

**ABSTRACTS OF PAPERS
PRESENTED AT THE STAR* SESSION
1994**

Keith A. Crook
Editor

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SOPAC Miscellaneous Report 182

*SCIENCE, TECTONICS AND RESOURCES NETWORK

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- Niuafou'u, Tonga: volcanic hazard and the risk from future activity/P.W. Taylor

FOREWORD

STAR was founded in 1985 as a vehicle to assist the international geoscience community to provide advice to SOPAC on Science, Tectonics and Resources in the SOPAC region particularly during the intervals between SOPAC International Workshops, the fifth of which will be held in Noumea and Lifou, New Caledonia later this 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 concerning its work program and to highlight technical and scientific issues of particular importance or urgency. This advice is tendered during the Technical Advisory Group sessions later in the Annual Session, and all STAR participants are invited and urged to participate in this phase of the meeting.

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 in the SOPAC region during the 1980's.

Traditionally STAR has been primarily concerned with "blue-water" marine geoscience, tectonics and resources, as its full name implies. However, STAR participants must be sensitive to changing national needs and priorities, so as to ensure that the relationship between SOPAC and the scientific community remains a relevant and working one. SOPAC's 1995 Work Program and its draft Medium-Term Plan, which all participants should examine, contain a great deal of work in fields that are not "blue-water" geoscience. The challenge here is to broaden the spectrum of participation in STAR so that SOPAC's Work Program and its forward planning are influenced by international science that is both excellent and relevant. SOPAC's track record demonstrates that this approach is synergetic, forwarding both national needs and fundamental research. I commend it to you.

Keith A W Crook
Chairman, STAR

Hawaii Undersea Research Laboratory
University of Hawaii, Honolulu, HI.

12 September 1994

REPORT OF STAR

1. The STAR component of the 23rd Annual Session of SOPAC was held on Friday 16 September. The Technical Program was opened by the STAR Chairman, Keith Crook, of Hawaii Undersea Research Laboratory, University of Hawaii. Seventeen oral and poster papers were presented, one of which was delivered as an interlude during the TAG session on Monday 19 September due to late arrival of a participant. Five short informational presentations were also given. More than 60 people participated. Saimone Helu, Naomi Biribo and Stevie Nion chaired segments of the STAR meeting.
2. Abstracts of STAR Technical Program papers are published in SOPAC Miscellaneous Report 182, which includes the meeting program and a list of informational presentations.
3. A brief business session was held after the conclusion of Technical Program. The following decisions were made:
 - 3.1. We agree that SOPAC's STAR network should henceforth be known as the **SOPAC Science, Technology and Resources network (STAR)**.
 - 3.2. We agree the STAR Working Groups need not meet during the 23rd Annual Session. We ask the Chairman and Vice-chairman to arrange for meetings of relevant STAR Working Groups during next years Annual Session.
 - 3.3. We ask the SOPAC Technical Secretariat to log-in the 1994 STAR Abstracts volume (including abstracts distributed during the session), as a SOPAC Miscellaneous Report, and to publish the title and number of that Miscellaneous Report in SOPAC News.
 - 3.4. The Chairman and Vice-chairman of STAR, the representative of the UNESCO Office for the Pacific States, and the SOPAC Technical Secretariat are asked to explore ways of strengthening relations between the Intergovernmental Oceanographic Commission, SOPAC-STAR and scientists in the SOPAC region.
 - 3.5. We ask the Chairman and Vice-chairman to arrange for presentations on global and local sea level change during the STAR Technical Program at the 24th Annual Session of SOPAC.
4. The Chairman of STAR, Keith Crook, and the Vice-chairman of STAR, Saimone Helu, were re-elected to hold office until the end of the next STAR meeting.

