PALEOMAGNETIC STUDY OF SIERRA DE CHICHINAUTZIN, MEXICO

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RESUMEN

Un estudio paleomagnético de 113 muestras orientadas y colectadas de 15 localidades en la Sierra de Chichinautzin, Valle de México, demuestra solamente direcciones normales de magnetización. La posición polar calculada (86.7°N, 239.4° E, α_{95} 7.2°) es consistente con las posiciones polares cuaternarias de México, excepto con el polo cuaternario obtenido para Baja California.

ABSTRACT

A paleomagnetic study of 113 oriented samples collected from 15 localities in the Sierra de Chichinautzin, Valley of Mexico, shows solely normal directions of magnetization. The calculated pole position (86.7° N, 239.4° E, α_{95} 7.2°) is consistent with Quaternary pole positions from Mexico except with one Quaternary pole obtained for Baja California.

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INTRODUCTION

Even today very limited amount of information is available on paleomagnetic directions and pole positions from Mexican rocks. These have been summarized by Pal and Urrutia (1977) and Pal (1978). Any new results on Mexican rocks should therefore prove useful to the scientific community. The present study reports results of a paleomagnetic investigation carried out in the Sierra de Chichinautzin at the southern end of the Valley of Mexico.

SAMPLING AND MEASUREMENTS

The Sierra de Chichinautzin is located in a major volcanic feature called the Mexican Volcanic Belt (MVB). The details of the MVB have been given by Mooser (1972). The Chichinautzin group forms the southern part of the basin of Mexico (Fig. 1). This eruptive phase is considered to be of short duration of Upper Pliocene to Holocene age which finally closed the basin to the south (Mooser *et al.*, 1974). No radiometric dates are available. The Chichinautzin range itself is overwhelmingly formed by younger cinder cones and lava flows, morphologically very fresh and all assigned to the younger Quaternary. Mooser *et al.* (1974) have given magnetization directions for samples collected from 40 different sites. They find all the flows (except sites 39 and 40) to be normally magnetized from which they conclude that it is reasonable to assign them an age of less the 0.69 m.y. Site 39 (Xicalco SE; old, much altered andesite) gives a shallow negative inclination (–8°) but a nearly normal declination of 38°; thus showing an inclined magnetization and not a reversal. Site 40 (Ajusco NE Oligocene-Miocene complex) on the other hand shows high α_{95} of 70°. However an Oligocene-Miocene age has been assigned to this site, perhaps on geological grounds, by Mooser *et al.*, 1974.

An attempt was made in the present study to sample several different sites on the same Chichinautzin group in order to gather more paleomagnetic data and to see whether all these rocks show normal directions of magnetization.

Location of the sampling sites is given in Table 1. 113 oriented samples (2.54 cm. diameter) were collected using a core-drill and one or more specimens of length 2.54 cm. were cut from each core for paleomagnetic measurements. The direction and intensity of remanent magnetization of each specimen were measured using a commercial spinner magnetometer (PAR-SM2), and their stability was tested using an alternating field demagnetization apparatus (Carrillo *et al.*, 1978). Typical a.c. demagnetization curves as well as changes in the direction of remanent magnetization are shown in Fig. 2. The NRM intensities of the specimens are distributed between 3.55×10^{-4} and 9.15×10^{-3} emu/cm^3. Thin sections were prepared for two cores of each site for microscopic study and the results are given in Appendix I. Mean directions of remanent magnetization were computed using Fisher statistics (Fisher, 1953).

RESULTS AND DISCUSSION

The results of the present study are given in Table 1. The mean directions of magnetization obtained from different sites are plotted in Fig. 3, which shows that the directions are scattered around the axial dipole field. Virtual geomagnetic poles for the fifteen sites are also given in Table 1 and plotted in Fig. 4. It can be seen that the directions of remanent magnetization are all of normal polarity. Unfortunately it is not possible to determine estratigraphic relationship of these volcanic units because of the complex geology of the area and the lack of radiometric age data. This makes it difficult to utilize the present data for computing the amount of secular variation of the geomagnetic field during the time span covered by the present sampling.

