ABSTRACTS OF PAPERS PRESENTED AT THE STAR* SESSION, 1995

Keith A.W. Crook and Russell Howorth

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SOPAC Secretariat, Suva

*SCIENCE, TECHNOLOGY AND RESOURCES NETWORK

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FOREWORD

STAR was founded in 1985 as a vehicle to assist the international geoscience community to provide advice to SOPAC on Science, Technology and Resources in the SOPAC region particularly during the intervals between SOPAC International Workshops, the fifth of which, devoted to seabed mapping, was held in Noumea and Lifou, New Caledonia last year. The first Chairman of STAR, Dr Charles Helsley, then Director of the Hawaii Institute of Geophysics, guided STAR until 1992 when I took over the helm.

STAR is not merely a technical meeting at which individuals present scientific papers and discuss results and implications. Participants have the additional responsibility to formulate advice to SOPAC about its work program and to highlight technical and scientific issues of particular importance or urgency. This advice is tendered during the Technical Advisory Group (TAG) sessions during the Annual Session, and all STAR participants are invited and urged to participate in this phase of the meeting. To facilitate this, STAR and TAG sessions on related topics have been scheduled sequentially

One of the great strengths of SOPAC is its ability to mobilise excellent science and bring it to bear so as to address the national needs of SOPAC's island member countries. The long-established working relationship between SOPAC and the international research community is a vital element in this endeavour, which STAR is charged to nurture. This relationship stimulated an order-of-magnitude change in the geoscience database for the SOPAC region during the 1980's. This is summarised in Marine Geology v. 98,p.155-165 (1991).

In earlier years STAR was primarily concerned with "blue-water" marine geoscience, tectonics and resources. However, as national needs and priorities have changed, the scope of STAR has altered so as to ensure that SOPAC's Work Program and its forward planning are influenced by international science that is both excellent **and relevant.** SOPAC's 1996 Work Program and its Medium-Term Plan, which all participants should examine, encompass a broad spectrum of geoscience activities. So, new fields have been added to STAR, such as sea-level change and geo-hydrology. Coastal processes and coastal mapping, which have been the focus of several special workshops and training sessions since 1984, have been included. SOPAC's track record demonstrates that this approach to program development is synergetic, forwarding both the national needs of island nations and fundamental research. I commend it to you.

Keith A W Crook
Chairman, STAR

Hawaii Undersea Research Laboratory
University of Hawaii, Honolulu, HI
16 August 1995

STAR Presentations at SOPAC Annual Session, 1995

PROGRAM

Time	Theme	Authors & Speaker	Title
		Friday	
13.00-13.25	COASTAL	Collen & Eagar	Biological production of sand, Western Pacific atolls
13.25-13.50		Goff, Dunbar & Chague-Goff	Relative sea level change (earthquake signature) recorded in wave graded sediments of Wellington Harbour, New Zealand
13.50-14.15		Shorten, Armstrong & Smith	Holocene sea levels and tectonics in southeast Viti Levu, Fiji
14.15-14.40		Nunn	Holocene coseismic uplift at a convergent plate boundary: the geomorphology of Tongatapu island, Tonga
14.40-15.05		Teai	On Sea Level Change
15.05-15.35	**AFTERNOON TEA**		
15.35-16.00	COASTAL cond	Pickrill	Application of high resolution swath mapping to environmental marine geology in Canada
16.00-16.30 (30 minute slot)		Nunn	Sealevel change in the Pacific over the past 1000 years: environmental consequences and futures
16.30-17.00 (30 minute slot)		Mitchum	Satellite altimetry comes of age
17.00-18.00	**PANEL**	**DISCUSSION ON SEA**	**LEVEL CHANGE**

		Saturday	
08.30-15.00	**TAG COASTAL**		
15.30-15.55	SEABED MAPPING	Lafoy & Scientific Party	Demonstrating the benefits of Swath-mapping: main results of the ZoNeCo2 cruise
15.55-16.20		Parson & Hunter	The last decade of sonar bathymetry and sidescan data in the Lau Basin compiled a seven map series in a key SOPAC area.
16.20-16.45		Helsley & Clement	Application of Swath Imagery to Habitat Assessment of Deep-water Fisheries
16.45-17.10		Keating	Publication of Seafloor Images around Hawaii
17.10-17.35		Pelletier & Auzende	Structure of the Vitiaz Trench lineament from Solomon Islands to Horne Islands
17.35-18.00	DEEPSEA MINERALS	Auzende, Halbach & others	Tectonic, magmatic and hydrothermal activity in the North Fiji Basin (16o50'S-173o30'E and 16o30'S-176o10'E) (SW Pacific): HYFIFLUX cruise

Monday			
08.00-08.30 (30 minute slot)	DEEPSEA MINERALS cont	Hosoi	Japan/SOPAC deepsea mineral resources survey program
08.30-09.00 (30 minute slot)		Fujioka (Presented by Ono)	The past ten years' results of Japan/SOPAC deep-sea mineral resources survey
09.00-09.30 (30 minute slot)		Sakasegawa	Introduction of the Cruise Report of the Japan Deep Sea Impact Experiment (JET), 1994, MMAJ
09.30-10.00 (30 minute slot)		Sugiura (Presented by Ono)	Introduction to the deep-sea mineral policy of Japan
10.00-10.30	**MORNING TEA**		
10.30-10.55	DEEPSEA MINERALS cont	Lee, Lee & Chang	Mineralogy and geochemistry of manganese nodules from KODOS area in the Clarion-Clipperton Fracture Zones
10.55-11.25 (30 minute slot)		Temakon & Gunn	The Vanuatu Airborne Regional Geophysical Survey
11.25-11.50		Petterson, Magu & others	Toward a New Geological Framework for Solomon Islands: Results of Recent Geological and Geochemical Investigations of Malaita, Isabel, Ulawa, Makira, Guadalcanal, & Choiseul, (1989-1995)
11.50-12.15	OFFSHORE	Wright, Parson & Gamble	Migrating cross arc volcanism and back-arc rifting in the southern Havre trough
12.15-13.15	**LUNCH**	**PLEASE NOTE THE TIME**	**CHANGE**
13.15-13.40	OFFSHORE	Taylor	Compositional and textural variation in volcanic glass from the Lau Basin Southwest Pacific
13.40-14.05		Wright	Volcaniclastic processes on modern submarine arc volcanoes; evidence form southern Kermadec Arc
14.05-14.30	PETROLEUM	Shaw, Conolly & Coleman (Presented by Exon)	Reassessment of the petroleum potential of the Republic of Vanuatu
14.30-14.55		Kroenke & Resig	Origin and development of prospective abyssal anoxic basins, northern Fiji - southern Tuvalu
14.55-15.30	**AFTERNOON TEA**		
15.30-18.00	**TAG OFFSHORE**		

Tuesday			
08.30-08.55	GEO-HYDROLOGY	Leguere	Study of fresh lenses on Lifou and Mare Island, Loyalty Archipelago, New Caledonia
08.55-09.20		Gingerich & Peterson	Numerical modelling of atoll ground-water systems
09.20-09.45		Gingerich	The hydrothermal system of Kilauea Volcano's East Rift Zone: conceptual and numerical models of energy and solute transport
09.45-10.00	**STAR CLOSING**		
10.00-10.30	**MORNING TEA**		
10.30-12.00	**TAG WATER**		
12.00-13.00	**LUNCH**		
13.00-15.00	**TAG TRAINING**		
15.00-15.30	**AFTERNOON TEA**		
15.30-17.00	**TAG INFO SERVICES**		
17.00-18.00	**TAG FIELD SUPPORT**		

(Poster)		Crook	Combining SAR data of Huon Peninsula and Hawaii MR1 data of Huon Gulf, Papua New Guinea, assists studies of tectonic and sedimentary processes
(Poster)		Duckworth	Hydrothermal Processes, Sulphide Deposits and the Ocean Drilling Program
(Poster)		McMurtry	Modelling recent sediment accumulation in coastal estuaries and embayments with 137Cs and 210Pb: examples from the Ala Wai Canal and Kaneohe Bay, Oahu, Hawaii
(Poster)		Petterson	Stratigraphy and Deformation of Malaita; New Evidence from 1990-1995 Geological Surveys. Implications for the deformation and obduction of Ontong Java Plateau, (OJP)'

(Reserve Paper)		Montgomery	Examples of space-based SAR imaging capabilities from the 1994 Shuttle Imaging Radar missions

(Abstract)		Cronan	Some controls on the geochemical variability of marine manganese nodules in the equatorial South Pacific: Implications for exploration and evaluation
(Abstract)		Coleman	Movements along the Melanesian Boundary - Economic Implications
(Abstract)		Greene & Coale	The Iron Hypothesis: Links to Global Climate, Results from Iron Ex-II
(Abstract)		Parson	The interpretation of United Nations Law of the Sea guidelines for the delimitation of maritime boundaries of SOPAC member states
(Abstract)		Sakasegawa	Introduction to the advance of deep-sea mineral exploration techniques and systems of R/V Hakurei-Maru No. 2

STAR

ABSTRACTS

1995

Tectonic, magmatic and hydrothermal activity in the North Fiji Basin (16'50'S-173'30'E and 16'30'S-176'10'E) (SW Pacific): HYFIFLUX cruise.

Jean-Marie Auzende', Peter Halbach, Andreas Allspach, Klaus Becker, Norbert Blum, Olga Bonnier, Marc van Gerven, Margret Halbach, Andrea Koschinsky, Dietrich Lange, Maria-Joao Madureira, Emanuil Manoutsoglou, Johann Mrazek, Ute Munch, Christelle Pratt, Erio Rahders, Ann van Reusel, Steffen Richter, Thomas Seifert, Thoralf Spangenberg, Jochen Stenzler, Frank Thiermann, Michael Turkay and Reinhart Windoffer

ORSTOM, Noumea, New Caledonia

Mapping of the junction of the West Fiji Ridge (WRF) with the North Fiji Fracture Zone (NFFZ)

During the HYFIFLUX cruise the WFR was fully mapped from 17'10'S up to its junction with the NFFZ. Two main domain scan be individualised:

1- The spreading zone characterised by two segments trending N1O"E. South of 17'10'S the spreading rift is propagating southward. From 17' 10'S to 16'51'S the spreading zone shows a 3100 to 5000m-deep graben. In its southern part from 17'S to 17'10'S the graben deepens towards its axis. Between 16'51'S and 17'S the graben is divided in two symmetrical graben by an axial dome 100 to 200 m-high.

2- The junction zone between the WFR and the NFFZ characterised by the curvature of all the structures. Towards the east the spreading axis graben abuts in a deep (more than 4000m), wide (about 10 km) east-west elongated depression. On the western side the spreading axis is bounded by an east-west elongated massive culminating at less than 2000m-deep and 10 km-wide. To the north the area is limited by a steep east-west scarp about 1000m-high. These different features constitute the junction between the WFR and the NFFZ. This junction could be interpreted as a RFF triple junction.

The Central spreading ridge (CSR): Sonne 99, Pere Lachaise and White Lady sites.

Deep tow (EXPLOS) survey: During HYFIFLUX cruise 10 deep tow (EXPLOS) profiles have been carried out in the Pere Lachaise area (between 16'58'S and 16'55'S). The graben shows an intense fracturation and fissuration affecting lava tubes, pillows and lava lakes in the axial part. The main observe directions of faulting, are N15, which is the direction of the segment on which is located the area, but also N160 and N45. The EXPLOS exploration allowed the definition of the limits of the Pere Lachaise fossil hydrothermal field previously explored by Nautile. North of Pere Lachaise a new very extensive hydrothermal field has been discovered between 16'58'S and 16'57'S (SONNE 99 site). It is about 10 m-thick, 100 m-wide and more than 1000 m-long sulphide deposit located on the western edge of the axial graben.

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Some controls on the geochemical variability of marine manganese nodules in the equatorial South Pacific: implications for exploration and evaluation

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Superimposed on traditional controls on manganese nodule compositional variability in the South Pacific, such as metal source and nodule mineralogy, are additional controls related to biological productivity, depth, the lysocline and the CCD. Fluxes of Mn, Ni and Cu to the nodules increase in equatorial regions of high biological productivity, but high values of these metals in south equatorial Pacific nodules appear to be influenced by the CCD. This is thought to result from the concentration of labile organic matter there, the

decay of which fuels the diagenetic reactions leading to Mn, Ni and Cu enrichment in the nodules. However, this process appears to be at its most intense on the flanks of the South Pacific equatorial high productivity zone. This is thought to be due to biogenic silica, the concentration of which is not depth dependent, replacing biogenic calcium carbonate as the main diluent of labile organic material under the most highly productive waters. The implications of these results in terms of locating and evaluating the highest grade nodule deposits in the equatorial South Pacific will be described.

