ON THE TERRESTRIAL ORIGIN OF THE TEPEXITL CRATER, MEXICO

Lucrecia Maupomé
Instituto de Astronomía, UNAM
México 20, D. F.
and
Centro de Investigación, IPN
México 14, D. F.
Román Alvarez
Instituto de Geofísica, UNAM
México 20, D. F.
Susan W. Kieffer
Dept. of Geology, University of California
Los Angeles, CA 90024
Robert S. Dietz
National Oceanic and Atmospheric Administration
Miami, FL 33149

The possibility of a meteoritic origin for Tepexitl crater in Mexico was proposed by Maupomé (1974), owing to the evident explosive origin of the crater, its circularity and its strong topographical resemblance to Wolf Creek crater, to the Pretoria Salt Pan, and to some lunar craters.

Located in Zacatepec plain, the crater is a bowl-shaped, nearly circular structure with a complete rim, Fig. 1a and 1b; its present depth averages 75 m from the top of the rim to the flat floor. Its measured diameters vary from 1180 m to 966 m. The rim varies in height above the crater floor from 57 m on the north to 92 m on the south. At the top the width is 2 to 5 m; the outer slopes are about 15° and the inner walls have slopes of about 27°. The crater has an inner ridge along the SE radius extending from the top of the rim to nearly the center of the crater. Tepexitl is located at 19°13′ N, 97°26′ W, in the NE part of the State of Puebla. The area is within the Mexican Volcanic Belt (Quaternary volcanism) and contains maars, calderas, volcanic cones, limestone outcrops and intrusive ryholitic domes. There are, however, few geological studies published on the area and those available cover it only partially (Ordóñez, 1905 and 1906; Ohngemach 1973). Tepexitl apparently had not been formerly described in the literature.

Geophysical studies were initiated in order to test the hypothesis of meteoritical origin (Alvarez *et al.*, 1975); aeromagnetometry and ground magnetometry surveys were carried out over volcanic cones, calderas, and Tepexitl, in order to study geophysically determinable differences. Such initial surveys yielded favorable results in support of an impact origin for Tepexitl since its magnetic response did not show the presence of a magnetic dipole detected at the majority of the other structures, thus suggesting a different origin for this crater.

Fig. 1a Aerial view of Tepexitl, the inner ridge is in the SE quadrant. North is to the top. (Fig. 4, Plate 6, Maupomé 1974).

