



Intergovernmental Oceanographic Commission
Workshop report No. 5

**IDOE International Workshop
on Marine Geology and Geophysics
of the Caribbean Region
and its Resources**

Kingston, Jamaica, 17-22 February 1975

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Unesco

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

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GEOPHYSICS OF THE CARIBBEAN REGION AND ITS RESOURCES

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<u>No.</u>	<u>Title</u>	<u>Publishing Body</u>	<u>Languages</u>
1	CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia /Report of the IDOE Workshop on/; Bangkok, Thailand, 24-29 September 1973. UNDP (CCOP), 158 p.	Office of the Project Manager UNDP/CCOP c/o ESCAP Sala Santitham Bangkok 2, Thailand	English
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974. (Unesco Technical Paper in Marine Science, No. 20)	Division of Marine Sciences, Unesco, Place de Fontenoy 75700 Paris, France	English Spanish
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean, Monte Carlo, 9-14 September 1974.	IOC, Unesco, Place de Fontenoy 75700 Paris, France	English French Spanish
4	Report of the Workshop on the Phenomenon known as "El Niño", Guayaquil, Ecuador, 4-12 December 1974.	FAO 00100-Rome, Italy	English Spanish
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources, Kingston, Jamaica, 17-22 February 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish

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SUMMARY REPORT

IDOE International Workshop on Marine Geology and
Geophysics of the Caribbean Region and its Resources

Kingston, Jamaica, February 17-22, 1975

1. Opening of the meeting

The meeting was opened by the Honourable Allan Isaacs, Minister of Mining and Natural Resources, on behalf of the Government of Jamaica (Opening address see Annex III). Mr. Hector Wynter welcomed the group in the name of the Unesco Executive Board, of which he is the Chairman. The Deputy Secretary of the IOC, Dr. Günter Giermann, then welcomed the Group in the name of the Director General of Unesco, and the Secretary of the Intergovernmental Oceanographic Commission. He thanked the government for hosting and organizing the meeting. The opening session was chaired by Sir Egerton Richardson, Honorary Chairman of the Workshop. (A list of participants is attached as Annex II).

2. Election of officers and adoption of the agenda

The Honorary Chairman invited the Group to elect a Chairman. Dr. Gabriel Dengo from Guatemala was proposed and elected unanimously. Dr. John Weaver from Puerto Rico was invited to serve as Rapporteur for the plenary meetings. Ad hoc groups, as requested under items 5 and 6 of the Agenda, were asked to elect their own Chairmen and Rapporteurs for the duration of those meetings. The agenda was adopted as in Annex I.

3. General review papers

In order to inform the group on the general state of research in the Caribbean region, six eminent scientists made presentations, as follows:

- Troy L. Holcombe, US Naval Oceanographic Office,
on Bathymetry and Sediments of the Caribbean Sea.
- John B. Saunders, Texaco Trinidad Inc.,
on Stratigraphy of the Caribbean Sea.

- James E. Case, USGS,
on Structural Geology of the Caribbean Region.
- Arthur A. Meyerhoff, Tulsa Oklahoma,
on Hydrocarbon Resources of the Caribbean.
- Otto Bohnenberger, Central American Research Institute, Guatemala,
on Tectonic Models (A discussion on this subject was led
by A.A. Meyerhoff).
- A. Bellizzia, Ministry of Mines and Petroleum, Venezuela,
on a Review of the Tectonophysics Symposium, Geological
Society of America Annual Meeting, Miami, November 1974.

A full day was devoted to these lectures, and their discussions. Phillip W. Guild, United States Geological Survey, Reston, Virginia, was unable to attend and deliver his paper on Mineral Resources of the Caribbean. A draft manuscript of his paper was copied and circulated to all participants.

4. Papers on specific geological problems and research interests of particular countries

This item was introduced in order to make it possible for scientists to report briefly on problems in their respective countries or in countries of which they have a profound knowledge. Reports on the following countries were received: Mexico (L. del Castillo, F. Guerrero, R. Cruz), Guatemala (J. Godoy), Nicaragua (Orlando Rodriguez), Costa Rica (R.M. Castillo), Panama (G. Recchi), Colombia (H. Duque Caro), Venezuela (J. Galavis), Netherland Antilles (H.G. MacGillavry), Trinidad and Tobago (J. Scott), Barbados and Lesser Antilles (J. Tomblin), Puerto Rico and Virgin Islands (J. Weaver), Dominican Republic (R. Llinas, I. Tavares), Haiti (F. Maurrasse, G. Georges), Cuba (A.A. Meyerhoff), Jamaica (E. Robinson), Turks and Cayman Islands (W. Horsfield), and Bahamas (A.A. Meyerhoff). A discussion followed the presentations. A full day was devoted to this item.

Most speakers were highly interested in investigations directed towards the search for petroleum and to some extent in mineral concentrations in offshore sediments. Other aspects of economic and sociological importance are the question of geological hazards, seismology and volcanology. The need for deep drilling, particularly in the Venezuelan basin to penetrate below the B" reflector horizon and the advantage of multiple channel seismic profiling for deeper penetration was stressed. Suggestions were also made for higher energy explosion seismic work, though one participant objected to this on environmental grounds.

Several speakers emphasized the need for more detailed knowledge of land geology which could be then projected to the interpretation of marine observation. In particular the report on the apparent occurrence of horizons A" and B" in southern Haiti stressed this aspect.

5. Need for further work and plans for further work

In order to implement this item the Workshop divided into three ad hoc groups on:

- | | |
|---------------------------------|------------------------------|
| 1. Geophysics and Tectonics, | Chairman : J. Ewing |
| | Rapporteur : W. Horsfield |
| 2. Stratigraphy and Sediments, | Chairman : K.O. Emery |
| | Rapporteur : J.B. Saunders |
| 3. Petrology and Metallogensis, | Chairman : A. Bellizzia |
| | Rapporteur : O. Bohnenberger |

Two full days for discussions and programme drafting were allowed to each of the three groups. The Programme of Research, as finally adopted by the Workshop, is attached to this report as Annex V.