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Combining SAR data of Huon Peninsula and Hawaii MR1 data of Huon Gulf, Papua New Guinea, assists studies of tectonic and sedimentary processes

K A W Crook D R Montgomery , J E Hughes-Clarke, Keyu Liu & G P Whitore5
Hawaii Undersea Research Laboratory, University of Hawaii, Honolulu, HI USA; 2 Jet Propulsion Laboratory, Caltech, Pasadena, CA USA; Dept of Surveying Engineering, University of New Brunswick, Sackville NB CANADA; CSIRO Division of Petroleum Resources, Glen Waverley VIC AUSTRALIA; Dept of Earth Sciences, James Cook University, Townsville QLD AUSTRALIA

Two swaths of AIRSAR Synthetic Aperture Radar digital imagery, acquired over the southern Huon Peninsula, Papua New Guinea, by a NASA aircraft, have been merged with HAWAII MRI digital sidescan imagery of the adjacent Huon Gulf seabed. This provides an areal coverage that is almost complete, with sidescan details being lost only in the narrow inshore zone in water depths less than 500 m. The area imaged is a collision zone in which the northern margin of the Australian Plate is being subducted beneath the South Bismarck Plate. The latter has been uplifted 4000 m during the Quaternary, forming the Finisterre Range on Huon Peninsula, which is being rapidly eroded.

When draped over a topographic base derived from digitised 1:100,000 contour maps of the Huon Peninsula and HAWAII MR1 digital 50 m bathymetry of Huon Gulf, the imagery enables tectonic structures, such as faults, to be traced from the seabed onshore through rainforest covered areas. Major sediment supply systems, which traverse clearly delineated coastal fan deltas, can be traced across the inshore zone into the complex deeper-water foreset slopes of the fan deltas and beyond into submarine channel deposystems and submarine canyons that debouch into the Markham Canyon that follows the submerged plate boundary. Drowned coral reef tracts occur on the Australian Plate to the south.

Data limitations, and techniques used for merging data and deriving the draped imagery, will be discussed together with the geological implications of the study.

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Biological production of sand, Western Pacific Atolls

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A project is underway for the study of the relationship of foraminifera and ostracods to sediment production and movement on the western Pacific atolls of Funafuti (Tuvalu), Tarawa (Kiribati) and Majuro, Marshall Islands). The faunas are poorly known, and there have been no ecological or productivity studies.

Larger foraminifera are important because of their contribution to sand and gravel-sized sediment. Atolls in the Tuvalu, Kiribati and Marshall Islands lack good indigenous sources of aggregate and, increasingly, sediment rich in the tests of larger foraminifera is being dredged from the beach, reef flat or lagoon for use as gravel and sand in concrete. Little is known about their ecology, life cycles and growth rates, but without this information the dynamics of the sand and gravel sediment system cannot be fully understood.

The distribution, abundances and ecology of foraminifera and ostracods in the atoll sediments are being determined. Monthly sampling of specific sites over at least a 14-month period will allow determination of biomass and growth rates, and hence the annual precipitation of calcium carbonate by the most important species.

The results will be used to calculate the size of the resource and the amounts that can be utilised each year on a sustainable basis, which may help provide a quantitative base to resource management planning. The study will also contribute to knowledge of sediment movement along the atoll beaches, and to a wider understanding of foraminiferal and ostracod distribution in the tropical Pacific.

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Movements along the Melanesian Boundary - Economic Implications

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Over the last five years, new data continue to support the notion that the Melanesian Boundary, Tonga to the Halmaheras, is carrying exotic terranes to the area of the Halmaheras - the "New Alaska". As with the Melanesian Boundary, most, if not all, oblique convergences around the world appear to be marked by a bordering mosaic of fault blocks and to have this 'conveyor belt' capacity, to translate fault-defined crustal blocks great distances. As well, these blocks may be rotated and shifted vertically, by large amounts, at rapid rates (Figures 1 and 2). This exoticism and the shifting attitudes of fault blocks means that the strategy and tactics used in the search for mineral deposits have to be tuned to peculiar conditions, which differ from those of conventional, provincial geology.

The Melanesian Boundary has 'carried' great allochthons for at least the last 25 myr. The Fiji Platform has at least two exotic terranes, as also the New Hebrides Arc, the Solomons Arc has three, eastern New Guinea has at least ten, and western New Guinea some fifteen. The ages of most terranes are Tertiary, but some go back to Late Palaeozoic. The older ones derived from the edges of the old Gondwana, the younger from Pacific arc complexes such as the Solomon-New Hebrides-Fiji block. In sum, the Melanesian Boundary is studded with assorted crustal blocks. Rotated, raised or lowered, their dominant motion is lateral, to the west. Their ultimate fate - barring some large and permanent change in plate geometries - is to be jammed up against Asia in the region of the Halmaheras.

Strike-slip action along accommodation boundaries has economic implications. Significant items include:

- Any large area has to be surveyed and prospected as an individual entity -one such in a conglomeration. The old-style regional survey - rapid, spotty, with random sampling, very likely was a waste of time and money, and did not give a true indication of prospectivity.
- Transtensional and transpressional situations arise within the fracture mosaic and provide 'plumbing' for diapiric convective hydrothermal systems with caps enriched in metals. Such ready access, along with other empirical evidence, suggests that epithermal and possibly also porphyry copper deposits are a natural consequence of strike-slip, jostling action. In arc terrains, the prospector looks for such deposits not in hope but with firm expectation. In the western Pacific they will probably be young, less than 7-8 myr.
- Arc systems change their form and configuration through time. They may incorporate continental slivers (for example, Tonga, Viti Levu, New Hebrides). They may also incorporate blocks containing hydrocarbon source beds derived from 'upstream' parts of the plate boundary. In other words, the assessment of petroleum prospectivity of a region of arc rocks should not be bound too much by the convention that source rocks need necessarily to have arisen within the region itself.

Conceptually, if hypothetically, plate boundaries such as the Melanesian Boundary play an important part in the evolving pattern of plates and plates interaction. Expressed simply, this style of boundary is a 'rubbery'

buffer and as a buffer it allows rapid changes in the direction and rates of movement of plates, without drastic rupture of plate edges or severe internal stresses. The boundary takes up sudden divergencies and allows for the inertial lag implicit in plate movement: it is an accommodation boundary.

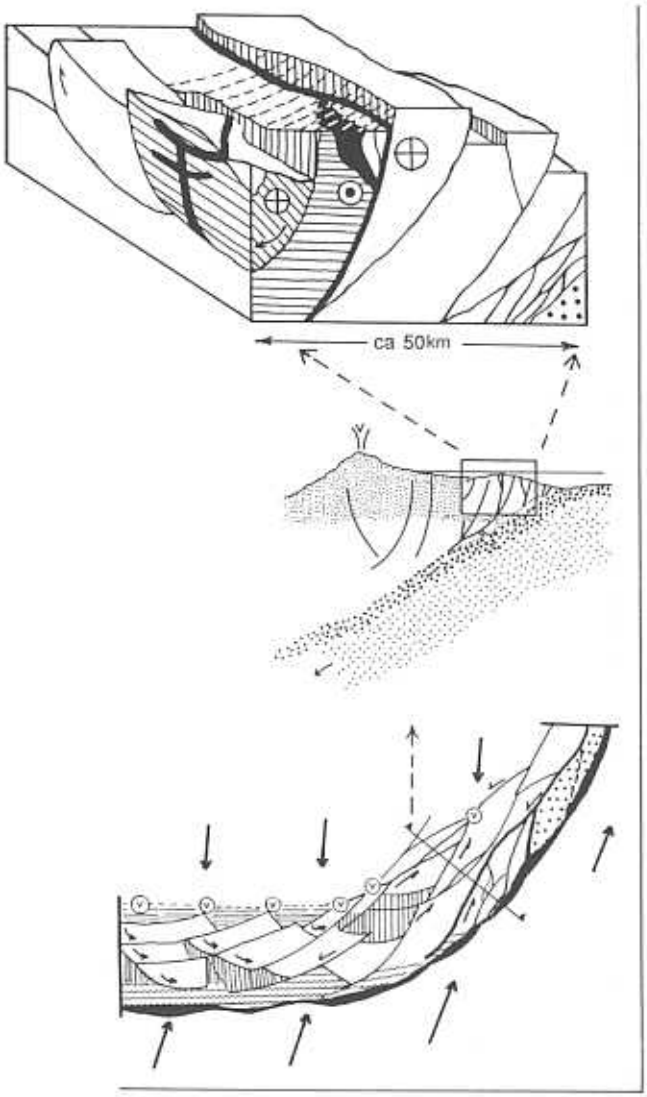

Figure 1. Cartoon of convergence with arc build-up and increasingly oblique angle of attack. The trench is in sinuous black; encircled **v** is a volcano. Bottom: plan view shows rotation, shearing and blocks with increased strike-slip fracturing as obliquity increases. Horizontal lines suggest summit or inner forearc basins, vertical lines basins of the pull-apart type, wavey lines near the trench are elements of the accretionary prism. The heavy line suggests the current master fault system. Individual blocks may be carried along the transform complex outboard of the master fault, for example, dotted block. Heavy bar is the approximate line of the section above: this is a profile of the arc with deep strike-slip fracturing - part is enlarged as the block diagram. These profiles stress the undulations in the fracture surfaces both in plan and in profile. Relative motion on these surfaces produces vertical and horizontal movement of blocks and also rotation and tilting. Transtensional and transpressional situations arise along fractures and provide 'plumbing' for diapiric convective hydrothermal systems with caps enriched in metals. These caps can be concealed by debris from a ramped block (centre) or tilted to give a misleading outcrop pattern (left) or even removed from the root stock.

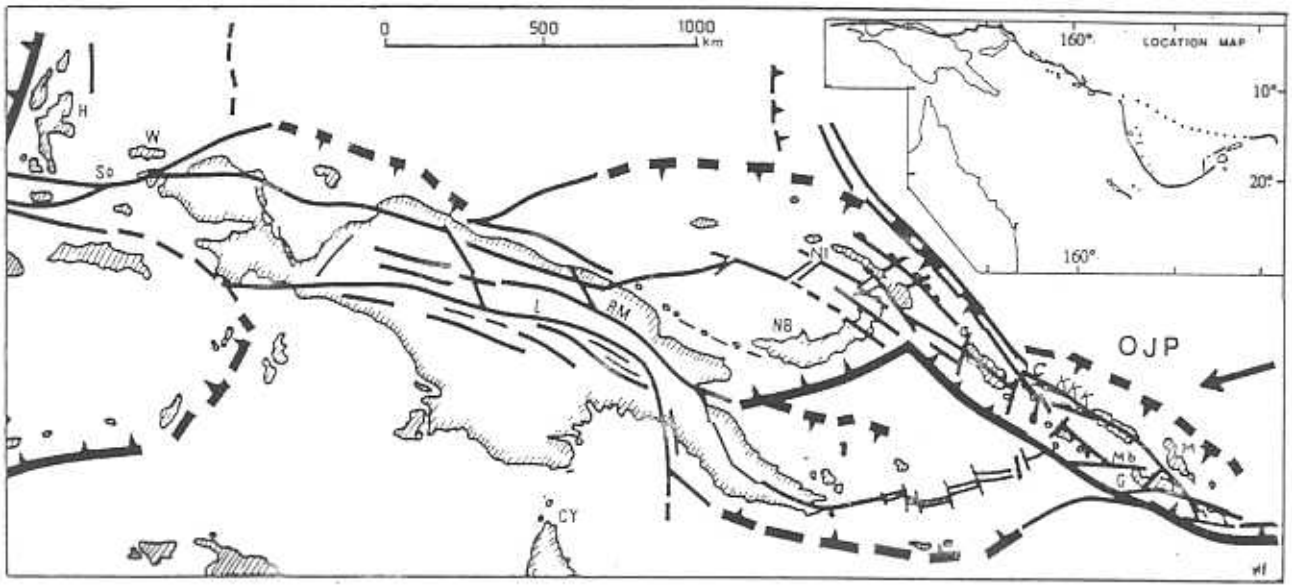

Figure 2. The central and western parts of the Melanesian Boundary, SW Pacific, Solomon Islands to Sulawesi (Celebes). Its extension east is shown in the inset location diagram. Convergence is highly oblique. Strike slip faults are prominent features of this plate boundary. Only the largest faults are shown, including - So-Rm - Sorong-Ramu Faults System K - Sula-Lagaip FS; KKK - Kia-Kaipito-Korigole FS. Inactive or past subduction zones are broken heavy lines with arrows. Subduction zones show tendency to transform to faults. Heavy arrow is convergence direction, Pacific plate. H - Halmaheras; So - Sorong fault; W - Wageo Island; T - Timor; L - Lagaip fault system; RM - Ramu-Markham fault system; CY - Cape York; NB - New Britain; NI - New Ireland; G - Guadalcanal; C - Choiseul; Mb - Mborokua lineament; M - Malaita; OJP - Ontong Java submarine plateau. As a composite transform convergence the total system operates as the boundary through geological time. The present-day functioning boundary includes the San Cristobal Trench - Solomon Trench - Bismarck Trench - Ramu-Sorong FZ.

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Hydrothermal Processes, Sulphide Deposits and the Ocean Drilling Program

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The Ocean Drilling Program is the largest international geoscience project in the world, and the state-of-the-art drill ship, the *JOIDES Resolution*, is permanently at sea. Each year there are six scientific cruises (Legs) which each last approximately two months. These legs are designed by geoscientists from the nineteen countries that subscribe to ODP. Australia and Canada share ODP membership under the banner of the AUSCAN Consortium.

