# A new permanent geomagnetic station at Colima volcano observatory, Mexico

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Received: April 4, 2000; accepted: July 10, 2000.

**RESUMEN**

El Instituto de Geofísica de la Universidad Nacional Autónoma de México (UNAM) y el Observatorio Volcanológico de Colima de la Universidad de Colima han instrumentado la primera estación geomagnética (COV) cerca del Volcán de Colima.

Esta estación mide el campo magnético escalar y pertenece a una red de monitoreo de volcanes activos en México, cuyo propósito principal es detectar anomalías volcanomagnéticas potenciales asociadas con la actividad volcánica.

Se presenta la comparación entre COV y el IGRF ( International Geomagnetic Reference Field), así como con TEO (observatorio Magnético de Teoloyucan) y que presenta un coeficiente de correlación alto (R=0.994), permitiendo obtener un lugar de comparación entre observaciones geomagnéticas de alta precisión en la parte occidental de México. Un sitio en la red puede utilizarse para consultar la información en tiempo real para la estación (http://www.igeofcu.unam.mx/geomagne/geomag.html).

**PALABRAS CLAVE:** Estaciones geomagnéticas, Volcán de Colima.

**ABSTRACT**

The first geomagnetic station (COV) has been installed near Colima volcano by the Geophysics Institute of the National Autonomous University of Mexico, and Colima Volcano Observatory at the University of Colima. This station measure the scalar magnetic field and belongs to the geomagnetic monitoring network of active volcanoes in Mexico.

Comparison between COV, IGRF (International Geomagnetic Reference Field) and TEO (Teoloyucan Geomagnetic Observatory) data shows a high correlation with a coefficient of R= 0.994. COV provides a suitable reference site for high precision geomagnetic observations in western and central Mexico. Web site provides access to real-time data for this station (http://www.igeofcu.unam.mx/geomagne/geomag.html).

**KEY WORDS:** Geomagnetic stations, Colima volcano.

## INTRODUCTION

The national geomagnetic network of Mexico includes the Teoloyucan Geomagnetic Observatory (TEO), and 51 stations distributed in the country (Cifuentes and Hernández, 1996). Average distance between stations is less than 350 km, making them suitable for a geostatistical spatial and temporal description of the geomagnetic field and its secular variation (Campos-Enríquez *et al.*, 1994; Hernández and Orozco, 1997). However, except for central Mexico (TEO), continuous records for most of the country have not been available.

Continuous and discrete geomagnetic records are important for the generation of reference fields and for correction, calibration or comparison of magnetic anomaly surveys. In particular, they are critical for the generation of regional and global models such as the International Geomagnetic Reference Field (IGRF). Models proposed for the IGRF are evaluated by the International Association of Geomagnetism and Aeronomy (IAGA). Differences among candidate models are quantified and models are compared with magnetic data from various sources including observatories, land and marine magnetic surveys and satellite observations (e.g., Dawson and Newitt, 1978, 1982; MacMillan *et al.*, 1997; Cohen *et al.*, 1977) Discrete and continuous records are used for the construction of Definitive Geomagnetic Reference Field (DGRF) models. One of the major problems in generating global models and in their evaluation is the uneven distribution of geomagnetic observatories. Large areas such as the oceans are not covered, and even in continents there are often large gaps between observatories. Mexico and Central America are clear examples of such regions (Figure 1).

The lack of permanent continuously recording geomagnetic stations in most of Mexico presents a major problem for geophysical surveys and special projects

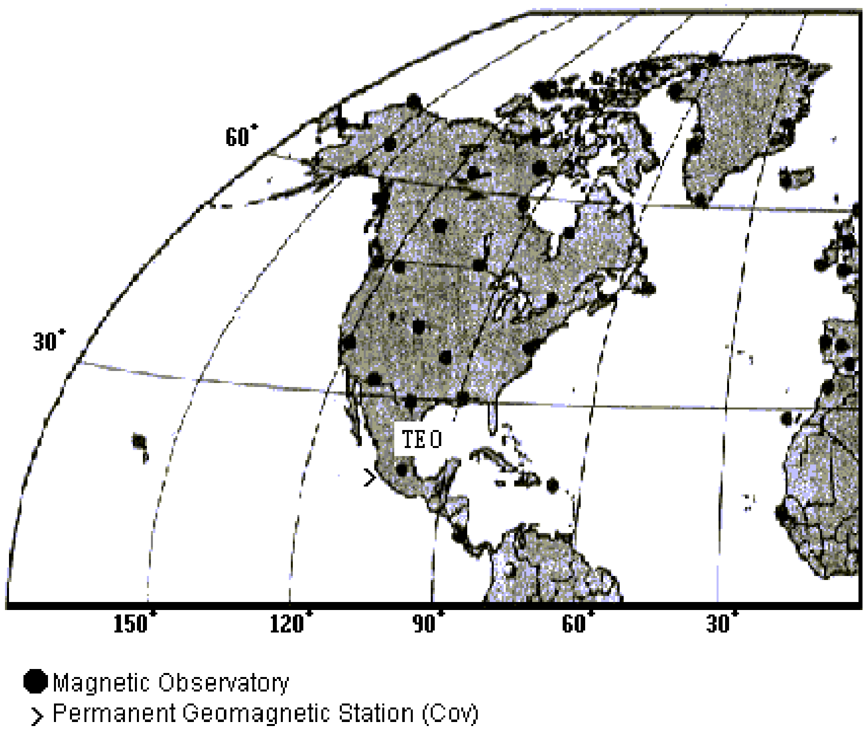


Fig. 1. Distribution of geomagnetic observatories in America (north of Equator) (modified from MacMillan *et al.*, 1997). Note the distribution of observatories and the large gaps in Mexico and Central America. The arrow marks the location of the new permanent geomagnetic station in western Mexico.