6. Recommendation for coordination and implementation of future work

The workshop discussed the questions of how the programme and its single projects could be best coordinated and implemented. The representative of Unesco and IOC explained that Unesco and the IOC might be in a position to give assistance to training and education in marine science to developing countries of the region, to assist in the publication of results, and to assist in setting up national and/or regional data (information) services. Mr. P. Grim spoke on the facilities provided by such a centre, taking as his example the National Geophysical and Solar Terrestrial Data Center of the US National Oceanographic and Atmospheric Administration (NOAA).

The Workshop appreciated these offers and formulated a set of recommendations which are attached to this report as Annex IV. Dr. J. Ewing was requested to bring to the attention of the International Programme of Ocean Drilling (IPOD), at its next meeting, the request of the Workshop for further deep drill holes in the Caribbean Sea. The Workshop participants voiced their appreciation of the work being carried out by Dr. J. Weaver who publishes at regular intervals compilations on the "Status of Geological Research in the Caribbean". Financial assistance for the continuation of this activity is sought.

After the discussion of this item, members of the group participated in two field trips which were kindly offered by the host country.

7. Adoption of the final report

The Group adopted the final report, the recommendations, and the programme. The Workshop further agreed that additional explanatory material for certain sections of the programme be included in Appendices A-D (Annex V-4).

8. Closure of the meeting

The meeting closed at noon on Saturday 22 February 1975.

ANNEX I

IDOE International Workshop on Marine Geology and
Geophysics of the Caribbean Region and its Resources
Kingston, Jamaica, 17-22 February 1975

AGENDA

1. Opening of the meeting
2. Election of officers and adoption of the agenda
3. General review papers
4. Papers on specific geological problems and research interests of particular countries
5. Need for further work and plans for further work
6. Recommendation for co-ordination and implementation of future work
7. Adoption of the final report
8. Closure of the meeting

ANNEX II

IDOE International Workshop on Marine Geology and
Geophysics of the Caribbean Region and its Resources

Kingston, Jamaica, 17-22 February 1975

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ANNEX III

Address by the Hon. Allan Isaacs, Minister of Mining and Natural Resources, at the Opening of the IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources, on Monday, February 17, 1975

The use of ocean resources has received increasing attention in the 1970's. The interest stems in part from the Law of the Sea Conference, which will be continued and, it is fervently hoped, concluded in Geneva at the end of March. This interest comes even more crucially from the realization, particularly in the metropolitan countries, of the diversity and abundance of offshore hydrocarbons, seabed mineral resources, the vastness of the capacity of the oceans as a source of food.

These considerations bring the necessity for international co-operation in ocean management and its relevant problems into sharp focus. Seventy per cent of the surface of the earth is water and most of the oceans lie beyond the limits of national jurisdiction and are subject to no specific ownership. Quite clearly the increasingly complex techniques for studying the ocean must be planned, organized and implemented. This is a problem to which the International Seabed Authority (most likely to be sited here in Kingston) must address itself. Solutions to this question are not however the objective of this Workshop which seeks to formulate and make known the status of present knowledge of the geology of the Caribbean Sea, the need for further work, the kind of work to be done in the future, and organizational requirements for the conduct of this work.

The ability of the Caribbean nations to conduct research is now merely incipient, which is regrettable because of the importance to Caribbean countries in involving themselves in ocean research in the region off their coast. There is a clear need for emphasis in marine research by the nations of the Caribbean in the future. Co-operation in investigations is essential and its most rudimentary form will consist of the exchange of data.

Individual developing nations such as those of the Caribbean have two main areas of concern in the marine sciences:

- 1) The development of indigenous national marine science programmes to which these countries should be firmly committed.
- 2) To ensure that ocean exploration and exploitation should be truly multidisciplinary in character.

The establishment and maintenance of national marine science programmes are beyond the resources of individual countries. Fuller international co-operation and assistance is therefore indispensable to realistic effort. This can be effected by means of:

- (a) The training of local scientists and technicians;
- (b) The provision of foreign experts to assist in special problems;
- (c) The provision of scientific equipment, scientific literature and technical data.

The transfer of technology in the marine sciences has so far been negligible. The truth is that it has scarcely been attempted. Indeed the idea of the transfer and exchange of knowledge and skills in marine science has not been current until now - certainly not in the present diversity of the disciplines involved in marine technology. It has not been a dynamic international purpose. It has therefore not been planned and organized on a truly international scale. Institutions in which these disciplines have developed have generally been situated in the established technological societies and exchange has taken place only among them.

In such a situation the question of financing the effort has simply not arisen. The whole concept is still in its formative stage but the process is evidently a dynamic one; and planning and organization will, I confidently believe, be correspondingly vigorous and will be imaginatively planned, practically organized and purposefully implemented.

Luckily a massive reservoir of knowledge exists and is available in a number of great institutions. The universities in each country are the repositories of knowledge and must now be heavily involved in the national programmes. The role of the university is not only the procurement of knowledge but the enlargement and exchange of knowledge. They must be the agents for the development of marine science and of the techniques of the recovery of national marine resources. These are essentially companion processes.

The sheer abundance and magnitude of the potential wealth of the sea, and the urgency of the need for that wealth on this planet, themselves constitute the most vivid indicator of the necessity to accelerate marine geophysical studies. Gravitational and magnetic surveys are required and it is important to produce seismic reflections and refraction diagrams for the purpose of delineating major marine structural features some of which may contain oil and gas resources. The exploration for marine minerals can effectively be pursued only with a good understanding of the geology, expressed largely in the form of geological maps, containing the necessary detail. This, together with an adequate appreciation of the geological history of the area of interest is the ultimate objective of the marine geologist.