The Australian Secretariat of the ODP has recently moved to the Department of Earth Sciences at JCU. It will be housed here for three years until April 1998, when it will rotate to another University. Professor Bob Carter is the Director of the Secretariat and Dr Rowena Duckworth is the Science Co-ordinator. The AUSCAN Consortium office is also currently housed at the Australian ODP Secretariat at JCU. The Canadian Secretariat is presently based at the University of Toronto, with Professor Steve Scott as Director and Dr Glenn Brown as Science Co-ordinator. Both Secretariats have major research interests in the ore deposits, both ancient and modern, and so there is currently a major drive by the AUSCAN ODP Consortium to make available data and technological information to the minerals industry.

This type of information includes data from drilling hydrothermal sites such as the hydrothermally active TAG black smoker complex on the Mid-Atlantic Ridge, drilled during Leg 158. The massive sulphide deposit underlying the black smokers is actually a pyrite-anhydrite breccia complex, and breccias also form the upper part of the stockwork. This is in contrast to the results from Leg 139 which drilled through the massive sulphide deposit in the turbidite-filled Middle Valley, northern Juan de Fuca Ridge, off the west coast of Canada. The massive sulphide deposit in this sedimented ridge is not brecciated to any major extent, and may suggest that the processes that form sulphide deposits in sedimented areas are different to those that form VHMS deposits in basaltic environments.

Legs scheduled for 1996 include two return trips to the Juan de Fuca Ridge which propose to:

- investigate further the Middle Valley hydrothermal region and associated sulphide deposits, and also the Escanaba Trough polymetallic sulphide deposits on the Gorda Ridge to the south (Leg 169, Figure 1).
- investigate the regional hydrothermal flow regimes on the Juan de Fuca Ridge, including at the transition zone between sediment-free and sediment-covered igneous crust (Leg 168).

In addition to these scheduled legs, there are several active proposals in the ODP system that aim to investigate hydrothermal deposits in the Pacmanus region, the Tyrrhenian Sea and the Red Sea/Atlantis II Deep. There is also a strong chance that the drill ship will be in the southern hemisphere around Australia and the Western Pacific in 1998-1999, and this will undoubtedly involve several Australasian port calls, which could generate over $2 million dollars in local revenue.

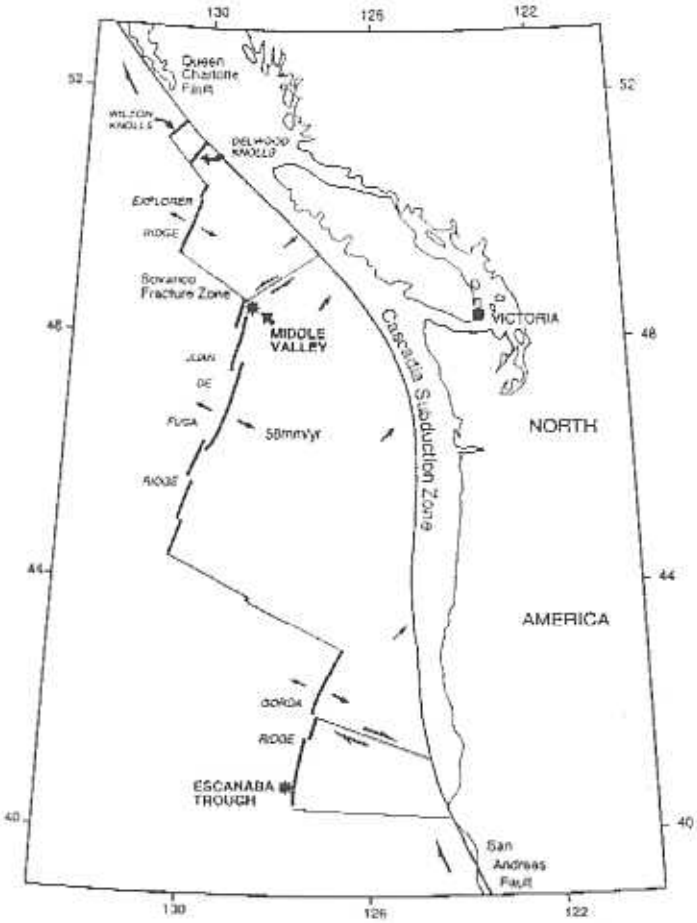

Figure 1. Location of the Middle Valley and Escanaba hydrothermal sites.

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Summary of the results of the Japan/SOPAC deep-sea mineral resources surveys over the past ten years

Hiroyuki Fujioka
Deep Ocean Resources Development Co., Ltd., Tokyo, Japan

In response to a request by the South Pacific Applied Geoscience Commission (SOPAC), the government of Japan has undertaken studies relating to mineral prospecting such as marine geological surveys to assess resources potential in the deep seafloor of offshore regions of SOPAC member countries.

Implementation of the survey has been consigned to the Japan International Cooperation Agency (JICA) as the Official Development Assistance (ODA), and JICA commissioned the Metal Mining Agency of Japan (MMAJ) to execute the survey since 1985. The survey was conducted in two stages, the First Stage for five-year period starting from 1985 and the Second Stage also for a five-year period from 1990.

Surveys of Manganese Nodules (Mn-Nod) and Cobalt Rich Crusts (CRC) were carried out within the exclusive economic zones (EEZ) of the Cook Islands, the Republic of Kiribati, Tuvalu and Western Samoa, and surveys of submarine hydrothermal deposits were carried out within EEZs of Papua New Guinea, Solomon Islands and Vanuatu.

The South Pacific Seafloor Atlas was published in March 1995, by JICA, MMAJ and SOPAC. The results of the surveys on the deepsea mineral resources in the South Pacific, carried out during the ten year period from 1985-1994, were summarised in the Atlas. The Deepsea Ocean Resources Development Co., Ltd. (DORD) has been ? by JICA-MMAJ for the surveys, and the Hakurei Maru No. 2 has been used throughout the period.

The results of the survey were summarised as follows:

Cook Islands	• average abundance; 10.97 kg/m^2 •average grade; 0.42% Ni, 0.26% Cu, 0.39% Co, 16% Mn, 16% Fe
Kiribati	•Ni rich type Mn-Nod; 2~3kg/m^2, 1.08~1.40% Ni •Co rich type Mn-Nod; 7~8kg/m^2, 0.26~0.33% Co
Tuvalu	•average thickness of CRC in the SBO8 seamount; 10.2mm •average grade; 0.89% Co, 0.62% Ni, 0.11% Cu, 23% Mn, 17% Fe
Western Samoa	•average thickness; 3.4mm •average grade; 0.41% Co, 0.23% Ni, 0.08% Cu, 18% Mn, 20% Fe
Papua New Guinea	•ore indications in the spreading center; iron oxides and iron hydroxides
Solomon Islands	•ore indications on the Kana Keoki Seamount: light gray clays (mainly sericite), siliceous and argillized rocks (disseminated by minor amounts of pyrite) and very small chimney-like substances (powdered galena and barite) •One specimen of the siliceous rock: microscopically-quartz, sericite and minor amounts of ore minerals (pyrite, chalcopyrite, tetrahedrite and sphalerite) analytically - 11.5g/t Au and 7.2 g/t Ag
Vanuatu	•ore indications: reddish brown precipitates containing iron oxides and a layer of manganese oxides

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Numerical modeling of atoll ground-water systems

Steve Gingerich and Frank Peterson
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One of the most difficult tasks in hydrogeology is to develop sustainable supplies of potable ground water from small atoll islands, since fresh ground water bodies within atolls are extremely fragile and sensitive to environmental and developmental stresses. Several investigators have used the numerical model SUTRA to simulate variable-density ground water systems within atolls. In this paper, the SUTRA model is used to examine the following aspects of atoll fresh ground water systems: (1) controls on the size and dynamics of the freshwater lens and (2) sustainable yields under varying recharge conditions. To study these problems, two different atoll models were simulated. The first uses a generic atoll island with hydrogeologic parameters that are a composite of several typical atoll islands in the Pacific Basin. The second uses the actual atoll island of Roi-Namur in Kwajalien Atoll, Republic of the Marshall Islands.

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The hydrothermal system of Kilauea Volcano's East Rift Zone: conceptual and numerical models of energy and solute transport

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The Lower East Rift Zone (LERZ) of Kilauea Volcano on the Island of Hawaii contains dike-impounded and basal groundwater affected by a hydrothermal flow system. Currently, a 25 megawatt geothermal production facility taps a deep geothermal reservoir to produce electricity for the Island of Hawaii. A study was conducted to determine the implications of geothermal development for the shallow ground-water system. To assess the impacts of development and gain a better scientific understanding of the flow regime in the LERZ, two phases of study were initiated: (1) a conceptual model of the shallow ground-water system was formulated based on previously published data and a shallow-well monitoring program and (2) numerical models of the hydrologic system were created based on the conceptual model. Continuous monitoring of water levels in shallow wells show that several factors obscure the changes of water level due to recharge events. Methods to remove the effects of ocean!

Tide and barometric influence from the water level records are presented. Temperature profiles in shallow wells show a warm water plume floating on the shallow aquifer. Numerical models of energy transport are used to estimate the flux of hot water entering the shallow aquifer from a deeper geothermal system. A numerical model of temperature and solute-dependent transport is used to investigate the flow patterns in the regional hydrologic setting.

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Relative sea level change (earthquake signature) recorded in wave graded sediments of Wellington Harbour, New Zealand

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Grain size trends at the northern end of Wellington Harbour are consistent with those of a wave-dominated coast, where an increase in mud content with increasing water depth is recorded. The eastern side of this

foreshore is exposed directly to incoming southerly storms, the effects of which dissipate to the west by wave refraction. Hence the eastern end of the foreshore has a deeper storm wavebase.

Two cores taken a short distance offshore show similar variations in percent mud over time, The relationship between sea floor sediment texture (percent mud) and water depth offshore is used to estimate changes in past water depth. A sharp decrease in mud of about 20% in each core correlates with an instantaneous change in water depth at these points of about 2.0 m. Changes in pollen and diatom assemblages, occurrence of industrial contaminants, and radiocarbon data, have been used to record changes in sedimentation rates. A review of chronologic data suggests that the instantaneous change in water depth is associated with a magnitude 8+ earthquake centered on the Wairarapa Fault in 1855.

Sedimentation rates vary by an order of magnitude from pre- to post-1855, with a more recent doubling over the past few decades. The increase in sedimentation rate is presumed to be driven by a combination of seismic and anthropogenic influences.

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The Iron Hypothesis: links to global climate, results from Iron Ex-II.

H Gary Grenne & Kenneth Coale

Over 20% of the world's open ocean surface waters are replete with the major plant nutrients (nitrate, phosphate, silicate) and light, yet standing stocks of phytoplankton remain low. If phytoplankton could grow to utilise these plant nutrients, they would take up carbon dioxide, thereby decreasing the concentration of this greenhouse gas in the atmosphere. We believe that during glacial times, there was abundant phytoplankton growth over much of the global oceans, whereas during the interglacials, phytoplankton growth was limited. The factors that limit phytoplankton growth and biomass in today's high nutrient, low chlorophyll (HNLC) areas have been vigorously debated, but not resolved.

It has been suggested that zooplankton grazing may contribute to the maintenance of low chlorophyll levels. Strong turbulence at high latitudes might also mix phytoplankton below the critical depth, resulting in light limitation of growth. We believe that in addition to these factors, micronutrient elements, such as iron, have the potential to limit phytoplankton production in HNLC areas Two studies were carried out to test this hypothesis in an unenclosed oceanic ecosystem.

The first experiment (conducted in 1993) resulted in a transient increase in production and a doubling of plant biomass, supporting the iron hypothesis, but the geochemical signal was weak. In the second experiment (conducted in May and June of 1995), a large geochemical signal was observed. In a 100 square kilometre patch enriched with 100 parts per trillion of iron, plant biomass increased by a factor of 30, carbon dioxide was depleted by 20% (100 microatmospheres) and 5 micromolar nitrate was taken up by phytoplankton resulting in the fixation of over 100 tons of carbon. Our results support the Iron Hypothesis and strongly implicate iron as the key factor controlling global climate.

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Application of swath imagery to habitat assessment of deep-water fisheries

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Worldwide attention recently has focused on the apparent depletion of fish stocks in many conventional fisheries. Within New Zealand similar concerns have been expressed, even though management of fish stocks through the Individual Transferable Quota (ITQ) system has provided fishermen with an incentive to

understand, maintain, and even enhance fish stocks. As a result of these concerns and the need to better understand the habitat of several important stocks of deep water fish, the New Zealand fisheries industry commissioned several swath mapping studies of portions of the New Zealand Exclusive Economic Zone (EEZ). These studies have focused on the understanding of the habitat of known fishing areas of orange roughy (Hoplostethus atlanticus) and the search for additional areas of similar acoustic character.

During the past year and a half, three research cruises have been carried out using the Hawaii Mapping Research Group's MRI system deployed from various fishing vessels. Several hundred thousand square kilometers of the New Zealand EEZ have been surveyed and extensive areas of suitable habitat have been identified. Experimental fishing on selected targets in these newly surveyed areas have yielded good catches and thus the exploratory effort using swath mapping techniques is considered to be very successful.

