Part 4: SUMMARY REPORT OF THE CCOP/SOPAC—IOC SECOND INTERNATIONAL WORKSHOP ON GEOLOGY, MINERAL RESOURCES, AND GEOPHYSICS OF THE SOUTH PACIFIC

Noumea, New Caledonia, 9–15 October 1980

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Preface

The Workshop is jointly sponsored by the Intergovernmental Oceanographic Commission (of UNESCO) and the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas, and will review and update the CCOP/SOPAC - IOC IDOE programme which was developed at the 1975 Workshop on the same subject (see IOC Workshop Report No.6). The terms of reference of this Workshop in accordance to decision WESTPAC 1-9, are to:

1. summarise present knowledge and ongoing research projects on marine geosciences in the South-west Pacific;
2. identify major unsolved problems in the field of geology, geophysics, and mineral resources, and further research work needed to solve these problems;
3. define new scientific research and training programmes for execution in the region.

Summary report

1. OPENING OF THE WORKSHOP AND ADOPTION OF THE AGENDA

The meeting was opened by His Excellency the High Commissioner of the Republic in the Pacific Ocean, Chief of the Territory of New Caledonia and Dependencies, Mr C. Charbonniaud. His opening address is attached as Annex III. The representative of IOC, Dr G. Giermann, Deputy Secretary of IOC, then welcomed the Workshop on behalf of the Director-General of UNESCO and the Secretary IOC and thanked the French Government for its kind offer to host the Workshop in Noumea. The representative of ESCAP, Mr L. Machesky, addressed the Workshop on behalf of the Executive Secretary of ESCAP. In his message, the Executive Secretary stressed the importance of close co-operation between the United Nations agencies and Member States for the benefit of the region. Additional greetings were made by the Chairman of CCOP/SOPAC, Mr R. Richmond, who also served as Chairman of the opening ceremony and by the Director of the ORSTOM Centre, Mr de Boissezon, being the host of the Workshop. The opening ceremony was attended by representatives of the Government Council and the Territorial Assembly as well as by the Lord Mayor of Noumea. Scientists from the following 18 countries participated: Australia, Cook Islands, Fiji, France, Indonesia, Japan, Kiribati, Nauru, New Zealand, Papua New Guinea, Philippines, Solomon Islands, Tonga, United Kingdom, United States of America, Union of Soviet Socialist Republics, Vanuatu, Western Samoa.

2. ELECTION OF CHAIRMAN AND VICE-CHAIRMAN AND NOMINATION OF RAPPORTEURS

The Workshop elected Dr S. Uyeda as Chairman of the Workshop and Mr R. Richmond as Vice-Chairman. Mr A. Macfarlane and Mr J. Dubois were appointed rapporteurs.

3. GENERAL REVIEW AND BACKGROUND PRESENTATIONS

On behalf of the two sponsoring organisations, the IOC representative introduced the IOC resolution under which the Workshop was established (decision WESTPAC 1-9) and read out the Terms of Reference (as quoted in the Preface). The Chairman then explained how the Workshop would be conducted. He stated that after a two-day review session (symposium) a two-and-a-half day Workshop would follow in which three Subcommittees would meet separately in order to update and reformulate programmes and projects. The last morning of the session would then be reserved for adoption of the Summary Report, the Subcommittee programmes and projects, and the general recommendations. The three Subcommittees were established as follows:

A. Tectonic evolution of arcs and back-arc basins / Evolution tectonique des arcs et bassins arriere-arc

(Chairman - P. Coleman)

B. Deep crustal structure, petrogenesis and thermal regime - evolution of the lithosphere / Structure profonde de la croute, petrogenese et regime thermique - evolution de la lithosphere

(Chairman - C.J. Allegre)

C. Stratigraphy, sedimentary provenance and metallogenesis / Stratigraphie, origine des sediments et metallogenese

(Chairman - J. Wright)

A list of participants in the Subcommittees is attached as Annex VII. In the symposium held under this agenda item, 32 speakers presented overview papers and specific papers which collectively summarised the state of present knowledge and drew attention to problems that remain to be solved. A list of presentations is attached as Annex VI.

The setting up of a volcanological institute has been proposed to serve the Australo-Asian or Western Pacific region. This institute could provide a formal course in the basic principles of applied and theoretical volcanology, assist in joint research projects on the geology and geophysics of active and dormant volcanoes, strengthen communication between volcanically active countries so that volcanologists could move quickly to critical areas during times of volcanic emergency, and provide a data bank for information on the volcanoes of the region. A resolution proposing such an institute was presented by the Australian National Commission for UNESCO to the twenty-first session of the General Conference of UNESCO, held in Belgrade (October 1980).

The prospects for further ocean floor drilling in the area were mentioned by Dr Keith Crook, Secretary of the Consortium for Ocean Geosciences of the Australian universities (COGS). He reported that COGS had recently received funds from the Australian Marine Science & Technology Advisory Committee (AMSTAC) to support a workshop which would consider Australian participation in the last year (1983) of the International Programme of Ocean Drilling (IPOD) and the subsequent Ocean Margins Drilling programme (OMD). The workshop, which will involve representatives of industry, government institutions, and universities, will be held in Canberra, in March. The OMD organisation is contemplating group membership, with several countries forming a group which would have a single vote. A group comprising Australian and SOPAC countries could be appropriate, and COGS therefore extends an invitation to CCOP/SOPAC to send an observer to the workshop. If Australia were to join IPOD, reinstatement of the recently abandoned programme of hydraulic piston coring in the South-west Pacific is likely.

4. DEVELOPMENT OF FUTURE PROGRAMMES AND PROJECTS

The three Subcommittees met and formulated the programmes and projects outlined in Annex V. In doing so, the Subcommittees took into account the Report of the CCOP/SOPAC - IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, held in Suva, Fiji, 1-6 September 1975 (IOC Workshop Report No.6), the Report of the WESTPAC Workshop on the Marine Geology and Geophysics of the North-west Pacific, held in Tokyo, 27-31 March 1980 (IOC Workshop Report No.23), and the Report of the Second International Workshop on Marine Geoscience, held under the sponsorship of IOC, SCOR, and CMG (of IUGS), in Mauritius, 1-3 August 1976 (IOC Workshop Report No.9).

The Subcommittees agreed that rather than updating the programme contained in the Suva Report of 1975, they would concentrate on a small number of new projects which could be implemented at an early date with the assistance of the countries in the region.

The Workshop was informed of a five-year proposal for Soviet research in the South Pacific, including the following.

A study of recent tectonic activities, in particular seismicity, including microseisms, tectonic strain indices, and tsunamigenic earthquakes;

a study of the main features of regional depth structure including the anisotropy of the upper mantle and the study of place and role of magmatic and metamorphic processes in the geodynamic evolution of the South-west Pacific;

a study of the main characteristic features of mineral resources distribution. A comprehensive study of magmatic and metamorphic rock associations of main regional structures and related endogenous mineralisation. A survey of modern geosyncline sedimentation and ore formation in comparison with phanerozoic geosyncline development. Investigations of sediment composition, their stratification types, ore content in different structural zones, at different distances from volcanoes and other active centres, a detailed study of hydrogenous and hydrothermal mineralisation.

The future programmes and projects of research which were developed under this agenda item are attached to this report as Annex V; special recommendations are contained in Annex IV.

5. ADOPTION OF THE SUMMARY REPORT INCLUDING RECOMMENDATIONS AND NEW PROGRAMMES

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

6. CLOSURE OF THE WORKSHOP

The meeting closed on Wednesday, 15 October,

at noon. The participants expressed their appreciation to the organisers of the Workshop for their excellent arrangements and their generous hospitality.

ANNEX I

AGENDA

1. Opening of the Workshop and adoption of the agenda
2. Election of Chairman and Vice-Chairman and nomination of rapporteurs
3. General review and background presentations
4. Development of future programmes and projects
5. Adoption of the Summary Report including recommendations and new programmes
6. Closure of the Workshop

ANNEX II

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ANNEX III

ADDRESS BY

Mr C. CHARBONNIAUD

On behalf of the Government of the French Republic, I am particularly happy to welcome the officials in charge of the technical departments of various countries and territories in the Pacific, and eminent scientists who in some cases have come a much greater distance, to this second Workshop organised jointly by the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas and the Intergovernmental Oceanographic Commission. As Chief of the Territory, I am glad that it has been possible to hold this meeting in New Caledonia at the ORSTOM Centre in Noumea, whose teams of geologists and geophysicists have contributed to a greater knowledge of the South Pacific.