The problem has been discussed in detail by McElhinny and Merrill (1975) who state that a long-standing difficulty in the application of conventional statistical techiques to paleosecular variation sudies involves the problem of whether or not the data are serially correlated. The data employed should ideally be drawn from a random population. Watson and Beran (1967) have produced a method for the detection of serially correlated results where a comparison is madė of the sum of the cosines of the angles between directions from successive lavas with sums resulting from random combinations of the same data. The amount by which the former exceeds the later sum is a measure of the amount of serial correlation.

McElhinny and Merril (1975) have argued that the data from a sequence of lava flows may appear to be serially correlated because a long-period change in secular variation exists, from which they conclude that the application of the Watson and Beran (1967) technique may be counter-productive in terms of searching for paleomagnetic information on secular variation.

As rightly pointed out by Watkins *et al.* (1977) a second difficulty in secular variation analysis of paleomagnetic data concerns the rejection of results which may represent anomalous geomagnetic field behaviour, such as transitions between opposite polarities, or excursions of the geomagnetic field. As summarized by McElhinny & Merril (1975), various authors have employed data cutoffs based on VGP latitudes raning from 40 to 45°, below which the results are assumed to represent anomalous behaviour. In certain cases especially when data volumes are limited, the cutoff choice can drastically affect computed S_F values.

A third decision which is necessary in computation of S_F is selection of the reference pole used to compute the total angular standard deviation (S_T)of the measured VGP's. This may be the mean VGP for the data set. Alternatively, since little evidence exists to suggest that the Earth's geographic pole position has changed significantly since the uper Miocene, the reference pole for the data can as well be the present geographic pole.

The mean pole position using the cleaned data of all the sites is 87° N, 239° E (n = 15, dp = 5°, dm = 8°). This pole position is consistent with the pole position (85° N, 76° E, n = 49, dp = 3°, dm = 6°) calculated from the data on Sierra de Chichinautzin given by Mooser *et al.* (1974). These poles are also in agreement with other Quaternary pole positions on Mexico except the pole from Baja Califormia (Pal, 1978).

The conclusion by Mooser *et al.* (1974) that the Sierra de Chichinautzin is a young volcanic group seems to be valid in the light of the new data. Perhaps if one takes into account very fresh morphology of the area, one can conclude that the Chinchinautzin group is much younger then 0.69 m.y. but this cannot be ascertained from the paleomagnetic data, as there is no way to subdivide the normal Brunhes interval. No evidence has been found (not even accidentally) which could throw light on the recent 'Las Champ' event.

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Table 1

Summary of paleomagnetic data of igneous rocks from Sierra de Chichinautzin, Mexico.

Site	Location		Cleaned remanent magnetization							a.c. field (Oe)	Polar coordinates			
	lat°N	long°W	N	R	D	I	K	α_{95}	δ		lat°N	long°E	dp	dm
1	19.1	99.1	8	7.904	357.6	26.7	72.7	6.5	8.9	550	84.5	253.9	3.9	7.1
2	19.0	98.8	14	13.937	6.1	12.9	205.4	2.8	5.5	200	76.2	304.9	1.4	2.8
3	19.1	98.8	12	11.981	330.3	46.6	576.7	1.8	3.2	150	61.5	165.4	1.5	2.3
4	19.03	99.03	9	8.950	342.7	11.6	160.2	4.1	6.0	200	68.6	224.9	2.1	4.1
5	19.2	99.02	11	10.915	345.4	18.6	118.0	4.2	7.1	200	72.9	221.4	2.3	4.4
6	19.3	99.2	17	16.947	358.0	34.3	300.9	2.1	4.5	100	88.0	202.7	1.4	2.4
7	19.3	99.2	11	10.884	354.6	33.7	86.0	5.0	8.3	250	84.8	197.6	3.2	5.7
8	19.2	99.2	9	8.843	7.2	33.4	51.0	7.3	10.7	250	83.1	2.6	4.7	8.3
9	19.2	99.2	8	7.939	4.5	27.1	115.0	5.2	7.1	550	83.5	321.2	3.1	5.6
10	19.2	99.2	9	8.932	6.0	34.9	118.1	4.8	7.0	150	84.3	10.4	3.2	5.5
11	19.3	99.2	12	11.952	16.1	36.1	229.7	2.9	5.1	100	74.8	14.6	1.9	3.3
12	19.1	99.2	13	12.431	6.4	15.9	21.1	9.2	17.0	550	77.4	309.6	4.9	9.5
13	19.3	99.2	8	7.938	355.1	38.9	113.5	5.2	7.1	0	84.7	158.5	3.7	6.2
14	19.3	99.2	8	7.954	356.8	52.3	151.2	4.5	6.2	0	76.1	110.6	4.3	6.2
15	19.3	99.2	7	6.903	356.1	33.6	62.1	7.7	9.5	0	86.2	202.3	5.0	8.8
Mean	19.2	99.1	15	14.513	357.8	30.9	28.8	7.2	14.6		86.7	239.4	4.5	8.1