Since the targeted species is known to inhabit waters greater than 700 meters, and fishing techniques limit the maximum depth of interest to about 1500 meters, it has been necessary to use both real-time bathymetry and imagery in the search for these new fishing grounds. High quality imagery is most important in the initial search and in the hands of acknowledgeable user is in itself a powerful tool for the recognition of a large area of seafloor. However, since the search is confined to a target depth range adequate knowledge of the general depth regime is also necessary and can be determined as the survey progresses. For inexperienced users, the interpretation of the imagery presents difficulties and thus high quality bathymetry, acquired in post cruise processing, has proved to be very useful. Means of concurrently presenting bathymetry and imagery to the enduser, the fishing captain, is a necessary future goal.

Preliminary conclusions from our surveys have been communicated to the New Zealand fishing industry along with detailed descriptions of the areas surveyed. In general, habitat suitable for orange roughy is more extensive than originally envisaged and thus plans can be made for a more conservative harvesting procedure. However, the more important conclusion is that swath mapping can be used effectively to assess large areas for their deep water fishing potential. Moreover, this may be a technique that can be adapted to the identification of other sites where other economically important species of deep-water fish may be present.

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Japan/SOPAC Deepsea Mineral Resources Survey Program

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This program started in 1985 as a five year cooperative study project between Japan and SOPAC. The purpose of this program is to assess the potential of deep seabed mineral resources, such as manganese nodules, cobalt-rich manganese crusts and hydrothermal deposits within the Exclusive Economic Zone (EEZ) of SOPAC member countries through the use of research vessel Hakurei Maru No.2. This project has been executed by the Japan International Corporation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ) under the supervision of the Japanese government.

Phase 1: from 1985 to 1989 was as follows:

1985	Cook Islands - North Penrhyn Basin for Manganese Nodules
1986	Cook Islands - South Penrhyn Basin for Manganese Nodules
1987	Kiribati - Phoenix Islands for Manganese Nodules & Cobalt-rich Crusts
1988	Tuvalu - Ellice Islands and Ellice Basin for Manganese Nodules & Cobalt-rich Crusts
1989	Kiribati - Southern Line Islands for Manganese Nodules & Cobalt-rich Crusts

The total survey area is 1 852 000 km

Phase-II which started in 1990 and concluded in March 1995 is as follows:

1990	Western Samoa - Samoan Islands for Manganese Nodules and Cobalt-rich Crusts Cook Islands - Southern Cook Islands for Manganese Nodules
1991	Kiribati -Gilbert Islands Group for Manganese Nodules and Cobalt-rich Crusts
1992	Papua New Guinea - Manus Basin for Hydrothermal Deposits
1993	Solomon Islands & Papua New Guinea (partial) - Woodlark Basin for Hydrothermal Deposits
1994	Vanuatu - Coriolis Trough for Hydrothermal Deposits

The total survey area is 2 664 200 km

Phase-III

Following on from the valuable results of both Phases I and II, and the keen interest and support shown by the Federated State of Micronesia, Fiji, Marshall Islands and Tonga to have their waters included in the survey program, the Japanese Government has approved the extension of this program for a further five years. The approval means 15 years of unbroken interest in deepsea minerals of the South Pacific shown by Japan. This record of continuity in deepsea mineral resources is unique in the Pacific. The marine resources (including seabed minerals) are important for the developing nations in this area. With the addition of swath mapping, this program gives added benefits to SOPAC member countries.

Phase-III which starts in 1995 is planned as follows:

1995	Tonga -Tonga Ridge and East Lau Basin for Hydrothermal Deposits and Cobalt-rich Crusts
1996	Marshall Islands - Whole Area (East) for Manganese Nodules and Cobalt-rich Crusts
1997	Federated States of Micronesia - Northern West Area for Manganese Nodules & Cobalt-rich Crusts
1998	Federated States of Micronesia - Northern East Area and Marshall Islands -Whole Area (West) for Manganese Nodules and Cobalt-rich Crusts
1999	Fiji - North Fiji Basin and West Lau Basin for Hydrothermal Deposits

Atlas

The results of projects over the past ten years have been incorporated into an Atlas "South Pacific Seafloor Atlas" which includes maps covering wide interests. The Atlas has been presented to the SOPAC member countries covering Phase-I and Phase-ll namely Cook Islands, Kiribati, Tuvalu, Western Samoa, Papua New Guinea, Solomon Islands and Vanuatu. Two hundred (200) copies of the 24-page full color Atlas in the AI format were presented by a Japanese mission to SOPAC in March 1995. This is the first Atlas of this kind produced for the South Pacific.

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Publication of seafloor images around Hawaii

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Many seafloor mapping systems have been deployed within the Exclusive Economic Zone (ZOO-miles) around the Hawaiian Islands. The surveys range from small localised areas mapped for submersible dives or dredge relocation work, to long narrow corridors for cable route surveys, to more regional mapping for navigational purposes. The mapping was carried out by a variety of agencies including the University of Hawaii, federal agencies, military organisations, and private business. The data from these disparate sea floor surveys have been compiled into a large format (28 x 40 inches) atlas containing maps, photographs,

side-scan sonar images, three-dimensional bathymetric models and interpretive text. The images provide us with a new look at the Hawaiian island and seamount chain.

The scientific studies associated with these mapping efforts provide a new understanding of the submarine geologic features, new targets for fisheries resources development, and more insights into geologic hazards associated with island-living. While each of these sea floor surveys was completed to meet a specific and limited goal, the images produced in these surveys often far exceed their initial purpose. In several cases, evidence of geologic features around the Hawaiian islands has raised considerable interest and, in some cases concerns, for the State of Hawaii Civil Defense. On the southwest margin of the island of Hawaii, faults can be observed within the side scan sonar images that result from the slumping of this margin of the island. The downward motion of this margin produced tsunamis and earthquakes but the size of the active region was not appreciated until these maps were prepared. Side scan sonar images of the nearby Loihi Seamount show that the feature is an actively growing seamount that will continually be a source of earthquake activity and a worry to residents of the southern coast of Hawaii. SeaBEAM surveys on the southeast margin of the island show massive landslide debris ramps and levees. Ocean Drilling sampled debris that is likely to be associated with this major landslide on the seafloor 200 miles off the coast of Hawaii. Sedimentary deposits high on the slopes of the island of Hawaii could well be the product of a tsunami caused by a marine landslide of this nature.

Much smaller landslides are present on Cross Seamount, just 150 miles off Oahu and Hawaii, that could produce tsunamis affecting the populated portion of the Hawaiian island chain. A large portion of the Johnston Island margin has slumped in a large slide that appears to dramatically affect the features of the island. Offshore the island of Oahu, side-scan sonar images document a young sediment-free lava flow on the slopes of the island, suggestive of young volcanism near the population center of Honolulu.

Of interest to fisherman, divers and the coral industry are the drowned reef terraces which step-down the margins of the Hawaiian islands. The side-scan sonar images (and an extensive survey of the seismic reflection records) show that the upper shelves of the islands are step-like. As the sea level rises relative to the island or islands sink relative to sea level (they have sunk in the range of 1-3 km.), new reefs form along the coastline. When the rate of sinking of the islands is too great or sea level rises, the reefs drown. When sea level rises, wave-cut notchs and cliffs are cut by active wave erosion. Thus the islands act as dip sticks in the ocean. The youngest of these drowned reefs represent excellent habitat for fish. On more isolated seamounts, maps of acoustic character are complete that would be an asset to the analysing of rockfish habitats for commercial fisheries.

During the preparation of the atlas, bathymetric data from SeaBEAM and HMRG mapping systems was merged with conventional bathymetry, and digital terrain models to produce a new bathymetric map of Hawaii. This data was then used to generate 3-dimensional bathymetric models and shaded relief maps of Hawaii. These color maps show very clearly the improvements in the shapes and details of land forms in the areas around the southern half of the island of Hawaii where detailed sea floor mapping surveys have been completed, Many features such as large marine landslides and young volcanoes can be seen in these detailed images. The fabric of the old Cretaceous sea floor on which the Hawaiian chain formed, stands out in marked relief. Old Cretaceous age seamounts trend under the Hawaiian chain and give the appearance that several old, small seamounts were probably buried by the massive Hawaiian volcanoes. The digital data set produced in association with the atlas will be available in September.

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Origin and development of prospective abyssal anoxic basins, northern Fiji-southern Tuvalu

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The application of new concepts during a recent interpretation of the SOPACMAPS data has provided new insight into the tectonic development and structural framework of the Melanesian Borderland. The SOPACMAPS data are a proprietary geophysical data set, which includes Symrad EM 12 multibeam imagery and swath bathymetry, as well as gravity, magnetic, and seismic reflection profiling data that were collected by IFREMER under contract to the South Pacific Applied Geoscience Commission (SOPAC) with European Union funding. The region encompassed by the SOPACMAPS surveys extends from the New Georgia Group in the Solomon Islands to the eastern end of the Vitiaz Trench in southern Tuvalu, The SOPACMAPS data reveal the presence of a series of large, steep-sided troughs in the northern Fiji and southern Tuvalu EEZs. These troughs are also marked by large, negative gravity anomalies, which may have misled earlier investigators into believing that they constituted the eastward extension of the Vitiaz Trench. Morphologically, however, the troughs resemble grabens which do not appear to be the eastward continuation of the Vitiaz Trench. Based on Seasat derived gravity data, as well as some of the seismic reflection profiles, the Vitiaz Trench appears to pass to the north of most of the troughs. We believe that these troughs comprise a series of large, deep rift-grabens that developed during a period of extensional tectonism accompanying the formation of either the Vitiaz or New Hebrides subduction zones. Similar extensional tectonism has been suggested to have accompanied the formation of the Mariana Trench (Stern and Bloomer, 1992). The grabens situated in the Vitiaz Forearc could have developed either as early as the initiation of Vitiaz subduction (~ 43 Ma) or as late as the inception of New Hebrides subduction (–12 Ma). Furthermore, these grabens form closed basins where anoxic conditions could have prevailed, and contain thick sequences of sediment. In addition to pelagic sedimentation, up to four episodes of volcanism within the region (that is, Samoan hot spot, New Hebrides Arc, North Fiji Basin rifting/spreading, and rejuvenated Vitiaz Arc volcanism) contributed sediments to the basins. Other sediment may have been derived from shallow reef platforms that form the banks adjacent to these thickly sedimented basins.

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Demonstrating the benefits of Swath-mapping: main results of the ZoNeCo programme

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The multi-disciplinary ZoNeCo programme aims to assess the non-living and living marine resources of New Caledonia's Economic Zone.

The second Offshore operation of the ZoNeCo programme, the ZoNeCo cruise, was carried out in August 1994 on board RV L'ATALANTE, north and east of New Caledonia mainland. ZoNeCo 2, a seafloor mapping, geophysics and physical oceanography survey was aimed at identifying both potential sites of interest for fishery targets and structural elements making up the Loyalty Ridge.

Newly discovered shoals, potential sites for living and non-living resources are present: (I) in the Grand Passage, located north of New Caledonia; (ii) along the Loyalty Ridge and its northern extension.

Water depths shallower than 500 m represent an area of: (I) 106 square kilometres within the Grand Passage; (ii) 230 square kilometres along the Loyalty Ridge.

Water depths between 500 and 1000 m represent an area of: (I) 1135 square kilometres within the Grand Passage; (ii) 3295 square kilometres along the Loyalty Ridge.

The ZoNeCo 2 cruise results allowed the HALICAL 1 (1994) and HALICAL 2 (1995) fishing cruises to be carried out. These exploratory fishing surveys aimed at assessing living resource potentialities of the "targets" selected after interpretation of the ZoNeCo 2 cruise data.

In 1993, the ZoNeCo 1 cruise carried aboard L'ATALANTE discovered new shoals, potential sites for living and non-living resources. Sixty volcanic features were mapped, of which 37 < 1000 m. Water depths shallower than 500 m represent an area of 347 square kilometres along the Norfolk/New Caledonia Ridge. Water depths between 500 and 1000 m represent an area of: (1) 2133 square kilometres along the Norfolk/New Caledonia Ridge; (2) 1,097 square kilometres along the Loyalty Ridge.

ZoNeCo 1 interpreted swath bathymetry and side-scan sonar imagery maps allowed to select targets for future assessment of fishery and mineral resources.

In 1996, we plan to charter a suitable boat to conduct a deep bottom trawling survey within the ZoNeCo 1 "Box" mapped by L'ATALANTE in 1993. Fishing targets are the Norfolk/New Caledonia and the Loyalty ridges. Target species are orange roughly and any other deep bottom fish.

Before ZoNeCo 1, along the Loyalty Ridge's guyot "K" centred at 24'45'S - 170'05'E, water depths shallower than 1000 m represented an area of 37.62 square kilometres along guyot "K". After ZoNeCo 1, water depths shallower than 1000 m represent an area of 96.25 square kilometres along guyot "K".

Swath bathymetry and imagery data are necessary (but not sufficient) to explore marine resources, as distribution and exploitation of resources are linked to: (1) the morphology and depth of the bottom; (2) the nature of the substratum.

In 1997, a dredging/coring survey is likely to be conducied on the ZoNeCo 1 "Box" mapped by L'ATALANTE.

