seen as a "mother culture" that dominated, inspired, and ultimately raised the other regions to the level of civilization (8). This feat was allegedly achieved through the diffusion of an art style in which Olmec cosmology, religion, ideology, and iconography somehow lay encoded. This view downplays evidence that (*i*) each region contributed its own repertoire of ceramic motifs, some more varied and elaborate than those at San Lorenzo, and that (*ii*) in the adoption of features like adobe architecture, lime plaster, stone masonry, and solar or astral building orientation, the Olmec lagged behind the highlands (5, 7, 9, 10).

Recently, Blomster, Neff, and Glascock (BNG) (11, 12) reported on the neutron activation of 944 potsherds from archaeological sites in the Basin of Mexico, Oaxaca, Tehuantepec, Chiapas, and the Olmec region. Instrumental neutron activation analysis (INAA) seeks to detect chemical trace elements in the hope of tracing each sherd to its source. BNG's first claim is that San Lorenzo was the ultimate source of all pottery carved with motifs of the art style in question; this site is said to have "exported Olmec iconography" to other regions while receiving none in return. They next claim that even neighboring highland valleys did not exchange carved pottery. Both claims have since been refuted by the petrographic thin-section analyses of Stoltman *et al.* (1). The study by Stoltman *et al.* is only the latest to indicate that INAA has serious limitations in tracing individual sherds to their source (13).

The BNG study, however, has problems beyond those of INAA. These problems range from biased sampling to questionable assumptions and a lack of bridging arguments between archaeological remains and sociopolitical institutions.

Sampling Bias

To appreciate the bias in the sample that BNG drew, one must first consider that all pottery assemblages of 3100–2850 B.P. consisted of (*i*) coarse, locally made cooking and storage vessels; (*ii*) somewhat finer but also locally made serving vessels; and (*iii*) still finer vessels whose color or decoration made them appropriate containers for gifts to other societies. Most trade vessels were likely to come from the latter category. At San José Mogote in the Valley of Oaxaca, where the excavators isolated each house and counted its potsherds, foreign trade wares contributed $<1\%$ of the sherds in each house (14).

Some 253 of the sherds that Blomster collected were from San Lorenzo; 48 of these, or 19%, were dismissed as "unassigned to source" by the Mahalanobis distance program that Neff and Glascock used to finalize their results. Of the remaining 205 sherds, only 5 were Calzadas Carved, the lone pottery type at San Lorenzo that bore the carved motifs that the Olmec are alleged to have exported. For the remaining 200 sherds, Blomster inflated his sample with pottery types irrelevant to the model, including undecorated local storage wares like Camaño Coarse. It is hard to see this sample as anything but an attempt to make the bulk of San Lorenzo's pottery appear "local" and to minimize the chances of finding foreign sherds misclassified as Calzadas Carved.

When Blomster sampled sites in the Basin of Mexico and Valley of Oaxaca, however, a different strategy was used. Here, he ignored local cooking and storage vessels, concentrating instead on sherds that looked as if they might have come from San Lorenzo. In Oaxaca, he sampled 48 carved gray sherds of the types Leandro Gray and Delfina Fine Gray. He did much the same at Tlapacoya, sampling 76 carved gray sherds of Tortuga Polished, Volcán Polished, and Atoyac Fine Gray while ignoring the drab utilitarian wares. It is hard to see this procedure as anything but an attempt to give misclassified foreign gray wares 10–15 times the opportunity to be found at highland sites as they were given at San Lorenzo.

Abbreviations: BNG, Blomster, Neff, and Glascock; INAA, instrumental neutron activation analysis.