focussed on monitoring geomagnetic changes. This is the case of the project for the geomagnetic monitoring network of active volcanoes (GMNAV). Operation of GMNAV requires the availability of suitable reference stations. As part of the GMNAV project, and given the importance of geodynamic processes on the Pacific plate margin and the reactivation of the volcanic activity on Colima Volcano in western Mexico, a continuously operating geomagnetic station suitable for comparison of regional land and marine magnetometric surveys on the Pacific margin was instrumented at the Colima Volcano Observatory. Its main objective is to serve as a reference station for the magnetic surveys and permanent geomagnetic observations carried out on the Colima Volcano.

Geomagnetic observations in the state of Colima date back to 1587 when Thomas Cavendish measured magnetic declination in Manzanillo (Sandoval, 1950). Since then, sporadic observations have been performed (Table 1), but unfortunately the different location of some stations over time precludes a long-term series analysis.

**Table 1**

Historical geomagnetic observations in Mexican Colima state, western Mexico. In this table are considered sea observations (Cavendish and Nichols)

| Year | Station | Observer | H (nT) | D (° ‘) E | Z (nT) |
|---|---|---|---|---|---|
| 1587 | MAN | Cavendish | | 2° 00.0' | |
| 1880 | MAN | Nichols | 33750 | 8° 05.0' | 31763 |
| 1907 | MAN | Moreno & Anda | 33000 | 8° 32.4' | 31836 |
| 1907 | COL | Moreno & Anda | 33120 | 8° 25.0' | 32043 |
| 1931 | MAN | R. Sandoval | 31536 | 10° 28.8' | 31624 |
| 1931 | COL | R. Sandoval | 31513 | 9° 57.8' | 31585 |
| 1955 | MAN | C. Cañón | 30727 | 9° 36.6' | 30577 |
| 1958 | ISO | C. Cañón | 30577 | 10° 17.4' | 30034 |
| 1962 | MAN | C. Cañón | 30424 | 9° 31.9' | 30490 |
| 1969 | MAN | C. Cañón | 30258 | 9° 12.9' | 30299 |
| 1990 | MAN | E. Hernández | 29198 | 8° 30.3' | 29838 |
| 1998 | COV | E. Hernández | 28749 | 8° 22.0' | 29947 |
| 1999 | COV | G. Cifuentes | 28703 | 8° 27.8’ | 29918 |

## COLIMA VOLCANO OBSERVATORY

Colima Volcano is located in the western sector of the Trans-Mexican Volcanic Belt (Figure 2). It is a part of a Quaternary volcanic complex that also includes, Nevado de Colima and Cántaro volcano. It is one of the historically most active volcanoes in Mexico, with a documented record of periodic activity since 1580 (Medina-Martínez, 1983; Luhr and Carmichael, 1990). The geologic record shows evidence

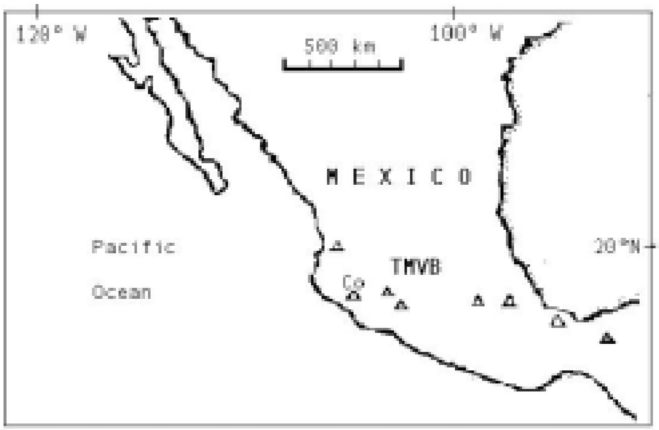


Fig. 2. Schematic map with the location of the Colima Volcano Observatory ($\Delta$Co symbol) in the western part of the Trans-Mexican Volcanic Belt (**TMVB**). Other volcanoes are marked with the open triangles (modified from Luhr and Carmichael, 1990).

of earthquakes, ash falls, rocks slides, mud flows, lava flows, pyroclastic flows, avalanches and caldera formation. The volcano poses a potential hazard of pyroclastic flows and debris avalanches to the city of Colima. Risk scenarios suggest that over 180 localities (486 900 inhabitants in the 1990 census) may be affected by the explosive activity of the volcano.