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Mineralogy and geochemistry of manganese nodules from KODOS area in the Clarion-Clipperton Fracture Zones

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Manganese nodules from 94-KODOS area in the Clarion-Clipperton Fracture Zones can be macroscopically categorised into massive, layered and mixed zones, based on the internal texture. The massive zone is relatively porous and highly reflective, whereas the layered zone is dense and low in reflectance. Both zones also show different micro texture, chemical composition and mineralogy.

The massive zone, texturally consists of crystalline lamella, has high content of Mn, Cu, Ni and Zn. Mineral phases are buserite and todorokite. Electron probe analysis show two types of mineral composition in the crystalline lamella; Ca-K rich and Al-Mg rich phases. The layered zone, texturally of low-crystalline lamella, has high content of Fe and Co, and mainly composed of vernadite. Electron probe analyses results show Fe-Si rich and Si-AI rich phases in the layered lamella. The mixed zone shows intermediate composition of massive and layered zone plotted in both diagenetic and hydrogenetic field in the Fe-Mn-(Cu+Ni+Zn) diagram.

These results are closely related to the surface and internal texture of manganese nodules. Nodules with gritty or rough surface are predominantly of massive texture, and nodules with smooth surface are of layered texture.

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Study of fresh water lenses on Lifou and Mare Island, Loyalty Archipelago, New Caledonia

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This study was funded by New Caledonia Territory and carried out between November 1991 and February 1993. Lifou and Mare islands are the southernmost islands of the Loyalty Archipelago located about 100 km east of the main island in New Caledonia.

They are uplifted coral reefs islands (average height is respectively 40 and 60 m) occupied by fresh water lenses which, expecting the rain water, are the only fresh water resources of the islands. The existence of these lenses, due to the density difference between fresh and salt water, is linked with the permeability of the aquifer strata, the rainfall supply and the anthropic exploitation.

This study concerns the quality (vulnerability map of the water lenses) and the quantity (exploitation map) of the underground water resource. It also permits a water-use budget to be defined along with some rules for protection and exploitation of the resource.

As part of this study a monthly report is published monitoring the underground water lens.

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Modeling recent sediment accumulation in coastal estuaries and embayments with 137Cs and 210Pb: examples from the Ala Wai Canal and Kaneohe Bay, Oahu, Hawaii

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Radiochemical studies of sediments from the Ala Wai canal, an urban estuary in Honolulu, and of soils and stream sediments from the central Honolulu watershed were undertaken to investigate the sediment accumulation history and estimate the sediment yield and denudation rate of the watershed. Modern high-purity Ge gamma spectrometry techniques were used to assess the activities of U-series and 137Cs radioisotopes in stratigraphic subsamples of three 1-2 m long sediment cores, fourteen watershed soil horizons, and grab samples of seven tributary stream sediments. Geochronology based on excess 210Pb, using either steady-state constant flux or constant activity models yield ages that exceed the known age of the Ala Wai canal. Geochronology based on a non-steady-state, 2-box, erosionhe-deposition model of fallout 137Cs yields sedimentation rates for the canal of between about 2 and 22 cm/yr. These rates generally exceed those based upon excess 210Pb by more than a factor of two and agree with the known age of the canal and with sedimentation rate estimates based upon bathymetry changes. Based on the 137Cs-model chronology from 1957 to 1991, the Ala Wai canal collects bulk sediment at a mean rate of about 3,100 metric tons annually. About 80% of the sediment is detrital clays from erosion of the central Honolulu watershed, whereas about 20% of the sediment is composed of marine authigenic and biogenous phases. The sediment yield for the central Honolulu watershed of about 60 metric tons/km a year equates to a physical denudation rate of ca. 6 mg/cm a year -- at the low end of the range of physical denudation rate estimates for the island of Oahu. Based on the mean 137Cs sedimentation rates and an average canal water depth of 2 m, the average time to fill the canal is about 60 years, assuming little sediment escapes. The mean fill time is only about 40 years for the middle canal segment, which receives most silt from the Manoa-Palolo drainage canal, whereas for the outer and inner canal sediments, mean fill times are about 70 years. For the Ala Wai canal, the flux of excess 210Pb generally follows the sedimentation rate, and is not constant with time. The variable excess 210Pb flux into the canal sediments may be related to a

complex mechanism of soil erosion that is amplified by the extreme sediment focusing of this watershed into the canal.

For Kaneohe Bay, the largest sheltered water body in the Hawaiian Islands, eroding reefs and runoff from the Kaneohe watershed provide sources of sediment accumulation. Recent sedimentation may have been altered due to a number of changes to the bay in the past 70-100 years, including dredging from ship channels, a shift from native-style to modern agricultural techniques in the bay watershed, dramatic urbanisation of the southeastern bay watershed, and substantial sewage input from the 1950's until 1978. Here we collected multiple sediment cores from five sites within the bay using a SCUBA-diver-operated piston corer. About 50-80% of the sediment is marine biogenous carbonates, whereas about 20-50% of the sediment is composed of detrital clays from erosion of the watershed. Sediment accumulation rates were determined by excess 210Pb geochronology using the steady-state constant activity model, and by the penetration depths of 137Cs. Using porosity-corrected depths, we calculate sedimentation rates of 0.4 to 1.4 cm/yr (mean = 0.9, 0.3 cm/yr) for the period from 1994 (collection) until 1977 to 1987, the exact date depending on the core. Prior to 1977 to 1987, sedimentation rates decrease to 0.1 to 0.4 cm/yr (mean = 0.3 , 0.1 cm/yr). Overall sedimentation rates determined from 137Cs penetration depths range from 0.34 to 0.64 cm/yr (mean = 0.57 , 0.06 cm/yr), and generally compare well with overall sedimentation rates based on excess 210Pb (range: 0.35 to 1.4 cm/yr, mean = 0.62, 0.18 cm/yr). These sedimentation rates are much lower, however, than previous estimates of bay sedimentation based on hathymetry profiles for the period 1927 to 1976 (range: 1.4 to 3.7 cm/yr, mean = 2.7, 0.5 cm/yr) that we believe are in error. The increase in bay sediment accumulation from the late 1970s could relate to the cessation of sewage input to the bay, or to population and housing increases for the Kaneohe Bay watershed. There are no significant changes in the rate of increase for either population or housing units for the late 1970's to mid 1980's period, but perhaps a better assessment of the effects of human population and housing construction on watershed runoff and bay sedimentation should consider where within the watershed growth of population and housing construction are located, rather than simply relying upon gross statistics. New construction within the steeper and wetter portions of the watershed will have a much greater impact upon runoff and detrital Sedimentation (as well as marine sedimentation--through enhanced productivity) than developments within less steep or drier watershed areas.

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Satellite altimetry comes of age

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With the launch of the joint US-French satellite mission named TOPEWPOSEIDON, sea surface height measurements from space have reached a level of accuracy that is comparable to that of sea level observations from tide gauges. The performance of the TOPE/POSEIDON instruments will be described via an intercomparison with the tide gauges measurements. The relative advantages and disadvantages of these two measurements systems will be discussed as well.

A review will also be made of various types of research that are being done with the altimetric heights. For example, a report on calculations aimed at estimating sea level rise will be given, and a critical examination of this approach will be offered. Also, the importance of the altimeter data to the monitoring and further understanding of the El Nino - Southern Oscillation events will be discussed.

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Sea-level changes in the Pacific over the past 1000 years: environmental futures and consequences

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The patterns of sea-level changes in the Pacific over the past 1000 years has been closely linked to temperature changes. Three periods are identified. The Little Climatic Optimum lasted from approximately 1200 BP until 650 BP and was a time of comparatively high temperatures and rising sea level. The Little Ice Age lasted from around 650 BP until around 150 BP (AD 1800) and was a time of comparatively low temperature and low sea level. The last 195 years have been marked by rises in temperature and sea level. The effects of these on coastal environments and reefs are described.

Emphasis is placed on the evidence for sea-level rise during the period of continuous monitoring in the Pacific. While there are significant variations, the best records all show sea-level rise to have been affecting Pacific island coasts for the past 100 years or so. Oral evidence over the same time period has been collected from interviews with elderly inhabitants of long-established coastal settlements.

The relationship between temperature and sea level in the past millennium is important to understand in the search for analogues of predicted future changes. Some comment on likely future environmental changes is given.

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Holocene coseismic uplift at a convergent plate boundary: the geomorphology of Tongatapu Island, Tonga

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Coseismic (earthquake-coincident) uplift is common along convergent plate boundaries in the South and West Pacific but has not been described before from Tonga.

The south coast of Tongatapu is cut by emerged notches and shore platforms at regular vertical intervals. The offshore Porolithon algal ridge is (unusually) terraced. The modern reef flat shows various degrees of emergence relative to mean sea level. These are all likely indicators of coseismic uplift. Analysis of their elevations shows that there are 9 emerged shorelines, each of which was probably elevated in a single coseismic event.

Coseismic-uplift events with a recurrence time of around 869 years and associated with uplift magnitudes around 0.74 m are responsible for the emergence. Late Holocene uplift averaged 1.6 mm/year.

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The interpretation of United Nations Law of the Sea guidelines for the delimitation of maritime boundaries of SOPAC member states.

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The sixty requisite signatures to the UN Convention of the Law of the Sea have been made as of November 1974, and thus the Convention has become a Treaty. Within the next decade, states ratifying the treaty will be preparing their proposed maritime boundary claims to the UN Commission dealing with the delimitation of territorial waters, Exclusive Economic Zones and areas of Continental Shelf. The SOPAC member states

have collectively a complex surrounding seafloor with a wide variety of islands, archipelagoes, plateaux, ridges, banks and spurs, and it is of crucial importance to ensure that the criteria provided by the UNCLOS guidelines are used efficiently in delimiting the outer limits of a coastal states' jurisdiction. The guidelines make allowance for areas of complex seafloor, and in some cases, extend beyond the nominal 200 nautical miles from baselines. Cases for such extension may be developed in conjunction with scientific advisors using standard data bases acceptable to the Commission. A series of examples of coastal states' claims will be discussed which involve the evaluation of, among other things, the status of archipelagic groups, natural prolongations, overlapping claims, resource assessment and the development of boundary claims.

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The last decade of sonar bathymetry and sidescan data in the Lau Basin compiled - a seven map series in a key SOPAC area.

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Swath bathymetry data, conventional echo-sounder profiler data, and long-range sidescan sonar data from fifty geophysical cruises completed over the past decade have been combined to develop a bathymetric chart series for the Lau Basin between 14 and 24 degrees south and 175 and 180 degrees west. Seven charts comprise a comprehensive set of data presenting isobaths at 100 metre intervals, accompanied by a detailed geological interpretation. Bathymetric contours have been compiled by hand, then scanned and vectorised to produce a readily upgradeable dataset readily interfaced to existing systems via a variety of formats. Hard copies, Internet distribution, tape or CD-ROM versions of these data will be available within 1995. The aim of this work is to provide a baseline for the Commission to build on, and the authors seek guidance as to what direction they feel the compilation should grow.

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Structure of the Vitiaz Trench Lineament from Solomon Islands to Horne islands

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The Vitiaz Trench Lineament limits northward the Solomon Island Arc, the North Fiji and the Lau Basins, and consists from west to east of the North Solomon Trench, the Cape-Johnson Trench, the Vitiaz Trench and three discontinuous and elongated troughs (Alexa, Rotuma and Horne Troughs) which connect the Vitiaz Trench to the northern end of the Tonga Trench. This seismically inactive lineament which is, although largely unknown, one of the most important tectonic features to be taken into account for the Cenozoic tectonic development of the SW Pacific since it separates the Cretaceous crust of the Pacific Plate to the north from the Cenozoic lithosphere of the North Fiji and Lau Basins to the south. The lineament is considered to be the convergent plate boundary between the Pacific and Australian Plates during middle to late Tertiary time when the Vitiaz Arc was a continuous east-facing arc from Tonga to the Solomon Islands. It has been generally accepted that convergent motion between the Australia and Pacific Plates since the Late Miocene was absorbed exclusively along the San Cristobal Trench, southwest of the Solomon Islands Arc and along the New Hebrides Trench west of the New Hebrides Arc. However progressive reversal and cessation of subduction from west to east in the Late Miocene-Lower Pliocene have been proposed. But precise structures and age of initiation and cessation of deformation along the Vitiaz Trench Lineament are unknown.

Parts of the Vitiaz Trench Lineament and adjacent areas have been surveyed in 1993 by the R/V L'ATALANTE during the three-leg cruise of the SOPACMAPS Project. Swath bathymetry, sonar imagery,

seismic reflection, magnetic and gravity data collected during the cruise provide new insights on the geometry and the structure of the lineament and on the tectonic evolution of the Pacific-Australian Plate boundary.

