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ON THE ORIENTATION OF PRECOLUMBIAN BUILDINGS IN CENTRAL MEXICO

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A tendency for many precolumbian buildings to align east of north is examined for possible astronomical motives. Stellar and solar phenomena are suggested as possible influences. The importance of clearly establishing the relative positions of observer and point of reference in any archaeo-astronomical analysis is emphasized. Certain misconceptions concerning chronological correlations of alignments and a new dimension in establishing orientations are discussed.

One fact which emerges from a careful study of the orientation of many precolumbian buildings of Central Mexico is the tendency for their north-south axes to align slightly east of astronomical north. In an earlier paper, Aveni (1975) reported that, on the basis of measurements made with a surveyor's transit, three Central Mexican sites (Tepozteco, Tenayuca, and Tula) possess nearly the same orientation as Teotihuacan (15° 25′ E of N). It is likely that Teotihuacan served as a model for the other sites, and that architects copied the sacred direction by laying out an astronomical baseline at the model site and transferring it to the new ceremonial centers. This same orientation appears in the Toltec period buildings at Chichen Itza (Aveni, Gibbs, and Hartung 1975). The present paper reports the results of measurements taken with a transit during January 1974 at ten additional sites in Central Mexico and suggests possible astronomical motives for the orientations thus found.

The orientations of all Central Mexican sites studied to date are listed in Table 1. The measuring techniques employed and range of accuracy have been discussed elsewhere (Aveni 1975). Building periods range from approximately 500 B.C. to A.D. 1500, but because of the uncertainty of the dates of completion of many structures, exact times are excluded from the table. Fig. 1 is a polar diagram showing the averaged orientation of each measured site. In all 14 cases the axes are skewed clockwise from the cardinal directions, ranging from 0°25′ E of N at Xochicalco to 27°05′ E of N for the Teotihuacan period ballcourt at Manzanilla, Puebla. In no case is an axis displaced counterclockwise from the cardinal directions.

We find no correlation between site axiality and site latitude or time of construction. The axis of Cuicuilco, the earliest building of those we measured, shows a clockwise skew ranging from 1°43′ to 7°38′, depending upon which measurement can be accepted given the ruined state of the stairway leading to the top of the building. On the other hand, the Teopanzolco pyramid in Cuernavaca, one of the latest precolumbian buildings to be constructed, has its outer face skewed clockwise from the cardinal points by only 00°43′. At Tlatelolco, the largest structure exhibits nine different building phases. The orientations range between 7°39′ and 11°47′ E of N, but again no systematic time variation is found to occur.