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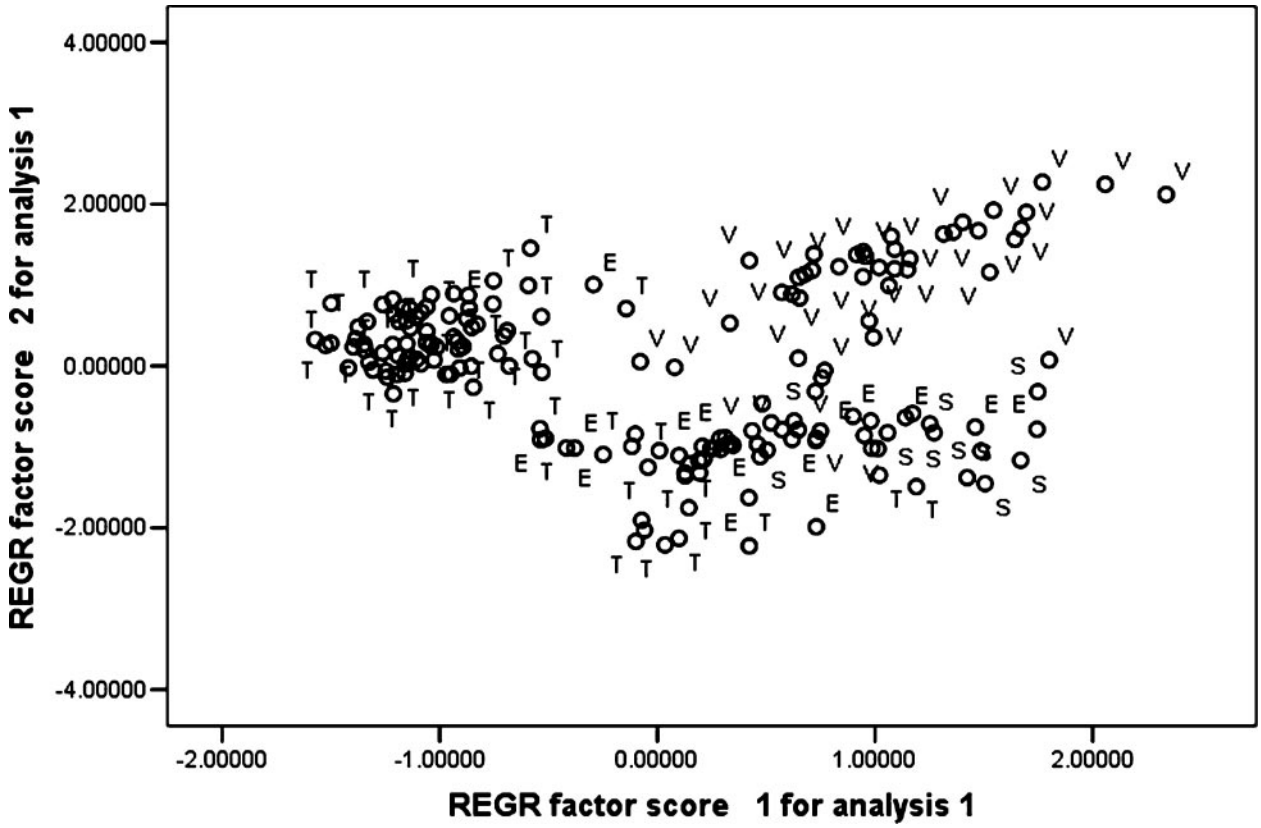

Fig. 1. Scatterplot of the regression (REGR) scores on factors 1 and 2 for 184 gray ware sherds from Tlapacoya (T), Etlatongo (E), the Valley of Oaxaca (V), and San Lorenzo (S). Most sherds found at Tlapacoya cluster at upper left; most sherds from the Valley of Oaxaca cluster at upper right; and most sherds from San Lorenzo cluster at the lower right. However, each region appears to have produced vessels that show up in at least one other region.

Finally, we must remark on the vast areas left unsampled. Entire states such as Morelos, Puebla, and Guerrero were omitted, and Blomster's Basin of Mexico sample included only Tlapacoya. Excluded from the sample was the site of Tlatilco, whose pottery was among the best made and iconographically richest in Mexico.