The surveyed areas located around Alexa and Rotuma Troughs reveals that the lineament is composed of a series of WNW-ESE and ENE-WSW segments in front of large volcanic massifs belonging to the Melanesian Border Plateau a WNW volcanic belt of seamounts and ridges on the Pacific crust. The Plateau and Pacific plate lying immediately north of the lineament have been affected by intense normal faulting, collapse, and volcanism evidenced by a series of tilted blocks, grabens, horsts and ridges trending N120 to N100 and N60-70. This tectonism includes several normal faulting episodes, the latest being very recent and possibly still active. The trend of the fault scarps and volcanic ridges parallels the different segments of the Vitiaz Trench Lineament, suggesting that tectonics and volcanism are related to crustal motion along the lineament. Although the superficial observed features are mainly extensional they are interpreted as the result of shortening along the Vitiaz Trench Lineament. The fabric north of the lineament would result from subduction-induced normal faulting on the outer wall of the trench and the zig-zag geometry of the Vitiaz Trench Lineament might be due to collision of large volcanic edifices of the Melanesian Border Plateau with the trench, provoking trench segmentation along left-lateral ENE-WSW transform zones. The newly acquired bathymetric and seismic data suggest that crustal motion (tectonism associated with volcanism), which is possibly still active, continued up to very recent times along the eastern part of the Vitiaz Trench Lineament, during the tectonic development of the North Fiji Basin.

The surveyed region east of Malaita Island, was interpreted as a piece of oceanic crust from the Ontong Java Plateau obducted over the old Solomon Islands arc during collision between the Pacific and Australian Plates. Data allow us to classify the successive parallel ridges mapped within the region as being recent volcanic or oceanic crust or deformed sedimentary ridges. Seismic profiling provides evidence of successive compressive events along the Malaita margin caused by the relative motion between the Solomon Islands and the Pacific Plate. The main phase of convergence probably occurred during Oligocene-early Miocene time, but some relative motion between the two domains are still being absorbed along the North Solomon Trench, east of Malaita.

Data collected during the SOPACMAPS Project also indicate left lateral transtensional deformation in the Melanesian Arc Gap between the New Hebrides and Solomon Arc, and along the southern edge of the Central Solomon Trough.

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Toward a new geological framework for Solomon Islands: results of recent geological and geochemical investigations of Malaita, Isabel, Ulawa, Makira, Guadalcanal, and Choiseul, (1989-1995)

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Recent field and petrological-geochemical investigations of mainly basement sequences from a number of the main islands of Solomon Islands have resulted in a new geological framework model for Solomon Islands, (Figure 1). We have used the classic Coleman-Hackman geological province model as our inspirational starting point, and revised and developed a new model in the light of a great mass of recently determined data. The new geological model subdivides Solomon Islands according to basement lithology/geochemistry and subsequent arc development, (or lack of development).

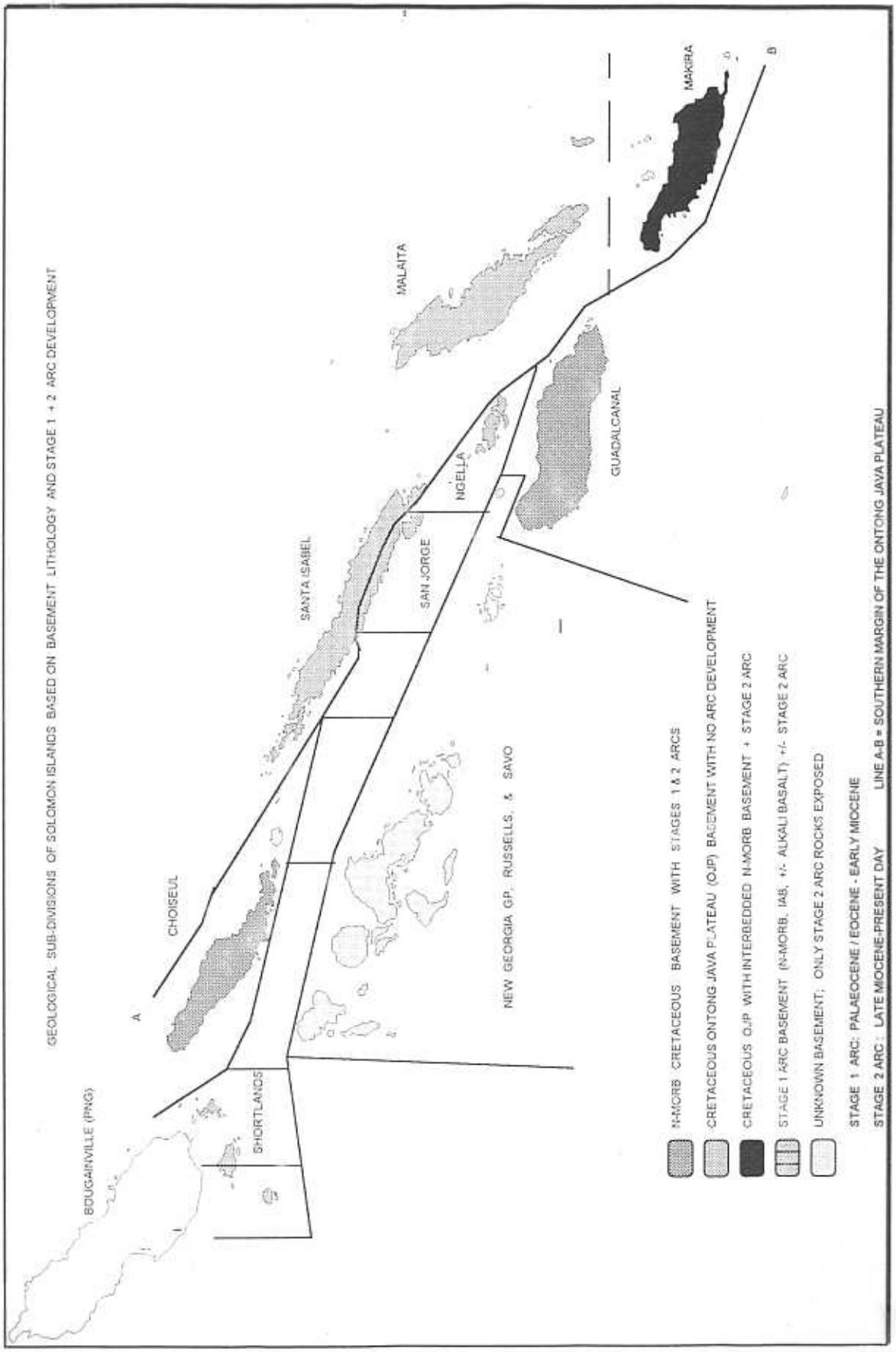
GEOLOGICAL SUB-DIVISIONS OF SOLOMON ISLANDS BASED ON BASEMENT LITHOLOGY AND STAGE 1 + 2 ARC DEVELOPMENT
BOUGAINVILLE (PNG)
SHORTLANDS
CHOISEUL
A
SANTA ISABEL
SAN JORGE
NGELLA
NEW GEORGIA GP., RUSSELLS, & SAVO
MALAITA
GUADALCANAL
MAKIRA
B
N-MORB CRETACEOUS BASEMENT WITH STAGES 1 & 2 ARCS
CRETACEOUS ONTONG JAVA PLATEAU (OJP) BASEMENT WITH NO ARC DEVELOPMENT
CRETACEOUS OJP WITH INTERBEDDED N-MORB BASEMENT + STAGE 2 ARC
STAGE 1 ARC BASEMENT (N-MORB, IAB, +/- ALKALI BASALT) +/- STAGE 2 ARC
UNKNOWN BASEMENT; ONLY STAGE 2 ARC ROCKS EXPOSED
STAGE 1 ARC: PALAEOCENE / EOCENE - EARLY MIOCENE
STAGE 2 ARC: LATE MIOCENE-PRESENT DAY
LINE A-B = SOUTHERN MARGIN OF THE ONTONG JAVA PLATEAU

Figure 1.

The Cretaceous basement of Solomon Islands is readily subdivisible into two major terrains: a 'Northern Ontong Java Plateau Terrain', '(OJPT)', and a 'South Solomon MORB Terrain (SSMT)'. The boundary between these two terrains is now well constrained by existing seismic, and new geochemical data.

The northern OJPT comprises the islands of Isabel, (north of the Kaipito-Korighole Fault, (KKF)), Malaita, Ulawa, and Makira. Isabel, Ulawa, and Malaita, comprise great thicknesses, (up to 3-4 km on Malaita,), of pillowed and massive basaltic lavas and silts with minor basic plutonic intrusive rocks; there is exceedingly little non-basaltic sediment between individual lavas testifying to rapid/very rapid extrusion rates. Isabel and Malaita have yielded basement ages of between c. 125Ma and 90Ma, (Tejada et al, (in press), and unpublished data). Geochemically the basalts of Malaita, Isabel & Ulawa form tight, well constrained fields, on numerous X-Y, (e.g. Figure 2), and normalised multi-element geochemical diagrams, indicating a typical plateau basalt composition transitional between 'N' and 'E' type MORB. The aforementioned basalt sequences are identical in composition and age with other OJP material derived from ODP boreholes, (e.g. Mahoney et al, 1993). A much deeper basement sequence is exposed on Makira, potentially many kilometres of basement stratigraphy are exposed, as it has been uplifted and deeply dissected in it's more recent geological past as a results of its frontal-forearc position relative to the San Cristobal Trench. Unlike the other OJPT islands Makira has been almost entirely stripped of its pelagic sediment cover sequence. Inter-lava limestones and cherts on Makira are evidence for periods of volcanic quiescence between periods of high effusive activity. Geochemically two thirds of the basalt samples analysed to date have typical 'Plateau' chemistries whilst one third have transitional N-MORB-PLATEAU compositions. In tectonic terms we interpret the OJPT as forming as a relatively distal-located depocentre to the massive OJP plumehead, plateau forming, eruptions. Makira was probably suited at the 'featheredge' of the OJP, (although still anomalously thick with respect to 'normal' ocean crust). and probably only received an unknown percent of the OJP lavas. Makira was possibly within an off-main-ridge transform-fault tectonic block, and accumulated lavas from both OJP and more normal ridge sources. Subsequent alkali basalt and alnoite magmatism affected parts of the OJPT during the Eocene-Oligocene.

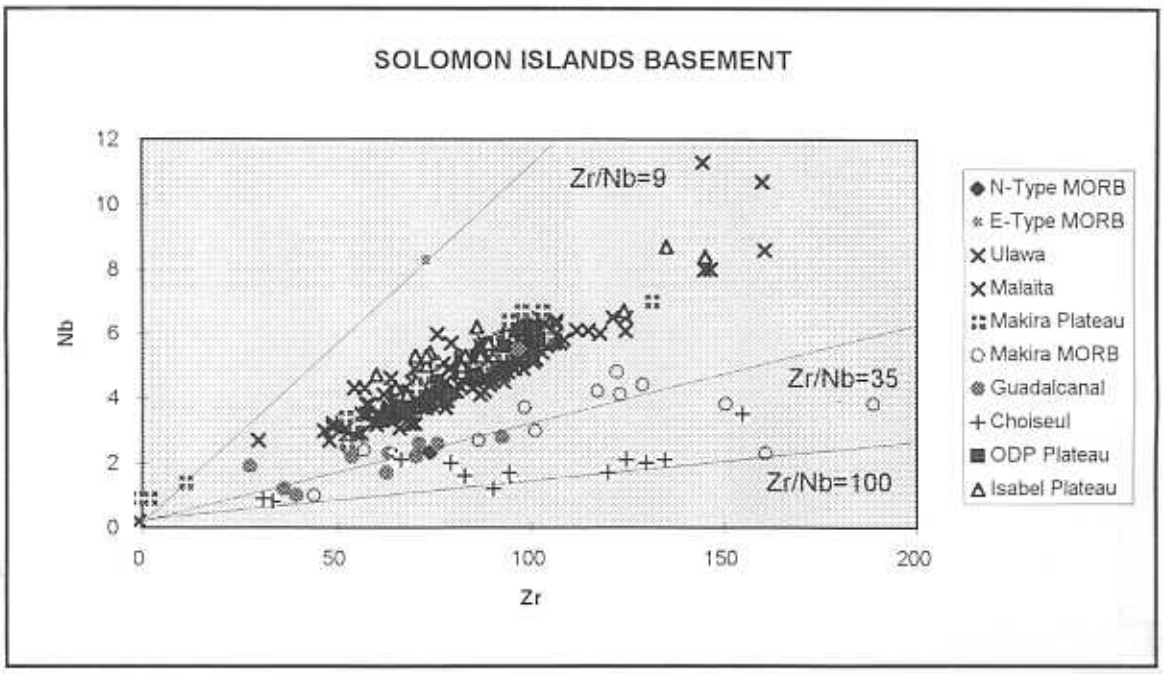

Figure 2.

Table 1. Tectonic-lithological-geochemical subdivisions of Solomon Islands.

