Intergovernmental Oceanographic Commission

Workshop Report No. 35

CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific

Suva, Fiji, 3-7 October 1983

Unesco

IOC Workshop Reports

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No.	Title	Publishing Body	Languages
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), 138 pp.	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 Sciences, No. 20).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish (out of stock)
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 (out of stock)
4	Report of the Workshop on the Phenomenon known as "El Niño", Guayaquil, Ecuador, 4-12 December 1974.	FAO Via delle Terme di Caracalla 00100 Rome, Italy	English (out of stock) Spanish (out of stock)
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 (out of stock) Spanish
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Suva, Fiji, 1-6 September 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/Unesco/EAC, Nairobi, Kenya, 25 March-2 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters, Penang, 7-13 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience, Mauritius, 9-13 August 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring, Monaco, 14-18 June 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock) Russian
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain, Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects, Fort-de-France, Martinique 28 November-2 December 1977.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area, Port of Spain, Trinidad, 16-18 January 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas, Abidjan, Ivory Coast, 2-9 May 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific, Santiago de Chile, 6-10 November 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Russian
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS), Moscow, 9-11 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
17 Suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System, Moscow, 2-6 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
18	IOC/Unesco Workshop on Syllabus for Training Marine Technicians, Miami, 22-26 May 1978 (Unesco reports in marine sciences, No. 4)	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
19	IOC Workshop on Marine Science Syllabus for Secondary Schools, Llantwit Major, Wales, U.K., 5-9 June 1978 (Unesco reports in marine sciences, No. 5).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian Arabic
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources, Bandung, Indonesia, 17-21 October 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
21	Second IDOE Symposium on Turbulence in the Ocean, Liège, Belgium, 7-18 May 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
22	Third IOC/WMO Workshop on Marine Pollution Monitoring, New Delhi, 11-15 February 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Russian
24	WESTPAC Workshop on Coastal Transport of Pollutants, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
25	Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters, Bermuda, 11-26 January 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (superseded by IOC Technical Series No. 22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region, Mexico City, 24 September-5 October 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Nouméa, New Caledonia, 9-15 October 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes Lima, 20 April-5 May 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
29	WESTPAC Workshop on Marine biological methodology Tokyo, 9-14 February 1981.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
30	International Workshop on Marine Pollution in the South-West Atlantic Montevideo, 10-14 November 1980.	IOC, Unesco Place de Fontenoy, 75700 Paris, France	English (out of stock) Spanish
31	Third International Workshop on Marine Geoscience Heidelberg, 19-24 July 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
32	UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime Paris, 27 September - 1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR) Halifax, 26-30 September 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa) Tenerife, 12-17 December 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific Suva, Fiji, 3-7 October 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English

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PREFACE

The Workshop was jointly sponsored by the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC), the Intergovernmental Oceanographic Commission (IOC) of UNESCO, and the United Nations University (UNU, Tokyo), to review and update the Programme of Research which had been developed by the CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, held in Noumea, New Caledonia, in October 1980 (see IOC Workshop Report No. 27). A keynote lecturer emphasized the importance of mineral resources research for the developing island states, and described socio-economical aspects relating to their exploration and exploitation. The Workshop was the third of a series of Workshops developing programmes and projects for the benefits of the South Pacific countries: the first was held in Suva, in 1975, the second in Noumea, in 1980.

SUMMARY REPORT

1. OPENING OF THE WORKSHOP, AND ADOPTION OF THE AGENDA

The participants were welcomed by Mr. Cruz Matos of CCOP/SOPAC and the meeting was then formally opened by the Acting Minister of Energy and Mineral Resources, The Hon. Livai Nasilivata, whose opening address is attached as ANNEX III.

Dr. Gunter Giermann representing IOC, conveyed the greetings of the Secretary of IOC, Dr. Mario Ruivo, to the Workshop. He introduced some new IOC concepts which bear on the South Pacific, including the overall programme called Ocean Science and Living Resources (OSNLR). This new programme implements Article 1 of the Commission's Statutes, which states that in joining the Commission Member States will learn more about "the Ocean and its Resources". It is co-sponsored by the United Nations Ocean Energy and Technology Office (OETB), located in New York.

He informed the Workshop that the Programme Group for WESTPAC, the arm of the IOC in the Pacific, has just formed a Group of Experts and has adopted two programmes in marine geology and geophysics of particular interest to IOC. WESTPAC also agreed to co-sponsor a joint body with CCOP/SOPAC which will be known under the name of STAR. WESTPAC recommended that the IOC Executive Council in its February 1984 meeting, formally approve SOPAC-STAR.

Dr. Giermann invited the Workshop to also take into consideration, when updating the programme, the recommendations of the Third International Workshop on Marine Geoscience, held in Heidelberg, July 1982, and of the WESTPAC Workshop on the Marine Geology and Geophysics of the NW Pacific, held in Tokyo, March 1980.

He thanked the representative of the United Nations University for the generous financial contribution of UNU to the Workshop, and expressed the wish that this cooperation be continued.

He finally stated that the outcome of the present Workshop will not only update CCOP/SOPAC's own programme, but will also allow STAR and IOC/WESTPAC to choose some of the projects for their own support and implementation. In this connection he informed the Workshop that WESTPAC will be particularly concerned with research relating to sea level, environments and tectonics (SET), and to margins of active plates (MAP). He made it clear to the Workshop that it was by no means the intention of WESTPAC to duplicate or supervise SOPAC activities, but to be complementary in order to provide an even better variety of services for the benefit of the countries of the South Pacific region. The new SOPAC-STAR Group will certainly serve as focal point for the co-ordination of all the diverse research activities of the UN bodies in the region.

The representative of the UN University (Tokyo), Dr. Eric C. Bird, then took the floor and made the following statement:

> "The United Nations University, established in Tokyo in 1975, has a programme designed to stimulate, support and co-ordinate research and advanced training in a variety of fields, including Development Studies. Its work is organised in a global network with Associated institutions, and as well as supporting UNU Fellowships for advanced study, it sponsors and co-sponsors workshops on specific themes. The present workshop is one of these, and as Project Co-ordinator for Coastal Resources Management in the UNU's Development Studies Division, my task here is to develop proposals for possible co-operation with CCOP/SOPAC on environmental and socio-economic aspects of marine mineral resources prospecting and exploitation in the South Pacific region.
>
> I bring you from the United Nations University the greetings of Rector Soedjatmoko, and of my Vice-Rector, Dr. Miguel Urrutia, with their good wishes for a useful and productive workshop here in Suva."

The Workshop was attended by 55 scientists of 13 countries (in alphabetical order): Australia, Cook Islands, Fiji, France, Federal Republic of Germany, Japan, Kiribati, New Zealand, Papua New Guinea, Solomon Islands, United Kingdom, United States of America, and Vanuatu. Scientists from the USSR in a message to the Workshop regretted that they were unable to attend due to reasons beyond their control.

Mrs. Mary B. Fisk represented UN/OETB, a co-sponsor of the IOC OSNLR programme. Mr. L. Machesky represented ESCAP. A list of participants if attached as ANNEX II.

The Agenda was adopted without change and is attached as ANNEX I.

2. ELECTION OF COMMITTEE CHAIRMEN AND NOMINATION OF RAPPORTEURS

Dr. Giermann was proposed as Workshop Chairman by the representative of CCOP/SOPAC and was subsequently elected. Dr. D. Tiffin was nominated plenary session rapporteur. The Workshop decided to establish two Working Committees:

Committee A on Geological Evolution of Island Arcs and Arc Basins, and the Genesis of Metal and Hydrocarbon Concentrations, and

Committee B on Distribution, Character and Genesis of Offshore Metalliferous Deposits.

Dr. C. Helsley was elected Chairman of Working Committee A, with Dr. B. Taylor as rapporteur;
Dr. N. Exon was elected Chairman of Committee B, with Dr. B. Bolton as rapporteur.

The Chairman then informed the Workshop on how the meeting would be conducted: He stated that after a 2-day review session (symposium), a 2-day Workshop would follow in which the two Committees would meet separately to update and re-formulate programmes and projects. The last afternoon of the Workshop would be reserved for adoption of the Summary Report including the Committee programmes and projects, and the general recommendations.

3. GENERAL REVIEW AND BACKGROUND PRESENTATIONS, and

4. SPECIFIC GEOLOGICAL AND BACKGROUND PRESENTATIONS

The general and the specific presentations (totalling 19 papers) are listed in the order of presentation in ANNEX VI.

One of the presentations led to the formulation of a General Recommendation on the use of manned and unmanned submersibles (ANNEX IV Rec. 4).

After the presentations, a small seminar was held dealing with results of the Tripartite I Cruises, and outlining plans for Tripartite II.This meeting was chaired by Dr. N. Exon.

5. DEVELOPMENT OF FUTURE PROGRAMMES AND PROJECTS

The two Committees met separately and formulated the programmes and projects outlined in ANNEX V.

In doing so the Committees took into account:

- CCOP/SOPAC-IOC-IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Suva, Fiji, September 1975;
- the Report of the CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Noumea, 9-15 October, 1980;
- The Report of the WESTPAC Workshop on the Marine Geology and Geophysics of the Northwest Pacific, Tokyo, 27-31 March 1980;
- The Report of the Third International Workshop on Marine Geoscience, Heidelberg, 19-23 July 1982;
- The report called "Ocean Science for the Year 2000", of an Experts consultation organised by SCOR/ACMRR, with the support of IOC and the Division of Marine Sciences of UNESCO, at Villefranche, France, March 1983;
- The Proposal of a Programme of Ocean Science in Relation to Non-living Resouces (OSNLR), prepared by SCOR, with the assistance of CMG, in Heidelberg, July 1982, and the Report called "Preparatory Consultation on the IOC Programme of OSNLR, Paris, 6-8 April 1983.

- The Report called Expert Consultation on Marine Geological and Geophysical Research in the WESTPAC region, Townsville, Australia, 15-17 September 1983, and the relevant paragraph (4.3) of the 3rd session of the Programme Group for WESTPAC, held in Townville, 19-24 September 1983.

Soviet scientists, who were unable to attend, submitted a proposal for an international Expedition to Study the Southwestern Pacific, which had already been tabled a year ago at the 11th Session of SOPAC in Wellington. The Workshop felt that the Soviet colleagues should provide a detailed research programme for such an expedition, and that only after its presentation, the decision could be taken whether a mechanism like the proposed expedition was the right vehicle to implement it. A recommendation was formulated and is attached as ANNEX IV (Rec. 3).

