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**PLANNING SEMINAR ON THE
ANDÉAN GEOPHYSICAL PROGRAM AND
GEOLOGIC AND GEOPHYSIC
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GEOCHRONOLOGY AND ISOTOPE GEOLOGY

by

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I. Introduction

The prime purpose of this paper is to provide a helpful contribution to the Buenos Aires Conference which will be attended by the leading Latin American researchers interested in the development of Isotopic Geology and Geochronology.

The data herein stated which attempts to summarize the principal activities accomplished on the above fields up to date, may be useful as basis for discussion and for a rational and integral planning of future activities.

For the preparation of this paper it has been of great assistance the information received from several centers of the region and without which it would not have been possible to effect a general combination. Special gratitude is rendered to the colleagues from the Chronological Research Center, K. Kawashita and G. Amaral; to Doctors E. Linares, Fernando Munizaga, Luis Aguirre, Francisco Munizaga, Gabriel Dengo, E. Maldonado-Koerdell, Eliodoro Bellido y Cecilia Martin-Bellizzia, researchers related to this field in their respective countries.

II. Development of Geochronology and Isotopic Geology in Latin America

Chronological data are currently considered as essential for most of geological mapping work, particularly for those made in regions where the sediments are without fossils or of a problematic stratigraphy, as well as in regions of precambrian rocks, where there are no other means to determine rock ages. In a general way, Latin America is not yet very well known geologically and available radiometric findings are still very scarce.

With respect to isotopic geology, its findings are of great value in specific cases to elucidate important geologic problems, such as genesis of mineral fields, determination of paleotemperatures, paleoenvironments, petrogenetic evolution of rock masses, and others. The progress of research in isotopic geology is minimum, much lower than in Geochronology.

Both subjects are of recent development, and their methods, techniques and interpretations are being continuously improved. Research on these fields in Latin America were made in a continuous way, and sometimes systematically, during the last ten years. At first they were made only through cooperation of foreign laboratories.

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In the field of Isotopic Geology the accomplished research so far shows only the determination of some isotopic compounds of Sulphur, Carbon and Oxygen of Argentinian fields made by E. Linares in the laboratories of Yale University. Some other sporadic additional data was obtained, always in foreign laboratories, with only local interest and they have often remained unpublished.

Concerning the field of Geochronology, in view of its great importance in regional mapping, radiometric data is being obtained, in a continuous way, more or less since 1960. The determinations are related nearly always to regional projects, and there are worth mentioning the K-Ar and Rb-Sr determinations made by laboratories such as the M.I.T., the Carnegie Institution of Washington, California University, the National Australian University and others, on regions such as Sonora (Mexico), Cuadrilatero Ferrifero (Brazil), Batolito Andino (Peru and Chile), Roraima formation (Venezuela and Guiana). Let us add also a few scores of determinations made in several laboratories of England, France and Holland on rocks of the three Guianas, to support the regional projects of geological mapping.

With the passing of time the local Latin American entities felt the need of maintaining their own laboratories for radiometric dating and to have their own trained specialists on the matter. At first, at the beginning of the decennium, some local laboratories were installed for dating through the Pb- α methods, equipment for which was of a relative low cost, and the analyses could be done quickly. Pb- α laboratories were installed in Santiago, Buenos Aires, and Belo Horizonte. At the same time, in order to obtain in the future installation of laboratories, several investigators were sent abroad for training in the techniques of radiometric determinations, particularly through the K-Ar and Rb-Sr methods. In that field several South American scientists specialized, some of which, like E. Linares, F. Munizaga and J. Gerken, still engage in Geochronological activities in their own countries.

The first laboratory specialized on the K-Ar and Rb-Sr methods installed in Latin America belongs to the University of Sao Paulo (1963-1964) as a result of cooperation from the University of California. Prof. J. H. Reynolds, founder of the enterprise, profited from the important help provided by the National Science Foundation, to purchase the equipment and transfer it to Sao Paulo. Further, he spent himself nearly a year in Brazil where he conducted the installation and guided the first operations of research. At the present time, after more than 6 years, they have made in Sao Paulo about 1.900 analyses through the K-Ar method and about 150 through the Rb-Sr method.

Other centers initiated subsequently the setting up of their specialized laboratories which to-day are in operation, as in Santiago de Chile and La Plata. Others are still undergoing the process of installation or planning, such as those of Buenos Aires, Caracas, Belo Horizonte and Mexico City. It is expected that they will be able to start operating soon.

III. Research Centers on Isotopic Geology and Geochronology in Latin America

1. Centro de Pesquisas Geocronológicas. Universidade de Sao Paulo. Sao Paulo, Brazil.

It is operating since the early part of 1964 as a result of a joint project implemented by the University of Sao Paulo and the

University of California. The equipment available at this centers permits the dating of samples by the K-Ar and Rb-Sr methods.