N = number of samples; R = resultant vector; D = declination (degrees); I = inclination (degrees); K = precision parameter; α_{95} = semiangle of the cone of 95% confidence about the mean direction; δ = angular standard deviation of directions from the mean direction; a.c.field = demagnetizing field in Oersteds; dp, dm = semiaxes of the oval of confidence about the pole position at the 95% confidence level.

APPENDIX I

PETROGRAPHIC DESCRIPTION OF THE SAMPLES

Macroscopic description: rocks of extrusive (volcanic) origin, massive porphyritic, vesicular, cryptocrystalline, finegrained matrix, olivine and calcic-plagioclase phenocrysts, "melanochratic" dark grey color.

Microscopic description: A general description is given below.

Texture porphyritic, hipidiomorphic (most crystals are subhedral). Mineralogic composition includes ~ 70% plagioclase (0.2 – 0.3 mm dia. andesine - labradorite - bytonite); ~ 10% olivine (olive green color, transluscent, phenocrysts with impregnation of magnetic) and ~ 1% iddingsite (brick red color, transluscent).

Among accesory minerals, one finds clinopyroxenes (light green, transluscent, sometimes pleochroism in hipidiomorphic crystals). Augite (0.1 – 0.2 mm diameter about 5% in abundance) pigeonite (augite-enstatite of 0.1 – 0.2 mm. dia. up to about 3%), magnetite (opaque, black, isolated crystals or sometimes in clusters, abundance about 5%) and ilmenite (opaque, black, in the form of bands or clusters, ~ 4% abundance are present. As a secondary mineral, hematite (opaque red, in the form of spots or clusters, ~ 3%) can be seen.

The matrix is composed of calcic and sodic plagioclase and a small proportion (~ 10%) of basic glass.

The classification of the rocks studied in this work is given in tabular form.

Site	Location	Geographic coordinates	Thin section from Specimen Num.	Total Num. of samples/ specimens	Classification
1	Tlalmanalco Fed.road to Cuautla	19.1 N 99.1 W	157 & 160	8/9	Olivine basalt
2	Tepetlixpa Fed.road to Cuautla	19.0 N 98.8 W	149 & 153	8/14	Vesicular olivine basalt
3	Juchitepec	19.1 N 98.8 W	145 & 142	8/12	Olivine basalt
4	Milpa Alta 19 Km.on Xoch. Tlalnepantla road	19.03 N 99.03 W	137 & 138	7/9	Vesicular olivine-augite basalt
5	Tlalnepantla 3.45 Km. on Xoch.-Oaxtepec road	19.2 N 99.02 W	129 & 131	8/11	Olivine(augite) basalt
6	2.02 Km. on Ajusco-Picacho road	19.3 N 99.2 W	120 & 124	8/17	Olivine(augite) basalt
7	5.2 Km on Ajusco-Picacho road	19.3 N 99.2 W	113 & 116	9/11	Olivine(augite) basalt
8	7.6 Km. on Ajusco-Picacho road	19.2 N 99.2 W	104 & 105	7/9	Olivine(augite) basalt
9	9.4 Km. on Ajusco-Picacho road	19.2 N 99.2 W	93 & 97	7/8	Vesicular olivine basalt
10	11.5 Km. on Ajusco-Picacho road	19.2 N 99.2 W	92 & 90	8/9	Olivine basalt
11	San Andres Fed.road to Cuernavaca	19.3 N 99.2 W	77 & 78	8/12	Vesicular olivine Basaltic andesite

