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The 20th International Geological Congress, Mexico (1956)

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The 20th International Geological Congress (IGC), held in Mexico in 1956, took place at a crucial time as the demand for raw materials increased significantly after the Second World War. The search for mineral resources provided a stimulus for the development of geology and its applied branches, geophysics, geochemistry, etc. Also, the foundations were being laid for a new global geological model, plate tectonics, which burst onto the scene in the sixties. The Congress had the largest attendance up to that time. Many of its sessions focused on prospecting for mineral deposits and drilling for oil and gas.

Organization of the Congress

The previous IGC was held in Algiers from 8–15 September, 1952, with the academician Charles Jacob (1878–1972) as President and Robert Lafitte as Secretary (1911–2003) (Durand-Delga, 2007). During the Congress the Mexican Government succeeded in having their country designated as host for the next Congress, which would be the twentieth since the first was held in Paris in 1878. Thus Mexico became the host nation for the second time after providing the venue for the Tenth Congress in 1906. Mexico's candidacy was proposed by Eduardo J. Guzmán, Deputy Manager for Prospecting for Mexican Petroleum (*Petróleos Mexicanos* or PEMEX) and the engineer Raúl de la Peña, first Director of the National Institute for Research into Mineral Resources.

Figure 1. (a) Luis Padilla; (b) Nabor Carrillo Flores. Both were members of the Organizing Committee of the XX ICG

In an agreement signed on the 29 September, 1953, the fifty-sixth President of Mexico, Adolfo Ruiz Cortines (1890–1973), appointed the Organizing Committee for the XX Congress (IGC), made up of politicians and technicians. The Committee was headed by the lawyer and economist Gilberto Loyo (1901–1973), Secretary for the Economy. Members of the Committee were the diplomat Luis Padilla Nervo (1894–1985), Foreign Secretary, José Ángel Ceniceros (1900–1979), Doctor of Laws, Secretary for Public Education between 1952 and 1958, the entrepreneur and politician Antonio Jáquez Bermúdez, General Manager of PEMEX from 1946 to 1958, and the engineer Nabor Carrillo Flores (1911–1967), Vice Chancellor of the National Autonomous University of Mexico (UNAM). The first secretary was Jorge L. Cumming (1954), prospecting manager for Mexican Petroleum, while the second secretary was Eduardo J. Guzmán, already mentioned (see Fig.1).

Organization of the sessions

In addition to the Organizing Committee and the Executive Committee, made up of Mexican geologists and engineers (see Fig.2) those who were to be responsible for each of the technical sessions were designated. There were sixteen sessions and twenty-eight coordinators, almost all Mexicans, and in some cases foreigners who had worked in the country. Five symposia were held in parallel (Gómez Caballero, 2005).

Taking advantage of the Congress, various meetings were organized of different Geological Committees and Associations (Fig.3). We should also point out the continuing great importance of French geology, the decline of Germany and the presence of US geologists. We also need to note the poor representation from Britain.

Figure 2. (a) Teodoro Flores from the Executive Committee, who had to be replaced due to his death in 1955. He was replaced by Guillermo Salas (b). (Oil paintings from the Geological Museum).

SECTION	SYMPOSIUM
Volcanology of Cenozoic	Symposium on oil and gas fields
The Mesozoic of the Western Hemisphere and its World Correlations	Symposium on Manganese Deposits
Petroleum Geology	Symposium on the Palaeography and the Basis of the Cambrian System
Hydrogeology of Arid and Sub-Arid Regions	Symposium on the Cretaceous system and its World Correlations
Relations Between Tectonics and Sedimentation	Symposium on Geochemistry, Geochemical Exploration and Isotopic Geology
Modern Ideas on the Origin of Mineral Deposits (Metallic and Non-Metallic)	**COMMISSION, MEETING OR SOCIETY**
Paleontology, Taxonomy and Evolution	Association of African Geological Services
Plutonic Rocks, their Origins and their Relationship with Tectonics	Commission for the International Geological Map of Africa
Applied Geophysics	International Palaeontological Union
Micropalaeontology	Society of Mining Geologists
Petroleum and Minerology	International Stratigraphy Commission
Geochemistry, Geochemical Exploration and Isotopic Geology	Subcommission for the Stratigraphic Lexicon
Genesis of Ancient and Modern Reefs (Biotherm and Biostrome)	Subcommission for Stratigraphic Terminology
Geology Applied to Engineering and Mining Marine and Submarine Geology	Commission for the Geological Map of the World
Miscellaneous Questions on General Geology	Commission of authors' summaries

Figure 3. Scientific sessions, symposia and commissions held in the 20th ICG.

Further details of the organization and proceedings of the IGC

In addition to official organizers and institutions of the UNAM, which allowed them the use of the Faculties of Odontology, Social Sciences and Economics as venues for the sessions, PEMEX/Mexican Petroleum was one of the principal sponsors of the Congress. It not only contributed to its funding but its senior management directly assumed organizational responsibilities. It should be noted that at the time of the Congress PEMEX was experiencing a notable increase in profits as a result of its booming oil installations. According to the Senator, Alberto Terrones Benítez (1956): "the lucidity, effectiveness and the success of this Geological Congress was due to the resolve of Mexican Petroleum" (Cf. minutes of the plenary session of the House of Senators, in which Terrones Benítez reported on the proceedings of the 20th IGC). This was the Congress with the largest attendance to date. The countries represented and attendance figures are set out in the table in Fig.4.

It can be seen that, except for the last topic, 'Miscellaneous Questions in General Geology', varied and unspecific in nature, the major contributions centred on aspects relating to prospecting for mineral resources: sixty on 'Genesis of Deposits', twenty-five on 'Geology of Petroleum', thirty-eight on 'Mining and Engineering Applications', and thirty-six on 'Applied Geophysics', a total of 159 (27%) of studies with an orientation towards industrial applications. A similar orientation can be observed in the parallel symposia, so that taken together the symposia concerned with prospecting for minerals, oil and gas, manganese and geochemical exploration comprised 165 studies or 65% of the total. The papers were presented in various languages: Spanish, French, English, German, and Russian.

The inaugural session

The inaugural session was held on 4 September. It began with an address given by Gilberto Loyo, explaining the importance of mining in the history of Mexico. Antonio García Rojas, installations manager for PEMEX, began with the reminder that "Mexico, had organized the Tenth International Geological Congress fifty years before". He stressed that "the foreseeable demand for mineral and petroleum products throughout the World exceeds present needs, for which reason the advance of geological sciences was one of the pillars supporting the progress of nations". As the principal objective of the XX IGC, he pointed out the importance of the economic aspects of geology, whenever the discovery and exploitation of many mineral deposits had been possible, with the application of techniques unknown at the beginning of the twentieth century such as those of geophysics and exploratory geochemistry. He ended his address noting that "the 1956 International Geological Congress aimed to promote the advance of geological sciences through meetings between geologists from a number of countries and bringing together those working on clearly scientific projects with those responsible for geological services and the representatives and technicians of the mining industry". Following this, the President of Mexico, Adolfo Ruiz Cortines, declared the Congress open (Fig.5).

Year	Host city	Countries Represented	Total Members	Members Present	Dele-gates
1878	Paris (France)	23		310	7
1881	Bologna (Italy)	22	420	224	15
1885	Berlin (Germany)	22	445	262	13
1888	London (Great Britain	25	830	422	37
1891	Washington (USA)	26	546	251	30
1894	Zurich (Switzerland)	20	401	273	14
1897	St. Petersburg (Russia)	27	1037	704	121
1900	Paris (France)	30	1016	461	61
1903	Vienna (Austria)	31	664	393	42
1906	Mexico City (Mexico)	34	707	321	52
1910	Stockholm (Sweden)	36	879	625	175
1913	Toronto (Canada)	49	981	467	362
1922	Brussels (Belgium)	38	518	321	123
1926	Madrid (Spain)	52	1123	722	277
1929	Pretoria (S. Africa)	50	575	298	117
1933	Washington (USA)	54	1182	665	141
1937	Moscow (USSR)	50	2362	949	157
1948	London (UK)	84	1778	1276	472
1952	Algiers (Algeria, France)	82	2910	1129	440
1956	Mexico City (Mexico)	105	3696	2120	607

Figure 4. Participation in IGCs up to the Mexican Congress (1956).

Figure 5. Photo of the inaugural session of the 20th IGC.

Excursions

During the Congress, three types of excursions were organized to enable participants to gain first-hand knowledge and a greater understanding of the general geology, economic geology, stratigraphy, tectonics and volcanology of the country.