This volcano has experienced ash flows and recurrent lava dome formation. Typically, after a quiescence eruptions start with lava flows and dome growth, and end with a large Plinian eruption. Radiometric dates of various volcanic products (e.g. Luhr and Carmichael, 1990; Allan,1986; Robin *et al.*, 1987; Luhr and Prestegaard, 1988; Stoopes and Sheridan, 1992) show that the average cycle lasts about 70 years. The previous cycle ended in 1913 and a new cycle and a cataclysmic event are possible within the next decade or two.

On January 20, 1913, a Plinian eruption took place, apparently without much precursory activity. This eruption lasted four days, and the top of the existing cone was destroyed and a crater was formed. After this event the volcano remained dormant with intermittent activity until a lava dome began to grow in 1957, 1961, 1975 and 1976. A strong fumarolic activity was observed in the 1980's and lava flows were observed in 1981-1982. In 1987 a phreatic explosion triggered landslides. In 1991 two eruptions caused rock avalanches and a lava flow. At present fumarolic activity coupled with intense seismic episodes lava flows, frequent explosions and sporadic ash emission is common since November 1998. There is a possibility that the current activity phase may end in a Plinian eruption similar to the 1913 episode when tephra was deposited on the flanks of the edifice, and ash fall was observed at Ciudad Guzman, Guadalajara and other cities (Waitz, 1932; Martin del Pozzo *et al*, 1995).

The history of frequent eruptions of Colima Volcano and the experience of previous presents volcanic eruptions in Mexico during the 80's were the basis for the development of the first risk map and assessment of hazards and risk mitigation in Mexico (Martin del Pozzo *et al.*, 1995).

The Colima Volcano Observatory (19.3814° N, 103.6744° W, 1212 m elevation) is located 15 km north of the city of Colima, and 20 km south of the crater. Access and infrastructure are adequate for permanent instrumentation including magnetometers and geodetic instruments. Standard techniques for diurnal variation correction require the use of a local base station (e.g. Cifuentes *et al.*, 1998) as magnetometric surveys (e.g. López-Loera and Urrutia-Fucugauchi, 1999) and other geomagnetic studies at Colima Volcano (Connor *et al.*, 1993) were handicapped by the lack of a permanent total field time series in the vicinity. Because of the high precision required for volcanomagnetic studies (e.g. Johnston, 1997) and the expected time variation of the magnetic field due to magmatic activity, a continuous reference station time series was especially important. Given the location of the observatory, it was feasible to obtain a real-time record of the station using a radio-modem telecommunication system linked to the University of Colima campus.

## PRELIMINARY GEOMAGNETIC SURVEYS

A detailed magnetometric survey of the Observatory facility was carried out in October 1998, using a Geometrics G-856 Proton Precession Magnetometer (PPM) with a nominal precision of 0.1 nT. Evaluation of this survey indicated that the northwest area of the Observatory was suitable to install a permanent total field station with a third-order geomagnetic repeat station, due to relatively small gradients of the total intensity of the magnetic field and the absence of manmade disturbances. Figure 3 shows the results from the survey of 10 east-west oriented profiles with a sub-meter sampling density.

By late February 1999, we carried out five more surveys in order to define the locations where gradients are lowest and to compare two different magnetometers. Figure 4 shows the location of the survey lines, and Figure 5 shows the spatial variation of local magnetic field measured with the Geometrics G-856 ppm, and Scintrex PPM magnetometers for 2,3 and 4 lines. These figures display the F values obtained for these lines as well as the vertical gradient $\Delta F$ using Scintrex gradiometer mode, making it is possible to locate