Committee A discussed the state of knowledge and past work in the SOPAC region in the fields of hydrocarbon resources in island arc sedimentary basins as well as island arc tectonic processes. It was decided to divide into two sub-committees, each of which produced key project recommendations:

A-1: Sub-programme on Sedimentary Basin Development in Island Arcs

- A-1.1: Stratigraphic Correlation in the Southwest Pacific;
- A-1.2: Evolution of Coral Reefs and Associated Environments;
- A-1.3: Hydrocarbon Source, Maturation and Entrapment Models in Island Arc Settings and Collision Terrains;
- A-1.4: Sedimentary Basin Delineation and Resource Assessment;
- A-1.5: Data Management

A-2: Sub-programme on the Tectonics and Resource Potential of Island Arcs

- A-2.1: Forearc and Backarc processes in the Tonga-Lau region;
- A-2.2: Backarc and rifting processes in the Fiji Platform-North Fiji Basin-New Hebrides Arc region;
- A-2.3: Arc reversal and forearc processes in the Solomon and New Hebrides Arcs;
- A-2.4: Initiation and Early Stages of back-Arc Basin Evolution;
- A-2.5: Evolution of Major Geomorphic Terrains in the Papua New Guinea Region ("Project 42");
- A-2.6: Pre-Pilocene Break-up History of the Southwest Pacific: A Regional Framework Study

Projects A-1.1 and A-1.4 and all of A-2 continue the general thrust of projects established at the earlier Suva and Noumea Workshops. Project A-1.1 links with ESCAP's current Sedimentary Basins Correlation Project which is IGCP Project 32. Project A-1.2 is a new project which follows a recommendation from WESTPAC-III (Sub-programme CREST). Project A-1.3 and A-1.5 are wholly new concepts focusing on regional exploration models and the management of exploration and scientific data respectively.

Committee B discussed the state of knowledge and past work in the SOPAC region in the field of offshore mineral deposits. It was agreed that five projects under the general programme title "Distribution, character and genesis of offshore metallic deposits" were needed to address outstanding regional scientific problems. These are:

B.1: Phosphorite, phosphatic sediments and associated ferromanganese crusts;
B.2: Near-surface submarine volcanoes: metallogenesis and assessment of volcanic hazards;
B.3: Nature, origin and development of metalliferous deposits along active rifts;
B.4 Distribution, composition and environment of deposition of cobalt-rich ferro-manganese crusts;
B.5 Environments of deposition of potentially economic nodules.

Projects B.1, 2, 3 and 5 continue the general thrust of projects established at the earlier Suva and Noumea Workshops, whereas Project B.4 is a new one. Linkages are apparent with the WESTPAC-III programme "Back-arc tectonics", and IGCP Projects 111 and 156.

As several participants expressed interest in mineral resources of nearshore areas, a small ad hoc Working Party was formed. The Party developed one project called C.1: Sediment budgets in reef-fringed lagoons (see ANNEX V).

6. ORGANIZATIONAL ARRANGEMENTS AND RECOMMENDATIONS FOR CO-ORDINATION AND IMPLEMENTATION OF FUTURE WORK

The Workshop noted with great satisfaction that several organizations such as CCOP/SOPAC, IOC/WESTPAC, and their joint body called STAR, decided to coordinate and assist in the implementation of marine geoscience projects in the South Pacific. It felt that there should be no new coordinating bodies in the South Pacific in the fields of marine geology, geophysics and resources research. It therefore was doubtful whether it was necessary to call for an international Expedition to Study the Southwestern Pacific, as the Soviet scientists wanted (see ANNEX IV, Rec. 3).

CCOP/SOPAC and WESTPAC are requested to not only implement joint projects under SOPAC-STAR, but also to consult each other and industry on scientific projects implemented individually by either of these bodies.

7. ADOPTION OF SUMMARY REPORT INCLUDING RECOMMENDATIONS FOR NEW PROJECTS

The Workshop adopted the Summary Report and the ANNEX IV (Recommendations) and ANNEX V (Programmes of Research) contained therein.

8. CLOSURE OF THE WORKSHOP

The Workshop closed on Friday afternoon, 7 October 1983. In its name, the Chairman thanked the organisers for the excellent arrangements for the Workshop and their kind hospitality.

ANNEX I

AGENDA

1. Opening of the Workshop and adoption of the agenda

2. Election of Committee Chairman and nomination of rapporteurs

3. General review and background presentations

4. Specific geological and background presentations

5. Development of future programmes and projects

6. Organizational arrangements and recommendations for co-ordination and implementation of future work

7. Adoption of Summary Report including recommendations for new programmes

8. Closure of the Workshop

ANNEX II

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ANNEX III

OPENING ADDRESS AND KEYNOTE LECTURE

A. Opening Address by the Acting Minister for Energy and Mineral Resources, The Hon. Livai L. Nasilivata

On behalf of the Government of Fiji, I extend to all of you our very warm welcome.

We consider ourselves privileged and honoured to be able to host this gathering of eminent men and women of science. We thank the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas, better known as CCOP/ SOPAC, the United Nations University, and IOC/ UNESCO for their efforts in initiating, organizing, and funding this Workshop.

Because of the recent successful completion of the Law of the Sea Treaty, all the small island nations of the Southwest Pacific now have full legal entitlement to the resources of very large Exclusive Economic Zones. To a considerable extent these areas abut against each other and together they constitute a major segment of the surface of our globe. The island nations still depend heavily on imported petroleum and other minerals, and are susceptible to the effects of changes in world prices of these commodities. It is therefore our hope that investigations of the large areas of ocean floor now under national jurisdiction will lead to local production of some of the minerals which we require, and in particular to production of petroleum.

We are, however, well aware that despite recent great advances, investigation of oceanic geology is still a frontier area of science, and in large part high technology science at that. Much of the required research has to be on a regional basis, because many geological structures cut across national boundaries: and it has to be carried out in collaboration with the international community, since none of the island nations possesses the necessary research resources to tackle difficult scientific investigations far beyond their coastal zones.

This Workshop will be considering useful and practical objectives and methods for such research, and the concentration of so much brain power on the problems can do nothing but good. We realize that much of the economic potential may require what has been called 'Twenty-first Century' technology for its development, and we realize too that a lot of the international research interest in the area arises from its importance to fundamental studies of how the crust of the earth evolves. It is the good fortune of the region that the interest is there. We are happy to collaborate and learn, and when the opportunity arises to try and guide the long term research in the direction of our shorter term economic needs. In the past we have always received a favourable response to our requests, and I am sure that will continue to be the case.

One of the themes of the Workshop will be the 'Geological Evolution of Island Arcs and Arc Basins and the Genesis of Metal and Hydrocarbon Concentrations'; this seems to hark back directly to the similar 1979 Workshop, also held here in Suva. Since then Fiji has had seven wells drilled for petroleum, so far without success. We are, of course, disappointed, but we are not downhearted. I understand that the first eight wells in the northern North Sea were dry, so we have one more to go. Many of the indications are favourable and you will all know of the oil seeps in Tonga, which prove conclusively that oil can be generated in an island arc situation. You will know, too, of the origin of metallic sulphide deposits in oceanic crust and its emplacement on land as a result of earth movements. In the southwest Pacific we can study such sequences and their associated metals on land, and with the necessary resources we can also study the present-day ocean floor processes in action.

Another theme of the Workshop relates to the economic significance of the heat conditions and crustal structure of the Southwest Pacific, and this is of course closely related to the evolution of the island arcs, and indeed of all the Pacific islands. How did they come to form as they did, and why are the rocks and metal deposits as they are? Here also we may hope to learn from comparison of past and present processes, and perhaps obtain leads as to where economic mineral potential can most usefully be sought.

Finally, a third theme is 'Manganese Nodules, Cobalt Crusts, and Metalliferous Muds: Origin, Distribution, and Economic Significance'. This is an area of high hopes for 'Twenty First Century Technology' or even 'Twentieth Century Technology'. It is a known fact that these deposits are vast, widespread and many are capable of being mined. Now that the legal position is clarifying we can expect big economic developments in this area, at least in some parts of the Pacific. It has been estimated that manganese nodules of the Pacific Ocean contain three times the known land reserves of copper alone. It very much looks as if sea floor nodules in the Pacific will become the main future world source of a number of important metals. Unfortunately, parts of the Southwest Pacific, including Fiji, do not seem to be too well endowed with these nodules, this is why Fiji is particularly interested in the possibility of metalliferous muds at the oceanic spreading centres in the region, and is pushing for their further study.

I cannot close without specially thanking the staff of CCOP/SOPAC for all their efforts in the region, on behalf of the ten member nations of the organization. We specially value their continuing presence, their technical help and their coordination of international effort on our behalf: and of course they have other functions for which we are grateful.

When opening the 1979 Workshop on a similar subject in Suva, the then Minister responsible for mineral resources referred to the growing consensus amongst scientists of every discipline that the South Pacific is one of the new exciting frontiers of science. The activities in the years that have passed since then have proved the above statement. Many people regard the South Pacific as a region simply endowed with good beaches and palm trees. It is indeed a great coincidence if such attributes are combined with scientific

activities which could lead to existing growth prospect for the region. Your presence here today gives me the confidence that research and exploration in the region would continue. From what I know of there is much work to be done and that is what this workshop is all about.

Gentlemen, I wish you every success in your efforts and indeed have great pleasure in declaring this workshop open.

B. Lecture by Dr. David Kear, DSIR, New Zealand, "The Science Programmes for Mineral and Hydrocarbon Exploration "

INTRODUCTION

I am honoured and pleased to be able to give this address to CCOP/SOPAC's Third International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific.

I am honoured, because CCOP/SOPAC has been recognised by the leaders of many South Pacific member countries and their senior officials as the most important collaborative effort in science between South Pacific Island States, and perhaps the best venture in any field. In addition, its programmes have been carried out by many first-class scientists who have devoted significant parts of their careers to work on the geology, geophysics and oceanography of this part of the world.

I am pleased, because I have enjoyed very much my own association with CCOP/SOPAC. This began several years before I personally attended any meetings, through a close association with the late Dr. R. W. Willett when he was developing the several options for consideration by South Pacific member countries to create the same kind of collaborative offshore prospecting activity as that already enjoyed by South-East Asia. Since attending meetings I have travelled widely in the South Pacific, and made many friends.

It is therefore good to be able to address you, particularly as this will be my last major scientific conference before I retire in less than 4 weeks' time.

There are two particular topics that I would like to discuss to-day. First, the place of science in the search for mineral and hydrocarbon resources, and second the desirable procedures and objectives for developing a science programme in an organisation like CCOP/SOPAC.