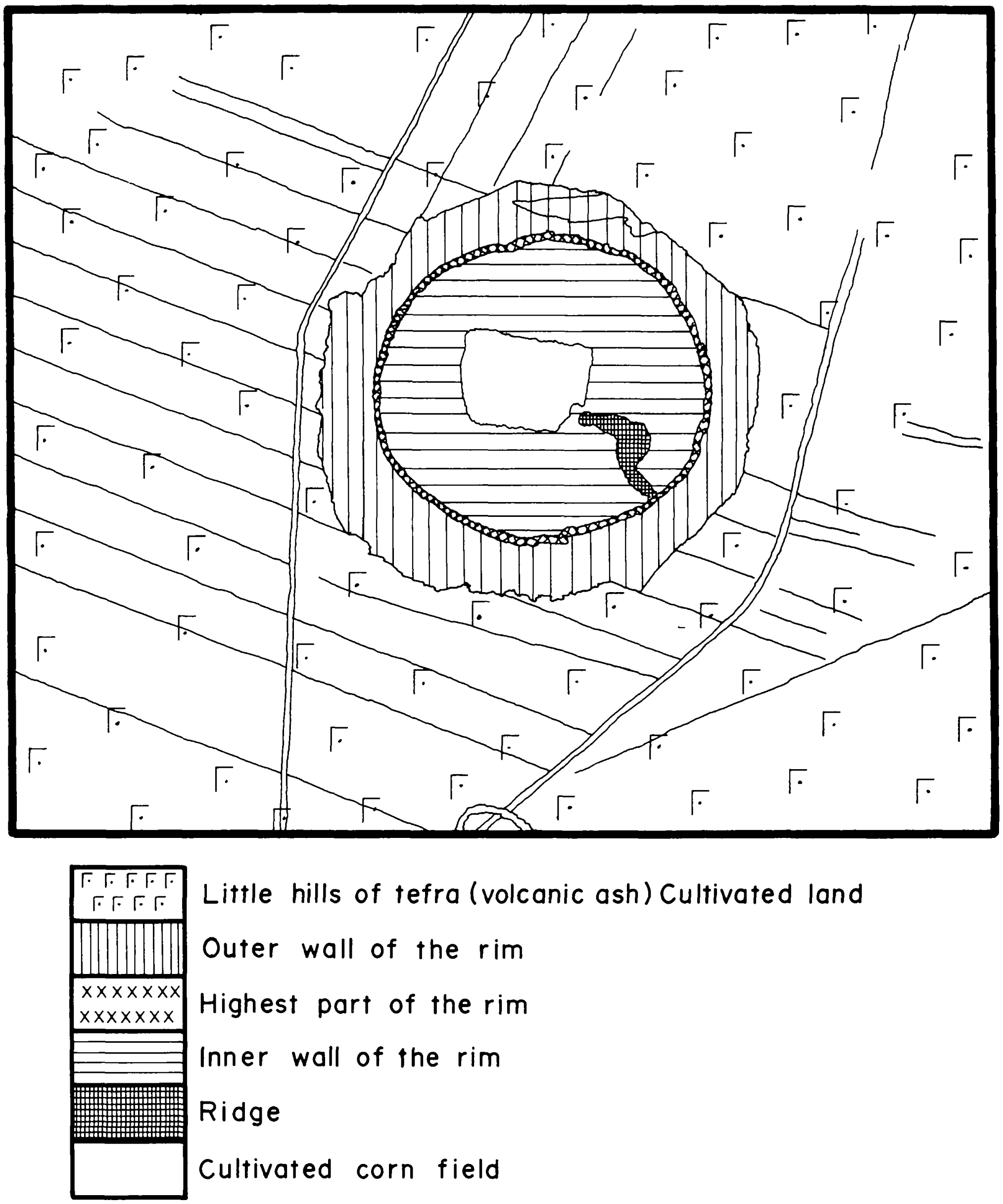

Fig. 1b Elements of the crater (Fig. 6, Maupomé, 1974).

Closer geological studies have indicated, however, that the origin of the structure is definitely volcanic. The crater is an ash ring composed primarily of volcanic glass (vitric) fragments. These were apparently ejected fairly cold as there is no evidence of welding of the ash into a welded tuff.

Although the crater floor has a depression below the regional level, the volume of the rim exceeds the volume of the bowl, indicating that there has been addition of material to the neighboring surface. This is unlike a meteorite crater where the volume of the ejecta is essentially equal to the volume of the hole since the volume of the impacting missile is negligible in comparison.

The crater wall is made up mostly of dip-slope beds which retain their initial dips, dipping both outward and inward with respect to the rim crest. There is no evidence of inverted or overturned stratigraphy. Beds described earlier by Maupomé (1974) as "overturned" are in fact "draped" over the inside of the crater wall; these, however, are not stratigraphically overturned beds. In addition, at this crater there is no uplifted country rock showing a quaquaversal dip. In fact, no country rocks are seen at all in the rim. The rim is entirely constructional, made up of volcanic ash, which is contrary to the expectation if it were an impact crater.

Further arguments against the impact concept are that we found no meteorites, no shatter coning (Dietz, 1946b), no rock flour, and no rocks which could be interpreted as probably shock metamorphosed. However, some percussion fractures, plumose fracture, and slickensiding were noted, in addition to some scouring which may have been due to the moving ash clouds. There is no fracturing, however, that we can associate with the type of shock generated by a meteorite explosion.

The following model proposed for the volcanic origin of Tepexitl is based upon the stratigraphy of the crater. The oldest units exposed are unwelded white ash beds of rhyolitic composition, Table 1. In all there are

Table 1
Composition of rocks from Tepexitl (Tepx) and Tepeyahualco (Tlco)*

Compounds (%)	Tepx (black)	Tepx (grey)	Tlco (white-grey)
SiO_2	74.15	73.68	73.03
Al_2O_3	14.05	14.00	13.83
CaO	0.70	0.73	0.50
Na_2O	4.05	4.19	4.16
K_2O	4.05	4.11	4.02
Fe as Fe_2O_3	1.21	1.16	0.69
MgO	0.07	0.06	0.08
TiO_2	0.08	0.08	0.02
(H_2O)	1.17	1.83	3.17
Total	99.59	99.84	99.50

*Tepeyahualco is a complex explosion crater, located 20 km to the north of Tepexitl. The compositions shown in these columns may be characteristic of many of the young volcanic features in this region.

perhaps 50 of these ash units in the crater wall. In several gullies it is possible to see beds draped over the rim in a continuous bend. It appears that the surrounding valley was covered by a Pleistocene lake at the creation of Tepexitl. This lake may have provided the water necessary to generate phreatic explosions above a shallow magma reservoir.