The peoples of the South Pacific have realised that the energy resources and raw materials of the land masses are limited or will rapidly be exhausted. They have turned their attention to the vast ocean around

them. They have great hopes of it - perhaps unduly great! But the scientists taking part in the exploration of the South Pacific are not yet in possession of enough reliable knowledge to encourage their hopes or to dispel their dreams.

I might mention that the South Pacific has been left relatively untouched in recent years by major scientific programmes, and, in particular, no IPOD drilling has been carried out there for some time. Oceanographic expeditions organised by bodies outside the South Pacific seem to have been less numerous than previously. I do not think that this is due either to lack of scientific interest in the region or to lack of interest in its potential; but our maritime zones are far from the large countries which can afford to promote such research, and the economic crisis has, without a doubt, caused them to revise their priorities. Furthermore, the size of the maritime zones to be explored is out of all proportion to the funds at the disposal of the countries and territories of the South Pacific.

It is therefore particularly important that, acting through international organisations such as the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas and the Intergovernmental Oceanographic Commission of UNESCO, we should be able to pool our efforts and even our funds in order to extract maximum benefit from national programmes or to co-operate in carrying out exploration programmes. In this connection, I am able to state on behalf of the government that France intends to continue to offer the services of its scientists and, as far as possible, its nautical facilities, as it has already done both in the past and very recently off the coast of Vanuatu.

You have met, then, to assess what has been learned and to devise research programmes which, in the years to come, will help us to advance our knowledge of submarine resources in the South Pacific and subsequently to make use of those resources. I hope that these programmes may further the advance of science, but, above all, I hope that any mineral resources that you may be able to detect will contribute to development and to a better quality of life for all the inhabitants of this region.

Ladies and gentlemen, in welcoming you to the Territory of New Caledonia, I should like to express my sincere hope that your proceedings and discussions may be fruitful and that your present and future research may provide the peoples of the South Pacific with reliable knowledge of the mineral resources of their vast ocean domain.

ANNEX IV

RECOMMENDATIONS

The Second CCOP/SOPAC - IOC International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific,

1. Recommends that the Chairman of the Workshop transmit for approval the adopted Summary Report of the Workshop (including recommendations and programmes of research) to the next session of CCOP/SOPAC, to be held in Tarawa, Kiribati, 20-28 October 1980, and to the Secretary of IOC for submission to the next session of the IOC Executive Council, to be held in May or June 1981 in Spain, as well as to the next session of the Programme Group for the Western Pacific (WESTPAC), to be held in Jakarta, September 1981.
2. Recommends that UNESCO and its IOC, CCOP/SOPAC, and ESCAP provide immediate training in marine geology, geophysics, and mineral resources as well as in data handling, so as to avoid delays in the implementation of the programmes of research.
3. Recommends that UNESCO arrange for a meeting of operators of seismographic networks with interested representatives of island groups, in order to discuss: (1) the improvement of communication between existing networks and the establishment of a regular exchange of seismographic bulletins; (2) the exchange of technical information on instrumentation; and (3) the establishment of new networks in critical areas.
4. Recommends that UNESCO and its IOC examine and improve, as a matter of priority, the co-ordination and interpretation of the seismic information system in Vanuatu, Fiji, Samoa, and Tonga, and tsunami warning communication system in the region.

ANNEX V

PROGRAMMES OF RESEARCH

1. REPORT OF SUBCOMMITTEE A ON TECTONIC EVOLUTION OF ARCS AND BACK-ARC BASINS

INTRODUCTION

The CCOP/SOPAC region is a key area for studying a wide range of fundamental problems, many of which are closely connected

with assessments of hydrocarbon and mineral resources potential, and geological hazards.

Elucidation of the crustal history of the region, which among other things will require integration of marine and land-derived stratigraphic and geophysical data, is an essential component in the assessment of the mineral and hydrocarbon resource potential of the region. Consequently the research projects treated below have been examined from a conjoint perspective in which relevance to fundamental scientific problems and relevance to resource assessments are integrated.

The region affords excellent examples of many important tectonic, geomorphic, and sedimentary features associated with the active margins of oceanic plates. These include: the active volcanic island arcs and their associated trenches which characterise the zones of plate convergence along the Melanesian Borderland and Tonga-Kermadec chain; fossil convergence zones such as the Fiji Platform; actively extending and inactive marginal basins with passive, oblique-slip, and active trench margins; active and inactive inter-arc basins diverse in size and sedimentary fill; and regions where the polarity of subduction may have been reversed following the collision of an oceanic plateau with a trench.

Each of these features displays considerable internal variation. For example, the active trenches vary in depth along their lengths. In three instances this variation is due to the presence of ridges on the oceanic crust which is being consumed at the trench. The Woodlark Rise, an active spreading centre is being consumed at a high angle beneath New Georgia, interrupting the Solomons Trench. An inactive ridge, the d'Entrecasteaux Fracture Zone, is being consumed orthogonally beneath Espiritu Santo, interrupting the New Hebrides Trench. The inactive Louisville Ridge, which is being consumed obliquely at the Tonga-Kermadec Trench, has swept southwards along the trench during the past few million years thereby contributing to morphological contrasts between the fore-arc regions in the Tonga and Kermadec segments of the Tonga-Kermadec arc.

Convergent margins in the region vary greatly in their vectors of motion relative to the earth's mantle. This feature of the region's lithosphere dynamics may account for the tectonic and geomorphic diversity within the region, and related variations in seismicity, volcanicity, and heat flow.

Geological and geophysical data attest to the dynamic nature of the region throughout the Cenozoic. The history of crustal evolution in the region is complex. Work under-

(Field Project 2-6) have been made by ORSTOM. Compilation of this project depends upon future work in the region under the aegis of IPOD or the Ocean Margin Drilling Programme (OMD). Other projects, such as the study of the Solomon and Woodlark Basins (Field Project 1-3), remain virtually untouched.

The present status of each of the previously proposed projects is tabulated in an appendix to this report. The CCOP/SOPAC meeting in Kiribati may wish to comment on this summary, and the WESTPAC recommendations, in the light of scientific, technological, and economic developments which have occurred since the projects were originally proposed.

PROJECT A-1 - Study of island arc sedimentary basins; correlation of reference sections and seismic stratigraphy

The geological history of island sedimentary basins is of fundamental importance to the study of island arc tectonics, their resource evaluation and geological hazards assessment. Detailed age, lithological and thickness data from sedimentary reference sections on the islands are vital to the recognition and understanding of offshore seismic reflection and refraction profiles. In particular, thickness and lithology observed in outcrops are the data to be used for comparison with velocity parameters obtained from refraction work offshore, as well as, where possible, on land (e.g., Guadalcanal Plains). These velocity parameters will also define total sedimentary thickness and basement.

taken since the first CCOP/SOPAC Workshop in 1975 shows that this history involves large lateral rotations of crustal blocks, such as Vanuatu and Fiji which rotated in opposite senses, and substantial vertical movements, with late Quaternary rates as high as 5 m/1000 years in parts of Vanuatu and New Zealand.

The thermal, deformational, and geomorphic consequences of this dynamic history are particularly relevant to sedimentary basins in the region, such as the Central Solomons Trough, which are prospective for hydrocarbons.

The 1975 CCOP/SOPAC Workshop proposed a number of research projects that fall within the purview of Committee A. Other projects were commended to this Workshop by the WESTPAC Workshop held in Tokyo in March 1980. Substantial progress has been made on some of these projects, for example, Field Project 1-2: Study of the North Fiji Basin. Essential preliminary studies have been completed on other projects, for example, the site surveys of the Tonga-Lau Transect

The purpose of this project is to provide basic stratigraphic and structural data to assist in the preliminary assessment of hydrocarbon potential and seismic hazards. This can be accomplished by detailed marine geophysical surveys including the collection of single and multi-channel seismic reflection, gravity and magnetic data, along with the land studies.

Such investigations are recommended in the island arcs of Manus - New Ireland, Bougainville, the Solomons, Vanuatu, Fiji, and Tonga, where detailed stratigraphic sections can be evaluated.

(1) In the Manus - New Ireland region, the Miocene Lauis formation and the Mio-Pliocene Rambutyo Beds may occur in offshore wrench fault basins.

(2) The mid-Tertiary sequence of Western Bougainville should be correlated with the Etoile-1 Well section.

(3) In the Solomon Islands, the detailed data available from the Shortland Group, Choiseul, and New Georgia Islands would usefully serve as a control for the Oligocene to Pleistocene stratigraphy in the north-western Central Solomons Trough. Likewise, the detailed data of the Late Cretaceous to Pleistocene sequence in southern Malaita, Nggela, and Guadalcanal would assist interpretation in the south-eastern part of the same basin.

