during the lunar night the thermal wave can penetrate about 1 m. One would therefore expect that rocks 1 m or larger in size would be effectively clamped after several days to the temperature of the subsurface of the moon. This temperature is believed to be about 220°K, which is close to our observed color temperatures of 200° to 230°K. The decrease of $\eta$ with increasing cooling time may arise because the smaller rocks cool first.

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6. We thank N. Woolf and G. Burnett for discussions, R. Maas and J. Stoddart for development of the infrared systems, and R. Maas and A. Ney for assistance in making the observations. Supported by NASA grant NGL-24-055-008. One of us (D.A.A.) acknowledges financial support from the Science Research Council and Cambridge University. Observations were made with the 30-inch telescope at O'Brien Observatory, University of Minnesota.

1 April 1969

## Olmec Cave Paintings: Discovery from Guerrero, Mexico

Abstract. *A cave in Guerrero, Mexico, investigated in 1968, contained previously unreported Olmec paintings. These paintings, some of the oldest known in Mesoamerica, are stylistically similar to Olmec art from the site of La Venta, on Mexico's Gulf Coast, but contain several important glyphic motifs never previously known to have existed at this time level. The iconography of the paintings confirms several important hypotheses concerning basic concepts of Olmec religion; the cave itself was probably a shrine to water and fertility. Several pre-Hispanic textile fragments found in the cave are probably from a later culture period.*

A series of paintings in Juxtlahuaca cave, Guerrero, Mexico (Fig. 1), reinvestigated in 1966, were identified as belonging to the art style of the Olmec culture (*1*), Mesoamerica's first civilization and first great art style. These sophisticated paintings, acclaimed as the "oldest paintings of the New World," are located on walls deep within the cave and include representations of several human figures, a jaguar, and a serpent. Until the discovery of the Juxtlahuaca paintings, Olmec art was known in primarily three forms: (i) large monumental stelae and colossal stone heads, (ii) small portable carvings in jade, jadeite, or serpentine, and (iii) in various ceramic forms.

Today, archeological pieces in the Olmec style are known from widely dispersed areas of Mexico, Guatemala, and even Central America, and the identification of the Juxtlahuaca paintings as Olmec has opened an entirely new facet in the study of Olmec culture. The actual heartland of this culture seems to be Mexico's Gulf Coast, in particular the states of Veracruz and Tabasco. Recent archeological work at two major Olmec sites in this region, San Lorenzo and La Venta (Fig. 1), has yielded a new series of radiocarbon dates which places the Olmec culture between 1200 and 600 B.C. (*2*, *3*), earlier than ever suspected (*4*). With the exception of the site of Chalcatzingo (Fig. 1) (*5*) in Mexico's central highlands and a newly discovered stelae near Arcelia, Guerrero, monumental Olmec stone carvings are restricted to the Gulf Coast sites. Olmec sites in the central highlands also appear to lack the ceremonial architecture of Gulf Coast sites, but have yielded a greater abundance of smaller archeological objects such as ceramics and jade carvings (*6*, *7*).

In November 1968, as a continuation of my studies of Olmec culture, a cave near Chilapa, Guerrero, was investigated (*8*); it contained a number of wall paintings of various types, most of which are unquestionably Olmec. The area in which the cave is located is only about 20 miles (12.5 km) north of Juxtlahuaca cave; because the indigenous villages of this area still retain the Nahuatl language, the cave is known locally as Oxtotitlan (Fig. 1). The cave sits high on a hillside, overlooking the valley of the Río Atentli. Unlike Juxtlahauca cave, the Oxtotitlan paintings occur in the mouth of the cave, in two large grottoes which open widely onto a broad cliff face. The largest of the paintings occurs on the cliff face in front of the grottoes. Whereas one of these is faded and virtually indistinguishable, the second is well preserved. This painting (Fig. 2) occurs high on the cliff, above the mouth of the south grotto (*9*); it represents a human figure seated upon a large jaguar-monster head. The figure wears an owl headdress mask, a feathered cloak, a jade pectoral, jade ornaments on his arms, legs, and feet, and a fringed skirt. The jaguar-monster head is reminiscent of the large stone jaguar-monster altars found at Olmec sites on the Gulf Coast. These stone altars are usually carved with a deep niche at their base which represents the jaguar-monster's mouth and iconographically probably also a cave. The jaguar-monster mouth-cave association has been noted at Chalcatzingo (*5*, relief ix, pp. 489–90) in connection with actual caves; and it is interesting, therefore, to note that the Oxtotitlan painting of the jaguar monster occurs above the mouth of the south grotto, which suggests a similar association. The main colors of this painting are red, ocher, and blue and it is approximately 5 by 7 feet (1.5 by 2.1 m) in size.