The laboratory accomplishes an average of 300-350 K-Ar analyses yearly and about 30 Rb-Sr analyses. New equipments for dating by the Carbon 14 method are being procured and for the scintillating through liquids techniques; there are plans for procurement of a new solid source, mass spectrometer, with a 6 or 9 inches radius of curvature, to permit greater efficiency and readiness for determinations of the Rb-Sr method.

2. Instituto de Pesquisas Radioativas. Federal University of Minas Gerais. Belo Horizonte, M.G., Brazil.

A mass spectrometry laboratory for Rb-Sr determinations is under process of installation under the responsibility of Physicist Jorge Gerken.

3. Instituto de Tecnología Industrial. Federal University of Minas Gerais. Belo Horizonte, M.G., Brazil.

As of the beginning of the 1960 decennium there was installed, under responsibility of Geochemist Claudio V. Dutra, a laboratory for age determination by the Pb- α method.

4. Instituto de Física. Universidad Federal del Ceará. Fortaleza, C.E. Brazil.

Physicist Homero Lenz César is responsible for the future installation of a mass spectrography laboratory which will undertake, among other activities the determination of Rb-Sr ages.

5. Instituto de Física. Federal University of Bahia Salvador, B.A., Brazil

A Center for the study of Weak Radioactivity is undergoing the process of installation with the cooperation of a similar Institute at Gif-sur-Ivette, France. For a near future the Center expects installation of a dating laboratory through Carbon 14, and a mass spectrometer to study oxygen isotopes.

6. Facultad de Ciencias Naturales y Museo. Universidad Nacional de La Plata. La Plata, Argentine.

In 1964, and under the responsibility of physicist Horacio Caseneuve, a Carbon 14 dating laboratory was installed. This laboratory, after a short operating period, has stopped its activities, due to lack of specialized staff.

7. Gerencia de Materias Primas. Comisión Nacional de Energía Atómica, Buenos Aires, Argentine.

A Pb- α laboratory is set up since 1963. This laboratory, under supervision of doctor E. Linares, performs from ten to fifteen Pb- α determinations per year on zircons.

8. Comisión de Investigaciones Científicas de la provincia de Buenos Aires. La Plata, Argentine.

Since 1965 there are plans made by this entity for the installation of an age determination laboratory through the Rb-Sr method. The laboratory is already installed and under process of adjustment of the main equipment; some preliminary determinations have been made.

9. Instituto de Geocronología y Geología Isotópica. Consejo Nacional de Investigaciones Científicas y Técnicas. Buenos Aires, Argentine.

This Institute was recently formed through an agreement between the following entities: National Commission of Atomic Energy, School of Natural Sciences and Museum of the National University of La Plata, School of Natural and Exact Sciences of the University of Buenos Aires, Yacimientos Petrolíferos Fiscales, and National Directorate of Mines and Geology.

The Institute, under the direction of doctor Enrique Ibarres, is already associating the units mentioned in items 6 and 7, and negotiations have been started to integrate also the Rb-Sr laboratory of item 8. The Institute will start dating samples by the K-Ar and Rb-Sr methods and for the next coming years the Institute plans to extend its laboratories procuring mass spectrometers to carry on researches with Sulphur, Carbon and Oxygen isotopes.

10. Laboratorio de Geocronología. Instituto de Investigaciones Geológicas Santiago, Chile.

Starting from the beginning of the 1960 decade, and under the direction of Chemist Fernando Munizaga, a laboratory for age determination through the Pb- α method was installed. The equipment for the Rb-Sr method was purchased in 1965 and is in operation, and a few scores of determinations have been accomplished. The Pb- α results also amount to some tens of cases.

11. Laboratorio de Geocronometría. Instituto de Geología. Universidad Nacional Autónoma de México. México D.F., México.

Since 1960 there is in operation at the above institutions a mass spectrometer for Rb-Sr datings, with possibilities of obtaining U-Pb datings, constructed through cooperation of physicist Pedro Morales Puente. At the present time Engineer César Ricón Orta is responsible for the laboratory and many analytic data having been obtained during the last few years.

12. Instituto de Física. Universidad Nacional Autónoma de México, México D.F., México.

Currently under the direction of physicist Morales Puente, it has under process of establishment a laboratory for the study of stable Carbon, Hydrogen and possible Oxygen isotopes.

13. Departamento de Ingeniería Nuclear. Instituto Politécnico Nacional. México D.F., México.

This institution is planning to develop a research program on Isotopic Geology under the direction of Dr. Pablo Mulás, with a view to paleoenvironment research.