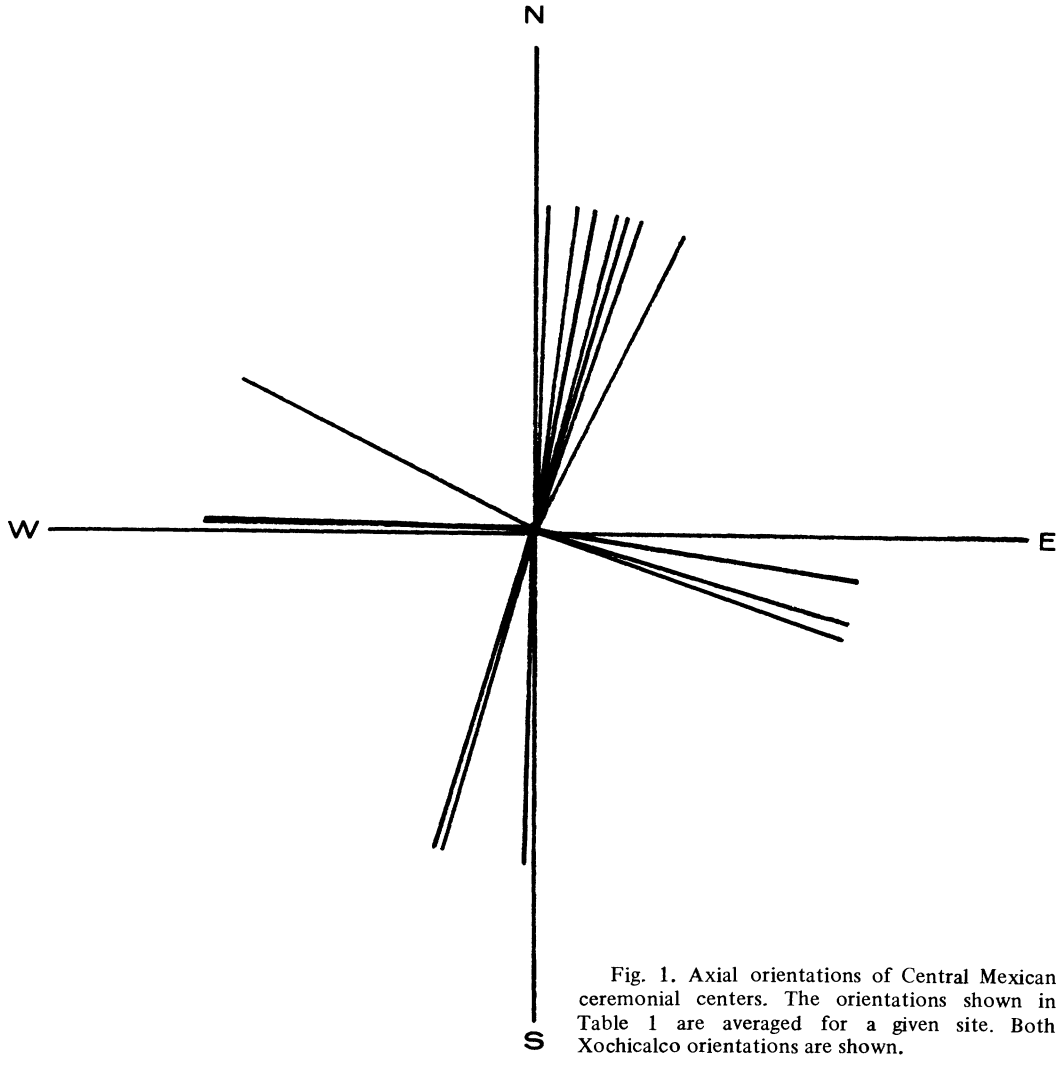

Fig. 1. Axial orientations of Central Mexican ceremonial centers. The orientations shown in Table 1 are averaged for a given site. Both Xochicalco orientations are shown.

Table 1. Orientation of buildings determined with surveyor's transit.

Site	Structure	Alignment	Orientation	Remarks
Teotihuacan Lat. 19°42'N Long. 98°51'W	Street of Dead	Axis	15°25' E of N	Ref. Million (1974)
	E-W Street	Axis	16°30' S of E	Ref. Million (1974)
	Ciudadela	Principal axis	16°55' S of E	Ref. Million (1974)
Tenayuca Lat. 19°31'N Long. 99°11'W	Pyramid	Base of steps on West wall looking South	17°42' W of S	Building faces West. Postclassic
		South wall looking West	16°27' N of W	
Tepozteco Lat. 19°00'N Long. 99°06'W	Temple	Base of steps on West wall looking South	18°00' W of S	Building faces West. Postclassic
Tula Lat. 20°05'N Long. 99°24'W	Temple B	Base of steps on South wall looking West	17°10' N of W	Building faces South
	North Ballcourt	West wall looking North	16°25' E of N 17°06' E of N	Axis of ballcourt is E-W
		South wall looking East	14°55' S of E 14°13' S of E	
	East Ballcourt	West wall looking North	15°04' E of N	Axis of ballcourt is N-S
	Tula Chica Circular Temple	Base of steps looking North	09°02' E of N	Building faces East. Postclassic
Tenochtitlan Lat. 19°27'N Long. 99°08'W	Templo Major	South wall looking East	07°06' S of E	Building faces West. Postclassic
Tlatelolco Lat. 19°28'N Long. 99°08'W	Principal structure	West walls looking North	11°47' E of N 09°57' E of N 09°43' E of N 09°36' E of N 08°58' E of N 09°30' E of N 09°09' E of N 09°30' E of N 07°39' E of N	9 consecutive building phases, listed in chronological order top to bottom. Building faces West. Postclassic
Teotenango Lat. 19°08'N Long. 99°35'W	Base of acropolis	West stairway looking North	13°33' E of N	Single measurement on western base. Postclassic
Teopanzolco Lat. 18°49'N Long 99°17'W	Principal structure	Base of steps on West wall looking North	00°43' E of N	Building faces West. Postclassic
Cuicuilco Lat. 19°18'N Long. 99°11'W	Circular temple	Various portions of base of steps looking North	07°38' E of N 05°42' E of N 01°43' E of N	Building faces East. Preclassic
Calixtlahuaca Lat. 19°20'N Long. 99°40'W	Temple of Tlaloc	Base of steps on East wall looking South	01°50' W of S	Building faces East. Postclassic
	Temple of Quetzalcoatl (Circular temple)	Base of steps on East wall looking South	01°12' W of S	Building faces East. Postclassic
Chalcatzingo Lat. 18°42'N Long. 98°46'W	Steps leading to principal reliefs	Base of steps (lower) looking East	17°17' S of E	Building faces North. Preclassic
		Base of steps (upper) looking East	21°22' S of E	