Within the north grotto of Oxtotitlan are a series of Olmec paintings executed primarily in black. Among these paintings are several profile faces with the baby-face mouth, a characteristic of Olmec art. Associated with one of these faces is a glyphic motif common in later Mesoamerican art, the speech scroll; it antedates any other examples by nearly 1000 years, and is the only

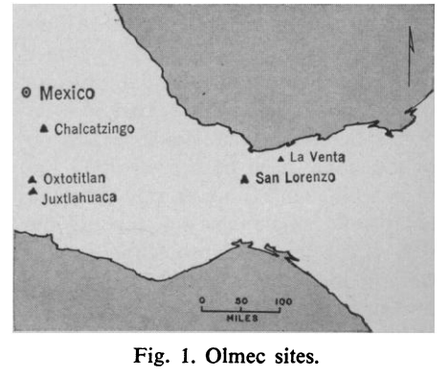


Fig. 1. Olmec sites.

example known in Olmec art. Two other paintings depict reptilian creatures quite similar to the *cipactli* which was common in later religious iconography, but various attributes of these paintings suggest that they may represent very early examples of the feathered serpent, a highly important religious concept to later Mesoamerican cultures. One of these reptilian creatures, depicted by the head only, is associated with a motif of three circles which may represent a number glyph. The entire context of this small painting could possibly be the earliest known date glyph in Mesoamerica.

Although several other paintings occur, including a number of still unidentified motifs, probably the most important of the north grotto paintings is a representation of a human figure standing beside a snarling jaguar (Fig. 3). The human is painted nearly entirely in black, with only his simple headdress, face, and pubic area in white. The jaguar, with its front legs resting upon an obscure motif, is in a semi-standing position. Because the jaguar is indistinct and portions of the painted rock are missing, the illustration shown was reconstructed from the original painting. Traces of red paint occur in the mouth area of the jaguar. The jaguar's lower jaw appears disproportionately large, but this can perhaps be attributed to missing portions of the painted rock in this area.

Scenes representing humans in association with jaguars are rare in Olmec art. Two such depictions occur at Gulf Coast sites, and they suggest an important and interesting relation between the jaguar and human figures. Monument 1 at Rio Chiquito and monument 3 at Potrero Nuevo (*10*), while both badly defaced, appear to represent women participating in sexual intercourse with jaguars. As Stirling noted (*11*), this may relate to the mythical origins of the human figures with jaguar characteristics, so prevalent in Olmec art. The Oxtotitlan painting of the jaguar and human confirms that this must have been a basic and important Olmec religious concept, for the painting appears to depict a double sexual connection. The tail of the jaguar passes up to the pubic area of the standing human, while what is apparently the phallus of the human passes toward the rear of the jaguar. Unfortunately, portions of this area are difficult to discern and may have once been intentionally defaced.

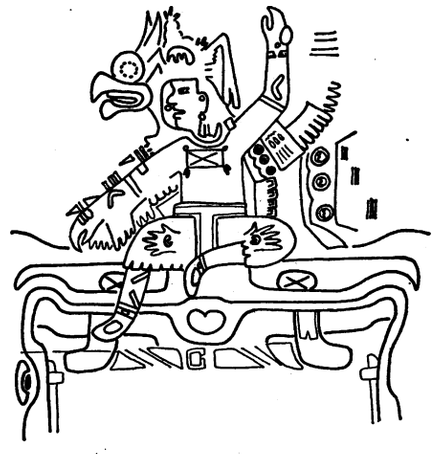

Fig. 2. Seated human figure on a jaguar-monster head.

A completely different type of painting occurs in the south grotto. These paintings, in red, are generally unsophisticated, usually only simple geometric and linear designs. They appear to be typical of the usual petroglyphic art found throughout the Americas. However, a few of the designs are more elaborate, and one, a simple *Tlaloc* (rain god) face, more highly evolved than any known in Olmec art, suggests that the south grotto paintings may be from a later culture period. Other traits among the various designs, however, indicate that even these more unsophisticated red paintings may be Olmec.

During the investigations in the cave, small collections of surface potsherds were made, but few were found within the cave or on the hillside outside. However, three ancient textile fragments, apparently pre-Hispanic, were discovered. They had apparently been cast aside by local treasure hunters. All three of these textiles are probably post-Classic (about A.D. 900 to 1500) in age (*12*).