The excursions which took place before the Congress were as follows:

- Excursion A-1: 'Mining geology and general geology, tectonics and structural geology'. Visits were made to the copper mines in Cananea, Sonora and Santa Rosalía as well as manganese deposits and metallurgic plants in Lucifer.
- Excursion A-2: 'Mining geology, general geology, sedimentation, structural geology'. With a trip to the deposits of lead, zinc, copper, manganese, iron, silver and gold in the States of Chihauhua, Durango, Zacatecas and Guanajauto. Uranium mines were visited in Chihauhua.
- Excursion A-3: 'Mining geology, regional and structural geology'. Silver, lead and zinc deposits were visited in the State of Hidalgo, as well as flotation and smelting plants.
- Excursion A-4: 'Mining geology'. Lead, zinc and fluorite deposits were studied in Taxco, with special emphasis on the general and structural geology of the region. Visits were also made to metallurgical plants.
- Excursion A-5: 'Mining geology'. An excursion to study the iron deposits in Durango, the deposits of silver, lead, zinc and gold in Fresnillo, and of silver in Guanajauto. The principal characteristics of surface and structural geology of the region were explained, culminating in a visit to the metallurgical plants.
- Excursion A-6: 'Mining geology'. The excursion was to study the gold and silver deposits in Natividad, Oaxaca, and pegmatites, gneisses and granite from the basal complex in Oaxaca. In addition, archeological sites were visited in Mitla and Monte Albán.
- Excursion A-7: 'General geology of the southern part of the Baja California Peninsula'. Intrusive and volcanic rocks, copper deposits in El Boleo and manganese in Lucifer, as well as sedimentation phenomena relating to prospecting for oil.
- Excursion A-8: 'Stratigraphy of the Paleozoic and Mesozoic formations in Altar-Caborca, in the State of Sonora'. Baryta mines were visited in Sonora. The demand for test drilling for oil had significantly increased their value.
- Excursion A-9: 'Stratigraphy, structures, tectonics and general geology between the Mexican capital and Acapulco'. Volcanic, intrusive and sedimentary rocks were studied.
- Excursion A-10: 'Structural and tectonic geology of petroleum'. Visits were made to the oilfields in Poza Rica, as well as to refineries and to sulfur recovery plants. Also an explanation was given of the regional geology for the Mesozoic and Tertiary periods.
- Excursion A-11: 'General geology of the southeast of the State of Puebla', with special attention to the stratigraphy of the formations of the Jurassic, Cretaceous and Cenozoic.
- Excursion A-12: 'Stratigraphy of the sedimentary basin of the States of Oaxaca and Guerrero'. Sedimentary and volcanic rocks of the Cenozoic were studied and the Jurassic and Cretaceous sedimentary rocks.
- Excursion A-13: 'Stratigraphy and general geology of the States of Chihauhua, Nuevo León and Coahuila', with special reference to the Mesozoic and Cenozoic formations.
- Excursion A-14: 'General geology, stratigraphy and tectonics of the States of Tamaulipas, Nuevo León, San Luis de Potosí and Hidalgo'.
- Excursion A-15: 'General geology and volcanology of the volcanic zone of Parícutin'.
- Excursion A-16: 'General geology and hydrogeology of the region of Guadalajara', with information on the geomorphology of the volcanic axis of Mexico and the closed basins formed by volcanic eruptions.

In addition, other excursions took place between 12 and 24 September, after the end of the IGC:

- Excursion C-1: Excursion A-3 was repeated.
- Excursion C-2: Excursion A-4 was repeated.
- Excursion C-3: 'Mining geology'. Visits were made to the silver deposits in Guanajuato and to those of lead, zinc, copper and gold in Concepción del Oro (Zacatecas), studying the general geology, stratigraphy, and tectonics of part of the Sierra Madre Occidental.
- Excursion C-4: Excursion A-1 was repeated.
- Excursion C-5: 'Stratigraphy and structures of the Upper and Lower Cretaceous of the Sierra Madre Oriental in the State of Coahuila, as well as the Jurassic of Huasteca Canyon'.

- Excursion C-6: Excursion A-14 was repeated.
- Excursion C-7: 'Geology of the Veracruz Basin, the Isthmus of Tehuantepec and the Yucatán Peninsula'. An excursion of general geological interest, stratigraphy and structures related to the geology of petroleum and salt domes with sulfur. Also, a visit was made to the Mayan ruins at Uxmal and Chichen-Itza.
- Excursion C-8: 'Stratigraphy and paleontology of the Jurassic and the Cretaceous formations of the region of Huauchinango (Puebla) and Huaycocotla (Veracruz) in the Sierra Madre Occidental'.
- Excursion C-9: 'Volcanology of the south of the Valley of Mexico and the region of Cuernavaca, with examination of the region's sedimentary and igneous rocks'.
- Excursion C-10: 'Mesozoic stratigraphy and tectonics of the Sierra Madre Oriental between Zimapán and Ciudad Valles'. Igneous and sedimentary rocks of the Cenozoic were studied and visits made to the refineries and production plants in Poza Rica (Veracruz). In addition, information was provided on the petroleum geology of the region.
- Excursion C-11: 'Stratigraphy of the continental Cenozoic of the southern sierras and the coast of the Gulf of Mexico between Coatzacoalcos and Veracruz'. The volcanology of the Pleistocene and the paleontological remains of vertebrates were analyzed.
- Excursion C-12: Excursion A-9 was repeated.
- Excursion C-13: Excursion A-10 was repeated.
- Excursion C-14: 'Speleology and karstic phenomena of the Cacahuamilpa grottoes'.
- Excursion C-15-A: 'Mesozoic geology and stratigraphy of the Upper Paleozoic in the State of Chiapas'. It focused on the sedimentary geology of the Tehuantepec oilfields and the study of salt domes with sulfur deposits.
- Excursion C-15-B: 'Sedimentary geology of the Oligocene, Eocene and Cretaceous–Jurassic'.
- Excursion C-16: 'Sedimentary geology and micropaleontology of the Eocene, Oligocene and Miocene localities and formations of the coastal plain of the Gulf of Mexico', between Poza Rica (Veracruz), Tampico and Ciudad Valles (San Luis de Potosí), with visits to the oilfields of Faja de Oro and Tampico.
- Excursion C-16-A: 'Visit to the rutile deposits of the pre-Mesozoic gneisses in Pluma Hidalgo'.

Finally, a further eight excursions were organized and took place during the days following the Congress:

- Excursion B-1: 'Visit to the 18th of March oil refinery (Atzacapotzalco)'.
- Excursion B-2: 'Visit to the plants of Mexican Copper, National Copper and Anaconda Pirelli Electrical Conductors'.
- Excursion B-3: 'Study of problems of soil mechanics in Mexico City'.
- Excursion B-4: 'Visit to the factories of National Diesel, National Manufacturer of Railway Carriages and Toyoda'.
- Excursion B-5: 'Visit to the mining district of Pachuca'.
- Excursion B-6: 'Visit to the mining district of Taxco'.
- Excursion B-7: 'Visit to the dissolution grottoes in Cacahuamilpa'.
- Excursion B-8: 'Volcanism in the Valley of Mexico'.

The excursions were predominantly to mining and oil installations, but stratigraphy was also important.

The state of geology and contributions of the IGC

Volcanology

The first scientific section was devoted to the study of the volcanology of the Cenozoic and was coordinated by the Mexican engineer, Federico Mooser. Mexico lies in a zone of concurrence of several tectonic plates and consequently is an area of great volcanic activity. The Californian Peninsula is being separated from the rest of the Continent through the interplay of transform faults, due to the sliding sideways of the North American Plate with respect to the Eastern Pacific Plate. Mexico is situated in the zone the Eastern Pacific Ridge, where the lateral shifts assume great importance. On the other side, on the Pacific Ocean Coast, from Cape Corrientes southwards, the Cocos Plate subducts beneath Mexican territory, forming a basin known as the Acapulco Trench. The magmatite rocks that have their origins in the subduction of the Cocos Plate gave rise to the Trans-Mexican Volcanic Belt, which crosses the country from the Pacific to the Gulf of Mexico. Similarly, on the Caribbean side, there is a ridge produced by the shift of the North American Plate towards the west and that of the Caribbean towards the east.

Volcanic activity was at its maximum in the Middle Oligocene (known in Mexico as the Middle Cenozoic Orogeny). For this reason, the study of volcanism was centred on the Cenozoic, although there is important volcanic activity in the Mesozoic and in the Quaternary. During the session, studies of volcanoes of different periods were presented.