Table 1. (Continued)

Site	Structure	Alignment	Orientation	Remarks
Cholula Lat. 19°03′N Long. 98°18′W	Base of Adosada	South face looking East	26°16′ S of E	Building faces West. Classic
Manzanilla Lat. 19°08′N Long. 98°08′W	Teotihuacan period ballcourt	Axis	27°05′ N of W	Axis of ballcourt is E-W. Classic
	Aztec period ballcourt	South wall looking West	27°02′ N of W	Axis of ballcourt is E-W. Postclassic
Xochicalco Lat. 18°47′N Long. 99°17′W	Structure E	South wall looking West	00°25′ N of W	Building faces South
	Ballcourt	South wall looking West	00°44′ N of W	Axis of ballcourt is E-W
	Temple of Plumed Serpent	Base of steps on West wall looking South	16°45′ W of S 17°13′ W of S	Building faces West. Classic

At some sites a conscious effort to preserve a particular alignment in spite of intervening terrain is indicated. Two temples at Calixtlahuaca are good examples. They align nearly precisely in the same direction even though they are 100 meters apart and at different elevations; the measured axes are directed 1°50′ S of E and 1°12′ S of E. An equally conscious effort to distinguish orientations seems indicated at other sites. For example, at Xochicalco both the Ballcourt and Structure E (Saenz' 1967 notation) are laid out ½° east of true north, but the Temple of the Plumed Serpent, built on a platform above the level of E, is skewed 17° clockwise from the cardinal points, possibly reflecting Teotihuacan influence. The astronomically related relief decorations on the Plumed Serpent Temple add to its distinction from surrounding structures.

Among the most interesting buildings in the Central Mexican group is the Templo Mayor of Tenochtitlan (latitude 19°27′ N), for here we find evidence in the early postconquest literature alluding to a possible astronomical motive underlying the orientation of the building. Writing in the sixteenth century, Motolinia tells us that the festival called Tlacaxipeualistli

> took place when the sun stood in the middle of Huicholobos, which was at the equinox, and because it was a little out of the straight, Montezuma wished to pull it down and set it right.

Considering Motolinia's statement in 1912, Maudslay infers that

> "the priest and worshippers doubtless faced to the east, to watch the sun rise in the space between the two oratories." [See Fig. 2].

Maudslay's inference is further supported by a 1524 map of the Aztec capital which shows a face representing the sun flanked by the twin temples (Huicholobos) on the top of the Templo Mayor (Fig. 3).

One might expect from Motolinia's remarks that the axis of the Templo Mayor aligned due east-west; and yet measurements show that it was directed 7°30′ south of east. It is possible, however, that this apparent conflict between historical and archaeological evidence may be resolved by a careful consideration of the crucial equinoctial observation.

The position of the circular Temple of Quetzalcoatl, west of the Templo Mayor along its extended axis, makes it a suitable spot from which to view "the middle of Huicholobos." Furthermore Diego Duran (1970) suggests that a solar observer was stationed there when he describes the duties of the priest attending the temple:

> At dawn when the sun was rising, the priest again sounded his drum, at the hour when bells ring at daybreak today. With this sound he announced the birth of the day, and thus travelers and strangers prepared for their journey according to that signal, as if they had been prohibited from leaving the city until then. Likewise, the farmers, traders, and merchants made themselves ready—with that sign—some going to the market places, others to their fields.