Statistical Problems

BNG finalized their INAA analysis with a Mahalanobis distance program that has been criticized because it rejects so many sherds as unassigned to source (13). Moyle and coworkers (1) have shown that when BNG's data set is separated from their undescribed "reference collection" and subjected to multiple discriminant function analyses, the results tend not to support a model of Olmec "one-way" trade, especially when no sherds are "unassigned."

To further examine alternative analytical techniques, Reynolds subjected a subset of the potsherds listed in table S2 of BNG's online supporting data (12) to a factor analysis. The subset comprised 184 gray ware sherds from Tlapacoya, Etlatongo, the Valley of Oaxaca, and San Lorenzo. The gray wares were selected because they bore the motifs crucial to BNG's model. The four regions were chosen because they all fell in the geographic area covered by Stoltman's petrographic analysis. Reynolds' factor analysis was based on chemical ppm data for each sherd, taken from BNG's table S2.

Although the analysis was carried to 33 factors, the first 2 factors account for 58% of the variation among sherds, the first 6 factors account for 80%, and the remaining factors add little. Neff and Glascock (11) evidently achieved similar results, because all of the elements that they paired to produce their confidence ellipses (Ca, Ce, Co, Cr, Fe, Mn, Ta, Th, Ru, and V) were prominently related (either positively or negatively) to factors 1 or 2 in Reynolds' study.

In Fig. 1, Reynolds' factors 1 and 2 are used to produce a scatterplot of values for all 184 gray ware sherds. Because Reynolds' subset includes sherds unassigned to source by BNG, the scatterplot presents the "amorphous shotgun-blast" appearance predicted by Stoltman and Mainfort (ref. 13, p. 20) for such data arrays. Close inspection reveals a cluster of dots at the upper left, scoring negative on factor 1 and mildly positive on factor 2. This cluster comprises mostly sherds found at Tlapacoya, suggesting that much of Tlapacoya's carved gray ware was locally made. This is not surprising, because Tlapacoya features many motifs not found at San Lorenzo. The same is true of the Valley of Oaxaca, whose gray ware is more loosely grouped in the upper right quadrant of Fig. 1. San Lorenzo's gray ware tends to score positive on factor 1 and negative on factor 2, placing it mostly in the lower right quadrant.

However, one to two sherds found at Etlatongo show up in the "local Tlapacoya" cluster; sherds found at Etlatongo and San Lorenzo overlap with the "local Valley of Oaxaca" scatter; and sherds found at Tlapacoya, Etlatongo, and the Valley of Oaxaca are found among the "local San Lorenzo" sherds. Thus, despite the known problems inherent in INAA (13), the results in Fig. 1 are reminiscent of those obtained by Moyle (1) for the complete BNG data set. They strengthen our belief that when the raw data are divorced from BNG's undescribed reference collection, they fail to support a model in which no highland valley ever exchanged carved gray ware with its neighbors or with San Lorenzo.

One other result of Reynolds' factor analysis should be mentioned. Some of the chemical elements most prominently associated (positively or negatively) with either factor 1 or 2 are Ca, Fe, K, and Na. Stoltman and Mainfort (ref. 13, p. 17) point out that those elements are found in soluble salts that can occur

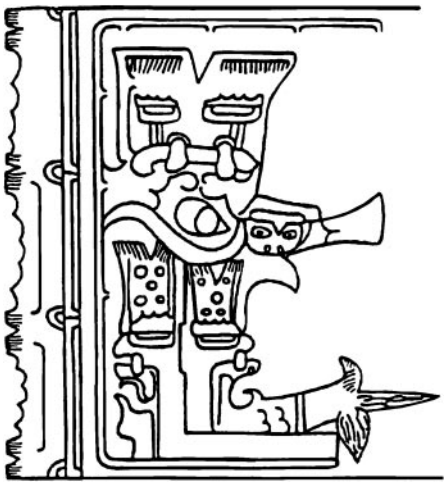

Fig. 2. Incised depiction of Earth on a Pilli White vessel from Tlapacoya, Basin of Mexico. The depiction shows an angry Earth, with a cleft head (earthquake fissure) and anthropomorphized versions of the four cosmic world directions. No vessel with a motif this complex has been found at San Lorenzo, which lacked a comparable white-slipped ware between 3100 and 2850 B.P.

either (*i*) in the water used by potters to moisten the clay or (*ii*) in the soil in which some of these sherds may have been buried for 3,000 years. One cannot, therefore, rule out the possibility that some of the most critical elements entered the sherds later, through diagenesis.