PROGRAM OF STAR PRESENTATIONS

Majuro, Friday, 16 September 1994

Time	Speaker	Title
8:30-8:40	Keith A W Crook (STAR Chairman)	Welcome and Opening Remarks
8:40-9:00	L.W. Kroenke, J.J. Mahoney and A.D. Saunders	"Assessing the origins, age, and post- emplacement history of the Ontong Java Plateau through basement drilling"
9:00-9:20	Y. Lafoy, Jacques Dupont, Raymond Le Suave and Guy Pautot	"The morphostructural fabric of the Loyalty Ridge's southern extension"
9:20-9:40	Nicolas Baudry (deferred)	"Off-shore seafloor mapping from satellite altimetry: results of surveys within Tuvalu and Papua New Guinea EEZs"
9:40-10:00	Jayson Meyers, Heiner Villinger, Andreas Rosenberger and Hans Gennerich	"Seismic reflection evidence for crustal uplift and volcanism along the Melanesian Alkali Volcanic Island Chain, Papua New Guinea"
10:00-10:30	MORNING TEA	BREAK
10:30-10:50	Rhett Butler	"Global seismographic network coverage of the Pacific"
10:50-11:15	Jiro Osako and Seizo Nakao	"Preliminary results of the recent Hakurei-Maru No. 2 cruise in the Solomon Islands waters;
11:15-11:40	Paul Taylor	"Niuafu'ou, Tonga: Volcanic hazards and the risk from future activity"
11:40-12:00	J.-M. Auzende, Y. Fouquet, V. Ballu, R. Batiza, D. Bideau, H-H. Cormier, P. Geistdoerfer, Y. Lagabriele, J. Sinton and P. Spadea	"Relation between tectonic, magmatic and hydrothermal activity on the EPR at 17°-19°S: NAUDUR cruise (Nadir-Nautile)"
12:00-13:30	LUNCH	BREAK
13:30-13:50	Seizo Nakao	"Submarine hydrothermal activity in Izu-Ogasawara arc area"
13:50-14:15	Alexander Malahoff	"Frontiers of deep submergence research in the Western Pacific"
14:15-14:40	E. Carl Granter (not given)	"Recent advances in Canadian ocean mapping technologies"
14:40-15:00	Michael Cruickshank	"Current research activities at the Marine Minerals Technology Center"
15:00-15:30	AFTERNOON TEA	BREAK
15:30-15:50	Jiro Osako and Seizo Nakao	"Progress of SOPAC Atlas on Deep-sea Minerals"
15:50-16:15	Neville F. Exon	"A comparison of Indian and Pacific Ocean manganese nodules and crusts"
16:15-16:40	Stuart Kingan	"An outline of the manganese nodule resource of the Cook Islands"
16:40-17:00	Se-Won Chang and Chan Hee Lee	"The occurrences of Todorokite and Buserite in deep-sea manganese nodules"

17:00-17:20	M. Allenbach (given as poster paper)	"Preliminary studies for setting a groyne on the coral island of Amedee Lighthouse, New Caledonia, South West Pacific"
17:20-17:40	M. Allenbach, P. Thollot and C. Chauvet (given as poster paper)	"Presentation and objectives of the impact study for construction of the littoral motorway by-pass Noumea-Mont Dore, New Caledonia, South West Pacific"
17:40	CLOSE	SESSION

Poster papers:

1. "Origin of Massive Dolomite, Leg 143, Hole 866A, Resolution Guyot, Mid-Pacific Mountains" by **Peter G. Flood**.
2. "Global seismographic network coverage of the Pacific" [supplement to oral paper] by **Rhett Butler**

Informational Presentations:

Don Montgomery (Jet Propulsion Laboratory): Radar imaging studies in the South Pacific.
Bruce Molnia (US Geological Survey): Recent USGS publications and program developments.
Tim Cummings (Defense Mapping Agency): DMA bathymetric mapping program.
Egil Olsen (OCEANOR): Conjoint use of satellite and ground data for studying cyclones and hurricanes.
Gary Mitchum (University of Hawaii Sea Level Center): Notes on the University of Hawaii Sea Level Center and some thoughts on sea level rise. (transmitted by Keith Crook).

