

No.	Station	Latitude $e_p$	Longitude $e_p$
1	Hydrometric Station of Usamacinta River (El Tigre.)	$16^{\circ}36'36''.1 \pm 0.9$	$90^{\circ}39'38''.6 \pm 0.6$
2	Station No. 2 of the control geodetic polygon (Ciudad Hidalgo)	$14^{\circ}40'45''.3 \pm 0.4$	$92^{\circ}09'03''.2 \pm 1.0$
3	Azimuth of side 2-2 of geodetic polygon		$= 229^{\circ}34'54''.4 \pm 1''.0$
4	Azimuth of side 73-74 of geodetic polygon		$= 278^{\circ}21'36''.6 \pm 2''.1$
5	Azimuth of side 270-279 of geodetic polygon		$= 212^{\circ}00'01''.4 \pm 2''.8$
6	Station No. 209 of the geodetic polygon	$14^{\circ}49'30''.7 \pm 1.0$	$92^{\circ}11'45''.3 \pm 0.9$

A T-2 Wild instrument was employed in the operation, following the method of equal heights of stars for the determination of the "hour" and that of Litrow for the latitude.

#### BIBLIOGRAPHY

MEDINA PERALTA, M. and F. ALONSO LERCH, 1962. Nuevas Tablas para la Aplicación del Método de Díaz Covarrubias para la Determinación de la Hora. *Anales del Instituto de Geofísica, U.N.A.M., Apéndice III*, 8 pp., 8 tables, 2 nomograms.

#### IV GRAVIMETRY

A) REPORT ON THE WORK OF THE DEPARTMENT OF GRAVIMETRY OF THE INSTITUTE OF GEOPHYSICS. N.A.U.M.

August 1963 - December 1966.

*Introduction.* During the period running from August 1963 to September 1966, the three principal programs of work on gravity measurements have continued as follows:

1. Mapping of gravity anomalies and related studies in the Mexican territory;
2. Gravimetric study of its northern part, particularly of the northeastern portion, where the Peninsula of Coahuila, an ancient geologic structure located in the subsurface, presents a peculiar lack of conformity of gravity anomalies with surface elevation instead of with geology (Woollard, G. P. & J. Monges Caldera, 1956), and
3. Study of the Neo-Volcanic Axis, which is the transverse igneous range crossing the Mexican territory from east to west, more or less at the latitude of parallel 19° N.

Although the three programs were planned prior to the initiation of the Upper Mantle Program in Mexico, when the Mexican National Committee of the UMP was established, all were incorporated in its activities.

Cooperation and assistance has also continued with the Central—American Republics in their gravity work in the area of the Gulf of Fonseca, surrounded by El Salvador, Nicaragua and Honduras as well as in other areas in collaboration with the Inter-American Geodetic Survey.

Lastly, the Institute of Geophysics has cooperated with the pendulum expeditions that have come to Mexico to participate in measurements along the International Gravimetric Calibration Line, in accordance with a recommendation of the International Gravity Commission, approved in Paris, in September 1962, as follows:

1. Gulf Quartz Pendulum, in charge of Richard L. Longfield (1964);
2. Cambridge Invar Pendulum, in charge of C. Browne (1965), and
3. Italian Pendulum in charge of Valentino Tomelleri (1965).

The three expeditions made measurements at Ciudad Universitaria, Mexico, D. F., and at Instituto Tecnológico, Monterrey, N. L., where a change in the observation site was made because of high vibration in the original one and intense changes of day and night temperature in its vicinity.

It must be mentioned that the Committee of Gravimetry and Earth Tides of the Commission on Cartography of the Pan-American Institute of Geography and History has its headquarters at the Institute of Geophysics, with the author of this report as Acting President. In this capacity, assistance was given to Prof. Ing. Eduardo E. Baglietto, Director of the Institute of Geodesy of the School of Engineering of the University of Buenos Aires, Argentina,

in his negotiations to obtain funds to continue his gravity work along the Argentinian Calibration Base Line.

Other programs are also being prepared to make gravity measurements in the area of the South-American Datum Point, in collaboration with appropriate persons and institutions in various countries (U.S.A., Brasil, Bolivia, Paraguay, Uruguay and Argentina), as recommended by the X Consultation Meeting on Cartography, held in Guatemala City, in July 1965, in the occasion of the VII General Assembly of the Pan-American Institute of Geography and History.

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### 1. MAPPING OF GRAVITY ANOMALIES IN MEXICO

This program is aimed at densifying and extending the network of gravity stations in the Mexican Republic. Since the inception of the program thousands of stations have been occupied, and their values calculated and related to base stations using bench marks along level lines as points of reference. Special gravity work has also been executed in marine ports and airports with known elevations while data processing and drawing of maps of gravity anomalies is carried out at the Department of Gravimetry, in Mexico City, thus constituting another very convenient reference network.