Lithological data from Rennell Island Miocene and Pleistocene limestones may assist in the interpretation of future seismic surveys in that region.

The Middle Miocene to Pleistocene sequence of Nendo Island in the Santa Cruz Group may usefully be correlated with sequences in nearby offshore basins, such as the North Fiji Basin and the northern New Hebrides Basin.

(4) In Vanuatu, detailed data on the Miocene and Pliocene sediments of Espiritu Santo and Malekula Islands, together with the Mio-Pliocene sediments on Maewo and Pentecost Islands, will assist the interpretation of seismic profiles in the adjacent Central Basin.

(5) In the Fiji region, detailed work on the Miocene-Pliocene sedimentary basins of western Viti Levu, especially stratigraphic, and thickness relationships between the Wainimala and younger formations would assist correlation of offshore seismic studies with land data.

(6) In Tonga, the Eocene-Oligocene and Miocene sequence of 'Eua, the Miocene sections exposed on various islands of the Nomuka Group, and the probable Pliocene limestones of Vava'u should be studied and presented in detail, to assist offshore seismic interpretation.

Recommendations

(1) For the success of Project A-1, the geological surveys of the respective island countries should produce bio- and litho-stratigraphic columns and correlations between adjacent islands. This study should be combined with shallow drilling (50-100 m) on land for stratigraphic section compilation, heat flow measurements, determination of physical properties, and to obtain samples for source rock analyses.

(2) Detailed, high quality, marine geophysical data (single-channel seismic, seismic refraction, gravity, magnetics, and bathymetry) should be collected in the key prospective areas of the Melanesian Borderlands. In addition, high frequency, true amplitude multi-channel seismic data should be collected to elucidate basin seismic stratigraphy, subsidence history, structure and tectonics, initially in the Central Solomons Trough and the Central Basin of Vanuatu.

(3) The presence of broad wrench fault zones such as those suspected between Manus and New Ireland, along the eastern and possibly south-western limits of the Central Solomons Trough and also the Central Basin of Vanuatu should be investigated in detail. The results of this investigation should be related to the ESCAP Sedimentary Basins Correlations Project (IGCP Project No.32).

PROJECT A-2 - Solomon Islands palaeomagnetic project

Palaeomagnetic studies have been carried out in Tonga, Fiji, Vanuatu, and Papua New Guinea over the last four years following the recommendations of the previous Workshop. Arc rotations demonstrated by these data, together with the sea-floor magnetics, provide an essential basis for Tertiary palaeotectonic and palaeogeographic reconstructions. The understanding of the geotectonic history of a region is a necessary prerequisite for hydrocarbon exploration and a desirable adjunct to mineral exploration.

Whether or not the polarity of the northern side of the Melanesian arc reversed in the Miocene is one of the more important unresolved problems of the tectonics of the arc complex. It has been suggested that the island of Malaita is part of a flake of the Ontong Java Plateau, thrust across the blocked subduction zone. The motion of the Pacific plate with respect to the asthenosphere in the northern Melanesian region is approximately westwards, and that of the Indian plate northwards. Because of these

contrasting motions, palaeomagnetic studies on well-dated rocks on Malaita and other islands of the group should indicate their plate associations and the timing of any relocations of plate boundaries.

The Solomon Islands arc may have originated on the Indian/Australian plate, or alternatively on the Pacific plate remote from the present plate boundary region. Palaeomagnetic studies of Palaeogene and Late Cretaceous rocks may resolve this question.

Another fundamental problem concerns the degree of integrity of an island arc during a back-arc or marginal basin sea-floor spreading episode. Miocene and Pliocene palaeomagnetic data from Vanuatu have strongly suggested integral arc rotation from six million years ago. Miocene and Pliocene rocks also occur in the Santa Cruz Islands. Since these are part of the New Hebrides island arc palaeomagnetic sampling on Santa Cruz Islands should resolve the style of arc rotation. Confirmation of the presumed tectonics of the remnant arc ("Vityaz Arc") should be gained by palaeomagnetic sampling of Fatutaka (Mitra) Anuta and adjacent eastern Solomon Islands.

Recommendations

(1) A detailed palaeomagnetic survey including magnetostratigraphic studies should be carried out on the islands of Malaita and Guadalcanal in the Solomon Islands. Some sampling may also be necessary on Nggela, San Cristobal, and Santa Isabel.

(2) A palaeomagnetic survey should be carried out on the eastern Solomon Islands.

PROJECT A-3 - Definition of Indian Pacific plate boundary north of Fiji

Most of the tectonic lineations along the South-west Pacific reflect the present and former plate boundaries between the Indian and Pacific plates. It is important to delineate the position of the present plate boundaries between the Pacific and Indian plates and between the plates and the marginal basins, both for scientific reasons and for the assessment of earthquake hazards.

The plate boundary between the North Fiji Basin, the Lau Basin, and the Pacific plate is poorly defined, especially in the region north of Fiji where there appears to be a complex zone between the two marginal basins and the Pacific plate.

It is recommended that the data collected since 1970 on earthquake activity in the North Fiji - Lau Basins area be re-examined. First motion determinations should be made together with relocation of foci using lithospheric seismic velocities obtained from recent refraction studies.

Accuracy of locations should also be improved by the installation of seismic stations on islands of the region such as Wallis, Futuna, Rotuma, and Nia'foou. Towards this end the Committee also strongly recommends that the complementary telemetered seismic network in Fiji be improved by the provision through aid sources of an on-line computer for interpretation of data (cf. Recommendation in Annex IV).

Target areas for plate boundaries studies should be selected from analysis of the seismic data and from the examination of magnetic anomalies located over the North Fiji and Lau Basins. These areas would be best located along active ridge sections and fracture zones and their intersections. Seismic and microseismic activity of the target areas should then be examined through the shipboard deployment of ocean bottom seismic arrays across and along these active tectonic features.

These studies should provide a precise definition of the marginal basin/Pacific plate boundary and a better assessment of the earthquake hazards and kinematic history of this region.

PROJECT A-4 - The geophysical and geochemical consequences of subduction of the Woodlark spreading system at the Solomon Island arc-trench system

The subduction of an active spreading system at an oceanic island arc-trench system is a significant tectonic occurrence. In the South-western Pacific this situation is occurring today, where the Woodlark spreading system (of post-Miocene age) is being subducted beneath the New Georgia Islands section of the Solomon Island arc. The Woodlark Basin - Solomon Islands region thus provides : (a) a unique opportunity to study the geophysical and geochemical effects of oblique subduction of an active oceanic spreading system at an intra-oceanic island arc; and (b) a natural laboratory in which the roles of sediment and altered oceanic crust in island arc magma genesis can be determined. We therefore propose an integrated study of this region with the following objectives.

(1) To ascertain the geochemistry of both the incoming (Woodlark Basin) crust and sediments and the voluminous Plio-Pleistocene subaerial and submarine lavas erupted in and around the New Georgia Islands.

(2) To determine the present heat flow regime in that part of the Solomon Island arc where the Woodlark spreading system is being subducted.

(3) To determine the ages of the main rock associations of the New Georgia group.

(4) To undertake a comparative study of the post-Pliocene vertical tectonics of the New Georgia group and the adjacent islands of the Solomons arc and hence to investigate possible links between subduction of buoyant Woodlark Basin crust and such vertical movements.

To implement this project approximately one month of shiptime would be required in the Woodlark Basin - Solomon Islands region. A shipboard dredging and coring programme would be necessary to collect a suite of oceanic crust and sediment samples representative of the materials being delivered to the Solomon Trench, and to sample the two recently active submarine volcanoes 20-40 km landward of the trench axis. The month of shiptime would also allow the mapping of the poorly known tectonic fabric of the eastern part of the Woodlark Basin (near the trench) and make possible the necessary measurements of the thermal regime at the trench and in the fore-arc and back-arc areas around the New Georgia Islands (including the Slot).

The New Georgia Islands are currently the subject of a 1:50 000 scale geological mapping programme being conducted by the Solomon Islands Geological Survey. This work will include petrographic studies and major element geochemistry of the main rock associations.

Samples of both subducted and erupted materials should be analysed for phase chemistry, major, minor, and trace elements and Nd, Sr, and Pb isotopic ratios.

An aeromagnetic survey over the Woodlark Basin before the shipboard programme would determine the magnetic lineation fabric in more detail. This would allow more precise location of the dredge sites.

Knowledge of the geothermal regime over the Solomon Island arc, and particularly over the thickly sedimented Central Solomons Trough (the Slot), will have important implications for the hydrocarbon potential of sedimentary basins in the Solomon Islands.