An event which shocked the world was the eruption of the volcano Parícutin (the destination of Excursion A-15). It was active from 1943 to 1952. A huge cone, now 224 m high, rose up out of farmland. Lava flowed for 10 km, burying the towns of Parícutin and San Juan Viejo Parangaricutiro. A stamp was issued commemorating both the eruption and the Congress (Fig.6).

Figure 6. Commemorative stamp for the XX IGC, issued in 1958, and corresponding photo.

Predominant among the forty-three papers presented were topics relating to volcanological research programs carried out in different parts of the world. Special mention should be made of the contributions of Sigurdur Thorarinsson (1912–1983), an expert on Icelandic volcanoes, who presided over the first session, the German, Reinhard Maack (1892–1969), who presided over the third session and was one of the pioneers of studies of the Paleozoic in the Paraná Basin and the Dutchman, Jan Westerveld, President of the fourth session, distinguished for his studies of Sumatra.

In the fifth session of the Congress Council a recommendation was made that during the next IGC a Symposium would be held on ophiolites, especially their petrography, formation, transformations and relations with tectonics. As observed by those present: "these rocks had been examined previously during the 19th Congress (Algiers, 1952), though only from the volcanic point of

view". The most notable scientist in this section was the Belgian, Paul Fourmarier (1877–1970), whose name is currently used to describe the most important prize awarded by the Belgian Geological Society (Fig.7).

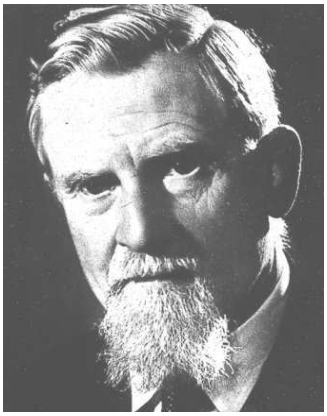


Figure 7. Paul Fourmarier.

Geology of petroleum

Section 3 of the 20th IGC concentrated on 'Oil and Gas-fields' and was coordinated by Eduardo J. Guzmán (Deputy Manager for Prospecting for PEMEX) and Raúl Pérez. In the London Congress (1948), there was already a section on the 'Geology of Petroleum' (Trümpy, 2004). In the World Petroleum Council, founded in London in 1933, it was proposed that international congresses on petroleum should be held every three years; and in 1955, the year before the 20th IGC, the 4th International Congress on Petroleum was held in Rome.

It was one of these sections that aroused the greatest interest, because of the worldwide importance of the supply of energy, not least in the host country. In addition, PEMEX had financed the Congress. Oil and natural gas resources of numerous countries were described.

It is striking that, of the eighteen papers on specific regions five referred to the Germany and the Carpathians. Consequently, at the request of D. N. Andrussov (Czechoslovakia), the IGC Council recommended the creation of a Commission to undertake the study of the Alps and the Carpathians. A significant paper, setting out the sequence of the geology of petroleum in Mexico, was presented by Luis Benavides: 'Notes on the geology of petroleum in Mexico' (López Ramos, 1998).

In 1938, the President of Mexico, Lázaro Cárdenas, ordered the expropriation of the Oil Industry. For its reorganization PEMEX was set up on June 7th. The following two years saw a reduction in the national hydrocarbon reserves (from 1,270 to 1,225 million barrels). With the aim of reversing this tendency, PEMEX created the Department of Prospecting in 1941 which achieved this objective with the discovery of new oilfields and natural gas fields in Misión (1945), of oil and gas in Reynosa, Tamaulipas (1946), the 'Francisco Cano' field in Tamaulipas and Nuevo León (1949), the 'José Colomo' field in Tabasco (1952), and the 'Ezequiel Ordóñez' field in Veracruz (1952). In addition, two new refineries were constructed in Salamanca and Reynosa, increasing the total volume of primary distillation by 315% and production based on catalytic disintegration by 369%. The 20th IGC came, therefore, at a time of revival of the Mexican oil industry (Márquez, 1989) (Fig.8).

Year	Drilling of wells			
	Total	Increase (%)	Success (%)	Kilometres drilled
1938-1940	6		50	8
1941-1946	39	550	16	44
1947-1952	286	633	35	506
1953-1958	590	106	30	1,060

Figure 8. State of petroleum exploration in Mexico (1938-1958).

The increase in drilling for oil and gas was especially remarkable during the period from 1953 to 1958: In barely a decade there were more than fifteen times more wells. This activity was reflected in geology by a large number of studies in this field. In the following table (Fig.9) one can see the increase in the number of geological exploratory surveys linked with petroleum during the period 1938–1958 (Sordo and López, 1988).

Year	Surface geology	Deep geology	Seismo-logy	Gravi-metry	Magneto-metry	Electric methods	Total
1938-1940	5	0	4	0	2	0	11
1941-1946	86	9	22	16	1	3	167
1947-1952	84	45	94	23	0	6	252
1953-1958	68	76	109	29	0	0	282

Figure 9. Geological research into petroleum in Mexico (1938–1958).

In 1956, passage through the Suez Canal was temporarily blocked as a result of the armed conflict between Egypt and Israel. This marked the beginning of what became known as the second oil crisis, which culminated in the creation of OPEC (1960), which was to have a decisive influence on world energy politics (Fig.10).

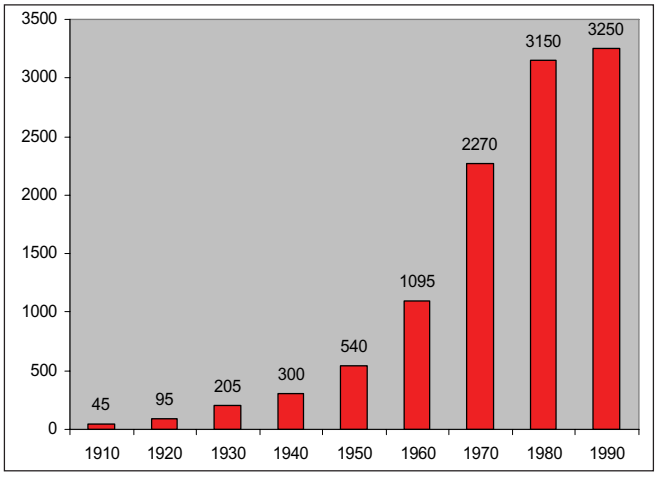


Figure 10. World petroleum production (1910–1990) in millions of metric tons.

In the scientific section, two papers were presented relating to offshore drilling and installation. Only a few years earlier, in 1947, a group of companies, led by the American company Kerr–McGee, drilled the first viable well operating commercially in deep water in the Gulf of Mexico at more than 15 km from the coast (Platt et al., 1997). One of the most significant presentations to the IGC relating

to offshore drilling was by T.R. Goedicke, published in the prestigious journal *World Oil*, being a study of potential areas of interest in offshore oil prospecting.

Among the excursions concerned with geology and oil production the following were noteworthy, though related themes also occurred in other excursions (A-10, C-10, C-15A, C-16 and B-1).

Paleontology and micropaleontology

In the 20th IGC two scientific sections were organized relating to paleontology: one was entitled 'Paleontology, Taxonomy and Evolution', coordinated by the Mexican paleontologists Manuel Maldonado-Koerdell (1908–1973) and Gloria Alencáster de Cserna; the other was called 'Micropaleontology', and coordinated by the specialist in foraminifers Hans Ernest Thälmann. The first of these sections consisted of forty-five contributions and the second of thirty-three.

The great boost for paleontology in Mexico came when PEMEX founded the Department of Prospecting and the Section of Petroleum Paleography, which had as its first objective the study of foraminifers of Tertiary stratigraphic columns. Responsible for this paleontological systemization was Manuel Maldonado-Kordell, who as Director of PEMEX's Department of Paleontology encouraged research in this discipline. During this period, which began in 1950, came the appearance of the journal *Mexican Paleontology* (1954), which, together with other publications like the *Bulletin of the Mexican Association of Petroleum Geologists*, with numerous articles on microfossils, contributed to the dissemination of discoveries in paleontology made by researchers both from Mexico and other countries (Carreño and Montellano-Ballesteros, 2005). Maldonado-Koerdell's charisma resulted in his election as coordinator of the six sessions, which comprised the section on 'Paleontology, Taxonomy and Evolution'. He also presided over one of the sessions. In addition, he presented his research on the paleontology and micropaleontology of the Upper Cretaceous and Eocene in Chiapas.