ABSTRACTS OF PAPERS**Preliminary studies for setting a groyne on the coral island of Amedee Lighthouse, New Caledonia, Southwest Pacific**

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Warned by the marks of a recent erosion affecting the North face of the island of Amedee Lighthouse, high tourist resort of New Caledonia (25,000 visitors/year), situated next to Boulari Pass, at about ten miles of the Mainland (long. 166°27.88' E, lat. 22°29.17'S), the Marine Service of the South Province has asked LERVEM of the UFP (French University of Pacific) to carry out a survey of the site. The steady methodological process consisted of approaching the problem set in to several successive stages with ascending power of means brought into operation:

- First stage: Comparative analysis of available cartographic and photographic documents and characterisation of the initial state of the site including a detailed topographic survey, a series of beach profiles and a sedimentological study of aerial and submarine beaches. This step has allowed to prove the existence of an important recession of one part of the island on the historical period, to determine its generating mechanisms, therefore justifying the implementation of a complementary study in view of precisising the evolution speed of the system and the volumes of the concerned materials.
- Second stage: Follow-up of the site upon an annual cycle by carrying out topographic surveys and trimestrial repetitive profiles of beach and characterisation of the meteo-oceanological environment (study of winds, flows, tides and waves). This step has allowed to prove the present continuance of erosive tendencies and to quantify the importance of it in normal weather cycle (linear recession of the soil stabilised at 7 m/year) and under the impact of cyclonic depression involving a very strong acceleration of erosion (nearly 5 m within some hours). The decision of implementing a specific defence is then adopted, justifying the carrying out of complementary studies destined for calculations of civil engineering.
- Third stage: detailed bathymetric survey of the site on the channelised area, vector of littoral hydrodynamics responsible of erosion in view of estimation of cubatures to be put into place and definition of installation techniques and of groynes construction.

The survey carried out upon an annual cycle, with graduated objectives has provided the Territory business leaders with the available data for deliberating upon justification of the groyne implementation.

(*) ALLENBACH M., 1993 - Littoral erosion of the coral island of Amedee Lighthouse, New Caledonia. Abst. 22nd SOPAC An. Sess. SUVA

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Presentation and objectives of the impact study for construction of the littoral motorway by-pass Noumea-Mont Dore, New Caledonia, Southwest Pacific

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Important works of infrastructure roadway are on way of implementation at the outskirts of Noumea in order to facilitate the traffic flow, overcrowded at peak hours. The disengagement way East is one of the components of these installations. The layout actually held in Normandie-Boulari area cross-checks mangrove zones and plans a passage over marine area, on 3,5 km long, at the level of Anse de la Mission. Situated in the North-East outskirts of the downtown, l'Anse de la Mission (long. 166°30' E, lat. 22°14' S) corresponds with the northern termination of Boulari Bay. It is a littoral area not deep (bottoms lower than 5 m), open towards the Southeast, but relatively confined by presence at some hundreds meters off the shore, of a barrier reef sub-outcropping almost continuous on which breaks the main part of the coastal hydrodynamism. Two rivers flow into the sea on the strictly speaking studied area: Yahouse and Namie Creek. The littoral morphology right upstream of the layout alternates low areas covered with mangroves dealing with a local traditional exploitation and urbanised hills.

Warned by serious nuisances of a management badly controlled in the past of the installation of coastal linear on Great Noumea, the provincial authorities desired to carry out an impact survey which was entrusted to LERVEM of UFP and which is today at final stage of implementation. The survey has taken the form of a multidisciplinary approach of the site with the participation of biologists and oceano-geologists. Three sectors relating to the areas covered with mangroves have been studied. The knowledge of sedimentological specifications of soils and marine zones of fore-mangrove was sought for coming on to a cartography of superficial covering and to a

definition of littoral sedimentary dynamics. A series of chemical dosages of main elements of substratum and diffractometric analysis of clays are on way of achievement. The takings of benthos were analysed in view of the taxonomic determination of animal and vegetal species living in maritime and ground environment for coming on to the characterisation of the initial ecological state of the site and the socio-conomical estimation of areas anthropised by the road. The physico-chemical characteristics of the sea water have been measured under principal prevailing weather conditions. A currentological study of the fore coast and a measurement of flows (speed and volume) covering the channels of the mangrove have been proceeded in accordance with local tide cycles. The whole works in association with the results of a detailed bathymetric survey of the littoral area and of a geotechnical study on the longitudinal profile of the work allow today to propose to the Management Board of Equipment of the South Province a series of installations to the work for preserving at best the perennality of mangroves areas isolated above the road.