Both the geochemical data and geothermal measurements acquired under this project would provide the important chemical (mass balance) constraints and physical boundary conditions required for the understanding of how oblique subduction of an active spreading system influences or determines island arc magma genesis.

PROJECT A-5 - Effects of subduction of aseismic ridges and small plateaus in the South-west Pacific

The entry of large oceanic plateaus, such as Ontong Java, into subduction zones is known to have profound geologic consequences. The collision and subsequent incorporation of small seamounts with island arcs have been documented in both the Tonga and Marianas regions. The interaction of features of intermediate size, such as elongate aseismic ridges and small plateaus, has not been as well studied, however, and is not fully understood.

Within the South-west Pacific, two key examples exist of such ridge-trench interactions, clearly differing in tectonic style. One is representative of orthogonal subduction of a small elongate plateau and fracture zone. The other is representative of the oblique subduction of an extensive aseismic ridge, effectively sweeping the island arc longitudinally. In the former example, the d'Entrecasteaux Ridge and the adjacent North d'Entrecasteaux Plateau are impinging on the New Hebrides Trench. In the latter example the Louisville Ridge is sweeping down the Tonga frontal arc.

Consequences of the apparent subduction of these aseismic ridges include:

(1) modification of the subduction geometry and patterns of seismicity;

(2) uplift and deformation of the fore-arc regions;

(3) changes in morphology of fore-arc and inter-arc basins which may include development of environments of restricted circulation;

(4) shifts in sedimentary provenance resulting in the introduction of land-derived sediment;

(5) in the case of obliquely subducted features, progressive changes in morphology and seismicity as the site of ridge subduction moves laterally.

Very little is known about the effects of aseismic ridge subduction on: (1) arc volcanism; (2) geochemistry of arc volcanics; (3) perturbation of the geothermal regime; and (4) tectonic erosion of the inner trench wall versus formation of accretionary prisms.

Particular note should be taken of the inadequate seismological coverage in the Kingdom of Tonga. Since Cornell University disbanded their deep earthquake seismological network in Tonga in 1975, no further seismic studies have been carried out in the area. It is important to note that Tonga has been the site of two great earthquakes (> 8, Richter scale) early in this century. Another major earthquake, measuring 7.8 on the Richter scale, occurred in 1977. Other major earthquakes may well continue to affect the area periodically. It is important, therefore, to monitor this activity with a view

to devising safety measures and long-term prediction of major events.

Recommendations

(1) Investigate possible perturbations in the geothermal regime due to subduction of aseismic ridges in Tonga and Vanuatu.

(2) Identify changes in subaerial and submarine geomorphology of the fore-arc region and outer and inner slopes of the trench, due to island arc-aseismic ridge interaction, including detailed bathymetric mapping, dredging, coring, and ocean-floor drilling along the fore-arcs in both Vanuatu and Tonga.

(3) Identify structural elements in Vanuatu and Tonga resulting from transcurrent fault and horizontal displacements.

(4) Undertake comparative studies on the crustal structure of the d'Entrecasteaux Ridge, North d'Entrecasteaux Plateau, and Louisville Ridge using seismic reflection and refraction techniques, together with co-ordinated studies on the crustal structure of the affected regions of the adjacent arcs to assess the effects of differences in subduction geometry.

(5) Compare the timing of sedimentary, magmatic, and deformational events in the Tonga arc with the timing of subduction events.

(6) Install a telemetered seismic network in Tonga, perhaps tied into the existing Fiji network to permit more efficient data reduction and to allow regional early warning of potential tsunamis.

(7) Study the shallow earthquakes in Tonga previously recorded in the disbanded Cornell network with a view to locating active shallow seismic zones.

(8) Train Tongan nationals as seismograph station operators.

(9) UNESCO and its IOC should examine and improve, as a matter of priority, the co-ordination and integration of the seismic information system in Vanuatu, Fiji, Samoa, and Tonga and the tsunami warning communication system in the region. (This Recommendation is repeated as Recommendation 4 of Annex IV.)

II. REPORT OF SUBCOMMITTEE B ON DEEP CRUSTAL STRUCTURE, PETROGENESIS AND THE THERMAL REGIME - EVOLUTION OF THE LITHOSPHERE

INTRODUCTION

Understanding the behaviour of lithospheric plates in subduction zones is a crucial element of global tectonics. Subduction zones are major plate boundaries and may be the locations for generation and/or destruction of continental crust. Subduction zones are also the loci of earthquakes and volcanic activity. Better knowledge of these phenomena, as they relate to the subduction processes, will contribute to more accurate forecasting of these potentially devastating events.

Convergent margins are associated with many important mineral deposits. These include massive chromite deposits within ophiolite complexes and the porphyry copper deposits associated with acidic and andesitic volcanism. Thermal anomalies are recognised throughout the subduction zone. The development of this geothermal energy may be an important energy supply for the countries within this area.

The South Pacific offers a nearly unique opportunity to study lithospheric plate behaviour without the interfering effects of continental lithosphere because the subduction zones and island arcs are completely detached from the Indian-Australian plate by intervening ocean basins. The region contains a variety of geodynamic features including the trenches, arcs, and back-arc basins typical of convergent plate margins. It should be noted that as a result of extensive previous studies in the region the basic tectonic and geodynamic framework is better understood. It is proposed that the next decade be devoted to more detailed studies dealing with processes rather than to reconnaissance surveys. The key areas needing detailed geophysical and geologic study may be identified and major problems needing study may be proposed.

Field and laboratory research projects done with the funding support of governments or research institutions should be continued and given encouragement on the international level. This is necessary to achieve the major scientific objective of understanding the evolution of the earth's lithospheric plates.

The studies which can and should be made on these fundamental problems are numerous and varied.

Many of these projects may be done without the need for international co-operation, but it is important that the results of these be co-ordinated with other programmes, and that the data be synthesised periodically.

Such co-ordination of research, data compilation, and synthesis should continue in three fundamental areas:

(a) cataloguing of active volcanoes and volcanic events;

(b) cataloguing and mapping of seismicity;

(c) systematic compilation of geological, geophysical, and bathymetric surveys. This should include satellite imagery and geophysical survey results.

A South Pacific information centre should be encouraged by appropriate funding to collect all documents relevant to these programmes. The information should be available to anyone who wishes to undertake research in this region.

Three specific projects are suggested for concentrated international co-operation during the next two years.

Project B-1 - Ophiolites; emplacement mechanisms variations; mineral resources.

Project B-2 - Mechanical properties of the oceanic lithosphere studied through bending processes.

Project B-3 - The thermal regime of the descending oceanic lithosphere.

All projects have specific importance to the South Pacific area. All have importance to the local populations in respect to mineral resources and to geological hazards.

PROJECT B-1 - Ophiolites; emplacement mechanisms variations; mineral resources

Ophiolite complexes have been recognised as a piece of oceanic crust "transplanted" on to the continent by some processes linked with plate convergence.

In recent years extensive exploration has been done on ophiolite complexes around the world, and these studies have given support to some early suggestions that the ophiolite complexes are not a unique petrologic association but contain several different kinds of associations reflecting varieties of oceanic crust. Some ophiolite complexes may have been formed in back-arc basins; others may be associated with island arc magmatism. Some may be generated in large ocean basins either at mid-ocean ridges, fracture zones, or as ocean islands.

The mode of transplantation on to the continent may not be unique. Some scientists support the obduction mechanism, others favour the back-subduction transplantation (BST), a third group emphasises the collision tectonic process, and recently a process of transduction has also been invoked.

Such variety is also apparent with respect to mineral deposits associated with ophiolites. Some complexes contain important chromite deposits associated with peridotitic harzburgites or with cumulative dunites; other have quite minor chromite deposits. Pillow lavas may contain important Cu, Zn, Fe sulphide associations, while others contain only minor Mn, Fe oxide crusts. Some ophiolite belts are expected to contain nickel sulphide enriched in platinum group metals.

Therefore, the present day scientific quetion is not only to understand ophiolite genesis, but also to classify and explain their diversities. Such compilation may give a clue to understanding oceanic lithosphere genesis and evolution, tectonic processes in subduction zones related to the development of mountain chains, and a systematic guide for the exploration of mineral deposits.

In this respect the western Pacific offers unique opportunities to develop such a project.

(1) The ophiolite complexes are numerous, well exposed, and seem to display large variations. Huge complexes are known in the Philippines, Papua New Guinea, and New Caledonia. Small complexes have been reported in the Solomon Islands, Vanuatu (former New Hebrides), and New Zealand.