Outstanding among the foreign scientists working in Mexico, was G. Arthur Cooper, President of the Paleontological Society in 1957, who concentrated on the Cambrian in Caborca and the Permian in El Antimonio, together with the German Heinrich Karl Erben (1912–1997), who studied the Jurassic cephalopods in Veracruz (Guío and Rodríguez, 2003). Cooper presided over the first session of the Paleontological section and presented a paper on 'Silicified Permian Fossils from the Glass Mountains, Texas'. For his part Erben presented two papers relating to research which, subsidized by the management of the Institute of Geology of the UNAM, he was carrying out with a view to revising the stratigraphy and tectonics of marine strata of the Lower Jurassic in the zones of the Huayacocotla and Huauchinango.

The section on 'Micropaleontology' came at the time when this scientific discipline was classified as an autonomous branch of paleontology, as it was becoming an effective tool in petroleum exploration. In 1955, there had been created a micropaleontological laboratory in the Faculty of Science in Paris. In the same year the *Colloque de Micropaléontologie* was held in Germany, and in England the following year.

Outstanding among the participants in this section were Hans Ernest Thälmann, Jean Cuvillier, as well as the Mexicans Federico Bonet and Agustín Ayala. Jean Cuvillier (1899–1969) was the founder of the *Revue de Micropaléontologie* in 1958 (Bignot, 2007), which was supported by the oil companies.

Thälmann was considered to be one of the most brilliant micropalaeontologists of that time. He undertook his research based at the University of California, where he would organize trimestral seminars, to which were invited the world's leading micro-palaeontologists. Among his students was Agustín Ayala, who later worked in the PEMEX Micropaleonotological Laboratory under the direction of Manuel Maldonado, and made a significant contribution in relating his studies on foraminifera to coastal dynamics and petroleum exploration (Soto, 2003).

All in all, these two scientific sections were of great significance in the Congress, principally for their linking with petroleum exploration, which was then at its height. In addition, the contributions of foreign paleontologists residing either permanently or temporarily in Mexico were very important, with many of them working for oil companies prospecting in Mexican territory (Guío and Rodríguez, 2003) (Fig. 11).

Year	Palaeontological studies on Mexico carried out by Mexican authors	Palaeontological studies on Mexico carried out by foreigners	Total
1700-1869	2	10	12
1870-1919	25	52	77
1920-1939	9	129	138
1940-1949	16	56	72
1950-1959	65	72	137

Figure 11. Paleontological research in Mexico (1700-1959).

The preceding figures underline the active participation of paleontologists from Eastern Europe, especially from the former USSR. The holding of the IGC provided the opportunity to convene a meeting of the International Paleontological Union, presided over by H. Terrier, with Harold Ernest Vokes (1908–1998) from the U.S. Geological Survey (USGS) as secretary. Excursion C-16 should be pointed out as particularly relevant to micropaleontology.

Stratigraphy

The second section was on the subject of 'The Cretaceous System and its relationships throughout the World' and was coordinated by Lewis B. Kellum from the University of Michigan (a specialist in the paleontology of Cretaceous invertebrates, who had worked in Mexico), W.E. Humphrey, who had also worked in Mexico, and by J. Ruiz Elizondo, from Mexico. A 'Symposium on the Paleography and Base of the Cambrian System' was also held, coordinated by John Rodgers, an expert in this area.

Taking advantage of the IGC, meetings were held of: 1. The 'International Commission of Stratigraphy', presided over by Raymond Cecil Moore (1892–1974), a paleontologist from the USGS and an expert in crinoids, bryozoa and corals, with John Rodgers as secretary; 2. the 'Subcommission for the *Lexique stratigraphique*', presided over by the geologist, Pierre Pruvost (1890–1997) (Fig.12) with his collaborator Jack Roger as secretary; and 3. The 'Subcommision for Stratigraphic Terminology', with Hollis Hedberg (1903–1998) from Princeton University as secretary, a specialist in petroleum exploration.

Figure 12. Pierre Pruvost.

Geophysics

The section on 'Applied Geophysics' was coordinated by the Mexicans Guillermo Hernández and Jesús Basurto García. In the fifties, large-scale profiles of seismic refraction were undertaken in cases showing numerous petroleum traps. In the Mexico IGC, much importance was given to applied geophysics. In the second session of the Council, Antonio García Rojas from Mexico proposed the creation of a Commission to address "the application and limitations of geophysical methods to regional geological studies". In the report distributed it was stated that "the geophysical methods for prospecting applied in the search for oilfields and mineral deposits enable information to be obtained on the geology of the subsoil in regions when the cover or discordant structure fails to facilitate investigation by means of surface geology. . . . For this reason it is fundamental to initiate an exchange of ideas between geologists and geophysicists in order to determine the possibilities and limitations of present geophysical methods".

It was decided in the third session of the Council to encourage efforts in university circles to coordinate advances in the knowledge and diffusion of geophysics in relation to geology. Shortly after the IGC the International Geophysical Year was held (1957–1958) (Buedeler, 1957). One of the sessions of the IGC was coordinated by A. Van Weelder, who in 1951 had been elected the first President of the recently formed European Association of Exploration Geophysicists.

Mineral fields

There was a section entitled 'Modern Ideas on the Origin of Mineral Deposits (Metallic and Non-Metallic)' coordinated by the Mexicans Eugenio Tavera-Amezcua and Rubén Pesquera-Velázquez. Great importance was given to the genesis and investigation of deposits, both metallic and non-metallic. Attention should be drawn to the interest in uranium and the fact that a symposium was held on manganese.

Jenaro González Reyna presented a summary (which was extended into a book of 497 pages) on the mineral deposits of the host country entitled: 'Mining resources and mineral deposits in Mexico'. Also present was the acclaimed author P.M. Tatarinov, who had just published his book, *Conditions de formation des gisements de minerals* (1955).

At the beginning of the twentieth century, metallogenetic studies began to attract interest thanks to the writings of the mining engineer Louis de Launay (1860–1938), author of *Traité de métallogénie: gîtes minéraux et métallifères* (1913) (Puche et al., 2008). In 1919, a group was formed in the USA, within the Geological Society of America (GSA), specializing in economic geology and giving birth to the Society of Economic Geologists in December 1920, with the participation of Alan Mara Bateman (1868–1971) and others. In 1940, W. Lindgren published *Mineral Deposits*, which was chosen as the subject of the paper that L. Graton presented in this session of that IGC: 'Lindgren's ore classification after fifty years'. In 1942, Alan Bateman published *Economic Mineral Deposits* and shortly afterwards P. Despujols and H. Termier published *Introduction a l'étude de la métallogénie et à la prospection minière* (1946) and in 1949 Mac Kinstry published *Mining Geology*. Around the same time in 1951 Fernand Albert Jean Blondel (1894–1968) (Fig.13) published his *La classification des gisements minéraux*. His participation in this IGC centred on the defence of his paper, 'Notes de géologie minière'. Another reference book, Pierre Routhier's *Traité de métallogénie*, did not appear until 1963.

Figure 13. F. J. A. Blondel.

Metallogenesis was at its zenith. General papers presented at the Congress should be mentioned, in particular: 'Classification of metalliferous provinces and deposits' by Charles Sullivan; '*Génesis de yacimientos minerales*' by E.C. Rayces; and '*Idées modernes sur l'origine des gîtes minéraux*' by H. Bidaut.

According to Locutura (2000): "It was after the Second World War that an impulse was given to the cartography of mineralizations and mineral concentrations, resulting in the exploration of large and little known areas. And a very varied cartography was to appear", so we had maps of mines, deposits and other signs, traces or indications recording the distribution of mineral concentrations in time and space, and forecasting maps, with a selection of zones favourable for particular mineral substances. In this context, it comes as no surprise to encounter the paper by K.Y. Dvorza and E.N. Gorezkaia in the IGC, entitled: 'Metallogenetic map compilation methods'.

For the metallogenic maps of Eastern countries the model of Yu's School was adopted (Bilibin, 1955). According to Morrison (2000), in these maps they placed special emphasis on relationships between endogenous mineralization and magmatism, "accompanying the different phases of the geosynclinal cycles".