THE PLACE OF SCIENCE IN ASSESSING NATURAL RESOURCES

(a) Minerals

In stressing the importance of science in searching for and assessing natural resources - minerals and hydrocarbons - I am no doubt preaching to the converted in this Workshop. The methods of prospecting for the two are of course significantly different from each other.

It is well recognised that there is a direct relationship between geology and/or marine environment, and the specific minerals that may be present. The best known global illustration of this is of course in the ancient rock assemblages of Gondwanaland having a mineral potential far greater than that of most other parts of the world. Their ancient "shield" rocks are hosts for a wide variety of valuable minerals, giving Australia, South Africa, and South America the mineral wealth for which they are all well known.

Most of the eastern CCOP/SOPAC region comprise islands formed of young basalt, coral, and very little else. The mineral prospects of such countries on land are therefore severely limited, by nature, to such materials as building aggregates, lime, and groundwater, with perhaps a purely scientific interest in unworkable bauxite deposits in the older intensely weathered rocks.

Further west, the variety of age of rocks increases, and new mineral possibilities arise. One of the more important world mineral developments of the last several decades has been that of the "porphyry copper" at Bouganville, Papua New Guinea. Such occurrences comprise very large quantities of low grade copper ores, and man's ability to work these on a large scale led to a major increase in world copper reserves. Geology showed clearly that these deposits are found in the root zones of large volcanos, of which the Tertiary volcanics of the South Pacific area are important examples. Although no other workable porphyry copper deposits have yet been located in the CCOP/SOPAC region, the occurrence of gold and base metals in complex eroded volcanic systems are known - eg, Waihi's Martha Mine in New Zealand and the Emperor Mine in Fiji.

Although these mineral occurrences are not the normal regime of CCOP/SOPAC because they are land-based, they are examples of where reconnaissance geology has identified areas in which specific minerals may occur. More expensive detailed geological mapping, geophysical surveying and/or drilling can be restricted to these more-prospective-than-normal regions.

At sea, the important minerals and comparable natural substances are also restricted to specific environments that science can identify. The eastern part of CCOP/SOPAC's region may lack on-shore metalliferous deposits, but off-shore it includes areas where water depth and chemistry have allowed the deposition of manganese nodules containing valuable metals as minor constituents. Although we may understand generally what causes manganese nodules to form, we still have something to learn about what specifically causes the nodules of some areas to be relatively rich in useful metals, while those of others to be relatively poor.

In the waters of many CCOP/SOPAC member countries, precious corals may well exist. The colours of corals, and their relative abundance, are clearly related to specific oceanographic environments. Hence, coral can be prospected for indirectly, with well-known physical oceanographic techniques.

The thickness, the physical characteristics, and the composition of materials that occur in and around South Pacific lagoons are well-documented in some areas, and this information can be extrapolated to places where little is yet known. This, and similar geological extrapolation, is an important technique that allows immediate initial advice on topics as widespread as the environmental factors in the economic use of lagoonal areas, and the search for gold deposits off-shore from the islands such as the Solomons.

(b) Hydrocarbons

The importance of a good knowledge of the geological environment of a resource, is nowhere more important than in the search for hydrocarbons. These most important energy sources occur only in the very special circumstances of there being an appropriate reservoir bed, an appropriate capped structure, a nearby adequate source, and a degree of "maturation" that has allowed natural gas and/or oil to develop, without that development being subsequently destroyed by an over-abundance of heat and/or pressure. Because of the requirement for an effective caprock, there are usually few surface showings of the presence of oil and natural gas, and, certainly in New Zealand's case, there is little precise correlation between the position of surface seeps and of the location of a major economic field at depth. This concealment of hydrocarbon deposits means that the geologist's co-workers in earth science, the geophysicist and the oceanographer have key roles to play in the location of places where conditions are correct for the accumulation of hydrocarbons.

Petroleum exploration is becoming an increasingly complex scientific operation. Past techniques located the more accessible hydrocarbon deposits. A number of reviews by non-earth-scientists have concluded that the world's hydrocarbon resources would be worked out in the foreseeable future. It is of course true that they are indeed limited; but new developments in exploration techniques have extended the range of prospective areas into new and exciting fields, and the world's resources become extended correspondingly. In recent years, interest in the oil prospects of volcanic arc areas, such as the South Pacific, has increased significantly. Although the successes are admittedly not as large as in the rather more traditional non-volcanic sedimentary basins, there have been successes; and, a number of speakers, such as Michel Halbouty, in last year's Circum-Pacific Minerals and Energy Conference in Hawaii, are convinced that there is a great deal more hydrocarbon resources to be discovered in volcanic areas yet.

In the case of assessing the prospects of any specific region, the important initial step is a review of total regional geology, to identify those general areas where additional geological and initial geophysical work could usefully be done. That latter second step would itself define more specific areas for undertaking more detailed geophysical and possible investigative-drilling in a third stage which would aim to locate actual targets for final drilling. These procedures are well-established. The point that needs stressing is that the sequence must start from the initial purely scientific investigations of the geologist, the geophysicist and the oceanographer.

Before the advent of modern plate-tectonics thinking, many earth scientists had somewhat simplistic ideas of sedimentary basin development. As earth scientists they certainly realised that the geological processes of the world are dynamic even though they may be slow. Detailed scientific investigations of the South Pacific and adjacent global regions in the last two decades have however provided important basic information on plate tectonics. These have also given important evidence on how the sedimentary basins of this region have developed, and on the regional sequence of volcanic and tectonic events. Plate tectonic influences affected directly the geography and the timing of the development of a number of sedimentary basins. Thus a knowledge of the regional geology, and particularly the geological history, is a most important input into the assessment of where prospective basins may be found, and of their size and structure. Detailed geophysics is expensive, and drilling is very expensive, so it is most important that these activities are restricted to the most prospective areas.

Once drillholes have gone down there is very little doubt as to what the subsurface geology is at that place. Once the detailed geophysics has been completed, there is little doubt as to where the basins are located. The importance of the earth scientist's work is to show, with the very best of his work, where the geophysics should be concentrated in the first place, and where the drilling should take place in the second. Both of these depend very strongly upon the high quality of the regional geological and geophysics work, and on the fact that those scientists have adequate backing from regional surveys that will allow them to have the right conceptual thoughts to put their conclusions on a secure basis. The excellence of the total effort will mean that the chances of locating hydrocarbons willbe that much greater for any given level of technical and financial resources.

SELECTION OF WORK PROGRAMME

It is particularly appropriate that I talk here on the question of the ideal selection of a work programme for CCOP/SOPAC, because I have been doing a parallel exercise to this in New Zealand over the past few months. I have been talking on the subject of "DSIR in the 80's" to the many scientific institutions and sub-stations that collectively go to make the Department of Scientific and Industrial Research (DSIR) in New Zealand. The talks have concentrated on the scientists' part, and the scientists' responsibility, in the total planning exercise that leads to the development of DSIR's scientific and technological research programme.

I will describe the New Zealand situation in some detail, because there are important parallels to the development of a research programme for an organisation like CCOP/SOPAC.

In New Zealand the field of government science undertakes about half the total effort, of which DSIR is overseen generally by the National Research Advisory Council (NRAC). NRAC has, in the past, carried out an investigatory and auditing role of the work of individual institutions, and

has also played a major role in the redistribution of staff into areas of higher national priority.

The Minister of Science and Technology is currently seeking advice widely on possibly changing the role of the scientific advisory council to government, from that of NRAC towards a Science and Technology Council. That Council, among other activities, would develop an overall annual Science and Technology Plan for New Zealand, to which individual departmental research programmes would conform. NRAC itself is currently producing the first such annual Plan. New Zealand has had an Energy Plan for several years now, which shows quite clearly the way in which national energy programmes will develop. It is updated every year. The Science and Technology Plan would emphasise growth areas, such as horticulture, fish processing, and manufacturing, and one would hope that the Plan, when produced, will have the courage to say in which areas of science less effort is required and recommended.

The programme for an individual scientific department or institution must realistically conform with the resources that are available, and must allow for the talents of current staff in specific areas of scientific endeavour,and how much the country can afford the minimum required resources that will let them do their job effectively. Adequate notice must be taken of what recent break-throughs have taken place in that particular area of science, and, most importantly, what break-throughs are likely to take place in the next few years. It is further necessary to determine what the customer of science requires by submitting what is effectively a list of science programme options to industry at all levels, and to the politicians. The programme will be modified and added to, but will not be seriously changed if the options are sensibly developed in the first place.

The individual scientist ("he" and "his" are used below, but these words are intended to include male and female) must be quite clear that his senior science management, his customers, and his political masters will be less able than he to understand the opportunities his discipline offers, and particularly what opportunities might become available by scientific developments that are "just around the corner". His immediate non-scientific neighbours at home, who pay the taxes that fund his salary and his work, will have even less idea as to what science should be done for the benefit of the country. This means that he has a very important input into the Science Programme of his institution and department, and towards a sensible Science and Technology Plan for the nation. His ideas may get changed, and certainly some choice will be made between his options, as the programme filters upwards to become part of the Plan; but he has a major responsibility to ensure that the plan does contain the best programmes that could be worked in his research area.

The scientist needs to put himself in the shoes of his neighbours to determine what options he should put forward as being the best in his discipline for the benefit of all those neighbours. He cannot expect that decisions in the detail of his science can be reached by senior administrators or politicians who simply do not have the breadth of knowledge and experience to be able to determine programme detail, even though they will have determined in the first place, the broad areas of the Institution's work, and the specialists it will employ.

The main problem in scientist's considering ideal options in this way, is the danger that he may misinterpret what is good for his fellow-citizens. It is most important that the programme that is developed has the right mix of short-term and long-term research and projects. Background information must be established upon which the short-term projects of future years can be based. The regional surveys of the land and oceans must be carried out if indeed the institution is to be able to undertake a detailed investigation into specific mineral and hydrocarbon resources which will be planned in a few years' time.

It is equally important however that the scientist, while holding the correct view that the right balance of long-term research must go ahead, should not take the attitude that long-term research will be good regardless of the areas in which it is undertaken. It is most important that it is undertaken in relevant areas. "Mission-oriented" research is essential in any government scientific effort, but this fact need not disadvantage the scientists in any way. There is a virtually limitless amount of research that might be done, and the quality of work is in no way determined by whether it is "mission-oriented" and therefore of long-term value, or whether it is oriented in no useful direction at all, and is of no reasonable use to those who are funding it in the long term.

This careful thinking by individual scientists in New Zealand is important; but I believe that he will find it an interesting, absorbing and rewarding challenge.