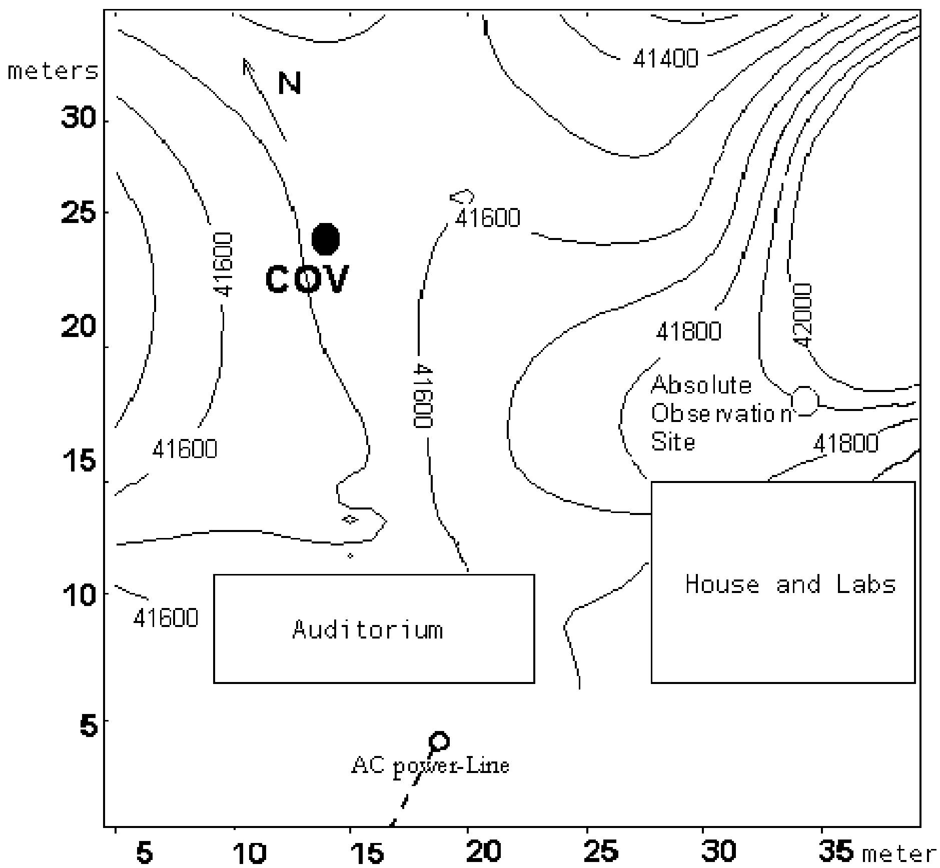


Fig. 3. Results of magnetic surveys at the Colima Volcano Observatory; location of COV station and absolute magnetic observation site.

several areas within the observatory where large anomalies exist due to metallic structures and power transformers. Analysis of Figure 3 indicates that the lowest horizontal gradient is located northwest of the observatory main buildings and point to the existence of a larger gradient to the east. The other detailed surveys were carried out in order to compare the two instruments, and to compare their reading signals with the observed vertical gradient. We observed a very good correlation between the readings of the magnetometers.

## COV GEOMAGNETIC STATION

Several methods to define true north play a key role for a geomagnetic periodic station. We used astronomical observations and we performed a series of observations in order to determine the azimuth of this reference point in relationship to the Sun using a Wild T-0 theodolite and astronomical tables (UNAM Instituto de Astronomía, 1998). Instrumental precision is within 0.1 minute on the horizontal circle and 1 minute on the vertical circle, well within the requirements for a third-order repeat station. Table 2 shows the set of azimuth results that showed the least dispersion of the 19 observations performed on October 24 and 25 1998. We installed two G-856 PPM magnetometers to register the magnetic total field and to record diurnal variations and verify that all the magnetic observations were carried out under stable conditions. Although there were some field instabilities early during the day which are attributable to a magnetic sub-storm, the record is otherwise stable. After determining the astronomical azimuth, the magnetic D, H, and Z components

**Table 2**

Azimuth results for October 24 and 25, 1999 to define a mark for declination component

| Observation | Local Time | Calculated azimut |
|---|---|---|
| 241098-8 | 10:52:04 | 24° 26.8' |
| 251098-11 | 10:55:08 | 27° 50.5' |
| 251098-12 | 11:07:10 | 24° 22.3' |
| 251098-13 | 11:11:57 | 24° 51.1' |
| 251098-14 | 11:13:25 | 27° 21.3' |

were measured using a Diflux magnetometer that usually operates at the Teoloyucan Observatory. As a quality control test, these results are compared in Table 3 to the expected IGRF model for 1995-2000 (Barton, 1996; MacMillan and Barton, 1997) calculated for: (a) declination of 8°22' east and s=8.6' , (b) horizontal intensity of 28749 nT and s= 27.5, and (c) vertical intensity of 29947 nT and s= 22.6. Our results show a very good correlation to the IGRF model considering the results of statistical analysis performed for the complete Mexican geomagnetic network (Hernández and Orozco, 1997), which yields s= 18.7' for the magnetic declination. COV observations show an overestimation of IGRF for H and Z components, (this means that IGRF forecast higher values than those observed) and an underestimation of magnetic declination. However, this behavior is consistent with previous analysis (Cañón-Amaro, 1990; Campos-Enríquez *et al.*, 1994; Hernández *et al.*, 1994; Hernández and Orozco, 1997). COV station is therefore suitable for long - and medium - period variations of magnetic field, and high-frequency monitoring that can be used for the purpose of monitoring volcano-magnetic effects.

## CONTINUOUS TOTAL FIELD RECORD

In addition to the periodic observations of the magnetic field components, we have installed a G-856 PPM magnetometer, that operates continuously and serves as a reference to the geomagnetic monitoring of the Colima Volcano. The magnetometer sensor (COV on Figure 3 and 4) is installed outdoors on a custom build wooden frame with the electronics inside the Volcano Observatory building. The PPM is linked to the University of Colima main campus, 15 km south of the Volcano Observatory, by means of FreeWave 900 MHz radio-modems. This setup allows a real-time access to the data through the Internet, making COV the first real-time permanent geomagnetic reference station in Mexico.