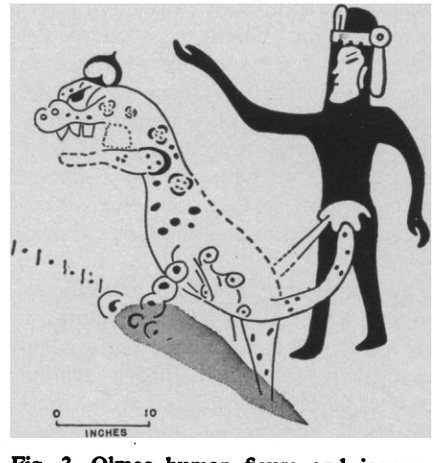


Fig. 3. Olmec human figure and jaguar. The shaded and dashed areas indicate obscure portions of the painting. Dotted areas indicate missing portions of the painting.

The iconography of the Olmec paintings at Oxtotitlan appears to be primarily related to water, rain, and fertility. The grottoes of the cave occasionally contain shallow lagoons of water during the rainy season, and these occasionally overflow into the fields below. Therefore, Oxtotitlan probably held the position of a sacred place, a shrine to water, rain, and fertility. The iconographic relation between caves, rain, and fertility is clearly indicated in an Olmec bas-relief at Chalcatzingo (*5*, relief I, pp. 486–7), and in post-Classic central Mexican religion. The complete connotations of all the paintings, including that of the jaguar and human, are beyond the scope of this report (*13*).

Although some scholars have regarded the presence of Olmec artifacts in Guerrero as a possible indication of early Olmec origins in this region (*14*), the new data from Gulf Coast sites and the central highlands suggest otherwise. The Olmec art at Oxtotitlan is well developed and sophisticated, and not an incipient style; its closest similarities are to Olmec art from La Venta and not the somewhat earlier style of San Lorenzo. Based on the revised dates for La Venta (*3*), the Oxtotitlan Olmec paintings date possibly about 800 to 700 B.C.

The spread of the Olmec from their lowland Gulf Coast heartland into Mexico's central highland area and the Pacific slopes of Guerrero can best be attributed at the moment to their quest for natural resources unavailable in the tropical environment of Tabasco and Veracruz. The patterning of Olmec sites in the central highlands suggests that they are located along trade routes between the sources of the exploited materials (usually stone) and the Gulf Coast. Guerrero with its complex igneous and metamorphic geology was probably the major Olmec source of jade, jadeite, and serpentine (*15*). Oxtotitlan and the neighboring site of Juxtlahuaca lie almost directly south of the Cuautla-Amecuzac river, which may have been a major Olmec trade route into Guerrero; Oxtotitlan and Juxtlahuaca fit the trade-route site-patterning hypothesis well. The fact that Olmec cave shrines, such as Oxtotitlan and Juxtlahuaca, were established outside of the Olmec heartland

indicates the strong emphasis on religion in Olmec culture, and the durability of Olmec trade relations with other areas (*16*).

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5. See, for example, D. C. Grove, *Amer. Antiquity* **33**, 486 (1968).
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7. It is unfortunate that most Olmec artifacts in Mexico's central highlands are found by "treasure hunters" seeking to satisfy the demands of art collectors. Most Olmec sites known in the highlands are already looted. The possibility exists that Olmec sites, with architecture, have simply not yet been found in the central highlands.
8. The cave was reported to me and to the Instituto Nacional de Antropología e Historia by Sr. Juan DuBernard, who learned of it from one of his employees, and who conducted a preliminary visit to the cave. Permission to investigate the site was granted to D.C.G. by the Instituto.
9. The designation north and south grottoes is used to clarify the location of the various paintings.
10. M. W. Stirling, *Bull. Bur. Amer. Ethnol.* **157**, 8, 19–20 (1955).
11. ———, *ibid.*, pp. 20–21.
12. Other pre-Hispanic textiles have been found in this region. See, for example, I. W. Johnson, *Rev. Mex. Estud. Antropol.* **21**, 149 (1967).
13. More detailed descriptions and interpretations of the paintings are in preparation.
14. For example, M. Covarrubias, *Indian Art of Mexico and Central America* (Knopf, New York, 1957), pp. 67, 110.
15. The trade route hypothesis has been presented by M. D. Coe [*The Jaguar's Children* (Museum of Primitive Art, New York, 1965), pp. 122–123] and by D. C. Grove [in *Dumbarton Oaks Conference on the Olmec* (Dumbarton Oaks Research Library and Collection, Washington, D.C., 1968), pp. 179–185]. Jade sources are reported for several areas of Guerrero; see for example, A. Caso, in *Handbook of Middle American Indians*, R. Wauchope, Ed. (Univ. of Texas Press, Austin, 1965), vol. 3, p. 896.
16. Olmec presence in the central highlands and Guerrero has previously been attributed simply to the diffusion of the Olmec religious cults, or to the spread of Olmec religion by actual missionaries. At the present time, the data still best support the trade route theory, although trade may have served as a vehicle for the diffusion of religion. However, I see little data showing a widespread acceptance of Olmec religion in regions peripheral to Olmec trade routes.