However, all this work will require financing on a generous scale, and this fact has scarcely penetrated the consciousness of the great international financing bodies or indeed, the budgetary agencies within the nations themselves. This default will now have to be made good and I presume that it will be an integral part of the general effort.

I wish you marine geologists success in your week long deliberations and hope that the contributions emanating from this scientific Workshop will enhance our comprehension of the Caribbean marine environment.

Your science constitutes the key to beneficial exploitation of the non-renewable resources of the Caribbean Sea. The challenge before your fraternity is to develop a powerful marine scientific community in the Caribbean, competent to reduce the scientific gap between the countries of this region on the one hand, and the more opulent and sophisticated industrial societies within and without our hemisphere, on the other.

I wish this Conference the success that the greatness of its role and the magnitude and urgency of its task so vividly indicate.

ANNEX IV

RECOMMENDATIONS

The IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources (held at Kingston, Jamaica, 17-22 February 1975),

Recommends that the Secretary of the Intergovernmental Oceanographic Commission bring the research programmes which had been developed by the Workshop to the attention of the Member States of the IOC, its International Co-ordination Group for CICAR, and other appropriate subsidiary and advisory bodies, Member States of Unesco not members of the Commission, to other intergovernmental and non-governmental organizations, all international and national institutions, laboratories and scientists, interested in the region, inviting them to consider the programme, and to make it known to the Secretary in which project(s) they wish to co-operate, keeping in mind that the programme is a preliminary one which should be periodically updated;

Recommends that the assistance of the IOC Working Committee on International Oceanographic Data Exchange (WC/IODE) be requested to ensure the exchange of data and information on data collected under the above programme, inviting countries of the region to consider the setting up of a regional data (information) centre for this purpose;

Recommends that information on existing and future data be sent to the WDC-A, Washington, D.C. on the International Geological and Geophysical Cruise Inventory Forms, which have been endorsed by IOC and the International Union of Geological Sciences (IUGS).

Recommends that the Division of Marine Sciences of Unesco and the IOC give assistance in the field of training, education and mutual assistance to the countries in the region which need this aid urgently to build up their infrastructures, such as the Dominican Republic, Haiti, Jamaica, etc.; that countries having sophisticated equipment and manpower, make this available to other countries in the region, if so required; and that governments of countries which have inadequate geological services and institutions give higher priority to the establishment and extension of such services and institutions;

Recommends that institutions which sponsor geological and geophysical research in the Caribbean, provide opportunities for scientists and students from other institutions, particularly those in the region, to enable them to participate fully in these research projects;

Recommends that Unesco, the IOC and national institutions and foundations, consider giving support for the publication of results from the above exercise, including probably an atlas, geotectonic maps, bibliographies, periodical reports on the status of research, etc.

Recommends that the proposals for deep drill holes which have been formulated in the framework of the programme be brought to the attention of the International Programme of Ocean Drilling (IPOD) (through Dr. John Ewing).

Recommends that the conduct of the field projects recommended by this Workshop be facilitated by the countries of the region (this concerns visas, custom and research clearances, logistic support, etc.);

Recommends that the US Geological Survey be urged to give highest priority to the printing of the tectonic map compiled by J.E. Case and T.L. Holcombe in order to provide the geological base needed to all future work in the Caribbean;

Recommends that future workshops should pay more attention to coastal zones, including studies of their origin, evolution and land-sea interaction.

ANNEX V

PROGRAMME OF RESEARCH

CONTENTS TABLE

1. Field projects :
 - 1.1 Oceanic crust on land, including a study of metamorphic and plutonic rocks with associated mineralization.
 - 1.2 Margin structure and dynamics
 - 1.3 Carbonate platforms
 - 1.4 Detrital prism off South America
 - 1.4 Basin floors, including a study of the structure of the Interior Sea
 - 1.6 A drillhole in the vicinity of an active volcano
 - 1.7 Paleomagnetic studies
2. Compilation projects :
 - 2.1 Caribbean geological and geophysical atlas
 - 2.2 Data on volcanic and plutonic rocks
3. Support for ungoing projects :
 - 3.1 Study of presently available dredge haul material and hard rock samples from cores
 - 3.2 Compilation of a correlation chart for the Caribbean Region

Appendices :

- A. Margin structure and dynamics (ref. field project 1.2)
- B. Studies of the structure of the Interior Sea (ref. field project 1.5)
- C. Paleomagnetism (ref. field project 1.7)
- D. Study of the tectonic evolution of the Caribbean region
- E. List of participants in ad hoc working groups
- F. Figure with geotraverses

ANNEX V-1 : FIELD PROJECTS

1. Field Project N° 1.1: Oceanic crust on land including a study of metamorphic and plutonic rocks with associated mineralisation

- (a) The extensive seismic reflecting horizon B" in the Caribbean basins has been interpreted through the Deep Sea Drilling Project (DSDP-Leg-15-results as representing the top of the oceanic crust overlain by deep sea sediments of Coniacian to Campanian age. However, in some areas, pre-B" bedded horizons can be identified. A problem of prime importance is the further study of the B" horizon and strata below it. One way of attempting to resolve this problem would be to identify and examine outcrops on land areas surrounding the Caribbean which are thought to be the equivalent of horizon B" rocks. The identification of sections containing oceanic crust on the land areas could, at the same time, allow us to reconstruct and, perhaps, to place limits on the former geographical extent of the ocean-floor regime in the Caribbean region.

Areas in which basaltic rocks of oceanic aspects are overlain or interbedded with Late Cretaceous pelagic sediments have been reported from several areas bordering the Caribbean, notably Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Curaçao, Desirade, Virgin Islands, Puerto Rico, Hispaniola and Cuba. The most interesting, extensive, and yet perhaps least known of these occurrences are in southern Hispaniola, Panama, N.W. Colombia and Venezuela. Field work should be initiated in these areas.