(2) The geodynamic situation in those areas excludes a tectonic emplacement by continent - continent collision (as in the Alps or in the Himalayas) and their evolution can be understood in terms of the plate tectonic history of the area.

(3) The western Pacific ophiolites are situated within the ocean-continent or ocean-ocean transition and therefore it is possible to study their character on land as well as offshore. Such studies have been conducted so far in Papua New Guinea and New Caledonia.

(4) Various ophiolites in the western Pacific are known to contain important mineral deposits; much economic hope can be attached to such a project.

(5) Such comparative projects can be best conducted by a co-operative effort involving scientists from the countries where these complexes are located.

Considering our present state of knowledge of ophiolites we suggest the following programmes for the next four years.

1. Mapping of the ophiolite complexes

Special emphasis should be given to

(a) evaluation of the thickness of the pillow basalts, dolerite dike-sill complexes, gabbros, ultramafics;

(b) study of the nature of sediments in contact with the upper pillow lavas;

(c) systematic use of the structure cross-sections.

2. Dating of the ophiolite formation and tectonic emplacements

(a) Dating of the ophiolite formation can be achieved routinely by two methods: Sm-Nd method applied to the gabbroic rocks using Plag Pyr combined with micropalaeontological dating applied to the sediments in contact with pillow lavas.

(b) Dating of the age of tectonic emplacements is more difficult to achieve because some ophiolites have been involved in polytectonic episodes; the dating can be made only by careful geological studies combined with stratigraphic and dating techniques. However, a systematic use of the ^{39}Ar - ^{40}Ar radiometric dating technique using the multiplateau concept may be a way to solve such a problem. Another way may be the direct dating of metamorphic minerals (amphiboles).

(c) Dating of the calcalkaline porphyries or granitoids which cut the ophiolites (such as in Papua New Guinea or New Caledonia).

3. Characterisation of the ophiolite complexes by chemical methods

(a) Defining the petrological suites by the use of classical petrological concepts and by major element chemistry.

(b) Studying a selected number of typical suites by mineral analysis using electron probe.

(c) Studying different suites by trace elements with special emphasis on immobile incompatible elements; REE, Ta, Th, Hf, Zr, Ti.

(d) Studying the isotopic composition of the different complexes by $^{143}Nd/^{144}Nd$, $^{87}St/^{86}St$, $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, $^{208}Pb/^{204}Pb$.

The data should be compared with analyses obtained on dredged samples from the same region. A systematic local comparison with island arc volcanism should be done to decipher the possible relationships between these two fundamental aspects of island arc petrology.

4. Studies on metamorphism and hydrothermal alteration

(a) Definition by petrological methods of the geothermal gradient associated with primary genesis (spreading centre) as opposed to the geothermal gradient associated with tectonic processes (low T high P gradient).

(b) Distinguishing by mineralogy and oxygen isotopes the alteration associated with spreading centres (sea water) from the continental alteration. Such distinction is specially important for serpentinisation which may be used as guide for mineral prospecting.

5. Studies on mineral resources and metallogenesis

(a) Making a systematic study of the sulphides and oxides associated with pillows and sedimentary sulphide blankets.

(b) Making a comparative study of chromite deposits considering chromite chemistry, host rock petrology, and deformation of the host rock.

(c) Making systematic studies of the nickel sulphide within the lower part of the gabbro sequence.

(d) Studying the concentration of nickel as alteration products of the peridotites in conjunction with the geomorphological evolution. A comparative historical geomorphology will be welcome.

6. Studies on palaeomagnetics and magnetism

The studies of rock magnetism of the ophiolites complexes of the western Pacific islands should be encouraged.

(a) The location of the Western Pacific relative to the geomagnetic pole position in the Tertiary time may help in the search for magnetic reversals in the ophiolite complexes.

(b) Conventional palaeomagnetic reconstruction may give important constraints on the tectonic "trajectories" of the ophiolite complexes.

(c) The study of the magnetic orientation in relation to the tectonic history may constrain models of tectonic formation.

(d) The measurement of NRM and magnetic susceptibility of the different components of the ophiolite suites may become a fundamental guide in interpreting exploration magnetic surveys.

7. Geophysical surveys inland

(a) Gravimetric survey: the high densities of peridotites and the sharp contrast of density between altered and fresh peridotites and within the country rocks (limestones and schists) permit construction of a deep structure model.

(b) Seismic reflection and refraction profiles: a systematic determination of Vp, Vs, V_p/V_s *in situ* in conjunction with laboratory measurements by ultrasonics on rock samples may help in reconstructing the shape of the bodies. Three dimensional modelling techniques should be used in some selected bodies.

8. Offshore survey

A systematic geophysical and geological survey of the offshore continuation of these ophiolites should be made. Such a survey should include seismic profiling, gravimetric, and magnetic data.

In connection with the IPOD programme, a coring programme in the offshore continuation of ophiolites in Papua New Guinea or New Caledonia should be encouraged.

9. Seafloor sampling

A comprehensive dredging programme is recommended to obtain samples of oceanic crust/upper mantle for comparison with the ophiolite masses. Two areas deserve special attention: (1) back-arc basins; and (2) the walls of trenches closest to the arcs.

PROJECT B-2 - Mechanical properties of the oceanic lithosphere studied through bending processes

Since the original rheological definition of lithospheric plates (which distinguished between an elastic plate and plastic or visco-elastic asthenosphere), much progress has been made in the study of lithospheric rheology. Studies of both oceanic and continental areas suggest that the mechanical properties of the lithosphere should be examined in a more detailed and careful way.

Recently the structure of the oceanic lithosphere has attracted much scientific activity. Several types of oceanic lithospheric plates can be distinguished; among others, oceanic plateau or seamount types are clearly distinct from the "normal" oceanic type.

Near a subduction zone, a plate of oceanic lithosphere frequently exhibits a characteristic bulge before plunging into the trench at a subduction zone. The western Pacific subduction zones are characterised by being of the ocean - ocean type. Their geometry is unique, since the angle at which the plate is subducted into the mantle is extremely large. We propose to use such a phenomenon to study the structure and mechanical properties of oceanic lithosphere.

1. Geometrical observations of bending

Good observations of the shape of the oceanic lithosphere are necessary, including detailed topography of the bulge and a good estimate of the depth of the trench. Therefore, accurate bathymetric maps are crucial for these projects as are seismic definitions of the dip angle and its possible variation with depth of the subduction zone.

In addition good observations are needed on the shape of the subducted lithosphere. These observations can be obtained by mapping the spatial distribution of earthquakes. These observations should be made at different places in order to obtain relationships with various geodynamical parameters including age of lithospheric plates, thickness of the plate.

2. Detailed seismicity studies including the use of ocean bottom seismometers

Seismicity studies should be continued in the South-west Pacific to determine the geometry of mantle seismic (Benioff) zones, earthquake focal mechanism solutions, spatial distribution of shallow earthquakes, and the seismic zonation of the region. For some regions, such as Tonga, for which there is no adequate distribution of seismograph stations, establishment of new networks should be encouraged. In regions where land is unavailable, ocean bottom seismometers should be deployed.

3. Gravimetry and geodesy

A systematic study of geodetic observations combining spacecraft radar altimetry with the marine gravimetric surveys will permit a better definition of the lithospheric characteristics.

Special attention should be given to the study of oceanic plateaus and the deflections caused by seamount loading and by subduction. Observations of instantaneous plate motions and deformations, using both spatial and terrestrial methods, should be encouraged.

4. Neotectonic observations

The neotectonics of the different islands give important information about the nature of deformation at convergent margins. This information can be obtained by mapping uplifted terraces and recent movements on faults.

5. Magnetics and experimental rock deformation

The bending of the lithospheric plate seems to be characterised by the disappearance of magnetic anomalies. Such phenomenon should be systematically studied by marine surveys, and by laboratory experiments to determine the stress regime at

which the magnetisation disappears on ocean basalts.

6. Theoretical modelling of the behaviour of bending plates

Computer studies should include both rheological and thermal models.

PROJECT B-3 - The thermal regime of the descending oceanic lithosphere

Three approaches to this problem are suggested:

(1) ocean heat-flow studies;

(2) volcanological studies;

(3) studies of surface geothermal manifestations.

The integration of results from these three approaches should lead to a better understanding of the thermal regime of the descending lithosphere. It should also lead to a better appreciation of the possibilities for economic exploitation of resources and to an increasing awareness of geological hazards for the people of the South Pacific.