Site	Location	Geographic coordinates	Thin section from Specimen Num.	Total Num. of samples/ specimens	Classification
12	Parres, El Guarda. Fed. road to Cuernavaca	19.1 N 99.2 W	71 & 75	8/13	Vesicular olivine (augite) basaltic andesite
13	Ciudad Universitaria. Cerro del Agua Av.	19.3 N 99.2 W	44 & 43	8/8	Olivine basalt
14	Ciudad Universitaria. In front of the Fac.de Leyes	19.3 N 99.2 W		6/8	Olivine basalt
15	Ciudad Universitaria. In front of the Fac. de Leyes	19.3 N 99.2 W		5/7	Olivine basalt

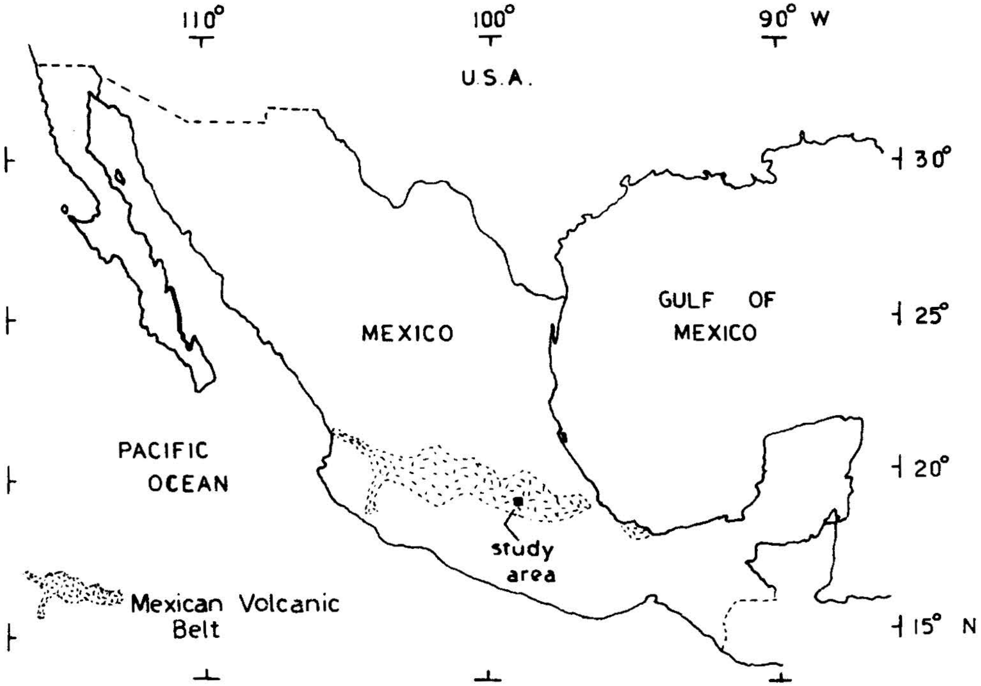

FIG. 1 Location of the study area (The map is after Mooser, 1972)

