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Mexico and the early history of magnetism*

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The phenomenon of magnetism has been known by mankind for more than three thousand years. This fact is documented in references to the naturally occurring magnetic mineral magnetite (the iron oxide Fe_3O_4) in clay tablets in ancient Mesopotamia, as early as the second millennium BC. Less known, however, is the possible evidence for the knowledge of the magnetic properties of rocks by the peoples of pre-Columbian America. In fact, archaeologists have found in Olmec sites in Mexico many objects made of iron ore that may reveal an early acquaintance with magnetism. The Olmecs constituted the first complex culture that appeared in the Americas, before 1000 BC, in the east coast of Mexico. Among these objects, there has been found a polished bar that is magnetic, dating from 1400-1000 BC, which has led to speculations that it may have been part of a magnetic compass, one thousand years before the first Chinese compasses were made.

Keywords: Magnetism; Olmecs; Mexico.

El fenómeno del magnetismo ha sido conocido por la humanidad hace más de tres mil años. Esto está documentado por referencias a la magnetita (el óxido de hierro Fe_3O_4), mineral magnético encontrado en la naturaleza, en tablas de arcilla de la Mesopotamia antigua, que son del segundo milenio AC. Menos difundida es la posible evidencia del conocimiento, de los pueblos de América pre-Colombina, sobre las propiedades magnéticas de las rocas. Arqueólogos han encontrado, en sitios Olmecas en México, varios objetos hechos en minerales que contienen hierro y que podrían revelar familiaridad de esta civilización con el magnetismo. Los Olmecas fueron la primera cultura elaborada que apareció en América - antes de 1000 AC - en la costa oriental de México. Entre los objetos se encontró una barra pulida magnética, datada de 1400-1000 AC, y que dio lugar a la especulación de que sería parte de un compás magnético, mil años antes de la construcción de las primeras brújulas chinas.

Descriptor: Magnetismo; Olmecas; México.

PACS: 91.60.Pn; 01.65.+g; 91.25.Ng

1. The Olmecs

The first complex culture that appeared in the Americas was that of the Olmecs, in about 1400 BC, centered in the coastal areas of east Mexico, in the present states of Veracruz and Tabasco [1,2]. The name Olmec means 'inhabitants of the region of the rubber plant (hule)'. The main sites are along the Gulf of Mexico: San Lorenzo, La Venta, Laguna de los Cerros and Tres Zapotes. They show in their sculptures a distinct art style, with a special way of treating volumes, and with a predominance of human figures. Some of these figures have characteristic baby faces, frequently with mixed jaguar traits ("were-jaguars"). The relation of kinship with the jaguars was apparently part of the myths of creation of the Olmecs.

The archaeological remains of the Olmec culture show that this society was able to mobilize manpower in large scale for building and earth-moving work. Some of the most remarkable finds left by the Olmecs are their characteristic colossal stone heads, weighing up to 50 tons; some sixteen of those have been found. The stone for these monumental sculptures in one site was quarried some 80 km away, in the Tuxla Mountains, floated down a river and dragged overland, an amazing feat in itself.

The Olmecs influenced the later civilizations that developed in Mesoamerica, especially the Mayas. For this reason they were traditionally described as a "mother" culture, although the present trend is to value the importance of the mutual influences between the different Mesoamerican cultures [1].

Many authors attribute to the Olmecs the creation of written language in the region, although there is still controversy on this point. This conviction has recently been supported by the finding of a cylinder seal dated 650 BC that contained symbols representing spoken words [3]. Other important achievements of the Olmecs include the invention of a calendar, which was later taken up by the Mayas. The Olmecs also acquired anatomical knowledge, having left a clay figure that is said to depict the earliest anatomically complete representation of the human heart [4].

One specially important Olmec site is that of La Venta, where many structures have been identified, covering an area of 200 ha. The buildings, like some others found elsewhere, show an overall north-south alignment - in fact differing 8° from the magnetic north direction [5]; it is believed that this alignment was obtained through astronomical means. The alignment of the Olmec ceremonial centers suggests that this had some ritual significance, reminiscent of the importance attributed by the Chinese to the orientation of buildings, a tradition known in China as geomancy.

2. Olmec sculptures

Many Olmec sculptures were made from basalt, a dark volcanic stone, relatively rich in iron, a fact which accounts for the magnetic properties of the material. These properties have been used by archaeologists in the search for remains of the Olmec culture. Magnetic techniques were used, for exam-

ple, in the investigation conducted on the site of San Lorenzo, 80 km from La Venta [6]: from 1500 BC to 1200 BC San Lorenzo was the largest urban center in Mesoamerica. Since the local soil has much less intense magnetic response, with an average magnetization of one tenth of the basalt objects (10^{-5} emu and 10^{-4} emu, respectively), this difference leads to anomalies in the magnetic field lines near each stone object (Fig. 1). Using a portable cesium magnetometer, the terrain was swept and a magnetic map was drawn. This study was remarkably successful, allowing the discovery of 17 monuments, one of them buried five meters deep. Why these objects were buried has not been completely explained.