When we turn from developing a science programme in New Zealand for DSIR to that for CCOP/SOPAC's work in the South Pacific, there is no change of anything but organisation and place. The same objectives and thought processes still need to be maintained. CCOP/SOPAC requires both long-term and short-term research, the former in the nature of regional surveys that will have relevance to the short-term work that is coming later on, and the short-term work to look for specific mineral deposits, or to investigate where sedimentary basins may occur in the search for hydrocarbons. Later on those individual basins will be subjected to even more detailed investigation, and hopefully drill-sites will be determined.

An important additional factor needs to be considered in the case of CCOP/SOPAC. Particularly in the hydrocarbons field, many South Pacific nations are finding the burden of financing their energy requirements a major obstacle. There is therefore a real degree of urgency for locating potential hydrocarbon-bearing basins, should they exist. Thus, while it is clear that any long-term research,which is to be considered as a part of the CCOP/SOPAC Programme, must be very carefully mission-oriented, there is a major reason to concentrate longer-term research in those areas which can be selected even now as having a somewhat higher potential than other parts of the region. It may be that, by so doing, some prospective areas, of which there is not the slightest hint at the present time, will be put to one side; but at worst they will merely be left for posterity. At best, by concentrating on what appear to be the better areas for our longer-term research now, we will hopefully hasten the day when the shorter-term work can be carried out with some degree of success.

This does not mean of course that no other oceanographic work can be done elsewhere in the South Pacific area. It means simply that there should be no attempt to pretend that all work must be a useful part of the total CCOP/SOPAC programme, nor any attempt to justify scientifically interesting research under the CCOP/SOPAC banner, that has no relevance to CCOP/SOPAC's aims. This Workshop, and the CCOP/SOPAC session that will follow it in the Kingdom of Tonga, should concentrate on developing both long-term and short-term research work, that is as relevant as it can be made towards the mission of effective off-shore prospecting for minerals and for hydrocarbons in the South Pacific for the benefit of CCOP/SOPAC member countries. In doing so the scientific planners will be contributing effectively to one of the most important coordinating scientific efforts in the South Pacific at the present time.

ANNEX IV

RECOMMENDATIONS

The Workshop

(1) Recommends that the Chairman transmit for approval the adopted Workshop Report (including Recommendations and Programmes of Research) to the next Session of CCOP/SOPAC, to be held in Nuku'alofa, Tonga, 11-20 October 1982, and to the Secretary IOC for submission to the next session of the IOC Executive Council, to be held in Paris, 1-10 February 1984, as well as to the next session of the Programme Group for the Western Pacific (WESTPAC), to be held in 1985;

(2) Taking Note of a proposal by Soviet scientists, dated November 1982, to organise an international Expedition to Study the Southwestern Pacific, an exercise similar in scientific approach to the IIOE of the late fifties;

Recommends that the Soviet scientists make available a more detailed Programme of Research, with individual research projects, to put the Workshop members in the position to judge whether such an important new vehicle like an international expedition will really be needed, or whether the present mechanisms consisting of CCOP/SOPAC, WESTPAC and SOPAC-STAR are sufficiently suited to supervise the proposed Programme of Research;

(3) Recommends the use of manned and unmanned submersibles in programmes designed to explore, study and understand the nature, extent and significance of hydrothermal deposits in the region, and invites the co-sponsoring organisations of the Workshop, particularly CCOP/SOPAC and IOC, to find ways and means to make available the use of submersibles.

(4) Recommends that in view of the interest of island states in the South Pacific in exploitable mineral resources of their nearshore zones, countries of the region should give increased attention to scientific problems concerned with the prospecting, mining and environmental management of these sea-floor resources. A Workshop on these topics should be held in the near future.

(5) Taking Note of the paucity of good, cloud-free satellite imagery in the SOPAC region,

Recommends that NASA and other agencies be strongly urged to collect and make available satellite imagery in the Southwest Pacific area including coverage out to at least 150 metres water depth.

ANNEX V

PROGRAMMES OF RESEARCH

A: Report of Committee A on Geological Evolution of Island Arcs and Arc Basins, and the Genesis of Metal and Hydrocarbon Concentrations

Introduction

From a geological and mineral/hydrocarbon resources viewpoint, two major environments are present in the CCOP/SOPAC region. These are best identified in plate tectonic terms as the Pacific Plate province and the convergent margin province at its western boundary with the Australia-India Plate. The earth shaping processes within this convergent margin are complex and in places poorly understood. The complex evolution of plate boundaries in this region makes the tectonic, sedimentological, and deformational histories difficult to interpret. Nevertheless, it is essential that this history be understood if we are to adequately understand the framework and assess the resource potential of the region.

The integration of marine geological and geophysical data with the limited land-derived data for the region is an essential element in deriving the overall understanding necessary for an assessment of the mineral and hydrocarbon resources of the region. We must not only develop a fundamental understanding of the crustal history of the region but we must also understand the fundamental processes that control the parameters that influence resource distribution.

The region affords excellent examples of many important tectonic, geomorphological and sedimentary features associated with the active margins of oceanic plates. These include: the active volcanic island arcs and their associated trenches which characterize the zones of plate convergence along the Melanesian Borderland and Tonga-Kermadec chain; fossil convergence zones such as the northern margin of the North Fiji Basin; actively forming and inactive marginal basins with passive, oblique-slip, and active trench margins, active and inactive interarc basins diverse in size and sedimentary fill; and regions where the polarity of subduction may have been reserved following a collision.

Regional plate and microplate boundaries all have complex evolutionary histories. The geomorphological and tectonic diversity of the region thus produced complicates the search for resources but also provides necessary elements required for the concentration of potential resources such as hydrocarbons and mineral deposits. Only through an adequate understanding of the processes involved in the evolution of the various island arcs, basins and plateaus of the region can we adequately assess the resource potential. This understanding will involve general studies of regional tectonics, seismicity, heat flow, sediment distribution, as well as

focused studies on specific areas where present background knowledge is adequate to suggest potential presence of resources.

The 1975 CCOP/SOPAC Workshop held in Suva proposed a number of research projects that would assist in providing the background knowledge necessary for this evaluation. The 1980 CCOP/SOPAC-IOC Workshop held in Noumea (IOC Workshop Report No. 27) refined these objectives and identified a number of specific projects that need to be undertaken for progress to continue toward an overall assessment. Some of these projects have now been completed and a review of the progress to date has suggested additional lines of investigation that would be worthwhile in order to continue and extend the overall regional assessment.

The projects cited below are largely recommended extensions of these previous projects in light of our current knowledge and incorporate the recommendations and strategies proposed in the recent IOC-WESTPAC meeting held in Townsville in September 1983. In view of the importance of this additional work, we recommend that these new proposals be endorsed as part of the overall work programme of the CCOP/SOPAC resources framework and assessment project. The proposals are not listed in any order of priority.

Co-chairmen for this Committee report were Dr C. Helsley and Dr D. Falvey.

A-1: Sub-committee on Sedimentary Basin Development in Island Arcs.

Sub-committee A-1 Participants:

BALEIVANUALALÂ, V.
BURNE, Robert V.
COLWELL, J. (Rapporteur)
DOUTCH, F.
FRANKEL, E.
GREENE, H.G. (Chairman)
HERZER, R.
KATZ, H. Rudi
MARLOW, M.
MOAINA, R.B.
RODDA, Peter
SIMPSON, Alf
THRASHER, G.
VEDDER, J.G.
WALSHAW, R.D.

Project A-1.1: Stratigraphic Correlation in the Southwest Pacific

At the 1980 Noumea Workshop, a major project (A-1) was proposed aimed at the study of island arc sedimentary basins: correlation of reference sections and seismic stratigraphy. The first part of that study was initiated through the multichannel seismic programme of the S.P. LEE under the Tripartite Agreement. Its continuation appears below as Project A-1.4.

However, the biostratigraphic correlation of sedimentary bodies in the SW Pacific Region as a whole has not been undertaken at an appropriate level. Recent biostratigraphic revisions carried out in PNG (by systematic re-sampling of some sedimentary sections) and in Fiji (by stratigraphic drilling) have led to substantial changes in local time-stratigraphic definitions.

A reliable time-stratigraphic correlation is the only possible basis for confident appraisal of the most likely settings in which economic mineral and energy resources may occur. In order to achieve such a regional stratigraphic framework, it is recommended that the following programme be undertaken:

1. Collation, revision and synthesis of existing time-stratigraphic and palaeogeographic data within the SW Pacific (*Refer also to Project A-1.5 - Regional geologic data development for the SOPAC area);

2. Any future basin assessment must include new, detailed time-stratigraphic studies.

This may be accomplished by:

(a) Palaeontology, especially the detailed examination of micro-fossils in order to correlate the rocks in which they are found with standard world sequences;

(b) Land based studies: with the advice and concurrence of national Geological Surveys

(i) amend and/or redefine key onshore stratigraphic units critical to regional offshore stratigraphy where this is considered desirable;

(ii) drill stratigraphic sequences to acquire a better understanding of their facies, and to revise and/or define stratigraphic units; to extend and enhance biostratigraphic correlation;

(c) Seismic stratigraphy: to identify offshore stratigraphic units, and to correlate with onshore stratigraphy whenever possible; to examine possible stratigraphic play concepts and hydrocarbon traps.

(d) Non-palaeontological projects: these include development of local sea-level change curves, magneto-stratigraphic measurement projects, and appropriate radiometric dating.

Project A-1.2: Evolution of coral reefs and associated environments

In the Southwest Pacific region, coral reefs exist in a variety of tectonic settings in the form of fringing, barrier and atoll systems. Similar systems may have occurred throughout the Cainozoic. Ancient reef systems may be important to many SOPAC countries as potential hydrocarbon reservoirs, while modern reefs are clearly important as resources for mining, fishing and tourism.

The main objectives of this programme are:

(a) to define the extent, age and geometry of reef systems in a variety of regional settings;

(b) to establish the relationship between reef growth and (i) volcanic activity, (ii) tectonism, (iii) eustatic sea-level change, and (iv) world-wide climatic change;

(c) to evaluate the inter-relationships between terrigenous, volcanogenic and biogenic inputs;

(d) to determine the origin and preservation of organic carbon in reef and associated deposits; and

(e) to study related environmental issues (see report of Ad Hoc Working Party on Mineral Resources of Nearshore Areas).

Methods of investigation should include shallow high-resolution (including multichannel) seismic, sediment mapping, stratigraphic coring, shallow vibrocoring, biostratigraphy, radiometric dating and geochemistry. Comparitive studies should be undertaken with reefs in a range of geographic and tectonic settings.