1. Ocean heat flow

A considerable data-set of ocean heat-flow measurements already exists and the broad pattern of behaviour is known. However, there is a need for heat-flow measurements to be made in a systematic way, with close spacing, to give adequate coverage of the various important regions associated with the descending lithospheric plate, viz; the "bulge"; the trench; the fore-arc region; the island arc; and the back-arc region.

Suitable study areas should be selected for these measurements across the Tonga and New Hebrides subduction zones.

2. Volcanology

(a) Constraints of thermal models

Obtaining constraints on the thermal behaviour of underthrust oceanic lithosphere may be made possible by petrological and geochemical studies of arc-trench-type rocks aimed at detecting the nature of the melting source regions. Origins within the wedge of upper mantle peridotite above downgoing slabs appear to be favoured at present, but the extent (if any) to which the wedge is modified by melts derived from downgoing ocean crust or from underthrust sediments (or both) should be determined. Whether or not melting takes place at the slab/wedge interface is critical in constraining the nature of the thermal regimes in downgoing slabs, and in understanding where metalliferous materials originate.

Volcano spacing may be a function of the depth and thickness of partial melting layers beneath the arcs. If so, volcano spacing may provide an additional constraint on where partial melting takes place - in the slab, or in the mantle wedge. Furthermore, because the distribution patterns of volcanoes in arc-trench systems are diverse (apparently reflecting particular deep-seated tectonic features), examination of volcano distribution - and separation distances - should be undertaken as a means of mapping deep-seated processes related to the nature of underthrust lithosphere.

(b) Eruption periodicity and tectonic activity

Studies of eruption periodicity of arc-trench-type volcanoes should be undertaken to determine if eruption frequency is related to : (1) similar frequencies of tectonic-earthquake activity; (2) changing rates of subduction; (3) earth tides; or (4) other phenomena.

(c) Volcanic hazard

Most countries represented in CCOP/SOPAC have active explosive volcanoes that pose a threat to life, property, and agriculture. Prediction studies, intraregional collaboration between volcanologists, and consideration of an IUGG proposal to set up a volcanological institute (whose primary function would be teaching of the basic principles of applied and theoretical volcanology) are therefore critically important recommendations for the well-being of SOPAC countries.

(d) Seafloor volcanic centres

The mapping of seafloor volcanic centres in the South-west Pacific should be undertaken, bearing in mind two points : (1) the tsunami-generating capacity of active submarine volcanoes; (2) the possible metallogenic capabilities of seafloor volcanic centres, particularly those in back-arc rift zones.

3. Surface geothermal manifestations

Surface and near-surface geothermal effects associated with the subducting lithosphere may have important consequences for island countries in the South Pacific region. These include the maturation of hydrocarbons in suitable oceanic sediments, mineralisation associated with geothermal activity, e.g., porphyry coppers and the practical exploitation of geothermal energy for power generation.

Reconnaissance geothermal surveys should be made in favourably located countries, such as Samoa, Tonga, Vanuatu, Solomon Islands, Papua New Guinea, and Fiji. Techniques should include geochemical investigation of thermal, spring waters, thermal infra-red

imagery, soil mercury surveys, and temperature gradient and heat-flow measurements in existing boreholes. Areas of high potential should be further investigated by detailed geological mapping, resistivity surveys, and microseismic studies. Offshore areas should not be neglected and may be studied by Curie isotherm mapping from aeromagnetics and from ocean heat-flow measurements.

Advantage should be taken of the considerable expertise in the fields of geothermal exploration and exploitation which already exists within the South Pacific region. Facilities for the training of personnel in the necessary techniques also exist in the region.

Summary of General Recommendations

Subcommittee B recommends:

(1) to form a Western Pacific Ophiolite Group to promote the exchange of ideas and data, to conduct field trips, and to hold symposia (cf. Project B-1);

(2) to expand the dredging programme of back-arc basins and trench walls, and to compare the chemical, isotopic, and petrological properties of these rocks with those of the ophiolite series;

(3) to co-ordinate regional seismograph networks in the South Pacific by holding regular meetings to establish exchange of data and technical information. (This recommendation is repeated as Recommendation 3 in Annex IV.);

(4) to use ocean bottom seismometers in addition to land stations for the study of geodynamical problems which cannot be studied by classical seismic land networks. This should improve hypocentre locations and focal mechanism solutions;

(5) to make a systematic study of the thermal regime of the descending lithosphere by means of closely spaced ocean heat-flow measurements and by the study of the distribution and petrology of volcanoes;

(6) to make a surface geothermal reconnaissance of island countries near subduction zones and more detailed follow-up studies where appropriate, with the objective of locating related economic mineral and energy resources;

(7) to establish a South Pacific Information Centre in which all published and unpublished material can be centralised, with a specialised library.

III. REPORT OF SUBCOMMITTEE C ON STRATIGRAPHY, SEDIMENTARY PROVENANCE AND METALLOGENESIS

PROJECT C-1 - Stratigraphy

Discussion and background

Research programmes established at the 1975 CCOP/SOPAC-IOC IDOE International Workshop and results from these programmes reported at this Workshop have been especially concerned with tectonic, volcanic, geophysical, and geochemical studies. Sedimentary units and processes have received much less attention, despite both their scientific importance and their economic relevance to the region. A detailed understanding of stratigraphic relationships and sedimentary history, as recorded in sediment accumulations on the seafloor, is important in unravelling regional and local tectonic events. Detailed stratigraphic studies are also of primary importance in assessing resource potential, particularly in identyfying potential sources and reservoirs for hydrocarbons. The Committee made the proposals outlined in order to stimulate specific attention on several major areas of stratigraphic and sedimentologic research.

Outlined below are four projects which identify major areas of current concern or topics whose prosecution would be of major significance to the South-west Pacific and the entire Western Pacific. The topics fall into two groups.

(a) Those concerned with the distribution of bodies of sedimentary rock and the discontinuities within them, their origin, nature, and significance. Three major stratigraphic projects are identified as being of particular relevance to problem-solving in the South-west Pacific. These are hiatuses and their significance, an identification of periods of change, i.e., major stratigraphic events and a delineation of sediment bodies. Apart from the interpretation of data collected by the Deep Sea Drilling Project in the South-west Pacific, little work has been done to correlate results from basins to ridges and between basins, and to establish an understanding of regional seafloor stratigraphy. Initially, primary data for these studies will be drill hole information from the Deep Sea Drilling Project. Sixteen holes have been drilled and cores collected from the Tasman Basin, Queensland Plateau, Coral Sea Basin, New Hebrides Basin, Lord Howe Rise, New Caledonia Basin, South Fiji Basin, Lau Basin, South-west Pacific Basin east of Tonga, and the Ontong Java Plateau. However, as the region has a diverse and complex geologic history many more holes will be

needed to map the region effectively. Until this happens considerable progress can be made in these stratigraphic studies using seismo-stratigraphic techniques.

(b) Those concerned with sedimentation and sedimentary diagenetic processes. There is at present a growing interest in the sedimentation, lithification, and diagenesis of carbonates and in the mineralogical changes taking place in volcanoclastic sediments under different conditions. Too little is known about the movement and diagenesis of sediments along deep ocean basin margins. Such studies help us understand the relationships between sedimentation and diagenesis of different materials under different conditions and therefore help us understand resource genesis and distribution.

Both groups of studies embrace a number of topics which are currently the subject of attention over a much wider area than the South-west Pacific alone. Many of the topics presented highlight problems common to the whole of the Western Pacific and therefore it is appropriate that they should be part of a WESTPAC programme.

It is realised that many aspects of the projects and the scientific objectives presented below impinge upon or overlap with the interests of other international geological bodies, e.g., the IGCP and subcommissions of the IUGS Commission of Stratigraphy. Such overlap is both inevitable and beneficial in topics of wide current interest, and co-operative efforts should be encouraged by WESTPAC.

PROJECT C-1.1 - Sedimentary hiatuses in ocean bottom sequences

1. Areas of interest

Queensland Plateau and adjacent shelf, East Australian shelf - Lord Howe Rise - Norfolk Ridge system, North Fiji Basin, South Fiji Basin, Western New Zealand shelf and slope, Hikurangi margin, and the Campbell Plateau.

2. Scientific objectives

(a) Mapping of regional hiatuses for various time periods and identification of their causes.

(b) Estimating volumes of sediment lost or bypassed at hiatuses and identifying sites of redeposition.

(c) Defining oceanic palaeo-current systems and their relationship to inter- and intra-plate movements, volcanic episodes, build-up of ice caps, sea level and biotic changes.

(d) Extrapolation of knowledge of on-land geology to better understand hiatuses offshore, especially with respect to glacio-eustatic movements of sea level.