3 February 1969

## Pheromone-Induced Changes in the Acidophil Concentration of Mouse Pituitary Glands

Abstract. *Pituitaries of female mice in anestrus resulting from colony housing were characterized by a 58.0-percent acidophil content. Subsequent exposure to restrained male mice for one and two nights failed to evoke significant acidophilic degranulation and resulted in pituitary acidophil values of 57.4 and 55.1 percent respectively. Exposure to released males on the third night produced marked acidophilic degranulation resulting in a significant decline in pituitary acidophils to 38.0 percent. These findings support the view that female pheromone suppresses and male pheromone favors the secretion of follicle-stimulating hormone and indicate that luteotrophic hormone is secreted at its assigned time in the sequence of cyclic ovarian events initiated by the secretion of follicle-stimulating hormone.*

The term pheromone, originally proposed to describe chemical substances used for animal communication (*1*), has come to connote substances which are passed to the exterior by an animal to be received by and to evoke one or more specific responses in others of the same species (*2*).

Pheromones produce marked effects on the mouse estrous cycle. One pheromone, secreted by grouped females, results in pseudopregnancy when female mice are housed in groups of four (*3*). This effect is intensified and produces overt anestrus when groups of 30 females are housed together (*4*). Another pheromone, secreted by male mice, releases nonpregnant females from cyclic inhibition and stimulates the attainment of estrus. In addition, it blocks implantation in recently bred female mice and again stimulates the attainment of estrus (*5*). Pairing of previously isolated nonbred females with males results in a peak incidence of mating on the third night thereafter with maximum mating occurring with females previously housed in groups (*6*, *7*). Physical contact between the sexes is not a requirement for this male-induced estrus since confinement of the male in a wire basket in the presence of females continues to evoke a maximum incidence of estrus on the third night (*6*).

The female pheromone may act to block the secretion of follicle-stimulating hormone (FSH), whereas the male pheromone acts to stimulate such secretion (*8*). Blockage of implantation, however, has been attributed to failure of luteotrophic hormone (LTH) secretion (*9*), and pregnancy has been maintained by injections of luteotrophin (prolactin) on the first, second or third day after mating (*10*). It has been suggested that a reciprocal relation may exist between the secretion of FSH and LTH (*11*, *12*) and that stimulation of gonadotrophin secretion may in itself inhibit release of LTH (*11*, *13*).

Numerous studies have indicated that hormone elaboration by the pituitary gland may vary quantitatively with numerical changes in the concentration of specific pituitary cell types in response to physiological or pathological stimuli. The concept of FSH-LTH reciprocity, if true, would call for marked changes in the secretion of luteotrophin in response to male and female pheromones. We studied these changes by comparing the concentration of pituitary acidophils in grouped female mice with that in females exposed to restrained male mice for the first and second nights and to released males on the third night after removal from colony housing.

Randomly bred Swiss mice approximately 10 weeks of age were housed in the central animal facility (24°C and 55 percent relative humidity). They were given free access to food and water and kept on 12-hour nonreversed periods of alternating light and dark.

Females were housed in colony cages in groups of 25 for 10 days. At that time, ten were selected at random, and their pituitaries were collected. The remaining females were then distributed in groups of three to cages containing one male restrained in a wire basket. After the first night, one female was removed from each cage, and her pituitary gland was collected. Pituitaries were collected from a second female in each cage after the second night's residence. The wire basket was then removed, and males were released to the females on the third night. These females were examined the following day for copulation plugs, and their pituitary glands were removed.

Mice were routinely killed between 12 noon and 1 p.m. Pituitaries were removed immediately, fixed in Helly's solution for 90 minutes, embedded in Paraplast, cut into 3-$\mu$ sections, and