In the fourth session of the Council of the IGC, approval was also given to the proposal referring to the drafting of a metallogenetic map of the world. The delegation from the USSR, the promoter of this initiative, set out in the document distributed for its discussion,

that "metallogenesis has acquired a notable increase in work in countries like the Soviet Union, Japan and Mexico, since it helps the discovery of the laws which govern the distribution of mineral deposits, and to explain the causes and the conditions for the formation of the different types of mineral deposits, and evaluate the prospects of the different zones of the planet as to the possibility of the existence of one or other raw materials". In accordance with these objectives, the promoters of this initiative proposed that the Metallogenetic Map Commission should undertake to:

a) Draw a map of the principal metallogenetic locations in the world to the scale of 1:10,000.000, as well as of the continents using a suitable scale.
b) Draw maps of the fundamental metallogenetic periods in the world on the scale of 1: 10,000.000.
c) Draw a map of carbonaceous deposits in the world, indicating their locations and the periods of their formation.
d) Draw a map of the locations of oilfields and hydrocarbon deposits, indicating the age of the originating rocks.
e) Orient and revise the results of general regional and special metallogenetic explorations taking place throughout the world.
f) Orient and revise the methodological task of drawing up metallogenetic maps, with their content and conventional signs.

The Metallogenetic Map Commission was associated with the Commission for the Geological Map of the World. In addition, it was proposed that it be recommended that a specific section be devoted to metallogenesis. The Commission for the Geological Map of the World met under the presidency of the French mining engineer, F. Blondel.

Metallogenetic cartography began to develop from this time in wide geographical contexts. In the USSR, sixteen maps were drawn of the country on a scale of 1:2,500.000, which task was completed in 1971. In Europe, mention should be made of the work of the BRGM in France in the 1960s and 1970s, and in the USA the work of the USGS in the 1970s, among others. In the fifth session of the IGC Council, it was also agreed to set up a commission for the classification of metal-bearing deposits and for the definition of different types of such deposits. As proposed, a revision of the criteria was necessary: "The classification of metal-bearing deposits has a double objective: (a) to facilitate information gathering; and (b) to facilitate exploration and prospecting. Nevertheless, it has been demonstrated that the existing classification based on physicochemical and geological properties exhibits grave deficiencies, due to: (a) ignorance of the formation of the rocks which contain the deposit; (b) ignorance of the chronological relationships between the metal-bearing concentrates and the rocks containing them (syngenetic–epigenetic alternatives)".

The need for manganese for industry had led to the discovery of large deposits in Africa and America. For this region, there was a special symposium on manganese, coordinated by Jenaro González Reyna (1905–1967), a researcher from the Institute of Geology. Eighty-eight papers were presented in the symposium with the participation of figures of the stature of the Professor of Mineralogy in Heidelberg, Paul Ramdhor (1890–1985), Éugene Raguin (1900–2001), Professor from the School of Mines, Paris, and Charles F. Park (1903–1990) of Stanford University. At that time there was little discussion of manganese nodules under the sea. One of the participants of the IGC, H. W. Menard, coinciding with the International Geophysical Year (1957–1958), spoke in favour of the enormous economic potential of the oceanic manganese nodules. The beginning of the sixties was when the mining consortia consisting of the United States, Japan, Germany, Great Britain, Canada, Belgium, and Italy, began exploring the North Pacific to the southeast of the Hawaiian Islands, and recovered nodules of manganese, with other metals.

During the IGC, a meeting was held of the Society of Mining Geologists, presided over by Ferdinand Cameron (President of the Society of Economic Geologists, in 1956) with Olaf Norgberg Rove as secretary. The excursions for mining geology (A-1 to A-6 and C-3) should be mentioned, as well as other visits to mines or mining districts (C-15A, C-16, B-2, B-5, B-6, etc.).

Geochemistry

It was a good time for geochemistry. Books had been published that are a source of reference even today: *Geochemistry* by Rankama and Sahama (1950), *Principles of Geochemistry* by Mason (1952), *Geochemistry* by Goldschmidt (1954), and the notable *Discovery of the Elements* was in preparation by Weeks. Other milestones in geochemistry from this time were the obtaining of the element Mendelevium artificially in 1955 by bombarding Einsteinium with Helium ions and the publication in 1956 by Clair Patterson on the age of meteorites, detecting high levels of nickel in undersea sediments, which he attributed to meteoric dust.

It is no wonder therefore that in the scientific session and in the symposium there should be participation of important researchers. W. H. Pinson Jr presented a paper on isotopic geochemistry ('Variations in Sr^{87} Relative Abundance in Meteorites and Earth through Cosmic Time'). Pinson had directed various projects from MIT, aiming to estimate the isotopic composition of strontium in tektites, which led him to conclude that it did not coincide with terrestrial rocks. There was an abundance of studies on isotopic geochemistry, which had experienced notable progress since 1940. Niels had calculated the isotopic composition of lead based on the radioactive decay of uranium to thorium, designed a mass spectrometer and established the basis of the K–Ar dating method.

The symposium on 'Geochemistry, Geochemical Exploration and Isotopic Geology' was coordinated by Thomas S. Lovering (University of Michigan, President of the Geological Society of America in 1952, who had worked in Mexico) and by the Mexican, Rafael Molina Berbeyer (1917–1991), a researcher in the Institute of Geology and Geophysics at the UNAM. In the geochemical symposium, great interest was shown in the techniques of geochemical prospecting applied to the investigation of deposits (Anon., 1956). One of the most notable papers was presented by G. T. Philippi, dealing with chemical methods to identify mother rocks in the production of petroleum. In 1943, Royal Dutch–Shell had initiated research to determine the contents of hydrocarbons in petroleum-bearing basins. It attempted to obtain information to help in the task of prospecting, as an improved knowledge of the geology and geochemistry of petroleum could be used in order to select better areas to explore. Later, some chemists and geologists developed various analytical protocols for the identification of mother rocks. Philippi proposed to the Congress a method based on the distinction between autocthonous and migratory petroleum. He suggested that not only should the quantity be estimated of hydrocarbons generated per unit of weight of dry rock, but also that the petroleum should be classified according to a qualitative scale (excellent, very good, good, poor, and very poor or with no commercial value).

Another of the sessions of this symposium was presided over by Fred Earl Ingerson (1906–1993). This US chemist was one of the pioneers in affirming that chemistry could be a useful tool for resolving geological questions. His ideas led to the creation of the Geochemical Society in 1955, of which he was President for its first two years, including the year of the Congress, and to the founding of the International Association of Geochemistry and Cosmochemistry, of which he was President from 1966 to 1972. In addition, he was responsible for geochemistry and petrology in the USGS (1947–1957). He also took part in the creation of such prestigious journals as *Geochimica et cosmochimica acta* (1950), and *Organic Geochemistry*. To these publications should be added another in 1956, *Geokhimiya*, published by the USSR Academy of Sciences. Ingerson contributed to the Symposium with his paper 'Fundamental Studies in the Branch of Geochemistry and Petrology of the Geological Survey in Support of the US Policy on Minerals'. In this paper, Ingerson set out the basic lines to follow in the USGS: study of primary solutions through the investigation of volcanic emissions; hydrothermal synthesis of minerals; knowledge of the formation temperatures of minerals, metal-bearing deposits and rocks; the search for new deposits of rare metals like indium and gallium, traces of which appear in the metallic minerals which are used to extract these traces from the principal metal; revision of *The Data of Geochemistry* by F. W. Clarke, last revised in 1924; studies on stable isotopes; determination of the relationship between the age of a deposit and that of the rocks containing it as a tool for geological and mining exploration; studies of lateritization; and intensification of geochemical prospecting. These objectives were presented to the Congress as a mode of orientation for other world geological services.

Another noteworthy participant was Leo Horvitz, considered to be one of the first Western geochemists to use geochemical methods at the surface, avoiding in the first exploratory phases the undertaking of deep test drilling in the search of oil and gas fields. Lastly, another participant should be mentioned, the French mining engineer Georges Matheron (1930–2000), who carried out geochemical surveys in Algeria for the French Geological Survey, presenting some of its conclusions in Mexico. Matheron has passed into the history of science as author of a theory to calculate mineral reserves which he called 'Geostatistics'. He set out his ideas in his book *Traité de géostatistique appliquée* (1962–1963). In the fifth session of the IGC Council the French geochemist R. Lambert stressed the necessity to adopt a universal colour-scale for the presentation of geochemical maps, especially at that time, when geochemical prospecting was consolidating its role in mining exploration.

Geological cartography

The appearance of photogeology and photometry gave impetus to the quality of geological cartography. In addition to the meeting of the Commission for the Geological Map of the World there was also a meeting of the Commission for the Geological Map of Europe under the presidency of the German geologist Alfred Bentz-Haus (1897–1964) with H.R. Von Gaertner as secretary, as well as of the Commission for the International Geological Map of Africa, with Ferdinand Blondel acting as secretary. In the IGC, rules were laid down for the compilation of an International Geological Map of Europe as well as for a Geological Map of the World.