(e) Studying breakup hiatuses in detail for the major episodes of continental fragmentation.

3. Methods of investigation

(a) Seismic reflection, especially high resolution and multichannel profiling.

(b) High resolution seismic refraction.

(c) Ocean floor drilling.

(d) Seafloor sampling, e.g., vibro-coring, piston coring, and dredging.

(e) Standard palaeontologic, sedimentologic, petrologic, and geochemical techniques on collected samples.

(f) Magnetostratigraphic techniques.

PROJECT C-1.2 - Study of major stratigraphic events in the SOPAC region

1. Areas of interest

Pliocene-Pleistocene boundary, Upper Miocene in the Outer Volcanic Arc region from Papua New Guinea to New Zealand, Cretaceous - Tertiary boundary, Cretaceous orogeny in the Lord Howe Rise - Norfolk Ridge region, evidence for possible Jurassic opening of the Pacific Basin.

2. Scientific objectives

(a) Identifying levels of major changes in the stratigraphic record.

(b) Tracing the areal extent and influence of these changes.

(c) Identifying their causes and relating them to the geologic record.

3. Methods of investigation

(a) Collation of stratigraphic data from ocean drilling and relevant onland data.

(b) Ocean drilling, vibro-coring, piston coring, and dredging.

(c) Seismic reflection profiling.

(d) Seismic refraction.

(e) Standard palaeontologic, sedimentologic, petrologic, and geochemical techniques on collected cores.

PROJECT C-1.3 - Delineation of sediment bodies in time and space

1. Areas of interest

Continental margin between New Zealand and South Fiji Basin, east of New Zealand, Lord Howe Rise - South Fiji Basin ridge and

trough system, New Ireland Basin, Central Solomons Trough.

2. Scientific objectives

(a) Delineating distribution of sediment bodies of different ages, and producing stratigraphic and isopach maps of the region.

(b) To establish, from detailed stratigraphic analysis of the bodies:

(i) basin genesis and tectonic setting;

(ii) depositional history;

(iii) facies relationships and palaeoenvironments;

(iv) sediment provenance;

(v) resource potential.

(c) To establish the stratigraphic relationship between sedimentary sequences of basins, ridges, and shelves.

3. Methods of investigation

(a) Seismostratigraphic and magnetostratigraphic techniques.

(b) Ocean drilling.

(c) Piston coring and dreding.

(d) Standard palaeontologic, sedimentologic, petrologic, and isotopic analysis of samples.

(e) Correlation of on-land geologic information.

Note

Where appropriate, the reporting of results of stratigraphic investigations should be in the format recommended for the ESCAP Sedimentary Basins Correlation Project (IGCP Project No.32) for which standards and specifications have been published and are available from ESCAP, Bangkok.

PROJECT C-1.4 - Sedimentologic studies in the SOPAC region

1. Areas of interest

Areas of carbonate sedimentation, Fiji area, the New Zealand margin of the South-west Pacific Basin, Samoa - Cook Islands region.

2. Scientific objectives

(a) Improving understanding of carbonate sedimentation and diagenesis under different environmental and climatic conditions.

(b) Improving understanding of diagenetic processes and products in volcanic sediments.

(c) Studying transport, deposition, erosion, redeposition and diagenesis along the margins of deep ocean basins and around seamounts, especially in the area of the Western Boundary Undercurrent.

3. Methods of investigation

(a) Ocean drilling.

(b) Piston coring, vibro-coring, and dredging.

(c) Sediment traps.

(d) Underwater photography and television.

(e) Long-term multiparameter observations at and near the sediment-water interface.

(f) Observation and sampling by submersible.

(g) High resolution seismic profiling.

(h) Side scan sonar.

(i) Standard palaeontologic, sedimentologic, petrologic, and geochemical analysis of samples collected.

PROJECT C-2 - Metallogenesis (including manganese nodules)

Discussion and background

The 1975 Suva Workshop recommended six projects, including field survey in the South Pacific for manganese nodules. The limited amount of marine survey which has been carried out between 1975 and 1980 has yielded economically disappointing results for the SOPAC area. It should not be assumed, however, that the possibilities for economically valuable deposits have been exhausted.

In the same period, however, very important new evidence has been found in the eastern Pacific on the accumulation of metalliferous deposits in close association with active rifts. These consist of iron, copper and zinc sulphides together with associated oxides and silicates.

The scientific emphasis of the programme proposed below is therefore placed firstly on a study (Project C-2.1) to find possible metalliferous deposits in association with active rifts in the South-west Pacific area, taking advantage of the recent studies in the Eastern Pacific. The importance of manganese nodule studies to the SOPAC area should not be neglected, however, and the Committee has made a proposal of second priority (Project C-2.2) to study further the environment of deposition of manganese nodules in the South Pacific. This project is intended to define the conditions under which nodules of ore grade may occur in the region and will relate conditions of formation in the southwestern area to those in

economically richer locations such as the northeastern equatorial Pacific and Central Indian Ocean. Surveys made as part of the project will provide further evidence on manganese nodule accumulations in South Pacific areas not already examined. The project should refine the criteria needed for ore-grade accumulations and is intended to focus future attention on the more profitable areas for survey. The Committee also considered that from a scientific point of view it was desirable to study (Project C-2.3) metal accumulation rates and growth rates in manganese nodules. This is proposed as a laboratory study on material already collected.

PROJECT C-2.1 - Nature, origin, and development of metalliferous sediments along active rifts, in the SOPAC region

1. Areas of interest

Tectonically active rift and volcanic areas within the arcs and marginal basins of the South-west Pacific, starting with the North Fiji Basin, the Lau Basin, and the Havre Trough.

2. Scientific objectives

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

3. Methods of investigation

(a) Compilation of existing seafloor data on magnetics, seismic activity, seismic structure, submarine volcanic activity, rifting and faulting, with a view to delineating active rifts where hydrothermal activity might occur.

(b) High resolution bathymetry, magnetics, gravimetry, and seismic reflection profiling in areas of interest outlined by (a) above, using multiple beam and deep-tow devices if possible.

(c) Heat-flow measurements.

(d) Measurements of the thermal and chemical properties of the bottom waters.

(e) Precisely located (using bottom transponders) sampling with corers and dredges.

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

(g) Geochemistry and sedimentology of recovered materials.

PROJECT C-2.2 - Environments of deposition of manganese nodules in the South Pacific

1. Areas of interest

The South-west Pacific Basin, the Samoa Basin, the Penrhyn Basin, and the basins of the equatorial Western and Central Pacific.

2. Scientific objectives

To determine the topographic, tectonic, stratigraphic, sedimentological, geochemical, and bottom-water characteristics of basins containing manganese nodules, in order to define the conditions under which ore-grade nodules might be found within the region.

3. Methods of investigation

(a) High resolution bathymetric and seismic reflection profiling 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 chemical composition.

(d) Measurement of bottom-water movements.

(e) Bottom photography and television.

PROJECT C-2.3 - Metal accumulation rate and growth rate studies on existing manganese nodule collections from the South Pacific

1. Area of interest

Areas of maximal concentration within basins in the South Pacific, particularly the South-west Pacific, Samoan, and Penrhyn Basins.

2. Scientific objectives

To determine the origin and sources of metals in nodules in the South-west Pacific; to compare the rates of metal accumulation with those of economically attractive nodules from the north-east equatorial Pacific; and to delineate past patterns of metal accumulation enrichment and, if possible, to correlate these observations on a regional basis.

3. Methods of investigation

(a) Alpha particle track autoradiography and/or spectrometry to obtain accumulation rates by the excess ^{230}Th method.

(b) Electron microprobe analysis for detailed microlayer chemical composition.

(c) Physical property determinations: dry bulk density and X-ray radiography.

(d) Mineralogy of selected layers by X-ray diffraction.

PROJECT C-3 - Sedimentary provenance

Discussion and background

Few studies have been carried out on sediment provenance within the South Pacific, but they can provide important information on the sources from which sediments have been transported to their present location. The Committee considered that it should propose two projects under this general heading, one (Project C-3.2) on the sources of sediment accumulation throughout the region, and a more specific study (Project C-3.1) of phosphorites. The latter is proposed because of the potential economic importance of phosphatic deposits to the SOPAC region. Recent work on phosphorites has indicated that the economic potential is greater north of the Tropic of Capricorn, in regions where the surface productivity is highest.

PROJECT C-3.1 - Phosphorites, phosphatic sediments and associated ferromanganese crusts

1. Area of interest

South Pacific north of latitude 23°S and between longitudes 160°E and 155°W.