- (b) A systematic and co-ordinated study of metamorphic and plutonic rocks with associated mineralization in the Caribbean is requested, including
- a petrological, geochemical and geochronological study of dredge hauls already available, and possible recovery of further hauls for examination with priority to the area of the Saba Bank and the Los Roques Trench, and the northern wall of the Nicaraguan Rise.
 - a similar study and mapping of metamorphic and plutonic rocks on appropriate land areas both in the islands, in meso-America and Northern South America.

This will permit the study of the petrologic evolution and delineation of the Caribbean Plate and its margin, at different times, in order to

- distinguish metamorphic rocks of continental and oceanic origin and the history and environment of metamorphism;
- investigate metallogenesis* and its relation to fracture zones, subduction zones and the genesis of the Caribbean crust;
- delineate source areas for possible economic mineral accumulation on the shelves, and to provide a basis for interpretation of seismic velocity patterns.

* Mr. Recchi suggested that particular attention be drawn on Panama and Puerto Rico.

Field project N° 1.2: Margin structure and dynamics (Appendix A)

The Group recommends the following regions and methods:

- REGIONS :
1. Margin of Colombia and Venezuela.
 2. Lesser Antilles - Barbados Ridge.
 3. Margin of Panama - Costa Rica.
 4. Interaction zone at the northern margin of the Caribbean.

- METHODS :
- Deep seismic reflection and refraction.
 - Seismological observations.
 - Magnetism and gravity.
 - Geology.

Brief description of the proposed research:

- 1) Margin of Colombia and Venezuela
 - Define the boundary between the oceanic and continental crusts along the northern margin of South America.
 - Study of the crustal and sedimentary transitions.
 - Resource assessments.
- 2) Lesser Antilles - Barbados Ridge
 - Study sediment and crustal structure of the trench and Barbados Ridge.
 - Study crustal structure of the Lesser Antilles Arc and adjacent basins and underlying mantle structure.
 - Study the southern boundary of the arc-ridge structure near Trinidad and Tobago.
- 3) Margin of Panama - Costa Rica
 - Investigate the bifurcation of the fold belts at the Colombia-Panama border area.
 - Investigate the possible extension of the fold belt offshore from Panama into the Limon basin of Costa Rica.
- 4) Interaction zone at the northern margin of the Caribbean
 - Investigate the onshore extent of Horizons A" and B" in southern Hispaniola and spatial and tectonic relation with the deep basin.
 - Investigate Hispaniola as the hub of the intersection of
 - (a) the Cayman Trench, (b) the Puerto Rico Trench,
 - (c) the Greater Antilles Islands, and (d) the Bahamas Platform.
 - Investigate the possible relation between the north-south-striking Beata Ridge (offshore) and the north-south-striking Central Cordillera (onshore).
 - Investigate the present and former movements across and along the Cayman Trench.

Field Project N° 1.3: Carbonate platforms

Platforms, largely of carbonate sediments, are considered of economic priority. These platforms range from large to small areas throughout much of the perimeter of the Caribbean.

They include the Nicaragua Rise, Honduras Shells, Los Roques, Tortuga Shelf, Saba Bank, and the shelves south of Cuba and east of Yucatan.

Existing knowledge from proprietary drill data, geophysical traverses, dredgings, and outcrops on adjacent land areas indicate that thick carbonate sections are underlain by early Mesozoic sedimentary rocks high in detrital and organic components. However, the thickness, age, stratigraphy and most everything else is poorly known for nearly all of these platforms. Much importance is attached to the acquisition of the presently proprietary drill-hole data, followed by the making of multichannel seismic reflection profiles accompanied by other geophysical measurements. Additional information must come from dredgings and especially from new drill holes.

Field work should be initiated in the above-mentioned areas.

Field Project N° 1.4: Detrital prism off South America

One of the Caribbean stratigraphic environments of highest potential economic priority is the long prism of largely continentally-derived detrital sediments between Panama and the Barbados Ridge. This priority is based upon the probable dominant detrital composition of the sediments and their high content of organic matter and, thus, of oil and gas. The general characteristics of the prism are known from existing bathymetry, shallow seismic and other geophysical measurements, wells, and land geology.

However, the great sediment thickness means that there are large gaps in the knowledge of its stratigraphy, composition, and petroleum potential. Existing information, as compiled on the correlation charts and atlas (see below), need to be greatly extended through new large-source multichannel seismic reflection traverses accompanied by seismic refraction, magnetic, and gravity profiles. At least 20 radial traverses and 2 connecting traverses are necessary. These traverses should reveal internal structures (reflecting horizons, unconformities, folds, faults, progradations, and perhaps diapirs) and the underlying basement seismic velocities and structure. Ages and compositions of these features must be based upon one or more deep drill holes, with priority to the Curaçao Ridge.

Syntheses of these traverses should permit construction of structural and isopach charts.

Field Project N° 1.5: Basin Floors, including a study of the structure of the Interior Sea

- (a) The nature and distribution of sediments on the basin floors of the Caribbean are best known in the area east of the Beata Ridge (Venezuelan Basin), from deep-sea drilling, seismic reflection and refraction studies, coring and dredging. West of Beata Ridge (Colombia Basin, Cayman Trough, Yucatan Basin) information is more fragmentary, particularly in the Yucatan Basin. Even in the Venezuelan Basin, there is virtually no information on the configuration and extent of sub-B" horizon. In the Colombian Basin the lack of deepest information is due to the excessive thickness of younger layers. Field work should be initiated in the Yucatan, Venezuela and Colombian Basins.

The Group would like to see further work on these basins using larger source seismic reflection equipment (to penetrate B"), magnetics and gravity.

Additionally, deep-sea drilling is suggested for stratigraphic control preferably in the Venezuela Basin and coring to examine the extent and distribution of turbidite layers in the more recent sediments. Sediment analysis of short cores, box samples, and other samples can provide information on modern sedimentary processes.