3. Magnetic Olmec objects

Archaeologists have found Olmec objects made of iron ore, dating from the Early Formative period (1500 - 900 BC) in sites in San José Mogote and San Lorenzo. These are small polished hematite or magnetite plates or "mirrors", either plane or concave, with up to 10 cm of diameter, which were apparently used as body adornments, and were probably a measure of social status [5]. The study of these "mirrors" with Mössbauer spectroscopy led to the conclusion that the iron ore used in plates found in San José Mogote came from sources 30 km away [7].

One evidence that the Olmecs may have known the properties of magnetic ores was the discovery in Izapa, in a site corresponding to the Late Formative period (300 BC - AD 100), of a carved stone turtlehead of 1.1×1.2 meters that is magnetic, with one of the magnetic poles coincident with the snout of the animal (Fig. 2) [8]. In the coastal plain of Guatemala it was found a statue of a jaguar with magnetic poles in each raised paw, and a crude statue

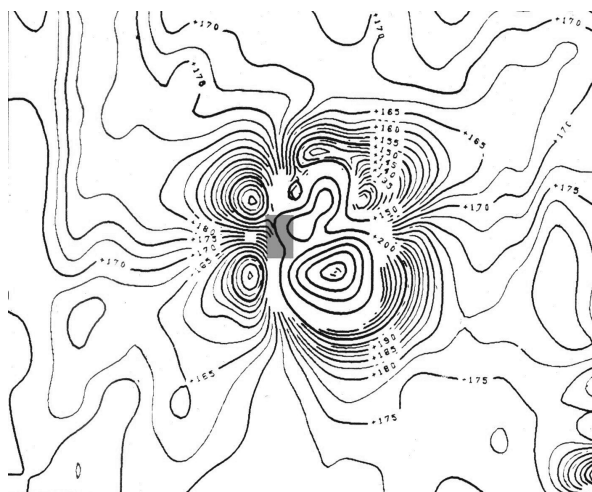


FIGURE 1. Fragment of magnetic polished bar with groove, found in San Lorenzo and dated 1400-1000 BC (Reproduced from Science **189** (1975) 753).



FIGURE 2. Stone turtle head found in Izapa and compass needle pointing to the snout (Reproduced from Nature **259** (1976) 390).

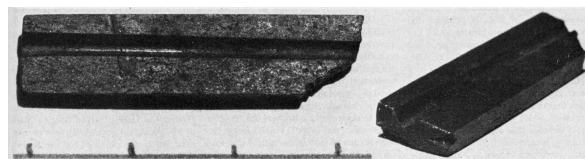


FIGURE 3. Magnetic anomaly in the magnetic survey at San Lorenzo, resulting from a stone "altar", in the position given by the dark rectangle at the center. The map has approximately 50m on a side (Reproduced from Am. Sci. **60** (1972) 566).

of two seated men made of a single block of stone, with magnetic poles on either side of the navel. The latter statue is dated 2000-1500 BC [9]. Although these patterns of magnetization may be accidental, or due to shape effects, one suspects of an intention of the artisans, in view of the significance of the location of the magnetic poles in the different objects.

One of the most interesting Olmec objects, found in strata dated 1400-1000 BC, is a fragment of a polished bar 3.5 cm long that is magnetic, with magnetic moment almost parallel to its longer dimension. It has a groove cut roughly parallel to its length, that could have been employed for sighting (Fig. 3). Analysis of its composition making use of Mössbauer spectroscopy established that it consists of almost pure hematite (Fe_2O_3) [10].

Since the intended use of this bar was not evident, this discovery has led to speculations that it was part of a magnetic compass. The head of the archaeology team that discovered the object, Dr. M.D. Coe, from Yale University, mounted the bar on a cork mat in a water bowl and observed its alignment in the Earth magnetic field [11]. If this hypothesis is confirmed, this object would be part of the earliest known compass, meaning that the Olmecs had anticipated the Chinese by more than one thousand years.

4. Conclusion

The use of magnetic iron ores in the manufacture of objects of daily use, such as the polished “mirrors” found in large numbers in Olmec sites, could have led to the observation of their magnetic properties. The special position of the magnetic poles in some finished stone sculptures could have been the

result of wilful action by the artisans. Above all, the fragment of a polished magnetic iron ore bar led to the speculation of its use as an early compass. In conclusion, these speculations on the knowledge of magnetism among the Olmecs raise an exciting possibility that is worth further investigation by the magnetism community.

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- *. Communication presented at the VI Latin American Workshop on Magnetism, Chihuahua, Mexico, April 2003.
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