2. Scientific objectives

Determination of the distribution of phosphatic and associated ferromanganese deposits in the designated area; radiometric dating of such deposits; geochemical analysis with a view to discovering the provenance, mode and rate of deposition, and 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, wherever possible, for information on associated sediments.

(d) Underwater photography.

(e) Submersible observations and sampling.

(f) Shipboard spectrophotometry to allow preliminary identification and estimation of phosphorus.

(g) Particle-track autoradiography and/or alpha spectrometry.

(h) Geochemical analysis.

PROJECT C-3.2 - The role of oceanic and arc evolution, and other processes, in determining sediment composition and provenance within the South Pacific

1. Area of interest

The island arcs and marginal basins of the South-west Pacific.

2. Scientific objectives

Studying the distribution of rock forming and minor elements, and the isotopic composition of sulphur, oxygen, and carbon, and on this basis to assess the contribution of oceanic and arc volcanism and other processes to the formation of seafloor sediments. Studying also the composition of sediments and volcanic rocks on the islands in order to evaluate further the relationships between volcanism and sediment composition.

3. Methods of investigation

(a) Bottom sediment sampling, and on-land geological sampling.

(b) Geochemical analysis of recovered materials.

ANNEX VI

LIST OF SCIENTIFIC PRESENTATIONS

OVERVIEW PAPERS

Tectonic Evolution and Kinematics of the South-west Pacific - *G.H. Packham* and *D.H. Falvey*, University of Sydney, Sydney.

Structural Evolution of the South-west Pacific Island Arcs by EVA Team (ORSTOM NOAA/NOS, Cornell University, University of Texas) presented by *J. Recy*, ORSTOM, Noumea.

Microchemistry and Mineralogy of Ferromanganese Nodules in the South Pacific - *S.V. Margolis* and *M.A. Meylan*, University of Hawaii, U.S.A., presented by *G. McMurtry*.

Metalliferous Sediments in the South-west Pacific; and Update - *D.S. Cronan*, Imperial College, London.

Plate Tectonic Evolution of the South-west Pacific - *R.G. Littlefield*, Phillips Petroleum Company, Oklahoma.

Tectonic Development of Oceanic Plateaux - *L.W. Kroenke*, University of Hawaii, Honolulu.

A Geophysical Discussion of the Oceanic Geoid for the South-west Pacific - *K. Lambeck*, Australian National University, Canberra.

The Geochemistry and Mode of Formation of Ophiolites in the South-west Pacific - *C.J. Allegre*, Institut de Physique du Globe, Paris.

SUBCOMMITTEE PAPERS

A. Tectonic evolution of arcs and back-arc basins

Geological Evidence Bearing on the Miocene to Recent Structural Evolution of the New Hebrides (Vanuatu) Arc - *J.N. Carney* and *A. Macfarlane*, Geological Survey Department, Vila.

South-west Pacific Tectonic Analysis from Palaeomagnetic Data - *D. Falvey, J. Terrill, R. Cassie, B. Rumph, R. Musgrave, A. James, A. Chivas*, University of Sydney, *B. Embleton*, CSIRO Mineral Physics, and *M. McElhinny* Australian National University, Canberra.

Geologic History of the Marianas Arc - Trench - Back-arc System - *J.W. Hawkins, C. Evans, S. Bloomer, J. Melchior*, Scripps Institution of Oceanography, La Jolla, California.

New Evidence Bearing on the Tectonic Evolution of the Solomon Islands Region - *G.W. Hughes* and *J. Ridgway*, Geology Division, Honiara.

New Britain - A Typical Island Arc - *R.W. Johnson*, Bureau of Mineral Resources, Canberra.

North Fiji Basin : New Data by EVA Team (ORSTOM, NOAA/NOS, Cornell University, University of Texas) presented by *B.M. Larue*, ORSTOM, Noumea.

Development of Marginal Basins in the South-west Pacific - *A. Malahoff*, NOAA/NOS.

The Geology and Basement Configuration of the Lamon Bay - Bicol Shel Basin, Luzon, Philippines - *R.D.S. Rieza*, Bureau of Energy Development, Manila.

Tectonic Stress in the Arcs - *S. Uyeda*, University of Tokyo, Tokyo.

Submarine Active Faults Along the Nankai Trough, South-west Japan - *N. Yonekura*, University of Tokyo, Japan.

B. Deep crustal structure, petrogenesis and the thermal regime, evolution of the lithosphere

Obduction of the Lithosphere : the New Caledonian Example - *J.Y. Collop, F. Missegue, G. Bitoun, J. Recy*, ORSTOM, Noumea, *G. Latham*, University of Texas, and *A. Malahoff*, NOAA/NOS.

Study of the Deflection of Oceanic Lithosphere at Subduction Zone by a Definite Element Method - *J. Dubois*, University of Paris-Sud, Orsay.

Deep Crustal Structure of Oceanic Plateaux - *J.F. Gettrust*, Hawaii Institute of Geophysics, Honolulu, presented by *N. Frazer*, Hawaii Institute of Geophysics, Honolulu.

Voltanology in Australasia : Hazards and the Future - *R.W. Johnson*, Bureau of Mineral Resources, Canberra.

Geochemistry and Mineralogy of Potassic Volcanics from Fiji - *B. Rao*, University of Queensland, Brisbane.

Heat Flow Measurements in Fiji - *N.J. Skinner*, University of the South Pacific, Suva.

C. Stratigraphy, sedimentary provenance and metallogenesis

Nickel Ore and Mining Diversification in New Caledonia - *M. Benezit*, Service des Mines et de la Geologie, Noumea.

Recent Investigations of Submarine Phosphorite Deposits in the South-west Pacific - *D.J. Cullen*, New Zealand Oceanographic Institute, Wellington.

Origin of Ophiolite and Chromite, Zambales Range Luzon - *C. Evans, J. Hawkins* and *G. Bacuta*, Scripps Institution of Oceanography, La Jolla, California.

Reference Sections, Biostratigraphy and Correlation of the New Caledonian Triassic and Jurassic - *H.J. Campbell, J.D. Campbell* and *J.A. Grant-Mackie*, University of Auckland, Auckland.

Continental Margin Accretion or Tectonic Erosion : Implications for Hydrocarbon Potential in New Zealand - *H.R. Katz*, New Zealand Geological Survey, Lower Hutt.

Visual Observations of the Tectonics and Mineralisation of Active Submarine Rift-Fracture Zone Systems - *A. Malahoff*, NOAA/NOS.

Lithostratigraphy and Deformation of the New Caledonia Ophiolitic Complex, Application to the Chromite Prospection by the French Team from Chromite Study, presented by *P. Podvin* and *J.P. Paris*, B.R.G.M., Noumea.

Structure, Seismic Stratigraphy, and Petroleum Potential of the Lord Howe Rise Area - *J.B. Willcos* and *P.A. Symonds*, Bureau of Mineral Resources, Canberra.

ANNEX VII

SUBCOMMITTEE PARTICIPANTS

A. TECTONIC EVOLUTION OF ARCS AND BACK-ARC BASINS

Branson, J.C.
Coleman, P.J. (Chairman)
Collot, J.Y.
Coulson, F.I.
Crook, K.A.W.
Falvey, D.A.
Greene, G.
Hughes, G.N.
Jouannic, C.
Katz, H.R.
Kroenke, L.W.
Larue, M.B.
Littlefield, R.G.
Macfarlane, A.
Malahoff, A.
Nion, S.T.S.
Packham, G.H.
Recy, J.
Richmond, R.N.
Saos, J.L.
Terman, M.J.
Tongilava, S.L.
Uyeda, S.
Weissel, J.K.
Willcox, J.R.
Yonekura, N.
Zdorovenin, V.V.

B. DEEP CRUSTAL STRUCTURE, PETROGENESIS AND THERMAL REGIME - EVOLUTION OF THE LITHOSPHERE

Allegre, C.J. (Chairman)
Cardwell, R.
Chatelain, J.L.
Collot, J.Y.
Dubois, J.
Evans, C.
Frazer, N.
Johnson, W.R.
Hawkins, J.
Lambeck, K.
Pontoise, B.
Rao, B.
Skinner, N.
Talandier, J.
Zhang, B.X.

C. STRATIGRAPHY, SEDIMENTARY PROVENANCE AND METALLOGENESIS

Cronan, D.S.
Cullen, D.J.
Daniel, J.
Doutch, F.H.
Eade, J.V.
Exon, N.
Grant-Mackie, J.A.
Lopatin, B.
Machesky, L.
McMurtry, G.
Malahoff, A.
Michel, R.D.
Utanga, T.A.
Winterstein, E.
Wright, J. (Chairman)

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