To a large extent this programme is based upon objectives determined at the 1983 IOC-WESTPAC Meeting in Townsville. Although applying to the western Pacific as a whole, these objectives are considered particularly relevant to the SOPAC region.

Project A-1.3: Hydrocarbon Source, Maturation and Entrapment Models in Island Arc Settings and Collision Terrains

The basis of hydrocarbons exploration is to:

(1) identify source rocks, from which hydrocarbons (oil and gas) are generated.

(2) identify source maturation from empirical data or from the tectonic history, i.e. burial and thermal geohistory.

(3) identify the play concept. This includes identification of potential reservoir rocks into which hydrocarbons can migrate and accumulate. This process is necessary in order

to attain concentrations and amounts which can be economically exploited. A reservoir rock is any type of rock that has sufficient porosity and permeability (pore space which is connected and through which fluids or gas can circulate). Additionally some sort of trap is needed which involves an up-dip seal on the reservoir.

The conditions for source rocks, reservoir petrology and quality, hydrocarbon generation and entrapment (the play concept) vary with tectonic setting, and differ greatly between island arc settings and collision terrains as opposed to continental and continental margin areas.

It is therefore recommended that:

A. The possible occurrence of source rocks be investigated, by taking suitable samples both onshore and offshore (by drilling if necessary) and carrying out the relevant geochemical analyses.

B. Studies be carried out of model play concepts through analysis of burial, thermal and tectonic history.

C. Studies be made of the reservoir rocks types and their tectonic settings (such as reefs and non-fan turbidites). The existence and extent of porosity and permeability should be determined, and occurrence of suitable rocks in sufficient extent and volume in appropriate type locations should be verified.

D. In order to achieve the above objectives in the best possible way, facies models should be developed by a study of contemporary environments and processes where possible, including the accumulation of organic carbon. Particular attention should be given to modern reef systems (Project A-1.2) and modern non-fan turbidites (such as in the Huon Gulf and possibly the New Britain Trench).

E. Studies should also be made of the seismic definition and seismic signatures (through model and field studies) of relevant environmental settings and conceptual model plays.

Project A-1.4: Sedimentary Basin Delineation and Resource Assessment

In the previous 1980 Noumea Workshop, recommendations were made for the study of island arc sedimentary basins (Project A-1). These proposals resulted in the multichannel seismic survey conducted by the S.P. LEE under the Tripartite Agreement (Tripartite - 1 and 2). A significant number of fore-arc and intra-arc sedimentary basins have been redefined and their resource framework outlined. A continuation of the

programme of basin delineation, review and assessment is strongly recommended. Indeed, the IOC-WESTPAC geoscience programme recommendations (Townsville, September, 1983), proposed a major subprogramme on Sedimentary Evolution on Active Margins (SEAM), and this proposal involves implementation of this subprogramme in the SOPAC region.

The occurrence of hydrocarbons is generally confined to sedimentary basins where rock formations are suitable for the generation and accumulation of oil and gas. To determine the suitability of these rocks a detailed study of the basin's history and its sedimentary content is therefore essential. Both the original outline of the depositional area and the present form of the basin must be considered. In addition, an understanding of facies development in time and space (vertically and horizontally) must be obtained before a comprehensive evaluation of hydrocarbons potential can be made. This project concentrates on regional aspects while the previous project (A-1.3) concentrates on exploration and play concepts in general.

It is therefore recommended that:

A. Compilation of available geologic and geophysical data in the form of structure and isopach maps, including overlays depicting facies changes in selected intervals be undertaken.

B. New geological and geophysical data, including mutlichannel seismic reflection profiles where appropriate, should be collected in areas of relatively poor basin definition such as:

   1. The insular margins of the Bismarck Sea,
   2. Northern continuation of the Tonga Platform,
   3. Lau Ridge,
   4. Rennell Ridge,
   5. The high plateaus between the Coral Sea and Northern New Hebrides Trench.

C. Synthesis of basin types (i.e. definition and classification of basins); this effort should be incorprated into the CCOP/SOPAC geophysical atlas.

Project A-1.5: Data Management

Geoscientific data collected by past, present, and future researchers represents a very valuable store of knowledge to any nation. In order to obtain maximum benefit from scientific investigations, not only must the interpretations and results of those investigations be preserved for future reference, the data upon which those interpretations and results are based must also be preserved. Future investigators, both public and private, must have access to past data in order to obtain maximum results from their own programmes. The high cost of geological and geophysical investigations means that past data can be archived and retrieved

for much less money than would be required to replace it.

Present geoscience investigations generate several types of information, all of which should be preserved for future reference. This information includes:

1) Published results and interpretations;
2) Unpublished investigations;
3) Raw data, such as geological and geophysical measurements, field notes, and laboratory results;
4) Geological samples and reference collections;
5) Maps, air photos, satellite images, seismic record sections, and other image-type data;
6) computer magnetic tapes of seismic reflection, navigation, well log and similar data.

Some CCOP/SOPAC member nations, such as Papua New Guinea and New Zealand, have adopted regulations which require the submittal of these data by industrial investigators and have set up systems for its storage and retrieval. Fiji has various data banks and legislation exists requiring the lodging by companies of various data (though not original magnetic tapes or copies). The Fiji petroleum exploration data bank was set up with the assistance of BMR. Papua New Guinea has recently set up an archive system with the help of a World Bank loan and assistance from CCOP/East Asia and from its neighbours. It accesses all types of petroleum exploration data. Other nations are attempting to operate data storage systems for government, research institutions and industry collected data. None of these systems appear to be operating as efficiently as they could be.

The amount of data collected by the geoscience community is rapidly increasing and the sooner all member nations have efficiently operating archive systems the easier it will be to keep up with incoming data. The sooner archive systems which include as much existing data as possible are in place, the more value they will be to the member nations.

A considerable amount of geological and geophysical data already exists for the CCOP/SOPAC region. Much of this data, or copies of it, is not currently held by the responsible government departments within the member nation, rather the data is held by numerous different research institutes, foreign government departments and foreign industrial organizations. Any attempt to maintain archives of CCCP/SOPAC sponsored data, along with future research or industrial data should also allow for the acquisition of as much existing data as possible.

The response of exploration companies to voluntarily contribute to archives has been impressive. This has been the experience of New Zealand and Papua New Guinea. To identify and obtain existing research institute and government data, however, is often frustrating and time consuming.

Through CCOP/SOPAC, the member nations have the opportunity to act as a unified organisation to identify what data has been collected within each member country, what the availability of that data is, and help each member nation to obtain copies of that pertaining to them. CCOP/SOPAC could also assist the member countries in upgrading their data archive systems to be able to meet the present and future needs of mineral resource prospectors.

Much modern geophysical and downhole electric log data are collected on computer magnetic tape. Both the Papua New Guinea and New Zealand Geological Surveys have discovered that these magnetic tapes are a valuable aid to hydrocarbon exploration companies operating within their countries. Unfortunately the storage, duplication, and processing of these tapes requires specialized equipment only available at a very few locations within out region. For the present it may be necessary for some member nations to arrange for storage or computer magnetic tapes at an outside facility. Because of the rapidly expanding exploration technology many other types of computer collected and stored data may be available in the future and should be allowed for in an archive system.

Many reference collections, most notably microfossil collections, have a very regional and international importance. Because of this CCOP/SOPAC and the larger geoscience community must continue to support the development of regional reference collections at locations where those collections will be maintained and made accessable to all users. The development of national reference collections should also be encouraged as a part of individual member nations data archive systems.

RECOMMENDATIONS:

1) CCOP/SOPAC find ways and means to assist member countries in archiving geoscience data and related products. This assistance should include training individuals from member countries in the efficient operation of archive systems.

2) CCOP/SOPAC develop a directory of previous geological and geophysical investigations within the member nations and identify the availability of data and related products generated by these investigations.

3) CCOP/SOPAC assist the member countries in the acquisition and archiving of existing data.

4) CCOP/SOPAC assist the member countries in the secure storage and accession of geophysical magnetic tape data.

5) CCOP/SOPAC encourage and support the further development of the ESCAP microfossil reference collection to cover the Southwest Pacific region.

6) Those countries within CCOP/SOPAC which have not drafted regulations or legislation requiring the lodgement of all data and results obtained by future geoscience investigations should be encouraged and assisted to do so. This should include regulations for the lodgement of any magnetic tape or other computerised data.

A-2: Sub-committee on the Tectonics and Resource Potential of Island Arcs

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Project A-2.1: Forearc and Backarc Processes in the Tonga-Lau Region

Tonga Forearc

Reconnaissance geophysical and geological exploration of the Tonga forearc has been sporadically initiated during the past two decades, but no coherent plan of study has emerged. As a consequence the structural and rock framework of the Tonga forearc is virtually unknown and its geologic evolution has not been deduced although analogies to the Mariana forearc seem justified.

It is recommended that a coherent plan of geological and geophysical studies to determine the type, distribution, and geometry of the major rock units forming the Tonga forearc, and the processes that emplaced deformed, and altered them, should be initiated. The work should initially involve multichannel reflection profiling as refraction seismology and surface rock sampling. DSDP-type drilling should be promoted. Evidence should be sought concerning the origin of the forearc's basement complex; the history of subsidence and uplift (e.g. vertical tectonics); magmatic activity; emplacement of ultrabasic masses; tectonic reaction to the subduction-

driven collision of the Tonga forearc and the Louisville Ridge, and; the direct tectonic consequence of the subduction process itself.thick sequence

Tonga Backarc (Lau Basin)

Geologic evaluation of the petroleum resource pctential of the Tonga Ridge requires an understanding of the fundamental process that created the Lau Basin. It is believed that the opening of the basin (1) rifted, and then geographically separated the eastern and western parts of the Tonga platform section thereby isolating potential source beds from reservoir units by hundreds of kilometers, (2) heated the platform section and may have generated hydrocarbons and forced their migration prior to rifting, and (3) created new lithospheric crust, magmatic centers, and associated magma chambers capable of circulating mineralizing hydrothermal fluids in the vicinity of the active Tofua arc and in the Lau Basin.

The opening processes forming the Lau Basin are not understood in detail, but the cause of the generation of new mafic crust resides in problematical concepts associated with the subduction of Pacific oceanic crust beneath the Tonga Ridge. The time of the opening is poorly known but probably was between 3 and 5 m.a. Only vague notions exist about pre-rift events (for example thermal uplift of the then Tonga-Lau Ridge, or the formation of pre-rift basins) that could have profoundly influenced the formation and location of petroleum and petroleum resources.