The Commission for the Geological Map of the World assumed responsibility for many areas of competence. Thus, in the third session of the Council of the IGC, V. Havlíèek (Czechoslovakia), an expert in the Palaeozoic, proposed the creation of a Commission to resolve geo-bioclimatic problems applying paleoclimatic knowledge. In the fourth session, it was established that this task should be entrusted to the Commission for the Geological Map of the World. It should be noted that a great impetus was given within the IGC to the thematic cartographies in metallogenesis, hydrogeology, geochemistry, etc. There was also a meeting of the Commission for the Physiographic Map of the World, presided over by Louis L. Ray (USGS), with M. Frysell as secretary. Similarly, in the third session of the IGC Council, the USSR delegates proposed the creation of a permanent commission dedicated to drawing up a Tectonic Map of the World. It was approved because of the importance attributed by the delegates to these studies, both from an academic and economic standpoint.

At the same time as the Congress there was an exhibition of geological cartography and scientific material, in which the geological surveys of the principal countries presented their maps. To mark the occasion of the IGC in Mexico a geological map of the country was published (1:2,000.000).

Hydrogeology

The fourth scientific section was dedicated to the study of the 'Hydrogeology of Arid and Sub-Arid Regions', coordinated by Alfonso de la O. Carreño, Director General of Geology of the Mexican Water Department. It was a very important problem for the host country because more than 52.8% of Mexico is defined as arid or sub-arid, exhibiting conditions of low rainfall (less than 300–500 mm/year), and high potential for evaporation, scant permanent surface water and high degradation and pollution of those that did exist (Romero, 2004). In the IGC Council, Jenaro González Reyna (Mexico) proposed that a Commission be set up entrusted with the study of arid and sub-arid regions, which was approved. The arid and semi-arid nature of numerous parts of the world led during the course of the twentieth century to a notable increase in the consumption of subterranean water. At the present time, the amount of underground water consumed on a global scale is estimated at around 600 or 700 km^3/year, of which 70% is destined for agriculture uses and 5% for industrial uses. In the middle of the twentieth century there was a notable increase in subterranean water resources, thanks to various factors: the invention of the turbine pump, which allows the extraction of large volumes of water at great depth and from submerged groups; advances in the technology of well drilling; and the knowledge of the origin, movement and localization of subterranean water (Llamas, 1999).

In Mexico, the most significant hydrogeological projects were realized from 1935 to the end of the sixties. Initially, the technology was linked to the extraction of petroleum and was organized through the Department of Agriculture and Agricultural Resources of the Mexican Government (Arreguín, 1998). For this reason, it comes as no surprise that this section was included in the XX IGC. In these years comes the appearance of the first great hydrogeological treatises, such as *Hydrogéologie* (1955) by Henri Schoeller (1899–1988). In addition, during the previous IGC held in Algiers in 1952, on the initiative of the French delegation, it was decided to set up the *Association Internationale d'Hydrogéologues* (AIH), although it was not officially constituted until the fifth session of the Council of the

IGC in Mexico. Shortly afterwards, in 1959, a Committee for Hydrogeological Maps was created.

Elsewhere, the *Association Internationale d'Hydrogéologie Scientifique* (AIHS) had been formed, which participated in the General Assembly of the International Union of Geodesy and Geophysics (created in 1919) as a constituent member (Rome, 1954; Toronto, 1957; Helsinki, 1960; etc.) UNESCO had asked AIHS to prepare a cartographic exhibition for Helsinki. In 1962, AIH and AIHS met at UNESCO headquarters in Paris in order to unify criteria with respect to the symbols to use in the maps and thereby achieve standardization. In the Mexican IGC there were some papers on hydrogeological maps.

The seafloor and plate tectonics

Introduction

The fourteenth scientific section of the IGC was devoted to 'Marine and Submarine Geology' and was coordinated by Ricardo Monges López (1886–1983), Director of the Institute of Geophysics of the UNAM and by Federico Mina Uhnik, head of PEMEX's Department of Geology and President of the National Association of Petroleum Geologists of Mexico from 1955 to 1957. Marine geology is one of the most recent branches of geology. Consequently, although its origins can be traced back to Darwin's voyage in the *Beagle* (1831–1836), it was not until the years following the Second World War that it acquired status as an independent discipline.

Gondwana

In 1915, the German meteorologist and geophysicist Alfred Wegener (1880–1930) formulated a theory of continental drift in his work *Entstehung der Kontinente und Ozeane*. Wegener postulated that in the past, at the beginning of the Mesozoic, the continents had been united, forming an immense mass of land that he called Pangaea, which as a result of large horizontal movements became fractured and formed the present continents. His explanation for these horizontal movements was based on the premise that the critical material of the Pangaea was rigid and less dense than that of the more viscous mantle over which it drifted, thanks to the forces created by tides and the Earth's rotation, like a ship plowing through a ductile ocean. But in the absence of sufficient evidence this theory was rejected by the majority of geologists.

The following years were characterized by a bitter dispute between defenders and detractors of Wegener's theory (Ayala et al., 2005). Among its strongest supporters was the South African geologist Alexander du Toit (1878–1948), who in 1923 received assistance from the Carnegie Institute, which allowed him to travel to Argentina, Paraguay and Brazil, studying the geology of these countries and demonstrating its similarity to that of South Africa. His ideas were published, together with F. R. C. Reed, in a work entitled *A Geological Comparison of South America with South Africa* (1927), in which he pointed out that his observations were consistent with the ideas of Wegener. Later, he published *Our Wandering Continents: An Hypothesis of Continental Drifting* (1937), in which he pointed out the existence of two proto-continents, Gondwana in the south and Laurasia in the north, separated by the Mesogea (Tethys Sea).

Because of the increasing importance given to these studies in the IGC in Algiers (1952) a symposium on Gondwana was organized and the subject was continued in Mexico (1956). A meeting was held of the 'International Commission for the Correlations of the Karroo System (Gondwana)', presided over by H. S. Haughton, a specialist in the geology of South Africa, with the Dane, Curt Teichert (1905–1996), a paleontologist and stratigrapher, especially of the Palaeozoic and Triassic, as secretary. The latter began his teaching career in Germany but he immigrated to Australia for political reasons in 1937 due to the rise of the Nazis in Europe.

There was also a meeting of the 'Commission for the Study of the Earth's Crust', presided over by Paul Fourmarier, Professor of Geology at the University of Liège and Permanent Delegate of the Belgian Government in the sessions of the IGC. The secretary was the Swiss, Eugène Wegmann (1896–1982), known for introducing the notion of 'Tectonic Stages'. In the sixth meeting of the Council they discussed the necessity to complete the geological studies of South America, both through the 'Commission for the Study of the Earth's Core' and the 'International Commission for the Correlations of the Karroo System (Gondwana)'.

Continental drift

The British scientist, John Joly (1857–1933), who had settled in Ireland, suggested that the radioactive heat generated within the Earth accumulates beneath the Earth's crust because of its poor conductivity, thus causing convective thermal currents. Similarly, David Griggs (1939), of Harvard University, thought that the earthquakes around the Pacific were due to the movements generated by the convective currents, which arise in the centre of the Basin and subside along its margins. In 1929, Arthur Holmes (1890–1965) had proposed a mechanism of thermal convection as responsible for the movement of the continents: the Earth's mantle contains cells of convection which dissipate heat originating from radioactive processes, which generate flows in the direction of the Earth's cortex and his *Principles of Physical Geology* (1944) included a chapter on continental drift based on convection.

In 1951, Beno Gutenberg was one of the organizers of a congress held in Hershey, Pennsylvania, centred on research into the flow in the Earth's interior. One of the principal conclusions reached was the confirmation of the importance of convective processes of the mantle, due to gravitational instabilities of thermal origin. The defenders of this theory were, among others, David Griggs, Harry Hess, and Felix Vening Meinesz. Others, such as Francis Birch, were in opposition. After this scientific meeting Gutenberg was convinced that convection played a key role in continental drift.

Plate tectonics

The theory of Continental Drift persisted, but without universal approval. The XX IGC was held at a key moment in its definitive acceptance and of marine geology in general, both of which would be intimately united in their developments in the following years.

In 1946, the US Office of Naval Research was created, which systematized marine research and in 1950 led to the foundation of the US National Science Foundation, which carried out important projects on marine geology. In parallel, other countries such as Sweden, New Zealand, USSR, Great Britain, France, Canada, Japan and West Germany, began to develop their own programs. Ph. H. Keunen (1950) then published a pioneering book in the field. Therefore, marine (and submarine) geology were going through their most important stages in the years leading up to the Congress.