The main equipment to be used will consist of a neutron generator at the Institute, and the method to be applied will be that of nuclear activation. Research is being planned, for Oxygen and Carbon isotopes.

14. Dirección de Geología. Ministerio de Minas e Hidrocarburos. Caracas. Venezuela.

Under the supervision of Dr. Cecilia Martín Bellizzia a Geochronological laboratory is under process of establishment at the above site; it will operate initially through the Rb-Sr method.

IV. Teaching of Geochronology and of Isotopic Geology in Latin America

Elements of Geochronology and Isotopic Geology are normally taught in Latin America within the curriculums of more general topics, such as Geochemistry or Geophysics, for Geologists, Geophysicists, Engineers, Geographers, etc. For the time being, regular specific courses are not common, although one can foretell their propagation in the coming years, with the establishment of specialized laboratories in diverse centers. The existing tendency is of teaching disciplines like geochronology or isotopic geology only at the level of post graduate or specializing students.

At the present there are regular courses at two centers:

- 1) Institute of Geoscience and Astronomy of the Sao Paulo University. Discipline: Geochronology, for post graduate students in geosciences.
- 2) School of Natural and Exact Sciences of the University of Buenos Aires. Discipline: Isotopic Geology, for Doctorate students in Geological Sciences.

Specialized training in Geochronology and Isotopic Geology essentially provided overseas in universities of the United States or Europe, by reason of the very scarce facilities existing for such training in Latin America. Up to the present time the sole Latin American center capable of furnishing training in Geochronology was the one at Sao Paulo. In this center and since its installation 24 permanencies lasting from 2 to 4 months, (12 Brazilian investigators, 11 from South American countries and 1 from the United States), were carried out:

V. Principal Research Lines in Geochronology.

The majority of geochronological studies performed in Latin America still have a character of preliminary survey as an assistance for regional mapping projects, or localized geological investigations. Complete studies, through diverse methods, and scores of samples, are not available yet, as occurs in other parts of the world, with views to the establishment of an absolute chronology for limited regions.

The obtained findings, many of them through cooperation from foreign laboratories, are to be found in scores of published papers, as shown in the bibliographical list attached hereto.

In the meantime many isolated or quite recent data remain unpublished, and have not been given, up to the present time, an adequate interpretation. Considering the published works and roughly estimating the obtained data, radiometric ages obtained for Latin America easily overpass the 3,000 figure nevertheless too small for an adequate cover of Central and South America.

The geochronological research projects in Latin America may be divided in two large groups:

1. Geochronological Studies in the Phanerozoic

They refer essentially to the elucidation of stratigraphic problems of the orogenetic or mountainous belts of the Andes and Meso-American, and the dating of the post-paleozoic anorogenic magmatic activities of the Guianan and Brazilian shields.

- a) Research related to epochs of metamorphism, vulcanism and granitic intrusions in the Andean and Meso-American orogenic belts.
Examples: Geochronologic studies performed through various methods in North American laboratories on rocks from Central America, Mexico, Peru, Bolivia and Argentine. Pb- α determinations made in Santiago on Chilean rocks. K-Ar determinations made at Sao Paulo on rocks from Chile, Colombia, Venezuela and Argentine.
- b) Radiometric determinations in the North Patagonian Argentinian Massif.
Examples: Rb-Sr ages obtained by M. Halpern and K-Ar ages obtained at the Geochronological Research Center in Sao Paulo.
- c) Age determinations on basaltic and related rocks from the sedimentary basins of Parana, Parnaiba and Amazonian.
Example: Research performed at Sao Paulo on basaltic and alkaline rocks of Southern Brazil. Ages obtained at Amsterdam of the Surinam and at Sao Paulo of the Amazonian and Parnaiba basins.

2. Geochronological Studies in the Pre-Cambrian

They refer essentially to datings related with geochronological survey of vast regions of the Guianian Shield or of the Brazilian Shield, where available data is also scarce. Their main target is to fix the limits of the great geotectonic units of the pre-cambrian of South America. Itemized regional studies are rare and still incomplete.