A Calibration Base Line between Mexico City and Monterrey, N. L., along the old Laredo Highway was established by terrestrial operations sometime ago, with a number of stations separated by adequate intervals. It was counterchecked by measurements at the airports of Mexico City, San Luis Potosí and Monterrey at a later period, and integrated into the World Calibration Base Line System, as described in a paper published in the *Anales del Instituto de Geofísica, U.N.A.M.*, in 1963.

With respect to gravity work in general, and the study of various problems in the Mexican territory, gratitude must be expressed to Prof. George P. Woollard, Director of the Institute of Geophysics of the University of Hawaii, for constant assistance and advice in his frequent visits to Mexico that are of enormous convenience for the development of research at the Institute of Geophysics of the N.A.U.M. Thanks are also given to members of the staff of the above mentioned institution, whose names appear in this report as well as to Mr. Joseph A. Koslosky, Chief of the Geophysical Branch of the Inter-American Geodetic Survey, with headquarters at Fort Clayton, in the Panama Canal Zone, for their friendly help in matters related to the scientific study of gravity in Mexico and Central America.



Fig. 3. Areas of gravity work in Mexico

## 2. GRAVIMETRIC STUDIES IN NORTHEASTERN MEXICO

As a continuation of gravity work reported upon three years ago, essentially consisting of a network of base stations for more extended measurements in the territory of the Mexican Republic, during 1964, 1965 and 1966, in collaboration with the University of Hawaii, a denser gravity network was developed in the northeastern part of the country through measurements taken along roads, and in villages and ranches that could be located in existing maps. Bench marks were taken as reference along level line roads with 6 to 12 Km intervals. Where no level lines were available, two Wallace & Tiernan altimeters were used for elevation of stations always related to values of bench marks or railroad elevations or some other measured points.

Measurements were also taken by Dr. Lawrence F. Machesky, of the University of Hawaii, in the States of Sonora, Sinaloa, Durango, Chihuahua, Coahuila, Nuevo León and Tamaulipas, along roads marked on 1:250,000 maps of Mexico during 1965 and 1966, with intermediate distances of 6 to 10 Km between observing points. These measurements were more or less easily made in level areas, but in the western part of Chihuahua the intricate configuration of the Sierra Madre Occidental (with many inaccessible portions and scanty communication facilities), gravity work is being executed in local airports or airstrips existing in the areas using light aircraft during the winter months of 1966-1967. In this way, Dr. Machesky and the writer occupied more than 400 (four hundred) airports and airstrips (Fig. 3).

Arrangements have already been concluded with the administrators of the Ferrocarril Chihuahua al Pacífico, that crosses the Sierra Madre Occidental, from northeast to southwest to provide transportation and permits to work at stations with 6 Km of interval. Later on, other crossings of the same Sierra Madre Occidental, 'north and south of that railroad', will be made to obtain gravity data of significance that will be included in the maps of gravity anomalies of the territory of the Mexican Republic.

## 3. STUDY OF THE NEO-VOLCANIC AXIS

A tripartite program of gravimetric measurements is being carried out by the Institute of Geophysics of the N.A.U.M., the Federal Commission of Electricity of Mexico and the Institute of Geophysics of the University of Hawaii along the Neo-Volcanic Axis of Mexico, as part of the Upper Mantle Program. It consists of a series of 5 (five) gravimetric profiles crossing that igneous range with intermediate stations whose elevations were already known or determined with altimeters by the field party, as follows (Fig. 3).

1. Mexico line:  
From Zumpango del Rio, Gro., to Zacualtipan, Hgo., through Pachuca, Hgo., Mexico, D. F., Cuernavaca, Mor., and Iguala, Gro.;
2. Veracruz line:  
From Tecolutla, Ver., to a point 20 Km to the north of Ixtlan de Juárez, Oax., through Nautla, Vega de Alatorre, Ciudad Cardel, Veracruz and Tierra Blanca, all in the State of Veracruz, and Tuxtepec, Oax.;
3. Morelia line:  
From Silao, Gto., to La Huacana, Mich., through Irapuato, Salamanca, and Moroleón, all in the State of Guanajuato and Morelia, Quiroga, and Ario de Rosales, all in the State of Michoacán.
4. Guadalajara line:  
From Juchipila, Zac., to Colima, Col., through Guadalajara, Ciudad Guzmán and Tecalitlán, all in the State of Jalisco.
5. Tepic line:  
From Acaponeta, Nay, to Puerto Vallarta, Jal., through Tepic and Compostela, both in the State of Nayarit.