Figure 6 shows an example of the results of the magnetic total field monitoring in COV and its equivalent record at TEO and the magnetic record obtained from February 28 to March 1th at COV and TEO simultaneously. The comparison between TEO and COV (472 km apart) shows a correlation coefficient of r= 0.994; with mean differences of 686.9 ±

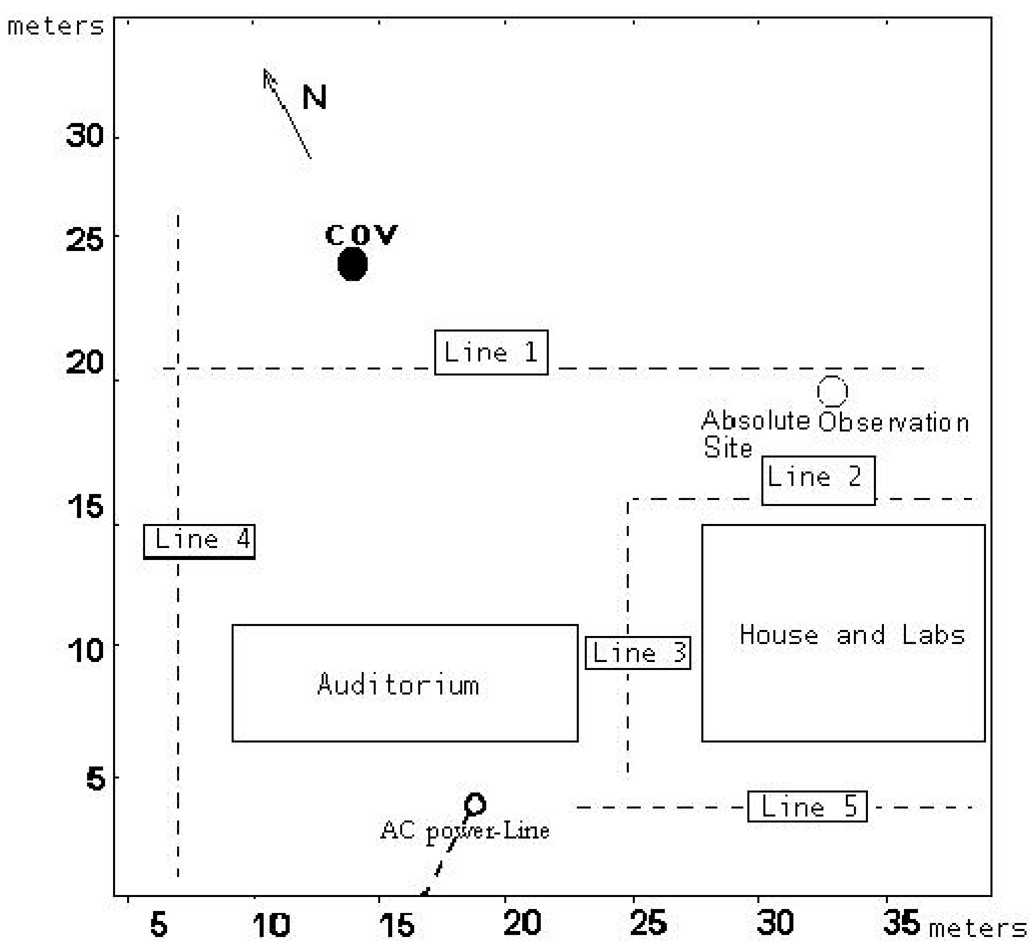


Fig. 4. Distribution of surveyed lines in Colima Volcano Observatory.