It is recommended that the formation of Lau Basin and the consequent thermal and rifting events of the former Tonga-Lau volcanic arc receive thorough scientific attention. Geologic sampling including DSDP-type scientific drilling, is emphasized. Multichannel reflection profiling intended to resolve pre-rift, rift and post-rift structures bordering both the Tonga and Lau-Ridge flanks of the basin is needed. Geophysical techniques (e.g. multichannel and refraction siesmology, heatflow measurements, etc.) are needed to locate magma chambers and thermal anomalies where mineralisation processes may be concentrated.

It is further recommended that the collection of regional information focus on resolving a number of key relations, which include (1) the timing of initial pre-rift thermal events along the length of the basin, (2) the initiation and lateral progress of rifting (lengthwise) along the margins of the basin, (3) the age and magmatic evolution of the active Tofua arc, (4) the style and progress of the spreading process that has expanded the basin to its present size, and (5) the entire opening process in relation to subduction events occurring at the regional plate boundary along the Tonga Trench.

Project A-2.2: Backarc and Rifting Processes in the Fiji Platform-North Fiji Basin-New Hebrides Arc Region

Magmatic arcs in the region are identified and the subduction polarity of some of the arcs has now been defined. The Fore Arc and Back Arc Terrain and the timing of the development of the structures need to be identified.

Massive sulphides may occur along recently active spreading axes within the North Fiji Basin. Kuroko-type sulphide deposits additional to those already investigated may have formed accompanying voluminous rhyolitic eruptions on Vanua Levu.

Considerable progress has been made toward improving the definition of the Indian-Pacific plate boundary north of Fiji (Project A.3, IOC Workshop Report No. 27). Two cruise legs of the R/V KANA KEOKI in 1981 focused on the complex junction between the Lau Basin, the North Fiji Basin and the pacific Plate. The geology of Wallis and Futuna Islands has been compared with that of Hunter, Matthew and Kandavu. These all appear to have similar structural settings. Additional work, however, needs to be done.

Re-examination of the data collected since 1970 on earthquake activity in the North Fiji-Lau Basins area has begun. The telemetered seismic network in Fiji has been improved by the provision of an on-line computer for interpretation of data. Since the accuracy of locations still needs to be improved, it is recommended that seismic stations be installed on islands such as Wallis, Futuna, Rotuma and Niu'a'fou.

Formation of North Fiji Basin and Spreading History and the evaluation of hydrothermal metallic mineral deposits

Within the North Fiji Basin fossil spreading patterns and parts of an active spreading system have been identified. Current stress release within the region suggests that these patterns have recently changed. In order to evaluate potential metallic mineral resources associated with hydrothermal activity, it will be necessary to map and examine both the presently active and formerly active spreading systems. Although some of these investigations were initiated during the 1982 Tripartite Cruises, it is recommended that geophysical/geological investigations of the North Fiji Basin be expanded. Types of surveys should include high resolution sea floor mapping techniques (SeaMARC II or equivalent), bottom-water sampling/bottom camera, and midwater geochemical anomaly detection.

Rifting on the Fiji Platform: Extension tectonics and the possible development of sulphide ore bodies

Possible rift graben development and recent alkalic volcanism in northern Fiji, particularly around Natewa Bay, may be evidence of the requisite extensional regime conducive to the formation of Kuroko-type sulphide ore bodies, submarine deposits of which are found on Vanua Levu. Kuroko-type deposits characteristically occur in linear belts containing numerous deposits (e.g. Japan, N. Turkey) and here there is potential for discoveries of further

deposits in the area. The tectonic and alkalic volcanic activity may be related to contiguous basin dilation to the north and east, i.e. in the eastern part of the North Fiji Basin and in the Lau Basin. It is recommended that comprehensive geophysical/geological studies of the northern margin of the Fiji platform be initiated. Shelf and basin morphology should be delineated using high resolution bathymetric and seismic methods. Bottom geochemical sampling should also be undertaken to detect anomalous metal concentrations.

Fiji Platform Arc Development: Terrain recognition as a guide to the evaluation of hydrocarbon potential

Formation of arc terrain in the Oligocene and Late Miocene may have provided a suitable substrate for platform carbonate deposition which could become the requisite source/reservoir rock for hydrocarbon accumulation. Arc deformation and overthrusting may also provide sites for the development of pinnacle reefs. Massive and recurring plutonic intrustions may have significantly elevated the regional thermal regime providing for the maturation of hydrocarbons. Several magmatic arcs have already been identified in the Fiji Platform area. Subduction polarity needs to be confirmed. Forearc and backarc environments need to be identified. It is recommended that compilation of existing seismic data be understaken and that additional single- and multi-channel seismic data be acquired in the nearshore and offshore waters of the Fiji Platform proximal to the arcuate structure. Delineation of the contiguous seafloor magnetic anomaly configuration may also provide insight into rotation and tectonism of the platform.

New Hebrides Arc Development: The potential for hydrocarbon accumulation and metal enrichment

Potential exists for both hydrocarbon accumulations and hydrothermal metal rich concentrations within the New Hebrides Arc. With respect to the former, a study of known sedimentary basins has already begun. It is recommended that:

a) detailed marine geophysical surveys including the collection of single and multi-channel reflection, gravity and magnetics be undertaken in the eastern margin of the Central Basin and across the less well-known basins off the Banks, Torres and Santa Cruz Islands;
b) heat flow data to test the thermal regime be acquired from all basins;
c) onshore bio- and lithostratigraphic correlation be made between adjacent islands in the forearc and back arc regions and that comparisons be made with dredged samples in the intra-arc basin between;
d) the limited preliminary source rock studies undertaken to date be continued and augmented by sampling from all formations with potential for hydrocarbon generation;
e) with respect to the potential for hydrothermal metal concentrations, detailed sampling is required over the known hydrothermal iron deposit associated with submarine volcanism

off Epi; a search be made in appropriate areas along the complete length of the magmatic arc (Central Chain) for similarly situated deposits;

f) supplementary investigations be undertaken with relevance to the development of the arc including radiometric dating of Miocene andesitic intrusives of the forearc Western Belt volcanics, and a survey of the little known West Santo Basin and West Torres Massif to the north of the D'Entrecasteaux Zone.

Project A-2.3: Arc Reversal and Forearc Processes in the Solomon and New Hebrides Arcs

New Hebrides-Solomon Islands Arc Reversal

In Vanuatu and the Solomon Islands a change in subduction polarity from southwestward to northeastward was preceded by emplacement of serpentinite diapirs on Pentecost and ophiolitic bodies on Malaita in the eastern chain of the archipelago. This raises the possibility that, as suggested for some arc systems elsewhere in the world, arc reversal and ophiolite emplacement were triggered by collision of the arc system with a continental fragment, inactive island arc, or oceanic plateau. Collision, in the late middle Miocene, would have involved southwestward underthrusting and possible loss of the colliding block beneath both the eastern chain and the Aoba Basin and New Georgia Sound.

Analogy with other regions suggests that the postulated collision was accompanied and followed by northeast-directed thrusting in and beneath the eastern chain, and southwest-directed back-thrusting with formation of assymetric anticlines in the late Miocene to Pliocene successions of the Aoba Basin and New Georgia Sound. It also suggests that late Miocene subsidence in the Aoba and New Georgia Sound basins was genetically related to the collision, was probably not accompanied by graben formation, and that the late Miocene sediments might be underlain at depth by older deposits of the pre-collision fore-arc basin. The back-thrusting provides a possible explanation for the submarine ridges in the Aoba Basin east of Malekula and Espiritu Santo. Back-thrusting further to the southeast, west of Malekula and Espiritu Santo, could have initiated northeastward subduction which propagated laterally along the length of the archipelago at the end of the Miocene, and which continues today.

Additional evidence for this postulated collision, together with more detailed knowledge of the geological processes accompanying it, would result in a major advance in understanding of the Miocene-Pliocene geological evolution of the Vanuatu-Solomon Islands arc system, could provide a tectonic model broadly applicable to collisions, associated ophiolite emplacement and reversals in arc polarity elsewhere in the southwest Pacific, and would yield further data on geological events accompanying late Pliocene or Quaternary collision with the d'Entrecasteaux fracture zone.

The Aoba and New Georgia Sound basins contain sedimentary sections of late Miocene to Pliocene age with possible petroleum potential. In the Aoba Basin north-trending anticlines

occupy a tectonic position, relative to serpentenite diapirs and a late Cenozoic volcanic arc, analogous to that of the oil- and gas-bearing back-thrust related assymetric anticline of the Central Lowlands fore-arc basin in Burma. An understanding of the post-Oligocene regional tectonic evolution of the Vanuatu-Solomon Island arc system would have major implications for the oil potential of the Aoba Basin structures, of similar structures which might be expected in New Georgia Sound, and of analogous structures in other Southwest Pacific arc systems in which back-thrusting might be expected. The results could also provide new evidence for mechanisms of ophiolite obduction and diapirism, with implications for the chromite potential of ophiolitic bodies elsewhere.

It is recommended that a work programme be implemented to include (a) evaluation of existing data to indicate areas for limited on-land geological investigations to obtain the closest possible time constraints on the emplacement age of the ophiolite bodies and time of arc reversal, together with (b) offshore multichannel seismic reflection profiling to identity gently-inclined thrust surfaces beneath and east of the eastern chain, and southwestward-verging thrusts or assymetric anticlines in the Aoba and New Georgia Sound Basins.

Fore-arc magmatism and mineralisation in the Solomon Arc

The western Solomons is a site of modern fore-arc magmatism associated with subduction of an active spreading centre. Investigations undertaken as part of Project A4 (IOC Workshop No. 27) identified one active submarine volcanic centre, Kavachi, as being mineralised. Stratiform copper pyrite deposits of Besshi-type have been ascribed broadly to this kind of tectonic setting.

The termal effects of spreading-ridge subduction are poorly known, as are the mechanisms by which fore-arc magmas are generated.

It is recommended that the following investigations in the western Solomons be implemented with the aim of developing a predictive-process model of forearc magmatism and associated mineralisation: a) petrogenesis of fore-arc magmas; b) aeromagnetic and areal gravity characteristics of fore-arc magmatic zone; c) precise dating of adjacent volvanic centres, in order to determine their relationship to deformation in the fore-arc; d) modelling of triple junction behaviour and its effects on the asthenosphere beneath the fore-arc; e) closely spaced sediment sampling in the vicinity of fore-arc volcanic centres such as Kavachi to study the local volcaniclastic contribution, and anomalous trace metal concentrations in sediments.

Project A-2.4: Initiation and Early Stages of Back-Arc Basin Evolution

The western Woodlark Basin-East Papua region is a contemporary example of an active small ocean basin extending by rift propagation through the crust of an ancient island arc complex. The Lau Basin-Havre Trough-While Island-Taupo region provides another example, in this case of a back-arc basin associated with a magmatic arc. Study of the two regions would help to elucidate the relation between the locus of rifting and earlier

magmatic arcs and also the relationship between rifting and the establishment of a new volcanic arc.

