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LOS HUMEROS CALDERA

SPECIAL ISSUE

The present issue of Geofísica Internacional is devoted to Los Humeros Caldera, a young volcanic structure located in central-eastern Mexico (Figure 1). The motivation for studying the area arose from its potential as a geothermal source. The results and analyses presented herein encompass seismic, gravity, magnetic, telluric, self-potential, and surface temperature data.

Mexico has two major tectonic areas in which the production of electricity from geothermal sources may become of economic relevance to the country: the Mexican Volcanic Belt (also called Trans-Mexican Neovolcanic Axis) and the Gulf of California (Alvarez, 1976). Geothermal generation of electricity comes at present only from the Cerro Prieto field (150 Mwe) near Mexicali, Baja California. However, intense exploration and development is being carried out by the Comisión Federal de Electricidad in Los Azufres, Michoacán, La Primavera, Jalisco, and more recently in Los Humeros, Puebla.

With potentially vast resources of a given energetic, a country must have adequate strategies for its exploration and exploitation. Several countries throughout the world support research groups trying to establish such strategies for the location and evaluation of geothermal resources. By publishing these reports we hope to make our local experiences available to the international community. The total number of papers is small and the amount of data presented in some of them will have to be increased when more precise estimations are needed and when more substantial support becomes available.

A preliminary geological description of Los Humeros was elaborated under the geothermal program of the Instituto de Geofísica, UNAM (Pérez-Reynoso, 1978). More recently geothermal explorations from the Comisión Federal de Electricidad, México, have required semi-detailed geological mapping not only of Los Humeros but of a larger area (Yáñez *et al.*, 1979), which partially overlaps with an area previously studied by Basán (1959) and by Ordóñez (1905 and 1906).

According to Pérez-Reynoso (1978), the formation of a large shield volcano took place in los Humeros probably during the Pliocene. In the Pleistocene basaltic flows covered the southern flanks of such structure in the Holocene explosive volcanic activity produced various cinder cones within the caldera (Figure 2). Robin (1976) suggests that during the Pleistocene times strong volcanic activity of basic composition took place in the area of Los Humeros. Yáñez *et al.* (1979) report that igneous and metamorphic rocks from the Paleozoic constitute the regional basement (pink granite, andesite and rhyolite porphyries, and green schists); they reported limestones of Jurassic and Cretaceous ages as above basement rocks. During the Miocene the major volcanoes of the area were formed in episodes that filled topographic depressions with pyroclastics; such volcanoes contain augite, hipersthene andesite and hornblend andesite. The activity continued throughout the quaternary with the formation of volcanoes, calderas, maars, domes, and cinder cones; Los Humeros is one such episode.

The aeromagnetic results (Flores *et al.*, this issue) indicate the existence of a central structure within Los Humeros caldera; it is a normally

magnetized body yielding a bipolar anomaly of dimensions comparable to the caldera dimensions. The computed model corresponds to a prism of 5 km in depth, whose top is located at 2 km from the surface. Having magnetized material at such depths implies that the prism's temperature is less than the Curie temperature, rendering such a body unattractive for geothermal exploration. The magnetic interpretation, however, does not preclude the existence of partially molten material, or material close to its Curie point, in the caldera perimeter.

Gravity results (Mena and González-Morán, this issue) support the existence of a central body although they cannot properly define its shape or depth to the top owing to the scant data points in that specific area. The gravity survey covers an area considerably larger than that of Los Humeros, defining regional structures adequately. A collapsing process is suggested to take place from South to North, with Los Humeros being the area of greater collapse.

The overall caldera response consists of a gravity low; such a low is explained in terms of low density caldera fill, which according to the calculations presented may reach up to 1 500 m in depth. Immediately to the East of Los Humeros gravity shows another low, which is interpreted as a second caldera of similar dimensions, but older than Los Humeros. Such a caldera (La Gata) would be completely covered by pyroclastics and alluvium and would be located between two major volcanic structures in the area: Los Humeros and Cofre de Perote volcano (4282 m).