The total number of stations in the five lines was 379, and measurements were taken with the Worden gravimeter # 33, using only the small dial, by Ings. Luis Canales, of the Institute of Geophysics and Armando de la Peña, a geologist of the Federal Commission of Electricity, under this supervision of the writer.

#### B) GRAVIMETRIC WORK IN THE GULF OF FONSECA, CENTRAL AMERICA

A program of collaboration between the Institute of Geophysics of the N.A.U.M., the Pan-American Institute of Geography and History, the National cartographic agencies of Guatemala, El Salvador, Honduras and Nicaragua and the Inter-American Geodetic Survey, with the economical assistance of the Oceanographic Office of the UNESCO, in Paris, made possible a submarine gravimetric study of the Gulf of Fonseca, Central America, under the direction of the writer. A LaCoste and Romberg marine gravimeter, model H4D, with a constant of 1.058 and a range of work of 200 milligals was used for this operation in the months of November and December of 1964, when a total of 73 (seventy three) stations covering the whole area occupied (Fig. 4).

Two measurements permitted to establish connection between the submarine network and the terrestrial network, using the submarine gravimeter

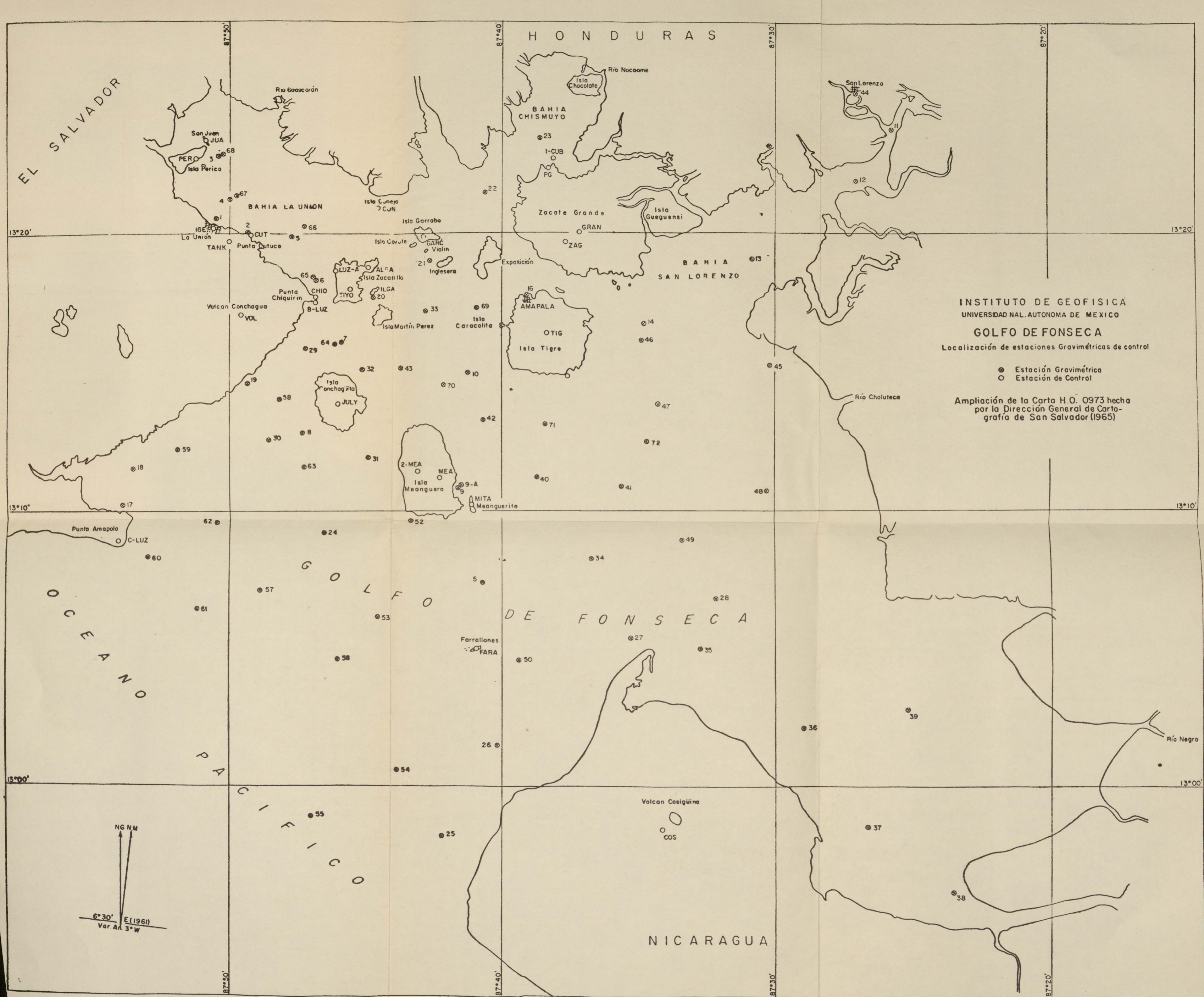


Fig. 4. Submarine Gravity Stations at Gulf of Fonseca, Central America.

on land. Measurements included the ports of Amapala and San Lorenzo, Honduras, although both sites are not within the above mentioned terrestrial network, but have well defined values for the connection of terrestrial and submarine networks, this work was also made with the Worden gravimeter # 33.