**Relation between tectonic, magmatic and hydrothermal activity on the EPR at 17'-19'S:
NAUDUR cruise (Nadir-Nautile)**

Auzende, J.M, Fouquet, Y., Ballu, V., Batiza, R., Bideau, D., Cormier, M-H., Geistdoerfer, P., Lagabrielle, Y., Sinton J. and Spadea, P.*

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The objective of the NAUDUR cruise of the French submersible "NAUTILE", was to explore the ridge axis in order to define the relationships between present-day tectonic, magmatic and hydrothermal activity. During the cruise, 23 dives allowed to discover 69 hydrothermal sites. These sites can be grouped into 14 hydrothermal fields, located in four geographical areas centred on 17'10'S, 17'25'S, 18'15'S, and 18'37'S. Observations made during the cruise support the succession of different types of hydrothermal discharge and associated deposits during the volcanic and tectonic evolution of a fast spreading ridge. The small size of most of the sites and the coverage by recent lava flows indicate a high instability of the hydrothermal systems at ultra fast spreading ridges. Four stages can be distinguished.

- 1: First stage. Shimmering waters on large surfaces occur immediately after a lava flow and the formation of lava lakes. No fixed animals and no mineral precipitates are seen. An important bacterial production is visible both in the water column and at the surface of the lava.

Sea water is just heated by cooling lavas and dikes related to the lava flow. This stage, observed at 17'25'S and at the south of the 18'37'S segment, is similar to the hydrothermal discharge observed at 9'50'N on the EPR by Haymon et al., (1993). Hydrothermal activity is probably less than one year old.

2: Fixed animals are settling on a large surface of diffusing waters and more focused discharge produces black smokers chimneys indicating highly reducing fluids related to deeper hydrothermal convection. This stage is present at 17'10'S, 17'25'S and 18'37'S. Information obtained in the same area in 1984, by the submersible Cyana, and the size of mussels and clams indicate that these sites are about 10 years old.

3: Absence of diffusion and more mature hydrothermal deposits. These sites are typically located in a graben structure in areas without any evidence of recent lava flows (18'15'S). This may indicate stable and deep hydrothermal systems focused along the major faults.

4: New volcanic episode starting at the bottom of a graben as seen in the 18'37'S segment. At its northern part two successive episodes can be seen, the first being the equivalent of stage 3 described above, the latter is represented by diffuse discharge and young black smokers growing directly on the talus along the graben. The reactivation of the hydrothermal system is probably produced by lava flows related to the new hydrothermal episode. The absence of fixed animals and the importance of shimmering waters favours a very recent start of the hydrothermal activity.

Offshore seafloor mapping from satellite altimetry: results of surveys within Tuvalu and Papua New Guinea

*Nicolas Baudry
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We present the results of two satellite bathymetry surveys conducted in the EEZ of Tuvalu and Papua New-Guinea. The objective of these surveys was to provide maps of the seafloor from all available bathymetry information, that is from direct ship-board bathymetry echo-sounding measurements, and from bathymetry information obtained from the processing of satellite altimetry measurements. All digitized ship-board bathymetry data have been compiled over the

two study area. The altimetry data from all available oceanographic satellites (SEASAT, GEOSAT, ERS-1, TOPEX/POSEIDON) have been acquired and processed in order to provide bathymetry information concerning uncharted or poorly charted seamounts. The bathymetry of these new features has been computed from satellite data using original algorithms developed for such seafloor surveys applications. Global bathymetry maps have been elaborated from these two bathymetry data sets (ship-board bathymetry and satellite bathymetry). These maps are compared to the existing bathymetry maps in the area and to navigation maps.