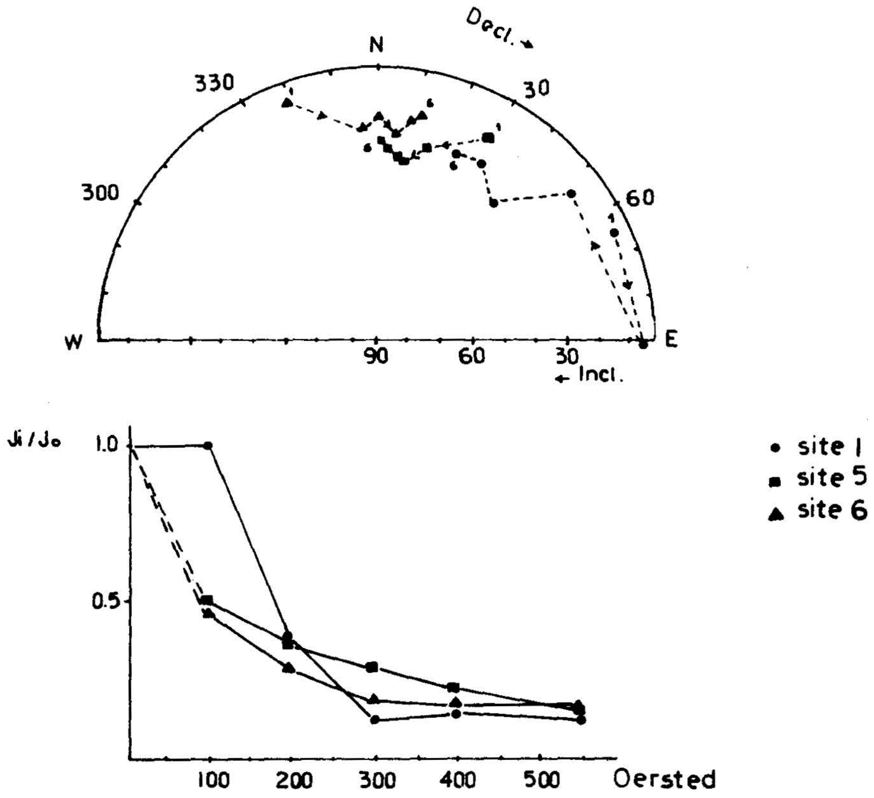

FIG. 2 Typical demagnetization curves of the remanent magnetization.

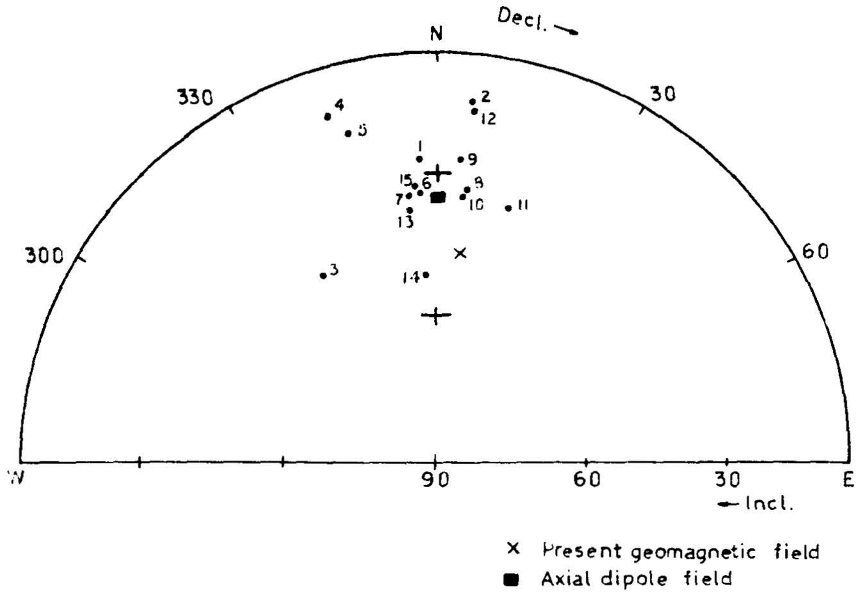

FIG.3 Mean directions of cleaned remanent magnetization obtained for the different sites (numbered after table I)

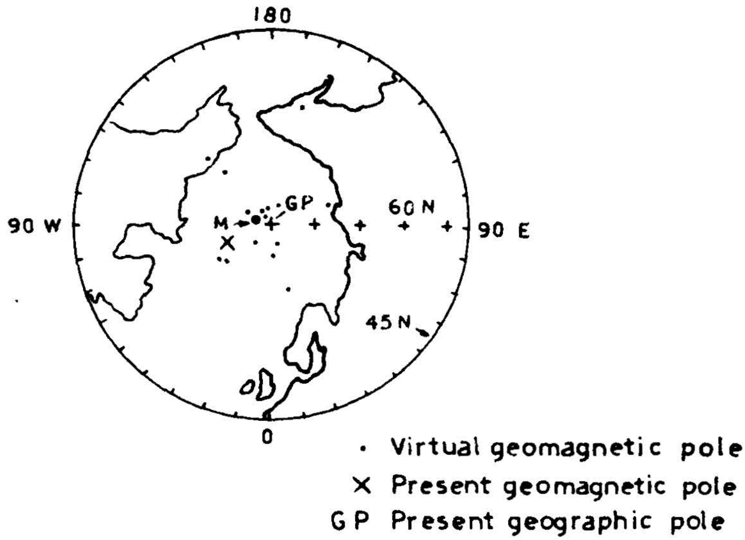

FIG. 4 Virtual geomagnetic pole positions for the fifteen sites (Table I) and also the mean pole position (M) from these sites.

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