Questionable Assumptions in the BNG Model

In addition to its sampling problems and reliance on chemical elements rather than minerals, the BNG model rests on several highly questionable assumptions. One of these is the notion that the motifs in carved gray ware have been "linked with the dissemination of the social, political, and religious institutions of the Olmec" (ref. 12, p. 1068). No such link has ever been demonstrated. First, as Marcus (9) has argued, the bulk of the motifs are simply stylized versions of Earth and Sky, often in their "angry" forms, Earthquake and Lightning. This cosmic dichotomy was so widespread in ancient Mexico that it can hardly be attributed to one ethnic group. Indeed, the notion that any one group's social and political institutions were somehow encoded in these motifs, or that receiving a carved pot could bring on a cultural metamorphosis, is without empirical support.

Second, it cannot even be shown that the motifs had chronological priority in the Olmec region. The oldest ^{14}C dates for the gray ware bearing them come from the Basin of Mexico, the region with the most diverse motif repertoire and most elegant examples of decorated ceramics (Fig. 2). In both that region and the Valley of Oaxaca, the relevant gray wares first appear toward the end of the previous stylistic period, at 3150 B.P. or before (7). In contrast, the scholars who originally defined Calzadas Carved and its companion ware, Limón Carved-Incised, state that at San Lorenzo, those wares "are added suddenly to a ceramic repertory inherited from Chicharras [the previous stylistic period]; the very abruptness of their appearance, right at the beginning of the San Lorenzo phase, suggests that they were elaborated elsewhere" (ref. 15, p. 159).

The Importance of Reciprocity

There also are problems with BNG's conclusion that San Lorenzo carried on unreciprocated or one-way trade, that is, gave away decorated pottery without receiving any in return. The underlying assumptions seem to be that (*i*) unreciprocated trade is viable, (*ii*) pots themselves were the traded items, and (*iii*) San Lorenzo might somehow be considered a less important chiefly center if it accepted a carved pot from another region.

Stoltman's analysis has now shown that San Lorenzo did receive carved gray pots from other regions. We further suspect that most pots were only the containers for desired products, and that most movement of motifs was no more than a byproduct of packaging. BNG also seem unaware of ethnographic/ethnohistoric data showing that Native American chiefs loved to get gifts from other regions. In the Mexican highlands, it was always the largest chiefly centers that received the most foreign wares (14, 16); for an Olmec center to have received none would imply that it was not a very important place.

Ethnography and ethnohistory reveal that unreciprocated trade among societies of this type is not typical or even viable, and that disparities in the size of chiefdoms do not imply mother cultures. Consider, for example, the chiefdoms of the Cauca River Valley in Colombia. This valley is 500 km long, a distance greater than that between Tlapacoya and San Lorenzo. When the Spaniards arrived, the valley contained 80 chiefdoms of all sizes and sociopolitical levels. The largest, like the Guaca and Popayán, were maximal chiefdoms on their way to becoming protostates; the smallest, the Catío, acted like a chiefdom only when forced to unite under war leaders (17, 18).

These chiefdoms were competitive with each other, warring frequently and turning defeated neighbors into slaves. Even the "Olmec-sized" Guaca and Popayán, however, could not be described as the "mother" of the smaller Cauca polities, nor can they be shown to have "exported" their institutions by somehow encoding them in motifs. In fact it was a medium-sized chiefdom, the Quimbaya, that produced the most elegant goldwork in the Cauca Valley, much as the medium-sized Basin of Mexico chiefdoms seem to have produced Mexico's most elegant ceramics. Cauca Valley trade was lively, but there is no evidence that elites either (*i*) tried to embargo iconography or (*ii*) refused to accept it from others; everyone accumulated all of the luxury goods they could afford (ref. 18, p. 176).