Two cross-sections of the caldera were modelled gravimetrically and compared to the telluric responses (Alvarez, this issue). The two sets of independent results show a high correlation in delimiting the caldera rim. Owing to such a correlation one can safely discard the northeastern caldera limits proposed by Pérez-Reynoso (1978) and substitute them for the limits obtained from gravity and telluric responses (i.e., about 4 km West of the limits shown in the photogeologic map of Pérez-Reynoso); the western limits determined by such methods coincide with those determined photogeologically. Telluric responses on the northern portion of the caldera suggests a series of blocks collapsing en échelon toward the East, while on the central area the blocks fall from the

center of the structure toward the West. The response along Line 1 appears to intersect the central body suggested by magnetic and gravity results. The central-eastern portion of the caldera appears to be an area of greater structural uniformity than the western and northern sections. The self-potential response shows that the electrical potential of the caldera is 800 mV higher on the western than on the eastern caldera rim; the western section also shows a clearly defined positive anomaly of approximately 600 mV in amplitude. Surface temperature readings yield average values which are 2° to 3°C higher on the western side than on the eastern side of the structure.

The seismological observations (Ponce and Rodríguez, this issue) showed an active area with very shallow seismic activity on the southwestern portion, both inside and outside the caldera. An area of anomalous absorption of seismic energy was detected on the western portion of the structure, roughly corresponding to the area where relative electrical conductivity, self-potential, and temperature anomalies were obtained. Large time delays between stations indicate the presence of a layer of unconsolidated material probably thicker than 50 m, correlating well with the result derived from gravimetric observations. Some microearthquakes appear to be caused by circulation of fluids in fractured rocks at shallow depths.

Summarizing, Los Humeros is a quaternary shield volcano with activity as recent as probably 10000 years as suggested by lava flows that have not yet developed complete drainage systems. It appears to be the result of a tectonic collapse beginning in an area about 50 km South of the caldera and ending abruptly at the northern caldera flank, in the gravitic mass of the Macizo de Teziutlán. Anomalies were obtained on the western section of the caldera for relative electrical conductivity, self-potential, surface temperature, and absorption of seismic energy; such anomalies are compatible with the presence of a heat source that may be of geothermal interest. Magnetics, gravity, and tellurics appear to be a viable combination for determining structural features in volcanic fields.

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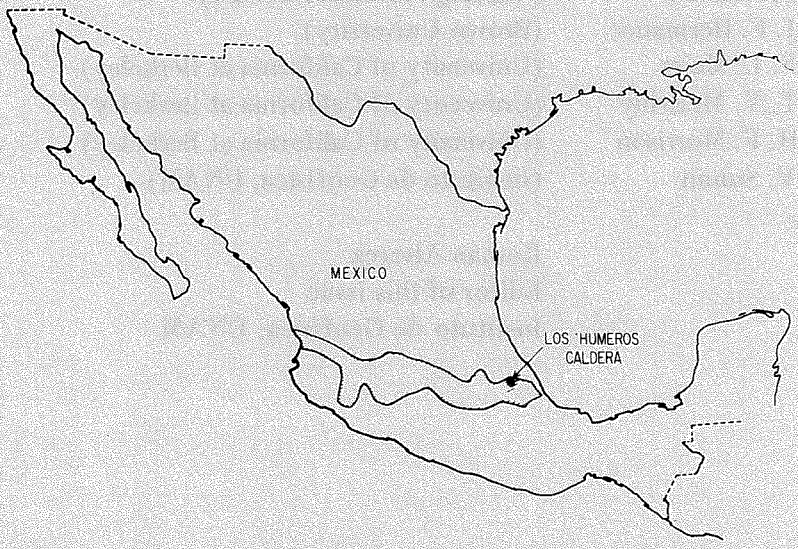

FIGURE 1. Location map showing the position of Los Humeros in the Mexican Volcanic Belt (hashures).