- a) Delimitation of the pre-cambrian orogenic strips of the Shield of the Guianas.
Examples: Geochronological studies performed in England, France and Holland, respectively on ex-British Guiana, French Guiana and Surinam, in connection with geological mapping. Studies performed at the M.I.T. and at Sao Paulo for Venezuela. Determination made in Camberra for the Roraima region. Studies carried on at Sao Paulo for the Amazonian region in general.
- b) Delimitation of the pre-cambrian orogenic strips of the Brazilian Shield.
Examples: Geochronological surveys performed at Sao Paulo in connection with the Northeast, East, South and Center West of Brazil, some of them in collaboration with the M.I.T.
- c) Regional geochronologic evolution in restricted areas.
Examples: Determinations carried out by U.S. laboratories on the "Cuadrilatero Ferrifero" (Minas Gerais). Studies made at Sao Paulo in relation to the "Grupo Acuncuy" (Sao Paulo), or to the "Cordilheira do Espinhaço" (Minas Gerais). Study on the "Serra dos Orgaos", collaboration between the University of Brussels and the GRC.
- d) Determinations of radiometric ages in nuclei considered pre-cambrian of the Andean and Meso American orogenic belts.
Examples: Studies made in Arizona on rocks from Mexico, and in Santiago on Chilean rocks considered pre-cambrian.
- e) Determination of radiometric age in the regions of the "Sierras Pampeanas", "Sierra del Tandil" and "Sierras Australes", Argentine.

Examples: Studies, through diverse methods, of rocks from the regions of Córdoba, San Luis, Tandil and Sierra de la Ventana, Argentine.

3. Studies Related with the Theory of Continental Drift.

In many instances, alongside regional studies, geochronologic comparisons between the South American and African Continents were developed with the aim of verifying the hypothesis of the continental drift. Moreover, the determinations performed on orogenic volcanic rocks of the Brazilian shield and of the South Atlantic were used to verify the tension movements associated to the growth of the ocean bed.

- a) Geochronologic comparisons between South America and Africa.
Examples: The cooperation work between the M.I.T. and the G.R.C. on the comparison of the geochronological provinces of South America and Africa along the entire coast line, Research of S. Hart in the Montevideo region.
- b) Vulcanism studies in the South Atlantic.
Examples: Determinations obtained at the G.R.C. on rocks of the Archipelagoes of Abrolhos and Fernando de Noronha and from the Trindade and Martin Vaz islands.

VI. Final considerations

As it may be deduced from reading the preceding chapters, Latin America shows very small development with respect to geochronological research and still less with respect to isotopic geology.

If the number of determinations available, the number of investigators in this field and the number of existing laboratories are compared with similar data corresponding to the United States, the Soviet Union or Europe, it may be readily seen that there is a large field here open to any initiative in Geochronology. Therefore, the establishment of new laboratories in diverse entities should be encouraged. However, these Centers should keep in mind that the formation of specialized personnel, able to operate the equipments, should precede the installation of the laboratories.

The initiated research projects are actually the most important and urgent to acquire the knowledge of the general geologic evolution of Central and South America. All of them are at their initial stage, and need continuous contribution of data. In due time, new projects with larger details should be undertaken, alongside the principal lines sketched herein.

The ideas expounded in the two above paragraphs are still more critical with respect to isotopic geology, since there is not yet a single laboratory, in full operation, in the specialized laboratory class, nor are there any definite research lines planned in Latin America.

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GEOCHEMISTRY

by

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I. Introduction

In preparing this report for the symposium of Problems of the Solid Earth a great deal of reliance has been placed on information supplied by respondents from the various Latin American countries, and we are extremely grateful to those who took the time and trouble to reply. Unfortunately, some countries are conspicuous by their absence and so gaps in this presentation of geochemical investigations of Latin America, are unavoidable.

Probably most of the geochemical activity in Latin America is in relation to mineral exploration, and in some countries this is the only type of geochemical investigation being carried out. In most cases, geochemical exploration is part of a United Nations assisted program, which includes various techniques for mineral exploration. These programs normally cover large areas of the country, in many cases where there is little known about the geology or mineral potential. Reconnaissance drainage sampling is the first step in this type of program followed by detailed studies of soil and rocks sampling. Mining companies have concentrated most of their geochemical exploration in selected areas, usually near mineral deposits and have not been involved in a comprehensive exploration programs like that of the United Nations, and usually only in countries where mining is traditional.

Geochemical exploration has a practical aim which is to assist in finding mineral deposits quickly and cheaply. More fundamental questions of geochemistry, have only been tackled in some countries. Particular mention can be made of Brazil, Chile and Argentina where the geochemical topics studied have shown a great deal of diversity and imagination of approach.

II. Organism carrying out Geochemical investigations (Table I)

In most countries the geological survey is responsible for some, if not all, the geochemical investigations, and as has already been pointed out above, often in cooperation with the United Nations Development Programs.

Mining companies have been carrying out geochemical prospecting only in a few countries, notable Peru and Chile, where mining is an important factor in the economics of these countries.

Not much geochemical research is being done at Universities although there are exceptions. Brazil is remarkable for the number of institutes involved in geochemistry and the variety of topics investigated.

⁺ United Nations. Proyecto Minero, Quito, Ecuador.