(b) Studies of the structure of the Interior Sea (Appendix B)

The Group recommends the following regions and methods:

REGIONS : 1. Yucatan, Colombian and Venezuelan Basins.
2. Grenada Trough.
3. Nicaraguan, Beata and Aves Ridges.

METHODS : - Deep seismic reflection and refraction.
- Deep drilling.
- Magnetism and gravity.

Brief description of proposed research

- Investigation in detail, using the best available methods, of deep crustal structure beneath the basins and ridges in order to permit inter-Caribbean comparison, and comparison among the Caribbean Sea, the major ocean basins, and other marginal seas.
- Define the morphology of the Caribbean basement and the structure and thickness of the overlying bedded material up to Horizon B". On the basis of existing information, the Group suggests that areas for proposed drill sites should be the Venezuelan Basin, the Yucatan Basin and the Cayman Trench.

Field Project N° 1.6 : A Drill-hole in the vicinity of an active volcano

To drill at least one hole in the offshore vicinity of an active volcano, preferably Mount Pelé, in order to improve knowledge of the marine record of volcanic deposits with the particular aim of determining the cyclicity or evolution of eruption activity, in order to explain possible interference between volcanic phenomena and stratigraphic sequences or mineralisation, and with a view to aiding in volcanic hazard predictions.

Field Project N° 1.7: Paleomagnetic Studies

The Group recommends the following regions and methods:

<u>REGIONS</u> :	1. Yucatan	4. Nicaragua	7. Hispaniola
	2. Guatemala	5. Northern South America	8. Jamaica
	3. Honduras	6. Cuba	9. Puerto Rico

METHODS : - Paleomagnetic sampling and analysis.
- Detailed geological mapping.

Brief description of proposed research (Appendix C)

The Working Group supports the recommendations for further paleomagnetic studies as outlined in the proceedings of the 1974 Guadeloupe meeting. This effort should make it possible to delineate large-scale rotations and/or

To implement this task the invitation of the Institute of Caribbean Science at Mayagüez to act as regional geological data and sample depository and information centre should be accepted.

ANNEX V-3

3. SUPPORT FOR ONGOING PROJECTS

3.1 A study of presently available dredge haul material and hard rock samples from cores

This project has already been suggested by the University of Miami, with preliminary work done on it by Fred Nagle in Miami. The Group feels that there is great merit in the study, since future field work must take into account material already available.

3.2 Compilation of a correlation chart for the Caribbean region

The American Association of Petroleum Geologists (AAPG) is preparing a new set of correlation charts for North America. John Saunders is co-ordinating this effort for the Caribbean and the Group discussed the aims and the methods by which the Caribbean contribution to this project might be achieved. In essence, stratigraphic columns for key land areas, DSDP sites, and some other offshore wells will be compiled. As the project develops, scientists conversant with each area will be asked to contribute data. Some basic work has been done and the project is perhaps ten percent complete. Completion is scheduled for mid-1976.

APPENDICES

Appendix A to Field project N° 1.2

Margin Structure and Dynamics (by the Geophysical ad hoc Working Group)

Northern Margin of Colombia, Venezuela and Trinidad

- Determine the structural configuration of the Southern Caribbean continental margin. This study could shed light on the tectonic evolution of this complex but critical region.
- The same study will help us to learn much more about the boundary between the South America continental crust and the Caribbean basement.
- Determine, if possible, the existence of seismic horizons A" and B" beneath the continental shelf, and trace them landward for correlation with known outcrops, which possibly are equivalent to A" and B". This study will help to understand the detrital prism off Northern America.
- Resources assessment; by knowing sediment thickness and basins shape, it will be possible to concentrate efforts on the more promising areas for oil and gas prospecting, porphyry copper deposits and other mineral resources. (Similar findings occur along the Pacific coast of Colombia).

Proposed Programme for Colombia, Venezuela and Trinidad

- Analyze all available information: onshore and offshore; seismic, magnetic, gravity, dredge hauls, cores and deep drilling results (onshore, platform, deep marine).
- New data to be obtained:
 - Deep high-resolution seismic survey (for example 24-channel equipment).
 - The seismic network has to be laid out in such a way that it will define adequately the structures at the continental margin.
 - Comprehensive sampling of the outer rise and slope.
 - Coring at such places where the recent sediment cover is thin (e.g. canyons), where high-resolution but shallow-penetrating systems can be used to pinpoint areas of bedrock outcrops.
 - Geodetic studies across major fault zones.
 - High resolution monitoring of seismicity.

Lesser Antilles - Barbados Ridge

The Lesser Antilles form one of the two small island arcs of anomalous situation in the western Atlantic Ocean. Both of these arcs appear to have migrated toward the east relative to the Americas plate during Cretaceous-Tertiary times. Understanding of the evolution and deep structure may thus be a significant factor in assessing the Mesozoic-Cenozoic evolution of the Caribbean region, but the deep structure of the island arc region is not yet well understood.

We need to know more of the sedimentary and crustal structure of the buried trench region, and the Moho has not yet been defined properly beneath the Aves Ridge, the Volcanic Arc, and the Tobago Trough. The nature of the northern and southern termination of the arc is obscure, and conspicuous lateral variations along the arc and associated features on the east need clarification. The Aves Ridge as a possible former volcanic arc also needs clarification. Although the economic potential of mineral resources probably is small, understanding of crustal structure should assist earthquake location and, therefore, volcanic-activity prediction. We suggest the following programme of geophysical investigations, bearing in mind that gravity and magnetic coverage already is quite good:

- Multi-channel seismic-reflection study of the buried trench system, particularly one line crossing just south of Barbados and arc lines further north (Antigua).
- Study of the southern boundary of the arc structure in the vicinity of Tobago, using east-west crustal-refraction lines on either side of the supposed South America (South Caribbean) boundary fault, and other methods as appropriate.
- A co-operative sea-to-land seismic exploration, to determine crustal structure of the volcanic arc-trench and adjacent basins. This could make use of some ocean-bed seismometers which would later be used to enlarge and enhance the seismic network for earthquake location, and
- Use of a seismic network to study upper mantle structure in the vicinity of the convergence or subduction zone.