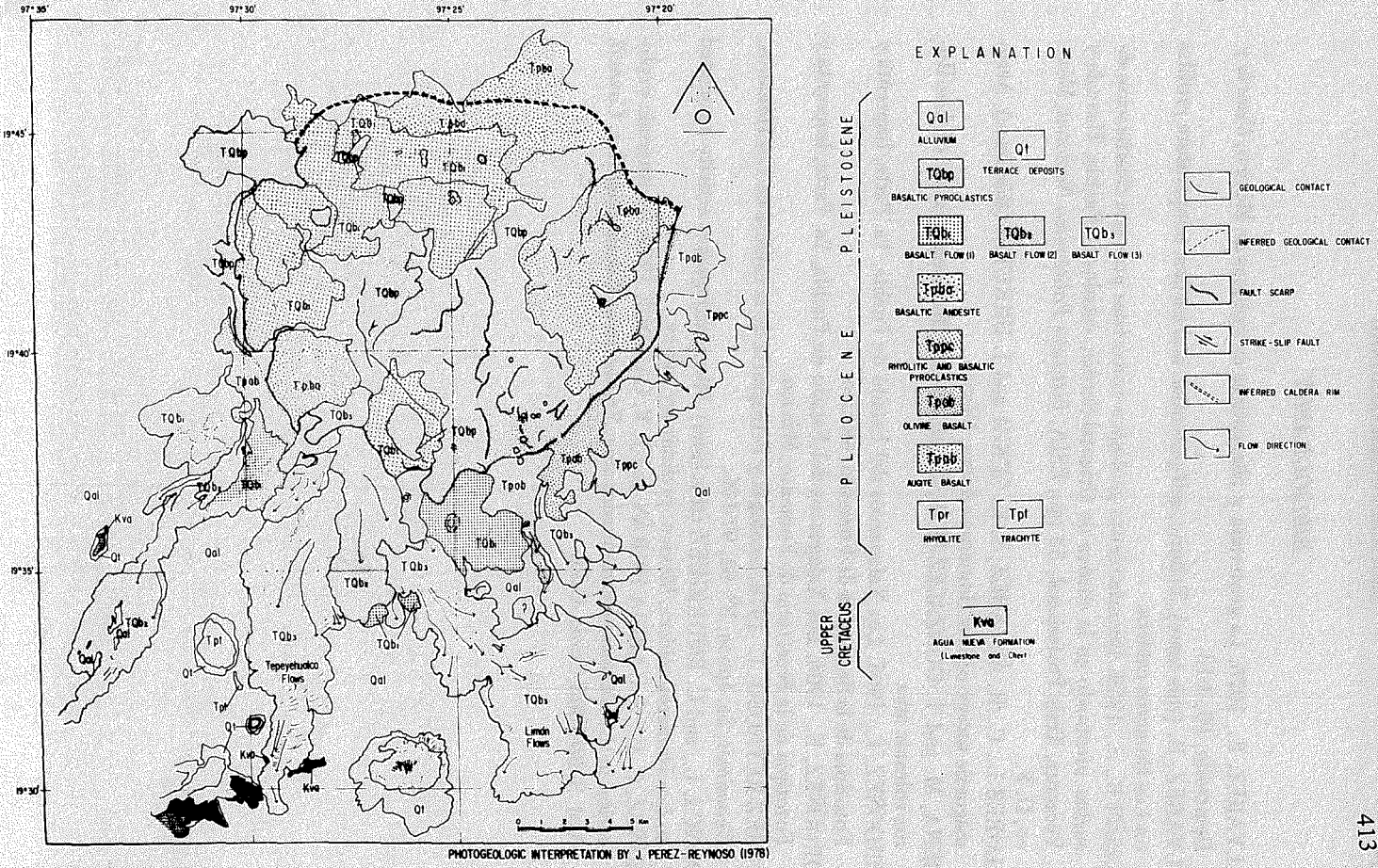

FIGURE 2. Photogeologic map of Los Humeros caldera. (After Pérez-Reynoso, 1978).

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