There is no unreciprocated trade in societies of this type; "the gift itself. . . obligates repayment" (ref. 19, p. 153). The notion that the Olmec would continue to send hundreds of decorated vessels to neighbors with no expectation of reciprocity flies in the face of everything anthropologists have learned about such societies. As Sahlins (ref. 19, p. 143) describes it, reciprocity in goods was the "concrete mode" of political dialogue; "its breakdown meant the whole political communication was in question." Among chiefdoms, Sahlins continues, it is not unusual for repayments to be even larger than the initial gift; in fact, the farther away the exchanged item is going, the greater the tendency to "cheat" by trying to get back more than the gift is worth. This should have been particularly true of the Olmec who, assuming their demographic superiority was as great as alleged, would have needed a higher inflow of goods than did smaller chiefdoms.

Non-Western exchange systems with demographic imbalances are fragile even when reciprocal. The problems experienced by such a system have been modeled by Wright and Zeder (20) using ethnographic data from Heider (21). Their eight-village computer simulation shows, for example, that exchange of salt and axes repeatedly breaks down when the needs of growing axe-producers cannot be met by declining salt-producers. The authors then tested Rappaport's hypothesis (22) that trade in utilitarian items can survive demographic imbalances, so long as perishable or rapidly consumable ritual items are added to the exchange system. Once high-demand ritual items (shells, feathers, etc.) had been added to the simulation, the system indeed survived demographic fluctuations.

In addition to underscoring the implausibility of unreciprocated exchange, the Wright–Zeder study suggests two reasons why trade in ritual items such as shell, iron ores, and decorated vessels was so extensive in the Formative: it was both (*i*) a form of social relations

and (*ii*) a means of helping utilitarian trade survive demographic imbalances. Thus, it would be no surprise to learn that the Olmec, given their greater needs, had to inject more ritual items into the exchange system than anyone else to keep it going.

Hyperbole vs. Research Design

The BNG model also raises issues transcending those of chemical and mineralogical analysis. Any understanding of the relations among Mexico's Formative chiefdoms requires a research design that uncovers social and political institutions, rather than placing all of the weight of explanation on ubiquitous items like potsherds and obsidian. Not only do the latter items not stand up to the explanatory challenge, they are usually irrelevant to the real issues. Hence, the attempt to make potsherds appear more important than they are, describing them as "ideologically loaded" even when they have nothing to do with political ideology. The truth is that we currently have no bridging arguments that get us from sherds to sociopolitical institutions, forcing advocates of the mother culture to overcompensate by describing the Olmec in hyperbolic terms. Three examples of such hyperbole should suffice.

When Coe (ref. 23, p. 119) excavated San Lorenzo in the 1960s, he considered the site to cover 52.9 hectares (ha). The most recent survey, however, portrays San Lorenzo as covering 690 ha (ref. 24, p. 67; ref. 25, p. 56) or 700 ha (ref. 8, p. 1055), 13 times Coe's estimate. This discrepancy, as Grove (ref. 26, p. 71) explains, results from including in the higher estimates "artifactual material that cannot be classified as to temporal period, and thus may represent areas of [later] Classic and Postclassic occupation." The 690 ha also include outlying occupations that were previously considered satellite communities in San Lorenzo's hinterland (ref. 27; ref. 28, p. 185). Had scholars surveying the Valley of Oaxaca (29) considered all outlying rural communities to be part of urban Monte Albán, that ancient city would be viewed as covering an implausible 2,100 km^2.