We draw attention to the following contributions:

Knowledge of the submarine ridges

Undersea drilling, after World War II, and the development of sonar to locate submarines (1957), had helped to study the sea bed. Hess, a petrologist from Princeton University, who had spent a large part of the war in a submarine carrying out bathymetric studies, verified the existence of meso-oceanic mountain chains and tried to explain them though the increase in volume resulting from the hydration of the peridodites, through the action of water which seeps into them and reached a temperature of up to 500º C.

Around 1950, Edward Bullard (1907–1980) of Cambridge University, Arthur E. Maxwell and Roger Randall Dougan Revelle (1909–1991) of the Scripps Institution of Oceanography obtained the first measurements of heat flows in ocean sea beds. They found a positive geothermic anomaly in the ridge zones, but this anomaly failed to explain Hess's theory.

The ridges are not continuous structures but exhibit frequent lateral shifts. We should mention outstanding studies, in 1952, of the fractures associated with the ridges by Henry William Menard (1920–1986) and Robert Sinclair Dietz (1905–1994) (Dietz and Menard, 1952), although a decade would have to pass before the tectonic processes generating them were understood. Topographical, seismic, petrological, and magnetic characteristics of these fracture zones could be deduced from the additional observations of Menard, which in 1964 helped J. Tuzo Wilson (1908–1993) to propose his idea of transform faults.

The twenty-eight papers of the fourteenth section were distributed in four sessions. During the first of these, there was an outstanding paper entitled 'Submarine volcanism in the Pacific Basin' by Henry William Menard, who would later preside over the third session.

Paleomagnetism

In actual fact, some years before, in 1937 and 1941, the Cambridge geophysicist Sir Edward Bullard (1907–1980), together with William Maurice Ewing (1906–1962), were forerunners of marine geology and geophysics, and carried out notable studies on the Earth's magnetism and seismic exploration. In 1954, the International Association for Geomagnetism and Aeronomy was created, which studies the Earth's magnetism. The reconstruction of the situation of the continents in the past was a key tool in the study of palaeo-magnetism.

In 1929, Motonori Matuyama had proposed the idea of inversions of polarity of the Earth's magnetic field during the Pleistocene, in order to explain observations of the magnetism of lavas in Japan. In 1956, Keith Runcorn (1922–1995) of Newcastle University, who had demonstrated that the magnetic field varies in polarity and intensity over time, pointed out that the paleomagnetic poles of North America and Europe coincide for ages above 200 million years. In the same way, around the same time, Edward Irving showed that the paleomagnetic directions coincide better with geological reconstructions of the continents. Similarly, between the mid-fifties and 1964, it was discovered that at the bottom of the oceans the rocks are laid down in parallel bands with 'normal' or 'reversed' magnetic orientations. All this led Hess at the beginning of the sixties to propose his theory of the 'Expansion of the Ocean Floor', a key for the development of plate tectonics. Hess acted as president of a session of one of the sections devoted to applied geophysics.

In this XX IGC, there was an outstanding paper in paleomagnetism in the session on 'Applied geophysics', presented by Neil Opdyke ('Paleoclimates and paleomagnetism') which brought together references to the work of Runcorn, Irving and others, and stated in conclusion: "Paleoclimatic evidence from Europe and North America agrees with the polar wandering inferred from paleomagnetism. . . . Considerable continental drift is required by paleomagnetism and paleoclimatology in the present southern hemisphere".

Subduction zones

In 1932, Benioff invented a seismograph to obtain information on deep earthquakes. In 1949, he described how deeper seismic foci were becoming discovered (Benioff, 1949). In 1954, he published a geological cross-section showing the seismicity under the Kamchatka Peninsula (Benioff, 1954).

Special mention should be made of the participation of T. Y. H. Ma, a Professor at Taiwan National University, who with Ch. L. Pan, in the section on volcanology presented the paper entitled 'Volcanic belts discussed with respect to the shifting of crustal masses due to the cenozoic sudden total displacements of the solid earth shell'. It cited the contributions of Benioff and his predecessor Kiyoo Wadati (1928, 1934), giving name to the 'Benioff–Wadati Zone'. It also mentioned the identification by Umbgrove (1947) and Kuenen (1950) of "earthquake zones, zones deficient in gravity [sic] and foredeeps".

Similarly, in this section Ma presented a study on 'Major submarine problem interpreted in the light of sudden total displacement of the solid earth shell', which linked up with another of his papers published the year before in *Oceanographia sinica* in which he argued that changes had occurred several times at the bottom of the sea in the geological past. He demonstrated that there were modifications in the sedimentary strata of the sea floor, which he attributed to dislocations and discontinuous movements of what he called the 'solid earth shell'.

The Russian A. N. Zabarisky (1884–1952), from the Department of Volcanology of the Academy of Sciences, thought that the regions with high tectonic activity corresponded to zones of high volcanic activity. (Some authors have also called the 'Benioff–Wadati Zone' the 'Zavarisky–Benioff Zone'.) Zavarisky was the author of a book titled *Island Arcs* (1952). An island arc is a kind of archipelago, formed as an oceanic plate subducts under another plate and volcanism is produced. B. Chingchang's paper entitled 'The island-arc development of Taiwan' should be mentioned and was presented in the section on 'Relationships between tectonics and sedimentation'.

Petrology, mineralogy and plutonic rocks

In Section XI, 'Petrology and Mineralogy', coordinated by Eduardo Schmitter Villada (1904–1982), a petrographer from the Geological Institute of Mexico, there were papers such as George P. Barsanov's (1907–1993) entitled 'Principles of a modern classification of minerals'. Modern classifications like that of the Bulgarian professor Iván Kostov (1913–2004) combined geochemical–paragenetic and crystal–chemical–structural criteria. Also, in the years preceding the Congress some early petrographical classifications were proposed: Kryrine (1945), Pettijohn (1949), and Gilbert (1953). Gilbert himself had elaborated a criterion in 1954 in order to differentiate sandstones with a high and low percentage of matrix material. There was a significant meeting of the International Committee for the Study of Clay, presided over by Ralph E. Grim (1902–1989) from the University of Illinois, with his colleague William F. Bradley (1908–1973) as secretary.

O. Tuttle and N. L. Bowen presented an outstanding paper entitled: 'Some laboratory experiments bearing on the origin of granite'. In 1926, J. J. Sederholm, upheld the generation of granite by anatexia, an idea which was later supported by the Swiss E. Wegmann (the 'transformist school'). Conversely, the magmatic origin of granite (the 'magmatic school') was proposed by P. Eskola. Also on this problem were papers by Read (1940–1949), Niggli (1942), Rastall (1945), Raguin (1946), Bowen (1948), etc. The course of this controversy is reflected in the work of H. H. Read *The Granite Controversy* (1957). In the study of Tuttle and Bowen presented at the Mexican IGC and published in 1958 they demonstrate that the granitoids could be produced through the crystallization of magma; and thereafter the process of granitization through anatexia lost credence. A few years later, there was a proliferation of magmatic theses deriving from knowledge contributed by the theory of tectonic plates. In another section of the Congress, specifically with reference to 'Modern Ideas on the Origin of Mineral Deposits', G. W. Bain expounded his study 'Granite origin and type of associated mineralization'.

Section VIII, called: 'Plutonic Rocks, their Origin, and Relationship with Tectonics', was convened by two Mexicans, a consulting geologist Georges Ordóñez**,** and by Salvador Ulloa. In this section there were local studies of little general relevance, but we should mention the presence among the coordinators of the German Jew Peter Misch (1909–1987) from the University of Washington (Seattle), who had earlier left Germany because of the Nazis.

Nuclear geology

On the 20 December 1951 in the US, electricity was generated with a nuclear reactor with about 100 Kw, but until 1954 no nuclear power stations were connected to the electricity grid until the Russian nuclear power station at Obnisk came on line. The first commercial fission reactor was at Calder Hall (or Sellafield) in the UK, which was connected to the electricity grid on the 27 August, 1956. In France too, the power station of Marcoule (Gard) began to produce electricity in 1956. In that country 24,386 million Kw were consumed in 1946, while in 1955 production was 49,566 million Kw (cf. *Minería y metalurgia*, November 1956). Production had doubled in scarcely a decade and it was imperative to harness all possible energy sources: coal, petroleum, nuclear, etc., and the search for energy resources gave a boost to geological prospecting and mining.