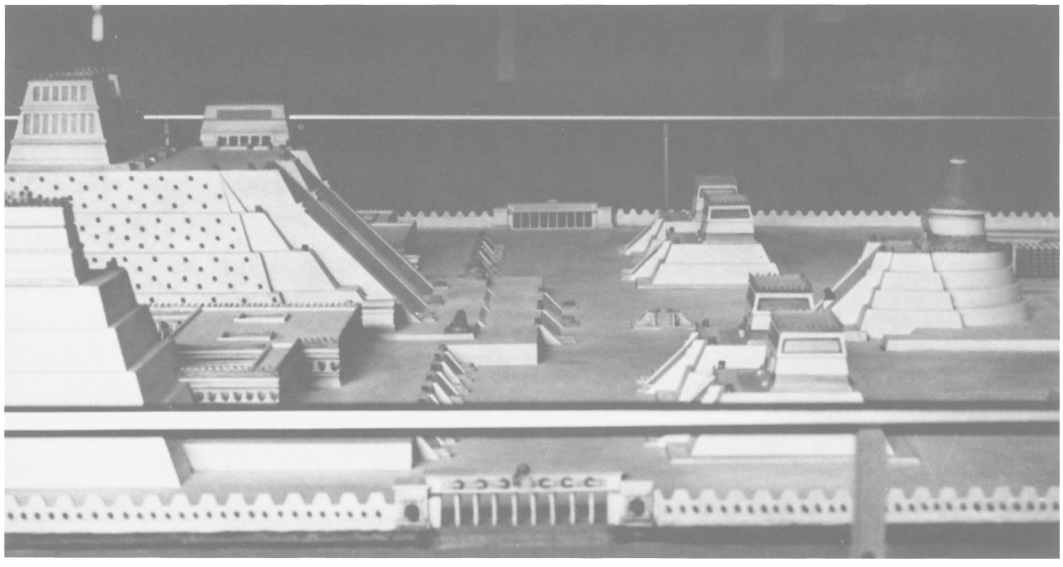

Fig. 2. View to the south showing the relative placement of the Templo Mayor (left) and circular Temple of Quetzalcoatl (right). Photo by Hartung from a model in the National Museum of Anthropology, Mexico City.

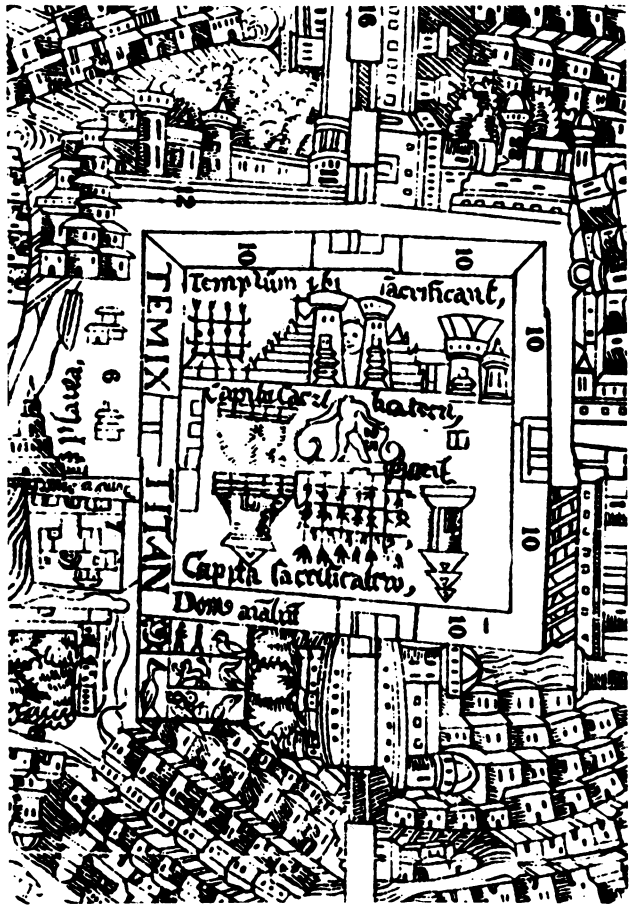

Fig. 3. Enlarged portion of a map of Tenochtitlan dated 1524. After Garcia (1910).

As shown in Fig. 4 an observer at the base of the circular temple would indeed see the equinoctial sun along an axis directed 7°30′ S of E, but only after it had risen to an altitude of 22° above the astronomical horizon. Twin temples on a platform 55 m above the ground would effectively frame the elevated sun for a ground-level observer 142 m away. For an observer situated at a higher level on the circular temple, the effective height of the Templo Mayor becomes 55 m plus the height of the observer.