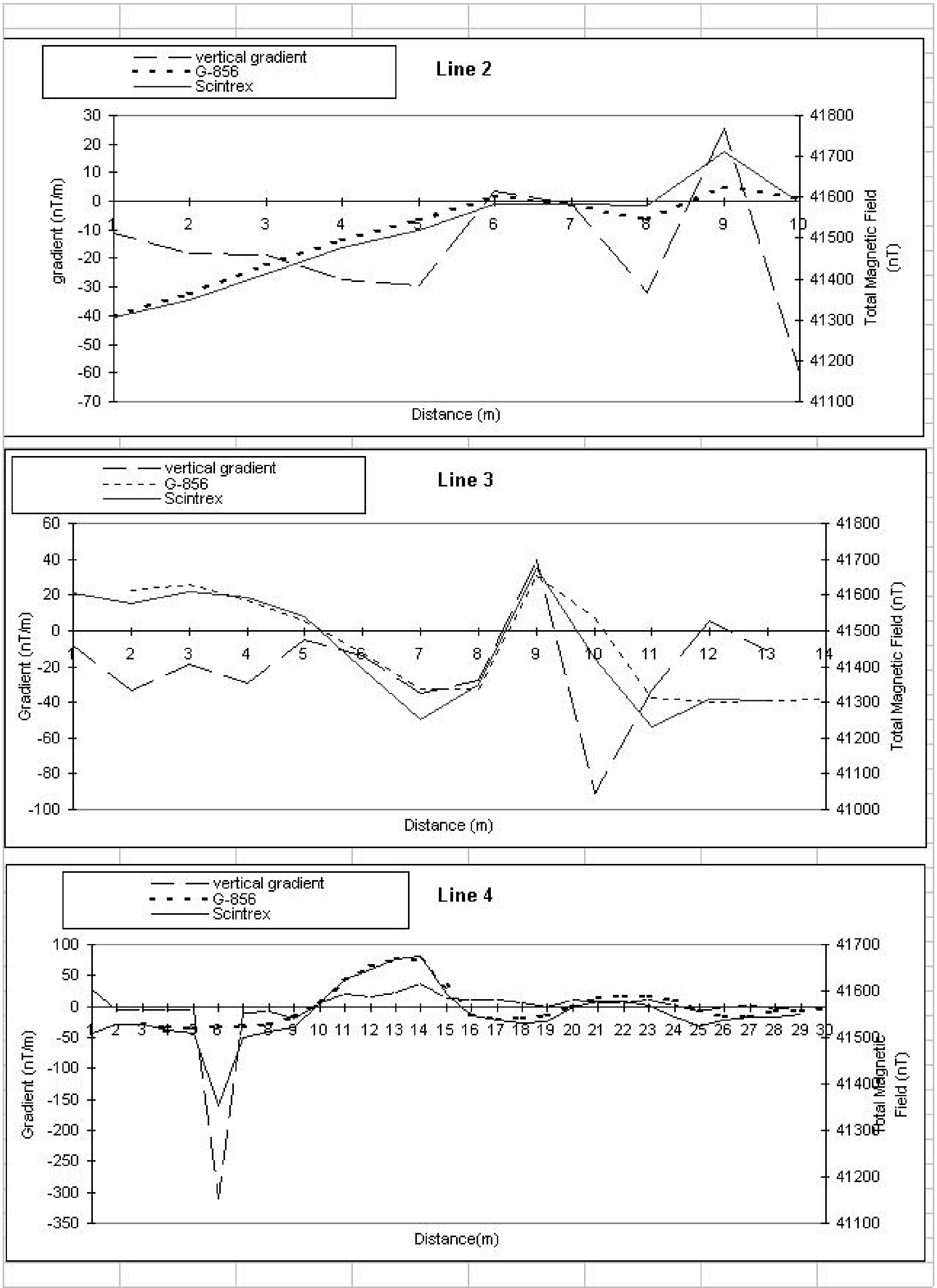


Fig. 5. Results of some of the surveyed lines for COV. Vertical gradient was obtained using a PPM-Scintrex gradiometer with two sensors positioned vertically in the staff with 50cm of distance between each other.

**Table 3**

Magnetic components measured compared with IGRF, and its respective differences

| Date | | Station | | | IGRF | | | Δ | |
|---|---|---|---|---|---|---|---|---|---|
| | H(nT) | D(° ‘) E | Z(nT) | H(nT) | D(° ‘) E | Z(nT) | H(nT) | D(° ‘) E | Z(nT) |
| 24.11.98 | 28767 | 8° 13.6’ | 29941 | 28909 | 8° 9.7' | 29977 | +142 | -3.9’ | +36 |
| 25.11.98 | 28762 | 8° 21.6’ | 29928 | 28909 | 8° 9.7' | 29977 | +147 | -11.9’ | +49 |
| 25.11.98 | 28717 | 8° 30.8’ | 29972 | 28909 | 8° 9.7' | 29977 | +192 | -21.1’ | +5 |
| 22.03.99 | 28722 | 8° 26.7’ | 29917 | 28829 | 8° 7.8’ | 30123 | +107 | -18.9’ | +206 |
| 23.03.99 | | 8° 29.8’ | | | 8° 7.8’ | | | -22.0’ | |
| 24.03.99 | 29383 | 8° 26.9’ | 29919 | 28829 | 8° 7.8’ | 30123 | +146 | -19.1 | +204 |