It is recommended that to understand the processes involved, detailed marine geological and geophysical surveys be undertaken including precision swath mapping and submersible investigations. It is also recommended that development of hydrothermal systems during rifting al old crust, particularly as related to metallogenic implications, be investigated.

This project forms part of sub-programme BAT (Back-Arc Tectonics) of the IOC (WESTPAC) Marine Geology and Geophysics Research Programme.

Project A-2.5: Evolution of Major Geomorphic Terrains in the Papua New Guinea Region ("Project 42")

Collision tectonics and arc reversals are known to have occurred across East Papua and the New Guinea Highlands. These are fundamental tectonic processes; their importance to the development of mineral resources having been repeatedly recognised by various scientific groups, Most recently, highlighted in the IOC/WESTPAC III Geoscience programme recommendation (subprogramme: Collision Tectonics). These tectonic events, accompanied by arc magmatism and back arc basin formation in the Bismarck Sea and Woodlark Basin and perhaps even in the Solomon Sea, seem to have controlled mineralization and sedimentary basin development facilitating known hydrocarbon accumulation. Understanding of the plate kinematic and tectonic history would substantially enhance chances of discovery of yet undetected resources.

In view of the foregoing, the WESTPAC III recommendations concerning the possible Tertiary arc-continent and arc-arc collision in Northern New Guinea are considered to be particularly relevant. It is recommended that a single broad-transect style of investigation embodying the attributes of the previous SEATAR transects proposed for the PNG region, be initiated. This will be particularly well suited to the solution of the major geodynamic problems relating to the accumulation of mineral and hydrocarbon resources in the region.

The methods that need to be applied include, among others, geological mapping, paleomagnetic studies, deep crustal studies, airborne and marine geophysics. Determination of the age of the Solomon Sea Basin is critical to understanding the kinematics of the region.

Project A-2.6: Pre-Pliocene break-up history of the Southwest Pacific: A Regional Framework Study

Upper Mesozoic and early Tertiary sedimentary history is recorded in rocks beneath the ridges in the Southwest Pacific. These ridges have moved away from Australia in east and northeasterly directions separating associated rock sequences (terrains).

Reconstructions of crustal elements in this area by returning the ridges to their original positions reunites a) island arcs, b) sedimentary sequences associated with those arcs, and c) basal rocks of the original terrans associated with the pre-breakup Australian continental margin. In the northern part of the region the single extensional picture has been complicated by other tectonic events, for example arc reversals and arc movement in the opposite direction. In the south, south of New Caledonia and Fiji, a basically simple picture of eastward migrating ridges remains.

Reconstructions of Tonga-Kermadec, Lau, Three Kings, Loyalty, Norfolk, and Lord Howe ridges will establish not only the tectonic history but will bring together the broken up sedimentary basins associated with the volcanic arcs. A study of each basin as a complete unit will assist greatly with the evaluation of the hydrocarbon potential of the eastern parts of the older basins which now lie on the Tonga and Lau Ridges.

A review of the tectonic history has revealed that while much progress has been made information in some areas is lacking and there is speculation about early break-up history. More information is needed on magmatic events especially the position of arcs in the Miocene. Information from outcrop studies on 'Eua, drilling on Tongatapu, single and multichannel seismic reflection and sea floor dredging on the stratigraphy structure of the Tonga Ridge have identified sedimentary sequences that thicken to the west. Little is known of detailed stratigraphy and structure of the Lau Ridge and other ridges further to the west. Single channel seismic reflection has reconnaissance cover only and multichannel lines are few and are limited to the currently active arc, Lord Howe Rise and near New Caledonia (?). Sedimentary sequences that outcrop along the edges of the ridges have barely begun to be sampled.

It is recommended that the following project elements be implemented. These will lead to a greater understanding of the breakup history of the Australian continental margin and the tectonic evolution of the region, particularly the sedimentary history and recognition of terrains;

a) east-west multichannel seismic reflection lines across Lau, Three Kings, Loyalty and Norfolk ridges and their margins with adjacent basins, to establish structural relationships of sedimentary basins present and allow better correlation between ridges;

b) rock dredging of Miocene and older sedimentary sequences along the margins of these ridges in areas where they have been least affected by subsequent volcanic events, to establish the nature of the sedimentary sequences, the origin of the sediments and environment of deposition;

c) rock dredging of basement sequences to establish pre-break up form of the Australian continental margin, present distribution of pre-break up terrains and subsequent vertical tectonic history of each ridge system.

B. Report of Committee B on Distribution, Character, and Genesis of Offshore Metallic Deposits

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Introduction

The 1975 Suva Workshop recommended field surveys in the South Pacific for manganese nodules and metalliferous sediments. A considerable amount of manganese nodule work was done before the 1980 Noumea Workshop, at which 5 projects dealing with metallogenesis were proposed. These included specific projects on phosphorites, manganese nodules, and metalliferous sediments.

Since the Noumea Workshop considerable work has been done in all these areas. Phosphate has been sought by CCOP/SOPAC in lagoons, and by CCOP/SOPAC and NZOI on offshore ridges and seamounts, with some scientific success. Major reviews of manganese nodule occurrences and some sampling were carried out by CCOP/SOPAC, reviews of nodule data were prepared by NZOI, and the Japanese Geological Survey was active in the northern part of the region. A review of geochemical data for CCOP/SOPAC pointed to a number of regions where metalliferous sediments might be found. Metalliferous sediments were found by CCOP/SOPAC off Epi in Vanuatu and by a Tripartite cruise in the North Fiji Basin. A joint NZOI/Imperial College cruise discovered hydrothermal manganese crusts on the western Kermadec Ridge, and metal enrichments in Lau Basin sediments.

Cobalt-enriched crusts and nodules have been found on sediment-free upper slopes of islands and seamounts in the western Pacific. Their economic potential stems from the fact that cobalt concentrations up to about 2% in samples from the upper slopes of the Hawaiian

archipelago, Mid-Pacific Mountains, Line Islands and elsewhere have been measured. These enhanced cobalt concentrations, make the upper slopes attractive targets for exploration.

The recent reviews of manganese occurrences in the region have shown clearly that ore-grade nodules are only likely to be present beneath the biological high-productivity zone along the equator from 10°S to 10°N, between the Gilbert and Line Islands. The subcommittee believes that reconnaissance sampling should largely be replaced by detailed studies of smaller prospective areas.

Metalliferous deposits in shallow-water areas are associated with volcanoes or vents in island arcs. In spreading centres in deep water elsewhere in the world sulphide deposits commonly contain such metals as copper, zinc, lead and silver in varying concentrations up to 10, 50, 0.25, and 0.05%, respectively. These values are 10 to 100 times the concentrations in deep-sea ferromanganese nodules. The massive sulphides and associated "black smoker" chimneys discovered so far are located along the axes of medium to fast spreading centres in the Pacific (6-10cm/yr).

This subcommittee recommends that 5 projects should be pursued in the near future: studies of phosphorite and lagoonal phosphate, metalliferous deposits in shallow-water arc environments and deepwater back-arc environments, cobalt-rich manganese crusts, and manganese nodules. The phosphorite and lagoon phosphate studies (B.1) continue the Noumea Workshop's Project C3.1, the metalliferous deposit studies in shallow water (B.2) form a new project, the metalliferous deposit studies in deepwater (B.3) continue C2.1, the cobalt-rich crust studies (B.4) are new, and the manganese nodule studies (B.5) continue C2.2 and C2.3. There are strong linkages between Project B.3 and the WESTPAC Back-arc Tectonics Programme. There is no order of priority, intended or implied, in listing these projects.

The subcommittee also stresses that opportunities should be taken to study hazards associated with arc volcanoes, and to gather oceanographic data, such as the physical and chemical properties of water masses and on deep ocean currents. These data will be of potential value, for example, for OTEC studies and any possible plans for dumping of hazardous wastes. The subcommittee believes that a future workshop should consider past and future research into nearshore mineral occurrences, such as sand, gravel and placer minerals.

Project B-1: Phosphorites, phosphatic sediments and associated ferromanganese crusts

1. Areas of interest

South Pacific north of 23°S, and between 150°E and 155°W concentrating on shallow banks along the northern margin of the North Fiji Basin, on the sea floor around known phosphorite-rich islands, on the northern Tasman Sea and Coral Sea seamounts, guyots and banks, selected lagoons and east of New Zealand on the Chatham Rise.

2. Scientific and resource objectives

Determination of the distribution of phosphatic and associated ferromanganese deposits in the designated area; radiometric dating of such material; geochemical analysis with a view to discovering the provenance, and mode of deposition as well as geological association (e.g. phosphate-ferromanganese associations); and interpretation of relationships, if any, between phosphorites on seamounts and those exposed on Pacific islands. Location of commercially exploitable deposits.

3. Methods of investigation

(a) High resolution profiling.
(b) Pipe and mesh dredging.
(c) Piston and box coring
(d) Underwater rotary drilling.
(e) Vibrocoring and rotary drilling in lagoons.
(f) Underwater photography.
(g) Submersible observations and sampling.
(h) Shipboard spectrophotometry to allow preliminary identification and estimation of phosphorus.
(i) Particle-track autoradiography and/or alpha spectrometry.
(j) Geochemical analysis.

Project B-2: Near-surface submarine volcanoes: metallogenesis and assessment of volcanic hazards

1. Areas of interest

Active near-surface submarine volcanoes of the southwest Pacific, including offshore Epi, Rabaul harbour, Kavachi, and the submarine volcano east of the D'Entrecasteaux Islands.

2. Scientific and resource objectives

To locate and study hydrothermal deposits, and to evaluate the potential hazards, of active near-surface submarine volcanoes.

3. Methods of investigation

a) Detailed bathymetry and side-scan imagery using swath-mapping techniques.
b) Deep-towed underwater photography.
c) Precision sampling with cores and dredges.
d) Submersible observations and sampling of the active vents, and studies of the morphology, tectonics, and extent of hydrothermal deposits.
e) Submersible deployment of geophysical and geochemical monitoring equipment.
f) Geochemistry and sedimentology of recovered materials.

Project B-3 Nature, origin and development of metalliferous deposits along active rifts

1. Areas of interest

Tectonically active rifts and spreading centres within the marginal basins of the Southwest Pacific, such as the Manus Basin, the North Fiji Basin, the Lau Basin, and the Woodlark Basin.