It is apparent that the consistency of historical and archaeological evidence in the case of the Templo Mayor depends upon the credibility of estimates of its height. By relying on postconquest accounts (including Motolinia's) of the *dimensions* of the temple, Marquina (1960) has estimated the height of the platform on which the oratories stood to have been about 42 m above ground level. The order of magnitude agreement between Marquina's height estimate and estimates based on archaeoastronomical evidence suggests that Motolinia's statements concerning the function of the skewed Templo Mayor are consistent with his statements concerning its dimensions.

The method offered as a possible means of reconciling history and archaeology in the case of Templo Mayor emphasizes the importance of considering dimensions in any study of the astronomical relations of building orientations.

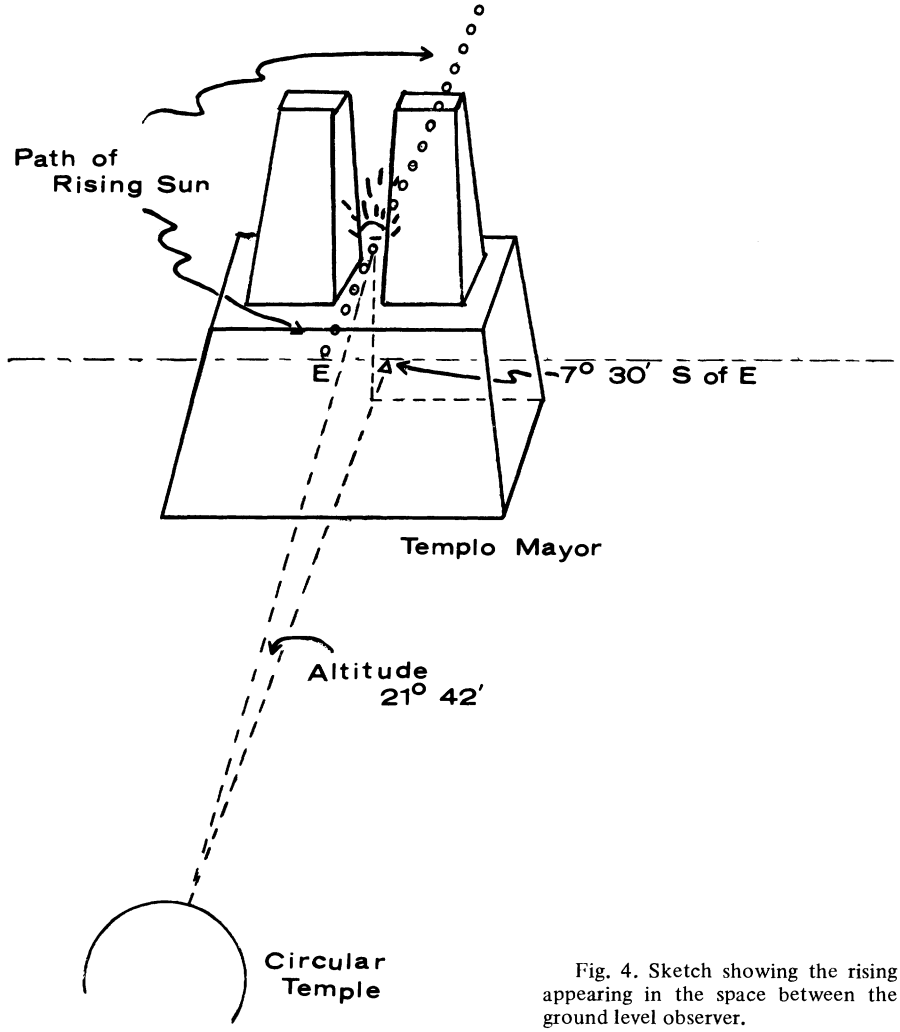

Fig. 4. Sketch showing the rising equinoctial sun appearing in the space between the oratories for a ground level observer.

By varying the elevation of the observer relative to the observed event, the position of equinox sunrise can be shifted horizontally to match many of the orientations listed in Table 1 (especially those in the range 0° to 10° E of N). For larger deviations from the cardinal points, other astronomical possibilities can be suggested. Alignments with a large skew could be related to a sunrise or sunset position on some significant agricultural, civil, or religious date of the year.