Panama - Costa Rica

Seismic and gravity surveys off the northern coast of eastern Panama indicate that a major fold belt now occupies a filled trench that subsequently was deformed by compression. This fold belt probably includes several thousand meters of Tertiary sediments.

Seismic coverage essentially ends at the northern terminus of the Panama Canal. However, all fold trends strike west towards the Panama-Costa Rica border, as do the general bathymetric trends. The trends may continue into the Limon Basin of Costa Rica, and it is important to know if this is true.

Some older seismic data suggest that this deformed margin off the north coast of Panama is a zone of underthrusting. Does this fold belt represent some real movement of the Caribbean Plate beneath the Panama-Costa Rica borderland or does it represent a secondary effect of relative movement between three plates - a Pacific Plate, Panama Block and the Caribbean Plate?

At least one deep seismic multi-channel reflection line is required to determine if this is a margin of understanding. A systematic single-channel survey might be able to determine if the offshore deformed belt continues to the Limon Basin.

Interaction zone between Greater Antilles and the Bahamas

Hispaniola is the hub, or "structural knot", where the Cayman Trench, the Nicaraguan Rise, the Cayman Ridge, the Puerto Rico Trench, the eastern Greater

Antilles, Cuba, the Beata Ridge, and the Bahamas - Cuba intersection zone meet. (Is the Bahamas-Cuba intersection a collision zone, or is the Cuba-Bahamas a single geological unit, as suggested by the field geology?) Thus this region probably holds the key to a proper tectonic interpretation of the northern margin of the Caribbean plate. Several problems must be solved in this area:

- Recent geological field work shows that, in the Southern Peninsula of Haiti, Late Cretaceous (Campanian) pelagic limestone beds directly overlie, or are interbedded with, igneous basaltic rocks. These stratigraphic and age relations are very similar to those found during Leg 15 in the Venezuela Basin, where Late Cretaceous pelagic carbonates also overlie, or are interbedded with, basaltic rock, and where the basaltic rocks are interpreted to correlate with the smooth seismic reflector, Horizon B". Thus part, if not all, of the Southern Peninsula may be uplifted (by block faulting) Caribbean oceanic crust.
- Similarly, Eocene chert and associated pelagic sediments crop out in the Southern Peninsula. This fact suggests the possibility that seismic Horizon A" of the Caribbean Basin also may be exposed on land.

The Southern Peninsula, therefore, may have the same tectonic significance as the north-south Beata Ridge system, which also has been considered to be an uplifted, block-faulted segment of the Caribbean crust.

- The north-south-striking Beata Ridge is south of, and on strike with, the north-south-striking segment of the Cordillera Central of the Dominican Republic, and a possible tectonic relation may exist between these two north-south-striking structural features.
- Other similarities between the Beata Ridge and the Southern Peninsula of Haiti are suggested by the seismic velocities measured beneath the Beata Ridge and the area at the entrance to the Gulf of La Gonave (north of the Southern Peninsula). Both areas show thickening of the 3.9 km/sec. layer. Are these two areas of thickening the result of the same tectonic processes?
- The Enriquillo - Cul de Sac Graben north of the Southern Peninsula may be bounded by high-angle reverse faults which have a strike-slip component. What is the relation of those faults to the tectonics of this region?
- To answer these questions, deep seismic-refraction and reflection lines are needed (1) across the margins (east and west sides) of the Southern Peninsula, (2) north and south of the Peninsula, (3) from the Southern Peninsula to the deep basin, (4) across the Cordillera Central of the Dominican Republic, (5) across the Beata Ridge, and (6) in the Muertos Trench south of the Dominican Republic. Work with Cuban scientists is highly desirable.

The proposed seismic lines, insofar as possible, must be tied to one another. Such lines would provide invaluable information regarding the block-fault and other tectonics of the area and the possible relations between Horizons A" and B" of the deep basin and their postulated equivalents onshore. Such data also may provide clues to the apparent relations between the north-south structural trends of the Cordillera Central and the Beata Ridge. Moreover, data should be forthcoming from the programme proposed above that will help evaluate (1) the resource potential (including diapirs in the Bahamas area) and (2) the earthquake hazards of the area. Finally, we wish to mention the fact that Dr. Giorgio Pannella of the University of Puerto Rico (Mayagüez) is heading a working group attacking some of the problems of eastern Hispaniola. Duke University is working north of the island and WHOI is about to commence work in the Cayman Trough. Miami is conducting programmes in the Old Bahama Channel.

Appendix B to Field project N° 1.5

Studies of the Structure of the Interior Sea (by the Geophysical ad hoc Working Group)

Introduction

Reconnaissance seismic refraction data indicate that the Caribbean crust in the Venezuela and Colombia Basins is of the order of 12-15 Km. thick. This is in marked contrast to the 6-8 Km thick crust observed in the major ocean basins. In addition, crustal velocity sequences of these basins are very different, a fact which contrasts with the comparatively simple velocity structure of the main ocean basins. The Yucatan Basin contrasts with both the Colombia and Venezuela Basins in that both the thickness of the crust and the velocity structure are similar to the structure of the main ocean basins. These differences in the geophysical character of the Caribbean and the main ocean basins suggest a fundamental difference in the manner of crustal generation or evolution. Unfortunately the above generalizations are based on only a few refraction lines and early state-of-the-art refraction technique. In order to better understand the geology of the Caribbean crust and to better constrain models of crustal evolution, it is important to accurately determine the velocity structure of selected representative areas within the Caribbean interior.