Magma probably entered the region under Tepexitl and, at shallow depth, either reached the level of the ground water table or came in contact with lake water. A vent opened through the basement which, in this region, is limestone.

Since the crater is slightly elongated in the NW-SE direction, the initial vent may have been slightly elongated in this direction. The more violent periods of eruption produced ash beds dipping outward from the crater. The less violent eruptions (implying a smaller vent) allowed beds to be draped over the rim.

An obsidian plug of rhyolitic composition choked the vent leading to a period of quiescence during which this plug cooled and solidified. Subsequent eruptions, probably driven by more water entering the magma until pressure was sufficient to ream out much of the obsidian plug, resulted in the deposition of a unit containing obsidian blocks as the vent reopened. As the eruption continued, ashes were deposited on top of the obsidian blocks. This last stage of eruption appeared to have tapped the deeper parts of the reservoir, culminating with the transport of limestone xenoliths and alluvial cobbles to the surface.

The last eruption was possibly off-center because the obsidian plug would have been substantially stronger than the volcanic ejecta and crater fill. We infer that this last eruption was off-center toward the south because: 1, the south rim is 35 m higher than the north rim – the extra 35 m of height consists of the last-deposited beds; 2, draped beds are missing in the southern sector, presumably scraped off by the final eruption – the draped beds are preserved on all other sectors; 3, the anomalous ridge in the southeast is a constructional unit, containing abundant large obsidian blocks from the obsidian plug.

In conclusion, the following evidence is against an impact origin for Tepexitl: 1, no meteorites were found; 2, no shatter cones were discovered; 3, we could identify no shock metamorphosed rocks; 4, the rim is entirely composed of ash with no uplifted quaquaversally dipping country rock; 5, there are no overturned beds or overturned flap; 6, ejected blocks are of small size, the largest observed being about 1 m^3; 7, the ejected material is entirely volcanic; 8, the volume of the rim exceeds that portion of the crater which is depressed below the regional level, so that new material has been added to the earth's surface; 9, there is no evidence of a central dome or ring syncline; and, 10, there is no suevite (impact-melt rock) as would contain cored bombs, polymict breccia, etc.

The small mass of the moon and its low internal pressure make volcanism unlikely on the moon (Dietz, 1946a). Furthermore, generatical similarity among Tepexitl and moon's craters can be readily discarded in view of the exceedingly anhydrous lunar environment which would obviously prevent the occurrence of shallow phreatic explosions.

REFERENCES

Alvarez, R., L. Maupomé and A. Tejera, 1975. Aeromagnetometry and Ground Magnetometry of Volcanic Structures in Puebla, Mexico (in preparation).

Dietz, R.S., 1946a. The Meteoritic Impact Origin of the Moon's Surface Features. *The Journal of Geology, Vol. LIV,* **6**, 359-375.

Dietz, R.S., 1946b. Geological Structures Possibly Related to Lunar Craters. *Popular Astronomy, Vol. LIV,* **9**, 1-3.

Maupomé, L., 1974. Possible meteorite crater in Mexico. *Rev. Mex. Astron. y Astrofis.* **1**, 81-86.

Ohngemach, D., 1973. Análisis Polínico de los Sedimentos del Pleistoceno Reciente y del Holoceno en la Región Puebla-Tlaxcala. *Communicaciones*, Fund. Alemana Inv. Cient. **7**, 47-49.

Ordóñez, E., 1905. Los Xalapascos del Estado de Puebla (la. parte, México: Imprenta y Fototipía de la Secretaría de Fomento).

Ordóñez, E., 1906, Los Xalapascos del Estado de Puebla (2a. parte, México: Imprenta y Fototipía de la Secretaría de Fomento).

Manuscript received 7/1/75