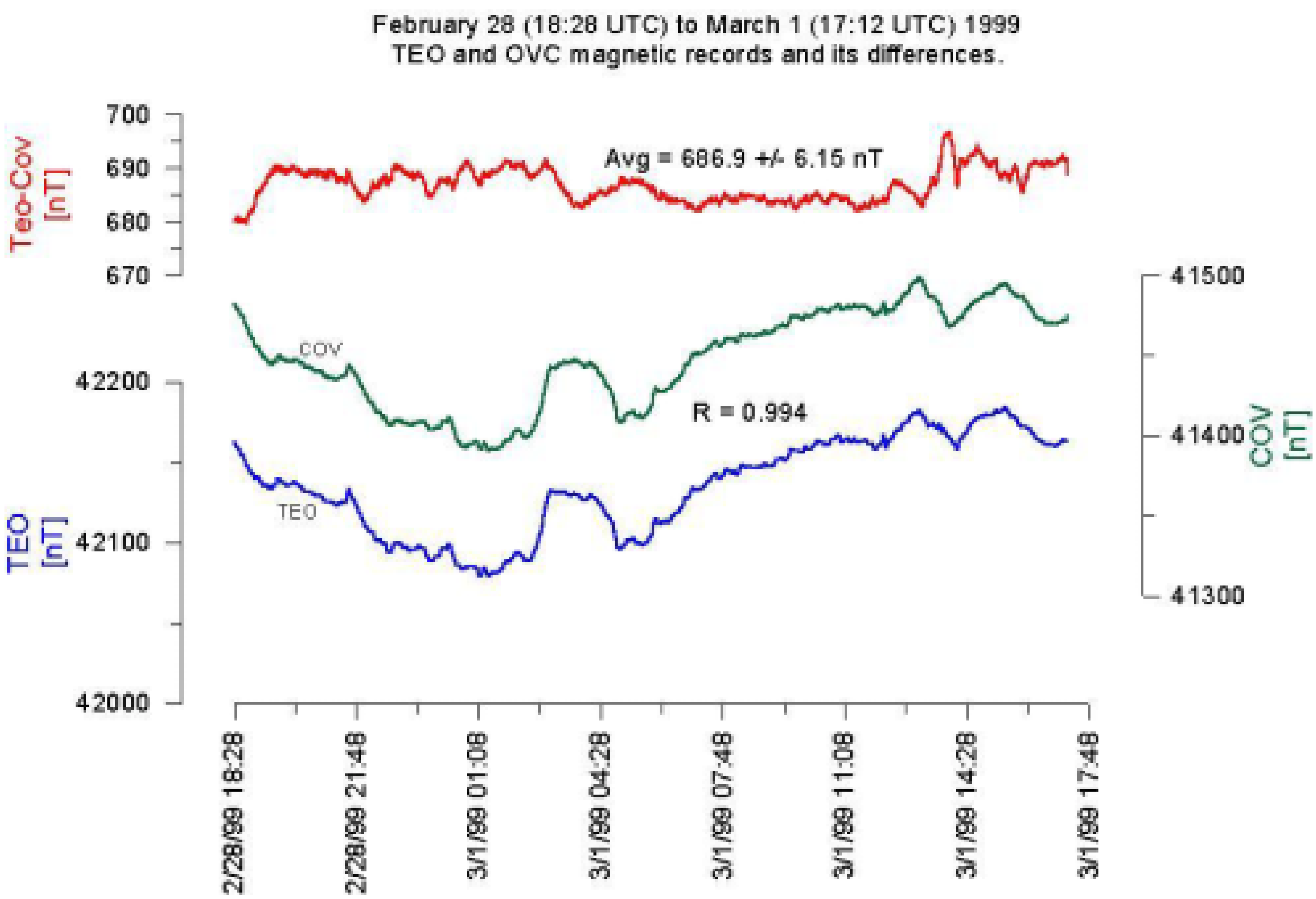


Fig. 6. Results of total Magnetic Record of Teoloyucan Magnetic Observatory (TEO), its comparison with Colima Volcano Observatory (COV) magnetic records, and their difference for February 28 to March 1, 1999. Time is UTC.

6.15 nT. IGRF estimate for COV 41714 nT, and 42372 nT for TEO. These magnetic records show that the field at COV can be compared to TEO time series with a high confidence level. This means, providing adequate operation and processing of COV time series records can be analyzed like a third order geomagnetic station. An example of a third order station is the Popocatépetl volcano station (Cifuentes *et al.*, 1998).

## DISCUSSION

A new geomagnetic station COV has been installed in western Mexico (see Figure 2) by the Geophysics Institute of UNAM and the Colima Volcano Observatory, University of Colima. Previously, the only permanent source of geomagnetic observations was the Teoloyucan Magnetic

Observatory, located in central Mexico (Figure 1). The total-field geomagnetic station at COV is part of the project to install a geomagnetic monitoring network at active volcanoes, whose main purpose is to detect potential volcanomagnetic signals associated with volcanic activity. Comparison of geomagnetic observations at COV with the IGRF 1995-2000 model shows differences of + 160 nT in horizontal intensity, -12.3' for declination, and +30 nT for vertical intensity. The average difference measured between TEO and COV geomagnetic records is 686 ± 6 nT (Figure 6). The average difference with respect to the IGRF model is 658 nT. The correlation coefficient for TEO and COV geomagnetic observations is r=0.994, noting that COV can provide an adequate time series in western and central Mexico.

Volcanomagnetic investigations can be performed with base stations such as COV. They can be located in areas with considerable anomalies like the Colima volcanic complex and Volcano Colima Observatory by combining the use of a third order geomagnetic repetition station (e.g., COV) in the same geographic location, and with a magnetic observatory (e.g. TEO) located more than 400 km away from the monitoring site. Together these stations can be compared with a high confidence level. Data is available at www.igeofcu.unam.mx/geomagne/geomag.html.

COV coverage in western Mexico is an adequate reference for magnetic anomaly land and marine surveys. Additionally, International Geomagnetic Reference Field has been successfully assessed in COV, in such way that can be used for regional and international geomagnetic models.

## ACKNOWLEDGMENTS

The authors greatly acknowledge the help of Eliseo Alatorre, Claudia Arango and A. L. Martin del Pozzo, throughout the various stages of this project. This project was funded by DGAPA-PAPIIT and UNAM-Patrimonio Universitario.

## BIBLIOGRAPHY

ALLAN, J. F., 1986. Geology of the northern Colima and Zacoalco grabens, southwest Mexico: Late-Cenozoic rifting in the Mexican Volcanic Belt. *Geol. Soc. Am. Bull., 97,* 473-485.

BARTON, C. E. 1996. Revision of International Geomagnetic Referenced Fiel Released. Http://www.agu.org/eso_elec/95206e.html. American Geophysical Union.

CAÑON-AMARO, C., E. HERNANDEZ-QUINTERO, H. NOLASCO-CHAVEZ, A. OROZCO-TORRES and G. ALVAREZ-GARCIA, 1994. Cartas Magnéticas de la República Mexicana para la Epoca 1990.0, Scale 1:5'000,000. Instituto de Geofísica-INEGI, México.