Single-channel seismic-reflection data have identified an extensive reflection called B" which drilling indicates as inter-bedded Upper Cretaceous sediment-basalt. Reconnaissance sono-buoy results indicate that the basalts of B" do not represent basement but that B" lies approximately 500 to 2,000 meters above basement. Single channel reflection data do not reveal the internal structure or the thickness of this material. A few select CDP* lines which have been made available to the scientific community indicate that the material below B" is stratified. If we are to understand the early history of the Caribbean basins and the evolution of the Caribbean margins during sub-B" time, it is important to determine the acoustic and lithologic character of the material lying between B" and the Caribbean crust. It is also hoped that CDP data would define the morphology of the top of the Caribbean basement. An understanding of the morphology could reveal important trends in basement which would reflect tectonic trends related to the evolution of the Caribbean crust.

Goals

To enhance our understanding of the properties of the Caribbean interior, we propose to do the following:

- To define more accurately the velocity structure of selected, representative areas of the Caribbean interior (Seismic refraction).
- To define the morphology and structural trends of the sediment-basement interface of the Caribbean basement (CDP reflection).
- To determine distribution, thickness, and acoustic stratigraphy of the material between B" and the Caribbean basement (CDP reflections and OBS**)
- As an outgrowth of these studies and the resulting interpretations, to select sites for deep drilling.

* CDP = common-depth-point

** OBS = ocean-bottom-seismometers

These results, after being interpreted, would provide a regional geophysical grid of the deep structure of the Caribbean Basin. The results would have several important implications:

- To provide a regional three-dimensional crustal-velocity model of the Caribbean crust providing constraints on models for the evaluation of the Caribbean interior.
- To provide a catalyst which would enhance communication among the research groups in the countries around the Caribbean.
- To provide a geological-geophysical base line or tie point for local margin-oriented surveys which would be initiated by research groups of individual Caribbean countries, and
- To hope that the genesis of such a standard grid will evolve through time as companies and research groups contribute geological and geophysical results to tie to the proposed original network.

Tools

Common-depth-point (CDP) seismic-reflection, sonotruoy reflection, seismic-refraction, and ocean bottom seismometers (OBS) are the principal tools that we envisage for geophysical investigation of the interior regions of the Caribbean.

Each method resolves geologic structure significantly better than older methods, CDP provides significantly greater penetration than older, less-sophisticated methods.

Appendix C to Field project N° 1.7

Paleomagnetism (by the Geophysical ad hoc Working Group)

General

Full support should be given to the objectives of the working group on Paleomagnetism of the Caribbean Region formed at the meeting at Guadeloupe Island in July, 1974 with the suggestion that the geophysical sampling and analysis be done in close collaboration with geologists familiar with the subject regions.

Objectives

The objectives of Caribbean research have been stated in the US Programme for the Geodynamics Project. An understanding of the complex interrelations of the geological history of the Caribbean should lead not only to a better understanding of the development of the Atlantic region, but also of the plate tectonics model itself. Paleomagnetism provides an almost unique method for looking back into the tectonic history of the area provided the rocks studied are suitable for paleomagnetic investigations. Experience to date shows that despite pronounced weathering of most Caribbean rocks due to tropical marine environment and the complexity of local geology, it has been possible to obtain some significant paleomagnetic data from selected areas of the Caribbean region. At the present stage of the investigations the data cannot as yet be interpreted uniquely. There are nevertheless reasons for believing that, although the Caribbean has not behaved as a rigid plate, it has probably been subject to a general northeasterly or easterly movement with accompanying rotations of its component blocks on its southern and northern margins.

The present data are, unfortunately, scarce and their quality too variable to allow firm conclusions. The aim of the paleomagnetic programme will be to improve and strengthen the information from areas at present under investigation and to undertake new studies in regions so far not investigated. It is hoped that a concentrated effort will make it possible to delineate large-scale rotations and/or translations of the Caribbean Plate and of its marginal components.

Appendix D

Study of the tectonic evolution of the Caribbean region (by the Geophysical ad hoc Working Group)

The evolution of the Caribbean region may be treated in two ways: the history of the plate movements and the evolution of the Caribbean basins and margins.

- History of plate movements:

The movement history of the Caribbean may be treated for simplicity in three aspects: the recent, the Cenozoic and the Mesozoic plate movements.

The starting point for any past reconstructions must be the delineation of present day plate boundaries and knowledge of rates and direction of movements. We may approach present day studies by delineating (1) young fault systems and deformed belts using offshore geophysics and onshore mapping; (2) by accurately determining the pattern of seismicity in the region and evaluating the relation between fault zones and seismic belts; and (3) by measuring active slip by geodetic methods.

Largest uncertainties in the delineation of young faults and deformed zones seem to fall into several regions:

- Eastern and western margins of Costa Rica and Panama and their interiors.
- The margins and interior of Hispaniola and Jamaica.
- The Anagada Fault and its relation to the Puerto Rico, Lesser Antilles and Muertos Trenches.

Detailed earthquake studies are badly needed in many areas throughout the Caribbean:

- Studies by Tomblin and others in the Lesser Antilles and Trinidad should be expanded.
- New studies should be made in:
 - Hispaniola and Jamaica.
 - NE Caribbean such as the Virgin Islands and Puerto Rico.
 - The North coast of Venezuela and Colombia.
 - Central America, especially on proposed seismic zones trending perpendicular to the mid-America Trench.
 - Intensified Pan-Caribbean determination of seismic slip vectors.

Geodetic surveys have been virtually non-existent in the Caribbean region, yet are crucial to measuring present day movements. Suggested areas for immediate study:

- The El Pilar Fault system from south of the Araya Peninsula to Margarita Island.
- Enriquillo-Cul de Sac Trough in Hispaniola.
- Across the Motagua Polochic Fault zones in Central America.
- Across the zone of intersection between the Bocono, Oca and San Sebastian Faults on the north coast of Venezuela.