LITHOLOGAL UNITS: BASEMENT & COVER SEQUENCES	AGE	ISLANDS	TECTONISM-MAGMATISM & SEDIMENTATION	REFERENCES
Ontong Java Plateau Basement sequence with pelagic sediment cover sequence. Alkali basalts interbedded with and alnoites intruded into cover sequence No arc development	OJP Basalts-125Ma-121Ma, (Malaita), 120-90Ma, (Isabel). Cretaceous-Pliocene pelagic sediments. Alkali basalts, (45Ma), alnoites (34Ma)	Santa Isabel, north of Kaipito-Korighole Fault, (KKF). Malaita Ulawa	Depo-centre for Ontong Java Plateau basalts erupted either at a ridge-centered or off-ridge plume head-fissure system. Subsequent deep-sea sedimentation, seamount alkalic volcanism & alnoitic plutonism.	Hawkins & Barron, (1991), Tejada et al, (in press), Hughes & Turner, (1976, 1977), Danitofea, (1981), Nixon et al, (1980) Neal, Mahoney, Duncan, Babbs & Saunders, (pers comm.)
OJP basalt and interbedded MORB basaltic basement with pelagic sediment interbeds. Probable post-basement pelagic sediment cover sequence, (now eroded).	Geochemical and lithological correlations suggest that basement is contemporaneous with OJP magmatsm.	Makira	Depo-centre for both OJP plume related basalts and N-MORB ridge-related basalts. N-MORB basalts 'contaminated' by OJP plume. Makira possibly centered within an -off-main ridge transform fault system.	Solomon Islands Geological Survey, (SIGS), (unpublished work). Babbs & Saunders, (pers. comm.)
N-MORB basaltic basement +/- ultrabasic intrusive rocks	Probable Cretaceous. e.g. 90+/-20Ma, (Mbirao Volcanics of Guadalcanal).	Guadalcanal Choiseul	Mid Ocean Ridge centered volcanism/plutonism	Babbs, Saunders, Mahoney, & Neal, (pers. comm.), Hackman, (1980), Ridgeway & Coulson, (1987)
Stage 1 arc sequence. U-mafic, N-MORB, BAB, & IAB +/- alkaline basalts. More evolved calc-alkaline andesitic-rhyolitic volcanic/plutonic rocks.. Volcaniclastic dominated sediments plus intra-arc carbonates.	Palaeocene/Eocene-Lower Miocene. 62Ma-46Ma, (Isabel) Floridas Basement Sequence (45Ma-37Ma) Poha Diorite, (Guadalcanal), 24.4+/-0.3Ma	Forms known basement of Shortlands, Santa Isabel south of the KKF, and Floridas. Guadalcanal Choiseul	Southwards directed subduction of Pacific Plate beneath Solomon Block at North Solomons/Vitiaz Trench. Arc related volcanism and sedimentation. Uplift of frontal arc	Ridgeway & Coulson, (1987), Turner & Ridgeway, (1982), Neef & Plimer, (1979), Hackman, (1980), Tejada et al, (in press), Kroenke, (1984), Pound, (1986), Coulson & Vedder, (1986)
Stage 2 arc sequence. Typical arc calc-alkaline basalt-rhyolite sequence. Unusual sodic basalts-dacites. Alkaline/shoshonitic basalts-trachytes. High-Mg basalts-andesites and picrites. Granites present on Makira. Volcaniclastic dominated sediments.	Upper Miocene-Recent. 6.4+/-1.9Ma, (Gallego Volcanics of W. Guadalcanal) 4.5Ma-1.5Ma (Koloula Diorite Complex, South Guadalcanal) 2.3+/-1Ma, (New Georgia)	Shortlands Choiseul New Georgia Group Russells, Savo ? Floridas Guadalcanal Makira	Northwards subduction of Australian Plate beneath Solomon Block with contemporary southwards directed (Vitiaz) subduction occurring locally. Arc related magmatism and sedimentation. Opening and subsequent subduction of Woodlark Basin. Shortening of S. OJP. Regional uplift.	Dunkley, (1983, 1986), Ridgeway & Coulson, (1987), Hackman (1980), Pound, (1986), Coulson & Vedder, (1986), Kroenke, (1984), SIGS, (unpublished data), Chivas, (1981), Turner & Ridgeway, (1982), Petterson & Wilson, (unpublished data).

The basement sequences of the SSMT exposed in Choiseul and Guadalcanal are compositionally distinct from the OJPT. They have higher Zr/Nb ratios, and lower LREE concentrations compatible with an N-MORB chemistry. The SSMT formed with a 'normal' ocean ridge setting, and was probably situated at some great distance the main locus of OJP volcanism.

Figure 1 and Table 1 further subdivides the Solomon Islands on the basis of variable development of stage 1 Vitiaz Arc, (Paleocene/Eocene-Lower Miocene), and stage 2 (Upper Miocene-Present Day) sequences. The basement of Shortlands, Isabel, south of the KKF, and the Ngella Islands formed during Vitiaz Arc times, (and has a predominant IAB-BAB-+/-M-MORB basalt chemistry). The youngest Solomon Islands, (New Georgia Group, Russells, and Savo), comprise stage 2 arc sequences on unknown basement. Choiseul and Guadalcanal have the most complex geological histories in Solomon Islands with crustal contributions from both stage 1 and stage 2 arcs. Within the OJPT only Makira has been affected by subsequent arc magmatism, with stage 2 arc granites, dacites, and acid tuffs being present.

References: Mahoney et al. (1993), Geochemistry. geochronology. of the Ontong Java Plateau, AGU Monograph, 77, 233-261.

Tejada et al ,(in press), 'Age and geochemistry of rocks from Malaita and Isabel, Solomon Islands', J. Petrology.

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Stratigraphy and Deformation of Malaita; New Evidence from 1990-1995 Geological Surveys. Implications for the deformation and obduction of Ontong Java Plateau, (OJP)

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There has been an explosion of papers in the recent scientific press dealing with numerous aspects of ocean plateaus. One of the more controversial aspects relating to ocean plateaus relates to the subject of subduction: Do ocean plateaus subduct, or do they ultimately become accreted to continents? This is clearly a most important fundamental question which has implications for crustal genesis, composition, and evolution.

A plethora of recently determined geochemical, geological, palaeontological, sedimentological, geochronological, and isotopic data, (for example, Petterson et al, this Abstract Volume), prove beyond any doubt that Malaita, Isabel, and Ulawa, (Solomon Islands), are a component part of the OJP. Recent geological investigations, indicate the following points relating to sedimentation and deformation on Malaita:

1. Deep sea, open ocean, sedimentation facies which had been prevalent from the Aptian, began to change c.5/6Ma-4Ma to a more basinal varied facies which included shallow marine facies, recording the gradual emergence of Malaita.
2. Only one deformation period is recorded on Malaita; this deformation was remarkably short lived, (4Ma-2Ma), but intense.
3. Many hundreds of dip, strike, minor fold and thrust fault orientation data, reveal a remarkably consistent strike trend with an average structural grain of 128' with some areas being locally discordant to this dominant structural grain by up to 20'. These data are interpreted as indicating a dominant 038'-218' compressional vector with penecontemporaneous, predominantly sinistral, strike-slip.
4. Upright to overturned asymmetric folds are the most common structural style. Fold vergence and thrust movement sense data indicate a main NE-directed fold vergence/thrust direction, with a later SW-directed backthrust phase.
5. Calculated percent shortening values are between 24% and 46%
6. Basement and cover sequences are both deformed in a geometrically coherent manner, (there has been no major decollement between basement and cover); between 1 and 4km of basement basalts have been deformed by the Malaitan structures.

7. The large asymmetrical folds on Malaita are probably the tip regions of basement thrusts with detachment surfaces between 1 and 4km beneath the sedimentary cover sequence, (total depths of 3-6km).

We suggest that Malaita started to become gradually emergent at 5/6Ma, and was deformed during 4-2Ma, with the overall movement sense being towards the NE, with accompanying strike-slip/rotational deformation. Thrusting re-activated, (in a reverse sense), older, extensional, fault structures. From 2Ma to ?End Pleistocene, Malaita became detached from deeper levels of the OJP along detachment surfaces which are situated at depths of least 6km and possibly deeper. Malaita was transported towards the SW, over the Solomon Block, and represents a thin Rake of upper OJP stratigraphy which has become obducted onto the Solomon Block.

Furthermore, seismic data and recently acquired SOPACMAPS imagery data imply that subduction of the deeper parts of the OJP is occurring at the present time, and possibly has been doing so since c. 15Ma. Thus the OJP may be an example of 'flake tectonics' applied to ocean plateaus; simultaneous subduction of 'deep' OJP and obduction of 'shallow' OJP.

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Application of high resolution swath mapping to environmental marine geology in Canada

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Canada has become a world leader in development of high resolution swath mapping and application to environmental marine science. Advancement of swath mapping technology in Canada has been via government, university and industry partnership through the National Action Committee for Ocean Mapping (NACOM). NACOM draws on the resources of the lead agency, Canadian Hydrographic Service to provide equipment and vessels, the University of New Brunswick through the Chair in Ocean Mapping has advanced processing and product delivery to a very sophisticated level, GSC Atlantic has contributed to resolving problems of motion sensing and enhancing data accuracy to IHO Standards and the application of swath products to marine geology. As technological advances are made, spin-off to the private sector is encouraged through commercial application and equipment and technology transfer.

Hydrographic application has been the principal driving mechanism in the move toward swath mapping. Following initial trials with multi transducer sweep vessels, two dedicated swath vessels have been equipped with EM100 and EM1000 systems and remote operated Dolphin vehicles equipped with EM100's. Two nearshore launches equipped with EM3000 systems are undergoing trials. All systems are designed for relatively shallow water application, most surveys having been completed in continental shelf depths but with operational capability to 500 m depths.

The accuracy of the, mapping system is determined by inherent errors within the hardware, vessel positioning, water depth, velocity and tidal corrections and motion sensor correction. Trials aboard the vessel Matthew indicate an accuracy greater than 1% of water depth with data binned in 3 m squares in 60 m of water, expanding to 16 m squares in 400 metres of water. The EM1000 aboard the vessel Creed has the capability to process the strength of the backscatter signal, as well as the depth data, enabling geologists to produce digital terrain models of bathymetry and backscatter. Combining the two produces a powerful tool with the equivalent of a low resolution sidescan sonar mosaic draped over a three dimensional bathymetric model that can then be viewed through interactive visualisation software.

Application of swath technology to marine geology has revolutionised our understanding of the seafloor. Repetitive swath surveys over the Fraser Delta are being used to determine the mechanisms and frequency of slope failure. Effects of sea-level rise in Canada show great spatial variability, swath imagery is being used to map drowned coastal landforms in order to reconstruct recent sea-level history. Mapping of surficial sediments and bedforms is being used to improve fisheries habitat management, identify offshore

sand and gravel resources, extend bedrock mapping offshore and advance understanding of bedformgenesis, migration and sediment transport. Swath mapping has being accepted as the standard for offshore cable route surveys and in identifying anthropogenic effects at the seafloor, spectacular results have been obtained in mapping mine subsidence and effects of dredging and disposal of spoil. Swath mapping has become an integral part of marine surveys at GSC Atlantic. Future development will see a move toward a new integrated coastal and nearshore mapping practise combining swath with high resolution seismic survey tools allowing new approaches to emerging problems of coastal zone management.

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Introduction of the Japan Deep Sea Impact Experiment (JET)

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Since 1989 the Metal Mining Agency of Japan (MMAJ) has been carrying out Environmental impact Research for manganese nodule development collaborating with NOAA/USA as an 8-year project which is planned and conducted by the Ministry of International Trade and Industry (MITI). The major objectives of the project are to collect basic data and information for establishing environmental and security criterion for future commercial mining activities. Deep sea bed mineral resources are expected to support future industries and comfortable human lives. Moreover biological communities in the same region are believed to be valuable resources for the future generations. It is necessary to consider not only the mining development but also ways of protecting and conserving the abyssal communities and organisms that are characterised by their specialised niches, fragility and rare abundance.

In 1994, as a part of the research, an environmental impact experiment named "Japan Deep Sea Impact Experiment (JET)" was performed to evaluate the effects of sediment resuspension and redeposition resulting from deep sea mining. MMAJ carried out JET using the Russian R/V Yuzhmorgeologiya from August 6 to 18 and August *23* to September 25.

JET consisted of three phases, namely a pre-disturbance survey, an artificial disturbance and a post-disturbance survey. In the pre- and post-disturbance surveys, sediment samples were collected using a Multiple Corer (MC). An artificial disturbance was created by the benthic disturber which was developed by NOAA with financial and technical assistance from MMAJ and designed to dredge sediment and discharge it as a slurry at about 5-m above the seafloor. In addition, throughout the experiment period, deep sea currents and sedimentation rates were observed by several mooring systems. As a result, 19 benthic disturber tow transects were conducted in the survey area and 9 200 000 litres of slurry or *352* tons of sediment (dry weight) were discharged and resuspended. The 27 sediment samples were collected and analysed to compare the pre- and post-disturbance conditions.

From the preliminary results, some disturbance effects were recognised from environmental and biological parameters, deep sea photographs and sediment trap data.

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Introduction to the advance of deep-sea mineral exploration techniques and systems of R/V Hakurei-Maru No. 2

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In 1979, Metal Mining Agency of Japan (MMAJ) launched a research vessel, Hakurei-Maru No. 2, exclusively designed for exploration of deep seabed mineral resources. After the launch of R/V Hakurei-

Maru No. 2, she has been engaged in exploration of manganese nodules, submarine hydrothermal deposits and cobalt-rich manganese crusts in the Pacific Ocean.