Of the three Central-American countries that share the Gulf of Fonseca, only El Salvador has finished establishing its gravimetric network, for which reason arrangements were made with the Inter-American Geodetic Survey and the National cartographic agencies of Honduras and Nicaragua to extend and densify their gravity measurements to zones adjacent to the Gulf of Fonseca.

It must be mentioned that the LaCoste and Romberg Inc. firm collaborated in this program in various forms, for instance, allowing a period of training in the handling of the instrument in Austin, Texas, and assisting in the solution of a number of problems. The rental of the instrument was kept at a minimum notwithstanding the fact that the time of use was longer than what the contract expressed.

### C) GRAVIMETRIC WORK OF APPLIED NATURE IN MEXICO

There are a number of Federal agencies that carry out gravity studies in search of oil and gas (Petroleos Mexicanos), minerals (Higher Council of Non-Renewable Resources), nuclear materials (National Commission of Nuclear Energy), and others. Much of this work gives results that are retained in the files of geological departments in view of their significance, although numerical data and other details are published in scientific or technical contributions or are available for consultation through proper arrangements. A synthesis of those programs will now be given for some of the above mentioned agencies:

**PETROLEOS MEXICANOS.** A total of 83,545 Km<sup>2</sup> have been surveyed and measurements made in 83,420 stations during the period 1964-1966. Study areas are located in northern, northeastern, eastern and southeastern Mexico, namely, Sierra del Burro, Villa Aldama, Ojinaga and Camargo (all in the State of Chihuahua), isolated localities in the States of Coahuila, San Luis Potosí and Tamaulipas, Uzpanapa (State of Tabasco) and many more in the State of Yucatán, where a gravity program was carried out as part of a diversified geophysical reconnaissance.

**CONSEJO SUPERIOR DE RECURSOS NATURALES NO-RENOVABLES.** Among other areas, this agency has surveyed gravimetrically a large tract in Mexicali, State of Baja California, just south of the Mexico-USA border; for this

purpose a four-sided figure was delimited and covered by 340 measurements arranged in 18 lines, approximately parallel at 2 Km of interval, with a N 50° E orientation, and variable lengths of the order of 19 Km. Gravimetric measurements were made with a Sharpe instrument and connected with the geodetic base at Pasadena, California, and processed by conventional methods to determine Bouger anomalies, indicating certain structural conditions below the surface. This work was executed as a collaboration for the Federal Commission of Electricity.

Another area explored for the evaluation of iron deposits was that of Las Truchas, State of Michoacán, using a Canadian gravity meter, a master base of arbitrary value and two first order bases strategically distributed; 1,180 stations were measured, and their data used to configurate a gravimetric map indicating various types of anomalies.

#### BIBLIOGRAPHY

- MONGES CALDERA, J., 1966. Red de Estaciones Gravimétricas Básicas en la República Mexicana. *Anales del Instituto de Geofísica, U.N.A.M.* 11: 5-25, 8 pls.
- MONGES CALDERA, J., G. P. WOOLLARD, J. A. KOZLOSKY & H. DUARTE VILLELA, 1963. Informe sobre Trabajos Gravimétricos en Centro América y Panamá. *Anales del Instituto de Geofísica, U.N.A.M.*, 8: 3-22, 3 maps. 1 sketch & tables.
- MONGES CALDERA, J. & M. RENDON. 1963. Estación Gravimétrica de Primer Orden Mundial y Base de Calibración de Gravímetros en la República Mexicana. *Anales del Instituto de Geofísica, U.N.A.M.*, 9: 55-68, 1 mapa, 2 figs., 2 tablas.
- MORONES, L. 1965. Sistematización de la Información Gravimétrica haciendo uso de la Calculadora Electrónica, *Boletín de la Asociación Mexicana de Geofísicos de Exploración*, VI (4): 219-238, 9 figs.
- WOOLLARD, G. P. & J. MONGES CALDERA, 1956. Gravedad, Geología Regional y Estructura Cortical en México. *Anales del Instituto de Geofísica, U.N.A.M.*, 2: 60-112, 14 figs.