A second example involves architecture. At the moment, our only confirmed Olmec residence is a modest wattle-and-daub house found at the site of La Venta by W. F. Rust (figure 2.3 of ref. 30). BNG, however, wish to give the impression that whereas highland chiefs lived in wattle-and-daub houses, Olmec leaders lived in palaces (ref. 12, p. 1068). Their reference to a "Red Palace" at San Lorenzo clearly implies a residence with the ground plan of a palace, such as the early example found by Spencer and Redmond (28) at Tilcajete, Oaxaca. In reality, however, Red Palace is simply the excavator's nickname for an amorphous patch of hematite-stained sand on which Monument 57, a broken basalt column, was found (24). A stone column that once supported a roof (if that is what Monument 57 was) is more likely to have been associated with a temple or other public building than a chiefly residence. It is ironic, indeed, that the most hyperbolic descriptions of San Lorenzo's architecture come from authors who have not actually excavated there. The less hyperbolic view of the site's current excavator is that "monumental mounded architecture arranged around plazas does not appear at San Lorenzo in the Early Preclassic period" (i.e., before 2800 B.P.). She adds that later Middle Preclassic architecture in the site center was not superimposed on any impressive earlier buildings (ref. 31, p. 98).

Our third example of hyperbole concerns the origin of hieroglyphic writing in Mesoamerica. Despite a lack of empirical evidence, mother culturists keep trying to attribute this accomplishment to the Olmec. Most recently, they have claimed that motifs on a ceramic roller stamp found near La Venta, Tabasco, and dated to somewhere between 2490 ± 40 B.P. and 2340 ± 90 B.P. are actual hieroglyphs (32).

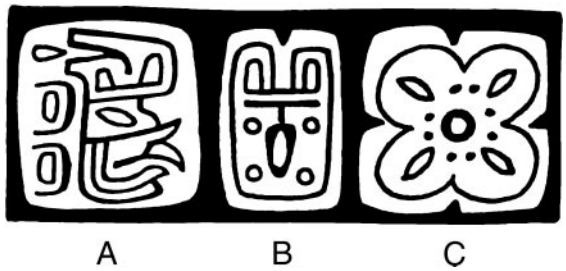

Fig. 3. Signs on a ceramic roller stamp from Tlatilco, Basin of Mexico, *ca.* 2950 B.P. (*A*) The profile head matches depictions of Earth. (*B*) An abstract sign for Earth and the four world directions. (*C*) The sign that became the Maya glyph *k'in*. This row of signs (*A–C*) is more convincing evidence of protowriting than that found on any stamp from the Olmec region. In fact, such stamps were almost nonexistent at San Lorenzo between 3100 and 2850 B.C. (ref. 15, p. 289).

This claim overlooks the fact that the central Mexican highlands were the actual epicenter of roller stamp production. More than 300 have been recovered from Tlatilco in the Basin of Mexico alone (33), and one of those stamps is not only an earlier but also a far more convincing precursor to writing (34). Dating to *ca.* 2950 B.P., the Tlatilco stamp (Fig. 3) is intriguing because all three of its signs seem to be actual logograms, and one of them went on to become the Maya glyph *k'in*, meaning sun, day, and time (35). No one knows whether roller stamp motifs were precursors to writing, but if they were, it is inappropriate to privilege one stamp from the Gulf Coast over earlier and more convincing examples from the Basin of Mexico.

Prospects for the Future

Archaeologists need to be conversant enough with the anthropology of living societies so that a red flag goes up when their model is implausible. The BNG model of unreciprocated gifts, denying even pottery exchanges among highland neighbors, raises such a flag with any archaeologist familiar with the ethnographic or ethnohistoric records.

Although the model of one-way trade has been refuted, we do not expect any study of potsherds to quiet the claim of an Olmec mother culture. The debate is reminiscent of that between evolution and creationism. Evolutionary archaeologists believe that sociopolitical institutions arise through the interaction of human groups, factions, and individual agents, sometimes cooperative and alliance-oriented, sometimes reactive and competitive. The mother culture advocates see Mesoamerican civilization as the product of a kind of intelligent design, with the Olmec providing the intelligence. The idea that each region made its contribution to the whole that was Mesoamerica, in other words, that Formative chiefdoms behaved like living societies in the ethnographic record, does not portray the Olmec as sufficiently gifted to suit their most extreme admirers.

All illustrations are by J. Klausmeyer (University of Michigan).

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