The tasks of the exploration work are to find mineral deposits and to evaluate ore reserves. In the process of exploration, efficiency is required to reduce time and cost as well as accuracy, multi-beam echo sounder (MBES) gives a significant improvement to bathymetric mapping. It saves considerable time and we can get topographic maps immediately. For the observation of sea floor, sidescan sonar (SSS) provides surface structure images and a deep-sea TV system gives us a continuous picture in colour on its survey line. The other geophysical surveys (narrow sub-bottom profiler, air-gun, proton gradiometer) and oceanographic probes (temperature, pressure, conductivity, Eh.) also provide useful information. Various sampling equipment is available for collecting sediment, rock and ore samples.

As for the finding mineral deposits, we have been standardising strategies of exploration for each deposit by using the above equipment, but for the evaluation of ore reserves advanced exploration systems are necessary for determining the extent of deposits (horizontal/vertical) with a high reliability. We have been studying the use of backscatter of acoustic energy by MBES to measure the horizontal extent and we got good results in comparison with TV picture, photographs and sampling. For recovery of core samples, R/V Hakurei No. 2 will be equipped with a sea floor submarine drilling system next year.

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Reassessment of the petroleum potential of the Republic of Vanuatu

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In 1994 the Australian Agency for International Development (AusAID, formerly AIDAB) commissioned a feasibility study on behalf of the Government of Vanuatu, to assess the petroleum potential of the Republic as the first phase of a Petroleum Exploration Promotion Project (PEPP).

The assessment involved a review of all pertinent geological and geophysical data including several new and significant data sets, notably geophysical data (bathymetric, magnetic, gravity and reflection seismic) from the 1993 SOPAC "LAtalante" cruise, seismic reflection data acquired during the earlier "S.P. Lee" cruises of 1982 and 1984 and since reprocessed by SOPAC, and Ocean Drilling Program results, in particular from Site 832. These data were interpreted and integrated with pre-existing data to provide new regional structural and geological frameworks, the starting point for the assessment of petroleum potential.

Reprocessed "S.P. Lee" seismic reflection data indicate the presence of numerous reefs at several stratigraphic levels, including those below the nominal threshold for petroleum generation. By analogy with petroliferous basins throughout Southeast Asia and the Pacific, these reefs are seen as providing primary reservoir targets. Moreover associated back-reef areas, flanking the shallow-water and island areas, would be ideal environments for the deposition of organic-rich source rocks of both terrestrial and marine origins.

Regional mapping of seismic data identified a previously unrecognised extensive platform area off, and extending across, the islands of Espiritu Santo and Malekula - the so-called Port Sandwich Basin. Sediment thicknesses are considerably greater than hitherto interpreted, and computer-modelled burial histories suggest that the thicknesses are compatible with the generation of hydrocarbons.

Overall, three regional petroleum play concepts emerged: the rim carbonate plays on the Torres Plateau in the north; carbonate plays in the Port Sandwich Basin; and deep-water anticlines induced by transpressional wrenching. Numerous leads were identified within each play type, and all are worthy of further exploration review.

Seismic refraction, reflection and gravity data appear different between the northern and southern parts of the Vanuatu Arc system. One proposition is that these differences reflect differences in the underlying crust,

and that the arc crust in the north (underlying the Vanikolo Basin and Torres Plateau) has continental affinities, whereas the crust in the south has oceanic affinities. If this proposition is correct, then the history of the northern part of the arc may date back to the break up of eastern Gondwana during the Mesozoic, in which case the petroleum prospectivity of the northern region could be enhanced and would require further assessment.

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Holocene sea levels and tectonics in southeast Viti Levu, Fiji

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Radiocarbon dates from four raised reefs in Fiji demonstrate the role of tectonism in the interpretation of regional Holocene sea level curves. In the Suva-Rewa region, significant local variation can be attributed to localised uplift on active fault zones. Three of the age determinations essentially support existing sea level curves for the Suva-Rewa and Savusavu areas, but the fourth, from Suva Point, lies well above the local curve. Dates obtained by earlier researchers from peat and wood samples indicate that the Suva-Rewa region as a whole is relatively stable or even possibly subsiding, whereas the reef at Suva Point appears to have undergone a degree of localised uplift comparable to the reefs near Savusavu, an area of recognised tectonism. A consideration of the offshore structure of southeast Viti Levu suggests that growth of much of the Holocene reef around Suva was initiated on the edges of uptilted blocks of Plio-Pleistocene strata near the margin of a largely offshore basin. These discrete, tilted structural blocks are separated by wide disturbed zones. At least one of these zones, the Lami Beacon Fault Zone, defining the southern margin of Suva Harbour, has experienced periodic tectonism up to the present time. The change in strike of the tilted Plio-Pleistocene strata from northeasterly to northwesterly trending, appears to be the result of distortion by right-lateral shear combined with normal movement along the Lami Beacon Fault Zone. The Holocene reef whose growth was initiated on the edge of the tilted block has experienced emergence as uptilting of the structural block, calculated to be in the order of 5 mm/yr, has continued along the southern side of the Lami Beacon Fault Zone.

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Introduction to the deep-sea mineral policy of Japan

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The ocean contains a vast amount of resources, among which are oil, natural gas and deep seabed minerals including manganese nodules, hydrothermal deposits and cobalt-rich crusts. Dissolved elements such as uranium and lithium are also gaining attention. The development of any of these minerals is imperative for resource-scarce Japan in view of ensuring stable supply of these resources to the Japanese market.

Despite the comparatively steady growth of the ocean development industry(*) in general, it has to admitted that these marine energy and marine mineral resources, high potential as they have, have not yet reached the stage of commercialisation and still remain immature as an industry. Accordingly, MITI has been providing necessary assistance in the above fields.

(*): The "Ocean development Industry" is defined here as the activities as the field of marine construction reclaiming, marine resources development, marine observation and fishery etc.

CONTENTS

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Compositional and textural variation in volcanic glass from the Lau Basin, Southwest Pacific

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With the completion of cruises of the RV Sonne (Leg 35 and 48) and ODP (Leg 135), data have become available to allow further elucidation of the mechanism and timing, and the volcanic and sedimentary processes which are taking place following the formation of the Lau Basin. These suggest that the Lau Basin has formed following a two-stage process of arc rifting, followed by extension via a southward propagating oceanic ridge system. During this time, volcanism has been initiated along what is now the Tofua Volcanic Arc (TVA). The majority of the available data, however, relate to the southern or central parts of the basin. This paper discusses the implications of the compositional and textural variation in glass shards from a deep-sea core (KK72-7) recovered from the northeast Lau Basin.

The core consists of a sequence of volcaniclastic units composed of both turbidites and ash-rich layers that may represent a record of the variation in the products of northern part of the TVA since the initiation of volcanism during the Mid-Pleistocene (approx. 0.5Ma). The high sedimentation rates (20-30m/Ma) suggest that this core records the volcanic processes which have occurred during the Late Pleistocene.

Microprobe analysis of a large number of the glass shards from the core shows a wide compositional range. SiO shows an almost continuous variation from 48% to 76%. All the shards that were analysed exhibit strong tholeiitic affinities. The considerable variation in shard chemistry, even within a single layer, suggests that a series of volcanic centres was the source of the shards. Several of the individual layers show a somewhat narrower compositional range, suggesting that individual volcanic centres may have been the source. Shard compositions indicate the most likely source to be the TVA located only a short distance to the east.

An examination of individual shards using the SEM also reveals a wide variation in their characteristics. Shard morphologies range from highly vesicular pumiceous shards with tubular vesicles, and platy, bubble/wall shards through equant, blocky shards with abundant, few or no spherical vesicles with abundant fracture surfaces, to drop-like fragments exhibiting fluidal surface features. An interpretation of the morphology of the individual shards and the nature and abundance of vesicles can be used to elucidate the eruptive mechanism and the conditions prevailing within the vent prior to or during eruption. For example, equant, blocky shards with abundant fracture surfaces and spherical vesicles have formed by a phreato-magmatic eruptive mechanism, with explosive fragmentation occurring high in the magma column. Those shards of the same type but having few vesicles have been formed deep within the magma column prior to the exsolution of dissolved magmatic gases. There is, however, a broad correlation between shard morphology and composition. Shards with a dacitic to rhyolitic composition commonly exhibit pumiceous and bubble-wall morphologies while equant, blocky and fluidal shaped shards are commonly more mafic in composition (basalt to basaltic andesite).

One group of glass shards with equant, blocky and fluidal morphologies within a single ash-rich layer (138 cms depth), has compositions of SiO 248%-500; TiO 1.3%-1.5%; AlO 14.8%-15.3%; FeO(tot) 10.4%-

10.8%, MgO 7.0%-7.5%; CaO 11.4%-11.9%; NaO 2.9%-3.3%; K2O 0.1%-0.3%. These are unlike those derived from an arc source. Products of this distinct Composition are exposed on Niuafo'ou Island located to the northwest of where the core was recovered and may represent the record of a discrete volcanic event which has occurred at this centre.

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Vanuatu regional airborne geophysical survey

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During 1994 the Government of Vanuatu undertook an Australian aid (AusAID) funded regional airborne geophysical survey of most of the nation's islands and some offshore areas, with the main objective of promoting the development of Vanuatu's mineral potential. The survey was planned and managed by the Australian Geological Survey Organisation (AGSO).

The survey totalled 60,000 line kilometres of both fixed-wing and helicopter magnetic-radiometric surveying along east-west flight lines spaced at intervals of 400m onshore and 800m offshore, with a nominal terrain clearance of 100m.

Surveying was completed in December 1994 and the data package was officially released on 15 May 1995. The data may be purchased in digital or map form from AGSO in Canberra (as agents for the Vanuatu Government), or in map form from the Department of Geology, Mines and Water Resources in Port Vila.

The survey was successful in revealing a number of previously unknown features of great significance to interpreting the regional geology and structure of Vanuatu to understanding the geological setting of known mineralisation, and to targeting other prospective areas.

following release of the data, the survey results were promoted to mining companies in Australia. As a result of this promotion, Vanuatu has already experienced a significant increase in mineral interest with several new Prospecting License applications.

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Migrating cross arc volcanism and back-arc rifting in the southern Havre Trough

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The southern Havre Trough (35'20' - 37'S) is an actively widening back-arc basin formed from the evolution and interaction of migrating cross-arc magmatism, and the progressive development of longitudinal rift grabens. Migration of the proto-Kermadec Arc front from the remnant Colville Arc at ~ 5 Ma to the presently active Kermadec Arc margin is recorded by the construction of arc massifs and seamounts trailed across the intervening, and contemporaneously rifting, back-arc complex. The Rumble V arc migration trail is the most prominent, forming a continuous, high-standing, magmatic arc ridge. The migration arc trails segment the back-arc region and initially limit rift development. Early rifting between the arc volcanoes forms fully developed rift grabens which, with progressive basin widening, propagate longitudinally across the trails of migrating constructional arc magmatism. Longitudinal rift propagation initially develops via partially penetrative, narrow (< 3 km wide), sigmoidal, relay rifts which subsequently

evolve into "inter-rift corridors" severing through the migrating arc ridge or seamount chain, and linking the bounding, fully developed rift segments.

It is postulated that the relative balance between rates of constructional arc magma production MR and destructional back-arc (rifting) extension VE is a prime determinant of basement morphology within rifting back-arc basins. When VE is high, MR is insufficient to keep abreast of destructional rifting, resulting in small, isolated arc massifs quickly dismembered by rifting. Conversely, when is VE is low, MR is sufficiently greater than rifting to produce a continuous, high-standing cross-arc ridges which segments longitudinal rift development. Migrating arc magmatism will be best observed, and preserved, in rifting back-arc basins when arc magma production (MR) is >600 km^3 Ma^{-1} 100 km of plate boundary and back-arc extension (VE) is<25 mm a^{-1}.

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Volcaniclastic processes on modern submarine arc volcanoes; evidence form southern Kermadec Arc

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Studies of volcaniclastic processes on modern, submarine, arc stratovolcanoes are rare. Facies models of submarine volcanism and associated volcaniclastic deposits have to date emphasised general and/or regional processes. Two andesite - alkali basaltic volcanoes (Rumble IV and V volcanoes) from the southern Kermadec Arc are "mapped with swath bathymetry and sidescan imagery. and photographic data, to characterise volcaniclastic processes on these modern, submarine, arc stratovolcanoes, and their interaction with ambient marine processes.

The principal observation from the Rumble IV and V data is the fine-scale spatial variability in the distribution of effusive lavas, various volcaniclastic deposits, and hemipelagic-pelagic sediments. Mass movement of volcaniclastic deposits is common, and includes (1) epiclastic debris flows, (2) pillow breccia talus deposition penecontemporaneous with lava eruption, (3) traction particulate gravity flows, and possibly (4) sector collapse. Epiclastic redepositing is inferred to be mobilised by episodic, but frequent, localised, small volume flows, which largely redeposit debris on the edifice. Winnowed and rippled volcaniclastic sediment indicates bottom-current activity is common, but localised, over the entire height of both volcanoes, down to a water depth –2200 m.

Irregular and ragged spatter agglutinates on Rumble IV interpreted as evidence of lava fountaining, and well-sorted, fines poor, scoriaceous deposits on Rumble V interpreted as evidence of explosive eruption, indicate the transition between effusive and explosive volcanism is between 650 - 700 m water depth.