In addition, we recommend an active programme for studying the earthquake and volcanic hazard potential in the Caribbean. In general, the history of plate motions through the Cenozoic in the Caribbean region has been quite complex and very few areas appear to be useful for quantitative estimates of plate offset through the Cenozoic. One area of great potential, however, is the Cayman Trough. The proposed spreading centre in the Trough can potentially give the timing and rate of movement between the Caribbean and North American Plates, and the transform faults bordering the trough can potentially constrain directions of movement. Thorough study of presently available magnetic, bathymetric, dredge and seismic reflection data in the trough should be done immediately to try to determine its history. If present data prove insufficient, new programmes involving drilling, more magnetic data, seismic observations and sampling by deep submersible should be undertaken.

If this movement is known, then the history of Caribbean - South America motion is easily determined utilizing computations of North America versus South America motion that are presently available. The Cenozoic history of Caribbean - Americas movement is critical to reconstructing the possible succession of source regions for the large sedimentary prisms off northern South America, the Tobago and Grenada Troughs, and Barbados Ridge. This history is also essential in reconstructing the paleogeographic positions of major land masses and basins at the end of the Mesozoic and early Tertiary when intense tectonic activity is recorded on all margins of the Caribbean.

It should be stressed that the accuracy of plate tectonic determinations is directly related to that of the input data. Reconstructions in this manner should be done hand in hand with lithofacies maps on onshore and offshore regions.

Combined paleomagnetic and geochronologic studies can provide important constraints on reconstructed movements of crustal blocks. Existing studies should be evaluated, and an expanded Pan-Caribbean programme should be carefully undertaken. Key regions are the Yucatan Peninsula and Central America south of the Motagua Polochic Faults. Recommended programmes should be undertaken in all the Greater Antilles.

Appendix E

List of participants in ad hoc Working Groups

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Ad hoc Working Group on Stratigraphy and Sedimentation

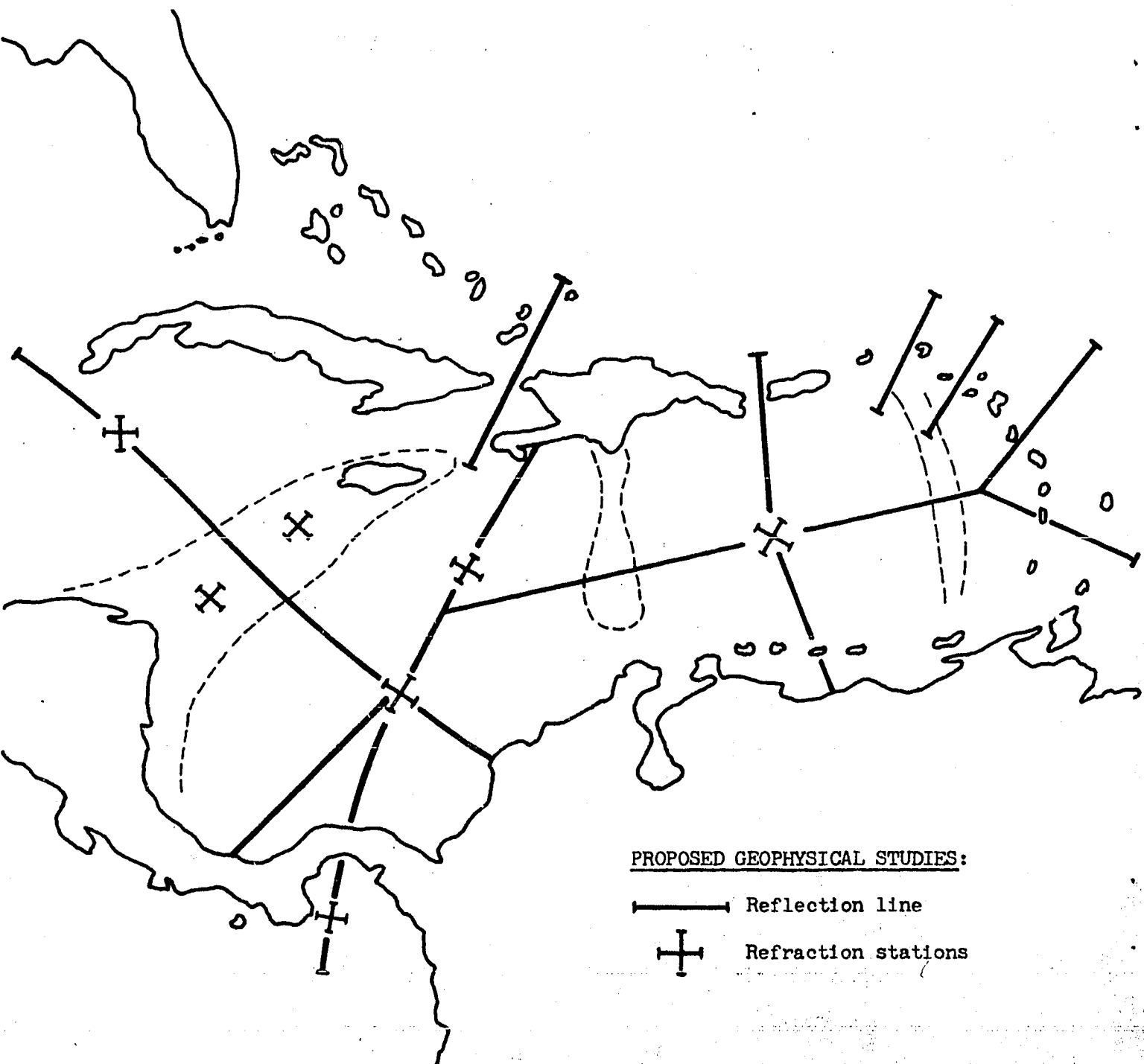
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Appendix F

Geotraverses (Figure)



Traverses shown in this figure are meant to show recommended studies in the Caribbean Interior Sea. Their extensions across margin regions might constitute a part of a study plan for the margins.