CAMPOS-ENRIQUEZ, J. O., E. HERNANDEZ-QUINTERO, H. NOLASCO-CHAVEZ, A. OROZCO-TORRES, C. CAÑON-AMARO, G. ALVAREZ-GARCIA and J. URRUTIA-FUCUGAUCHI, 1994. A preliminary assessment of IGRF-1990 for Mexico. *Phys. Earth Planet Int. 82,* 103-109.

CIFUENTES G. and E. HERNANDEZ, 1996. Cartas Magnéticas Sintéticas Epoca 1995.0 para la República Mexicana. Reportes Internos 96-18, Instituto de Geofísica, UNAM.

CIFUENTES, G., E. HERNANDEZ-QUINTERO, E. CABRAL, R. CHAVEZ-SEGURA, J. URRUTIA FUCUGAUCHI, A. L. MARTIN DEL POZZO and C. ARANGO, 1998. Simultaneous magnetic observations at Teoloyucan Magnetic Observatory and Popocatépetl volcano. *Geofísica. 48,* 149-159.

CONNOR, C. B., S. B. LANE and B. M. CLEMENT, 1993. Structure and thermal characteristics of the summit dome, March, 1990-March 1991: Volcán Colima, Mexico. *Geofís. Int., 32,* 643-658.

DAWSON, E. and R. NEWITT, 1978. IGRF comparisons. *Phys. Earth Planet. Inter., 16,* 1-6

DAWSON, E. and R. NEWITT, 1982. Comparison of IGRF models with North American magnetic data. *J. Geomag. Geoelectr., 34,* 393-400.

HERNANDEZ-QUINTERO, E., H. NOLASCO-CHAVEZ, J. O. CAMPOS-ENRIQUEZ, A. OROZCO-TORRES, C. CAÑON-AMARO, G. ALVAREZ-GARCIA and J. URRUTIA-FUCUGAUCHI, 1994. Evaluación Preliminar del Campo Geomagnético de Referencia Internacional IGRF-1990 para México y Anomalías Magnéticas Corticales. *Geofís. Int., 33,* 235-241.

HERNANDEZ, E. and A. OROZCO, 1997. Magnetic Field Work and IGRF Models for Mexico, Three Examples for the 20th Century. *J. Geomag. and Geoelectr. 49,* 387-392.

JOHNSTON , M. J. S., 1997. Review of electric and magnetic fields accompanying seismic and volcanic activity. *Surv. Geophys., 18,* 441-475.

LOPEZ-LOERA, H. and J. URRUTIA FUCUGAUCHI, 1999. Spatial and temporal magnetic anomalies of Colima volcano, western México. *Geofís. Int., 38,* 3-16.

LUHR, J. F. and K. L. PRESTEGAARD, 1988. Caldera formation at Volcán Colima, Mexico, by a large Holocene debris avalanche. *J. Volc. Geoth. Res. 35,* 335-348.

LUHR, J. F. and I. S. E. CARMICHAEL, 1990. Geology of Volcán Colima. UNAM, Instituto de Geología, Boletín 107, México, D.F., 1-101.

MEDINA-MARTINEZ, F., 1983. Analysis of the eruptive history of the Volcán de Colima, México (1560 - 1980). *Geofís. Int., 22, 2,* 157-178.

MACMILLAN, S. and C. E. BARTON, 1997. Magnetic field maps for IGRF 1995. *J. Geomag. Geoelectr., 49,* 149-156.

MACMILLAN, S., D. R. BARRACLOUGH, J. M. QUINN and R. J. COLEMAN, 1997. The 1995 revision of the joint US/UK geomagnetic field models – I. Secular variation. *J. Geomag. Geoelectr., 49,* 229-243.

MARTIN DEL POZZO A., M. SHERIDAN, D. BARRERA, J. LUGO-HUBP and L. VAZQUEZ-SELEM, 1995. Potential Hazards from Volcán de Fuego de Colima, Mexico. *Geofís. Int., 34,* 363-376.

ROBIN, C., P. MOSSAND, G. CAMUS, J. M. CANTAGREL, A. GOURGAUD and P. M. VINCENT, 1987. Eruptive history of the Colima Volcanic Complex (Mexico). *J. Volcanol. Geotherm. Res., 31,* 99-113.

SANDOVAL R. O. 1950. Elementos Magnéticos en La República Mexicana. Instituto de Geofísica UNAM, México D.F. 223 pp.

STOOPES, G. R. and M. F. SHERIDAN, 1992. Giant debris avalanches from the Colima Volcanic Complex, Mexico: Implications for long-runout land-slides (>100 km) and hazard assessment. *Geology, 20,* 299-302.

UNAM, INSTITUTO DE ASTRONOMIA-. 1998. Anuario del Observatorio Astronómico Nacional, México.

WAITZ, P., 1932. Datos históricos y bibliográficos acerca del Volcán de Colima. (Acad. Nac. Cien. Antonio Alzate Mem. y Rev. Tomo 53, 9-10, 349-384, 5 pls.1935)

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