On 25 March 1957, the European Community of Atomic Energy (EURATOM), was created and, on the same day, the EEC. In the same year, the International Atomic Energy Agency (IAEA) was formed. Both organizations had the mission, among others, to promote the peaceful use of nuclear energy. As a result of a Presidential Decree on the 15 December 1955 in Mexico, the National Commission for Nuclear Energy was born (López Ramos, 1988). In the IGC, the person responsible for the delegation from the Mexican Geological Society, Castillo Tejero, presented a paper, 'Creation of a Section on nuclear geology', which would be held at every Congress (Anon, 1956b). In the Mexican IGC, as in geological publications of the time, there were numerous studies on uranium.

Other topics and agreements

There were also other sessions of lesser interest:

'Relationships between Tectonics and Sedimentation', coordinated by the Mexicans Rogelio Van Vloten and Zoltan de Cserna (Institute of Geology, UNAM).

'Genesis of Ancient and Modern reefs (Bioherm and Biostrome)', coordinated by Federico Bonet (1906–1979), a paleontologist from PEMEX.

'Geology Applied to Engineering and Mining', coordinated by the Mexicans Alberto J. Terrones Langone (1916–1997), a UNAM engineer and Heinz Lesser Jones, an engineer specialising in hydrogeology.

'Miscellaneous Questions of General Geology', coordinated by Manuel Alvarez Jr, a member of Geological Resources of the National Institute of Scientific Research and by Francisco Viniegra Osorio, a biologist from PEMEX.

The meeting of the Association of African Geological Surveys should also be mentioned, presided over by F. Dixey (Director of the Colonial Geological Survey), and as secretary, the French mining engineer Blondel.

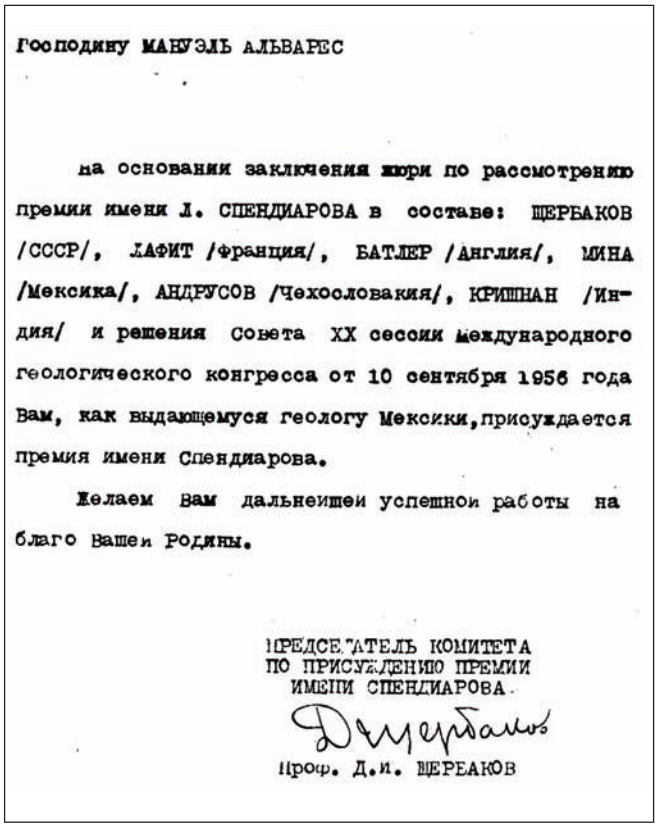
Various agreements of the IGC were decided by the Council, which was made up of representatives of all the institutions involved in the holding of the Congress. It met on seven occasions. After approving the proceedings of the preliminary meeting and the plenary meeting, the participants proposed a series of courses of action. For example, the delegate from New Zealand, H. Fyfe, expressed interest in his country hosting the XXI Congress, provided it would serve to commemorate the Centenary of the Founding of the Geological Survey of New Zealand. It was decided unanimously that it should be recommended to the organizers of the next Congress, the XXI, that they consider this offer. In the fourth session of the Council, an invitation was presented to hold the XXI IGC in Denmark (1960), with the proposition that the four Scandinavian countries, Denmark, Sweden, Norway and Iceland, should collaborate with the organization. After ruling out countries like Venezuela, India, and Germany, it was decided unanimously that Copenhagen should be the venue for the XXI Congress and if there were organizational problems in Scandinavia, it should be held in West Germany.

At the third session of the Council, the Dutchman Henrich Moritz Emil Schürman (1891–1979), an expert on the Precambrian, proposed that an international 'service' of abstracts of geological studies be created, which was extensively debated. In Schürman's opinion "this service would serve to communicate to the scientific world advances realized in the field of geology".

In the fourth session, Guillermo Salas (Mexico) gained approval for his proposal that a Commission be set up to standardize geological terminology and nomenclature, by means of a dictionary and in parallel, to create an Association of Latin American Geological Surveys. A dictionary should be compiled, and in print within four years, in time for the next IGC. The printing would be undertaken in the Spanish Geological and Mining Institute.

The Russian Yevgeny Leonidovich Krinov (1906–1984) expressed the need to establish a Meteorite Commission. This proposal was also approved by a majority of the delegates.

Finally, in the sixth session, it was announced that the Spendiarov Prize had been awarded to Manuel Alvarez Jr (Member of Geological Resources of the National Institute of Scientific Research) (Fig.14). It is a prize awarded by the IGC to a geologist from the host country, a bequest from a Russian nobleman that is awarded at every Congress by the leader of the Russian delegation. The Spendiarov Prize Commission was presided over by D. I. Scherbakov, of the USSR Academy of Sciences.



Господину МАНУЭЛЬ АЛЬВАРЕС

на основании заключения жюри по рассмотрению премии имени Л. СПЕНДИАРОВА в составе: ЩЕРБАКОВ /СССР/, ЛАФИТ /Франция/, БАТЛЕР /Англия/, МИНА /Мексика/, АНДРУСОВ /Чехословакия/, КРИШНАН /Индия/ и решения Совета XX сессии международного геологического конгресса от 10 сентября 1956 года Вам, как выдающемуся геологу Мексики, присуждается премия имени Спендиарова.

Желаем Вам дальнейшей успешной работы на благо Вашей Родины.

ПРЕДСЕДАТЕЛЬ КОМИТЕТА
ПО ПРИСУЖДЕНИЮ ПРЕМИИ
ИМЕНИ СПЕНДИАРОВА

Проф. Д.И. ЩЕРБАКОВ

Figure 14. Notification of the awarding of the Spendiarov Prize.

In the seventh session of the Council, topics were proposed for the next Congress in the name of the USSR delegation:

a) Phases in Formative Diagenesis of Sedimentary Rocks: their Epigenesis and Early Metamorphism.
b) Formation of Sedimentary and Volcanic Rocks.
c) Ancient and Present Day Processes of Erosion.
d) Physico-Chemical and Thermodynamic Elucidation of the Processes in the Formation of Rocks and Veins.
e) Types of Tectonic Structure and their Origin.
f) Structures of Mineral Fields.
g) Theoretical Bases of Metallogenesis.
h) Methods for the Prospecting of Mineral Resources.
i) The Stratigraphic Column.
j) Questions on the Origin of Petroleum.

At the same time, other possible topics were put forward for future symposia:

A) Absolute Scale of Geological Chronology and Methods for its Determination.
B) Continental Tectonics.
C) Geology and Resources of Coal Fields.

The most novel symposium of those proposed was 'A'. It should be remembered that in 1955 Maurice Roques (1901–1977) developed in Clermont-Ferrand a technique of absolute dating, using Rb/Sr. One of the most important ideas of this Congress was the recommendation to establish national geological commissions to coordinate national delegations and 'filter' the topics to be presented in the IGCs, given that it was felt that in the Mexican Congress there had already been too many papers.

Conclusions

It was the IGC with the largest attendance so far.

- Participants came as researchers, presidents, or coordinators of scientific sessions, or simply as speakers, some of the most important researchers in geology at that time: Menard, Ramdor, Ingerson, Cuvillier, Tatarinov, Fourmanier, Blondel, Bateman, Bowen, Clark, Hess, Thälmann, Erben, Troelsen, etc.
- There were important contributions in geophysics, exploratory geochemistry, organic geochemistry, isotopic geology, mineral deposits, petrogenesis, etc.
- The necessity for geological resources (metals, petroleum, uranium, etc.) gave a great boost to applied geology, as witnessed by the numerous papers presented in this IGC.
- As far as plate tectonics was concerned, it can be seen with hindsight how the foundations for the birth of this theory were in part laid at the XX IGC.

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