2. Scientific and resource objectives

To locate and study submarine hydrothermal metalliferous deposits in basins containing active rifts. Comparison should be made with rift-related hydrothermal deposits on mid-ocean ridges.

3. Methods of investigation

(a) Compilation of existing marine geological and geophysical data, and data covering seismic activity, submarine volcanic activity, rifting and faulting, with a view to delineating active rifts where hydrothermal activity might occur.

(b) High resolution bathymetry, side-scan sonar, magnetics, gravimetry and seismic reflection profiling in areas of interest outlined by (a) above, using swath-mapping techniques such as SeaMARC.

(c) Deep-towed photography.

(d) Measurements of the thermal and chemical properties of the bottom waters, in particular analysis of hydrocasts to detect anomalous ^{3}He, Mn and CH_4 in the water column.

(e) Sampling with corers and dredges, precisely located.

(f) Submersible observations along selected areas of the rifts in order to collect samples and study the tectonics, morphology, physical properties and extent of hydrothermal deposits.

(g) Geochemistry, petrology, and sedimentology of recovered materials.

Project B-4: Distribution, composition and environment of deposition of Cobalt-rich ferromanganese crusts

1. Areas of interest

Bathymetrically favourable sites in the Line Islands, Phoenix Islands, Cook Islands, northern Tonga and Samoa.

2. Scientific and resource objectives

To investigate the extent, composition and environment of deposition of Cobalt-rich ferromanganese crusts in the southwest Pacific.

3. Methods of investigation

(a) High resolution bathymetric and seismic reflection (including 3.5kHz) profiling.

(b) Precisely located bottom sampling using grabs, corers and dredges.

(c) Detailed investigation of seafloor topography and possible delineation of crust material by seafloor imaging systems, including bottom photography, television and side-scan sonar.

(d) Measurements of bottom-water properties including temperature, salinity and density.

(e) Geochemistry, mineralogy and petrology of recovered materials.

Project B-5: Environments of deposition of potentially economic nodules

1. Areas of interest

The equatorial basins between about 10°N and 10°S, and in particular the region between the Line and Gilbert Islands and the northern Cook Islands.

2. Scientific and resource objectives

To determine the locations and environments of potentially economic nodules in the equatorial western Pacific.

3. Methods of Investigation

(a) High resolution bathymetric and seismic reflection (including 3.5 kHz) profiling.
(b) Precisely located bottom sampling using grabs and corers including box corers.
(c) Measurements of bottom-water properties including temperature, salinity, and density.
(d) Bottom-current measurements.
(e) Seafloor imaging, including bottom photography, television and side-scan sonar.
(f) Geochemistry and mineralogy of recovered material.

RECOMMENDATIONS

Committee B recommends:

(1) TO CONTINUE studies on the nature, extent, environment of deposition and economic potential of offshore metalliferous deposits in the southwest Pacific.

(2) TO CONTINUE investigations of the distribution and geological relationships of submarine lagoonal phosphorites in the southwest Pacific.

(3) TO ENCOURAGE and promote closer cooperation with IGCP Projects 111 (Manganese) and 156 (Phosphorites).

(4) TO STUDY nearshore, shallow-water areas surrounding island countries to assess the extent and distribution of industrial/construction materials, placer and lode minerals, and the potential environmental impact of their extraction.

Report of the Ad Hoc Working Party on Mineral Resources of Nearshore Areas

Working Party Participants:

BIRD, E.C.F. (Chairman)
CROOK, K.A.W.
FRANKEL, E.
GLASBY, G.
MACFARLANE, A.

Introduction

Although the mineral resources of nearshore areas were not considered in detail in the Workshop Committees, several participants expressed interest in these, and an ad hoc

working party was set up. It recommended that a scientific programme should be outlined for further development at a subsequent Workshop on Marine Research in Nearshore Areas. Such a Workshop would benefit studies aimed at the assessment of nearshore mineral resources.

Such a programme should include geomorphological, sedimentological and related biological studies of existing reef, lagoon and coastal environments; the mapping and correlation of submerged palaeocoastal and palaeofluvial features (notably incised and infilled river valleys traversing nearshore shelves and slopes), with reference to tectonics and isostatic adjustments; the mapping of patterns of seagrass and mangrove communities in relation to nearshore sediment distribution and flow; analysis of beach and nearshore hydrodynamics; documentation of sea level changes; and quantification of sediment yields from rivers, and from the erosion of coastal cliffs, rock platforms, and reef formations.

It is also recommended that pilot research projects in at least some of these fields be initiated with the support of IOC and other UN agencies, in association with universities and research institutes in the South Pacific. A pilot project on the budgeting of reefal sediment inputs to the Suva lagoon, where coralline sand and gravel are being extracted, has already been planned, and will prepare the way for more extensive assessments of nearshore sand and gravel resources and of the environmental effects of their mining from nearshore lagoonal areas.

Project C-1: Sediment budgets in reef-fringed lagoons

It is known that large quantities of sand and gravel occur beneath the floors of lagoons between outlying coral reefs and island-mainland coastlines. Some of this material is of terrigenous (mainly fluvial) origin, but the bulk of it is coralline detritus produced by wave erosion of reef fronts and reef crests, followed by landward overwash. Some reef sectors are actively generating such overwash; others show only meagre, if any, coralline sediment inputs in the lagoon. Where sand and gravel extraction is contemplated, it may be preferable to exploit lagoon sectors receiving such overwashed sediment rather than those where the bottom sediment is evidently largely relict. Geomorphological and ecological studies of reef sectors are needed as a basis for the classification and mapping of nearshore environments in terms of contemporary sediment budgets, supplemented by studies of the nature and abundance of fluvial sediment yield, and the distribution of the resulting lagoon-floor deposition.

1. Area of interest

Initially, as a pilot project, the Suva lagoon, S.E. Viti Levu, Fiji; eventually the near-shore zones of all coral-fringed South Pacific islands.

2. Scientific objectives

Determination of sediment budgets, flow patterns, and depositional distributions in lagoon sectors between outlying coral reefs and island-mainland coastlines as a basis for generally applicable classification and mapping of these dynamic environments.

3. Methods of investigation

(a) Geomorphological, ecological, and sedimentological mapping.

(b) Reef front and reef crest surveys using remote sensing and ground measurements.

(c) Quantification of trans-reef sediment flow using interceptor troughs and dams.

(d) Field monitoring of movement of sand cays and splays into lagoon environments.

(e) Fluvial sediment yield quantification from sampling and interceptors.

ANNEX VI

LIST OF SCIENTIFIC PRESENTATIONS

Speakers are underlined. Only the affiliation of the speaker is given.

CENOZOIC TECTONIC EVOLUTION OF THE SOUTHWEST PACIFIC

L.W. Kroenke
Hawaii Institute of Geophysics

ISLAND ARCS AND SEDIMENTARY BASINS IN THE NW PACIFIC RIM

Eiichi Honza
Geological Survey of Japan

ISLAND ARC BASINS AND PETROLEUM PROSPECTS IN THE SW PACIFIC: A SYNOPSIS

H.R. Katz
New Zealand Geological Survey

MAXIMUM UTILIZATION OF SATELLITE IMAGERY IN THE SEARCH FOR OIL AND GAS, ONSHORE AND OFFSHORE

Ward H. Austin
Pacific Energy & Minerals Ltd., Fiji

GEOMORPHOLOGICAL IMPLICATIONS FOR SEA FLOOR MINERAL PROSPECTING

Eric C.F. Bird
University of Melbourne, Australia

MANGANESE NODULE DEPOSITS IN THE CCOP/SOPAC REGION

N.F. Exon
Bureau of Mineral Resources, Australia

SOME AREAS FOR FUTURE WORK ON MARINE METALLIC RESOURCES

Y. Shimazaki
Geological Survey of Japan

A PRELIMINARY INVESTIGATION OF POLYMETALLIC CRUSTS FROM THE D'ENTRECASTEAUX ZONE, SOUTHWEST PACIFIC

B.R. Bolton & R.V. Burne
La Trobe University, Australia

SOME TECTONIC CONTROLS ON METALLOGENESIS IN ARC SYSTEMS

A.H.G. Mitchell
United Nations, Philippines

GEOLOGY OF NORTH FIJI BASIN

J.V. Eade & L.W. Kroenke
New Zealand Oceanographic Institute

GEOCHEMISTRY OF METALLIFEROUS SEDIMENTS FROM THE NORTH CENTRAL NORTH FIJI BASIN

Gary M. McMurtry
Hawaii Institute of Geophysics

RECENT WORK ON FIJI HYDROCARBONS PROSPECTS RELATED TO THE GEOLOGICAL EVOLUTION OF VITI LEVU

R.A. Eden & R. Smith
Mineral Resources Department, Fiji

THE WESTERN EXTENT OF SAMOAN VOLCANISM AND THE MARINE GEOLOGY OF SEDIMENTARY BASINS SOUTH OF VITI LEVU, FIJI

R.M. Brocher, R. Duncan, J. Sinton, R. Holmes, & C. Helsley
Hawaii Institute of Geophysics

LOW STRESS DROP EARTHQUAKE IN SOUTH VANUATU: A FACTOR OF LOW HAZARD

R. Louat
ORSTOM, New Caledonia

THE RENNELL ARC

R.V. Burne
CCOP/SOPAC Technical Secretariat

1982 KANA KEOKI CRUISE IN THE WOODLARK-SOLOMONS REGION

B. Taylor
Hawaii Institute of Geophysics

EVOLUTION OF THE WESTERN SOLOMONS AND WOODLARK BASIN: EVIDENCE FROM SEDIMENTARY PETROLOGY AND GEOCHEMISTRY

Keith A.W. Crook & Gordon R. Taylor
Australian National University

REVIEW OF PALEOMAGNETIC RESULTS FROM PNG - REGIONAL TECTONIC FRAMEWORK

D.A. Falvey
Bureau of Mineral Resources, Australia

HYDROTHERMAL METALLIFEROUS SEDIMENTATION IN THE TONGA-KERMADEC RIDGE AND IN ADJACENT MARGINAL BASINS: IMPLICATIONS FOR SULPHIDE METALLOGENESIS IN THE SW PACIFIC

D.S. Cronan, with S. Moorby, G. Glasby, and K. Knedler
Imperial College, England

TRIPARTITE GEOSCIENCE CRUISE PRESENTATIONS

Presentations were made by:

Tongan R/V LEE Cruise - D. Scholl (USGS)

Vanuatu R/V LEE Cruise - G. Greene (USGS)

Solomons R/V LEE Cruise - J. Vedder (USGS)

Tripartite II MOANA WAVE cruises - B. Taylor (HIG)