Motolinia's statement about the orientation of Tenochtitlan may be contrasted with that of Sejourne (1957) who, after Marquina, attributes all peculiar orientations to alignment with the sunset position on the days of its passage through the zenith:

> In keeping with Nahuatl cosmology, it is the solar monument which dictates the orientation of all the others. This orientation offers an interesting peculiarity in that the west-east axis, representing the trajectory of the drama of incarnation and liberation adopted all over Mesoamerica, is modified 17 degrees to the north. After careful investigation, the architect Ignacio Marquina finally discovered that this direction was caused because the pyramid faced the point where the sun is hidden the day it passes directly overhead [translated from the French].

Sunset on the day of the zenith passage occurred 21½° N of W in precolumbian Central Mexico (not 17° as Sejourne implies). But allowing for elevation differences, this direction could be a match for some of the alignments with a large skew. Indeed, Girard (1966) has emphasized the importance of the position of zenith passage sunrise for the present-day Maya who consider that direction to determine the cardinal east point.

The Pleiades star group must be emphasized as a likely motive behind the Teotihuacan orientation. There, an east to west baseline (Dow 1967, Millon 1974) between the pecked cross petroglyph about 50 m north of the Viking Group on the Street of the Dead and a similar marker on Cerro Colorado, 3 km to the west, points, within 1°, to the position of disappearance of the Pleiades in the west during the earliest building phases at Teotihuacan. That Teotihuacanos may have considered the Pleiades a significant stellar group is suggested by their association with the local zenith. Not only would the Pleiades have passed close to the zenith when transiting the Teotihuacan meridian, but also their heliacal rising (first annual pre-dawn appearance) would have occurred on the same day as the first annual passage of the sun through the zenith. Thus, the Pleiades could have served both to indicate the position of the local zenith and to announce the day of the sun's passage through it. Fig. 5 is a simulated view (reconstructed with the aid of a Planetarium) of the western horizon of Teotihuacan as viewed from the marker north of the Viking Group. The Cerro Colorado petroglyph is behind the large tree (arrow). The stars appear in their A.D. 150 positions relative to the horizon. The Pleiades is the conspicuous

Fig. 5. The western horizon of Teotihuacan in A.D. 150 showing the Pleiades immediately prior to extinction. The observer stands at the marker 50 meters north of the Viking group viewing the Cerro Colorado petroglyph (arrow).

group situated above the arrow. Other possible astronomical motives for the Teotihuacan alignments have been discussed by Dow (1967). An alternative explanation for the Teotihuacan building plan has recently been advanced by Heyden (1975) who suggests that a cave beneath the Pyramid of the Sun may have determined the placement of that building.

In conclusion, no single explanation, astronomical or otherwise, can be advanced to explain the peculiar orientation of all precolumbian buildings in Central Mexico. The aforementioned astronomical events have been considered in discussing the orientation schemes not only because they coincide closely with alignments taken at the sites, but also because (a) the surviving literature tells us that these astronomical constructs were of considerable importance in Native American religion and folklore, and (b) they could have served to establish important dates in the civil, agricultural, or religious calendar, e.g., the heliacal rising of the Pleiades is still used among the contemporary Chorti Maya to demarcate the planting season (Girard 1966).

In 1974, Franz Tichy published the results of an aerial survey of the highlands of Mexico in the region of Cholula, Puebla, and Tlaxcala. He found that postconquest fields, villages, and towns in the area aligned generally east of north. Three distinct families of axial directions are evident in his data: a group near 7°, a group near 17°, and a group near 26° east of north. The existence of similarly oriented precolumbian buildings in the Mexican highlands led Tichy to postulate that the later structures preserve directions of importance in antiquity. Tichy's survey adds an interesting dimension to the study of precolumbian orientations. As a result of his work, we can include the ruins at Pedrera (7° E of N), Xochitecatl (4° E of N), Cacaxtla (3° E of N), Coapan (15° E of N), and La Luna (12° E of N) in a list of clockwise-skewed ceremonial centers in Central Mexico.

Acknowledgments. The authors are grateful to Arqto Horst Hartung for a critical reading of this manuscript and to Joseph Carr of the Planetarium of the University of South Florida for his assistance in the preparation of Fig. 5.

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PRISMATIC BLADE REPLICATION

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A series of experiments to replicate prismatic blades with use of direct percussion, indirect percussion, and pressure techniques are discussed. Similar prismatic blades can be produced by a number of techniques and