Global seismographic network coverage of the Pacific

*Rhett Butler,
The IRIS Consortium, Arlington, Virginia, USA*

A global network of state-of-the-art, digital seismographic stations is being installed by the Incorporated Research Institutions for Seismology (IRIS - a nonprofit consortium of 80 Universities in the United States). A network of 128 stations uniformly distributed over the Earth is designed for studies of earthquakes, the three-dimensional structure of the Earth, and earthquake related hazards such as tsunamis. The IRIS global seismographic network (GSN) has been funded since 1986 by the U.S. National Science Foundation and works in cooperation with the U.S. Geological Survey. To date, 57 GSN stations have been installed, including new seismic stations at Monasavu Fiji, and Rapanui (Easter Island); and the upgrade of existing seismic stations at Guam; Honiara, Solomon Islands; Port Moresby, Papua New Guinea; Rarotonga, Cook Islands; South Karori, New Zealand; and Oahu, Hawaii. The GSN is being built for many decades of use. The focus for the growth of the GSN in the coming years is the oceans. The primary effort will be island sites, but research and development for ocean-bottom siting will also be important. Siting plans include Midway Is.; Wake Is.; Johnston Is.; Kwajalein Is.; Hawaii Is.; Tarawa & Kiritimati, Kiribati; Funafuti, Tuvalu; Kermadec Is.; the Marquesas; and Pitcairn Island. To improve the signal-to-noise characteristics of the stations, many will have seismometers installed in 100-meter-depth boreholes. Station operators are trained by IRIS personnel. Local interest in the data from the GSN sites is strongly encouraged, and all IRIS data is made freely available to the international community.

The occurrence of Todorokite and Buserite in deep-sea manganese nodules

Se-won Chang and Chan Hee Lee
Korea Institute of Geology, Mining and Materials

Manganese nodules display great variations in morphology and complex internal features which reflect the different environment and the complex history of formation. In this study, various types of deep-sea manganese nodules from KODOS-92, 93 cruises showing distinct structural changes and textures were taken and analyzed by electron microprobe (EPMA) and X-ray diffraction.

The internal features, the variations of chemical compositions, and X-ray diffraction patterns between different textural zones of various types of surface texture were considered and the characteristics of different lamellae in various types of textural zone and the relationships between each component were compared.

New data on the chemical compositions of lamellae are presented and two varieties of 10A manganese hydroxides, Al-Mg phase and Ca-K-Mn phase are recognised in this study. We compared the chemical compositions quantitatively and X-ray diffraction patterns with thermal treatment, and assigned the Al-Mg phase for Todorokite and Ca-K-Mn phase for Buserite.

The average chemical compositions (wt%) of Todorokite by EPMA are Mn:34.87, Si: 0.09, Fe: 0.38, Co: 0.06, Al: 2.00, Ni: 3.04, Cu: 2.35, Mg: 3.36, Ca: 0.21, Na: 1.38, K: 0.08, and those of Buserite are Mn: 38.81, Si: 0.37, Co: 0.09, Al: 0.28, Ni: 1.23, Cu: 1.61, Mg: 1.55, Ca: 1.58, Na: 1.90, K: 1.12 in this study.

Current Research Activities at the Marine Minerals Technology Center

Michael J. Cruickshank
Technical Director, Marine Minerals Technology Center
School of Ocean and Earth Science and Technology
University of Hawaii

Current research thrusts at the OBD emphasise the characterisation of metalliferous deposits in the ocean basins in water depths of over 1000 m, and coastal sand deposits in water depths less than 500 m. Exceptions have been made to these thrusts for projects of unusual interest supported by the recommendations of the Council. Research thrusts related to technology in water depths over 1000 m, include: Characterisation of deep seabed manganese crust deposits;

Geochemical characterisation of the OMCO manganese nodules from the Clarion-Clipperton Fracture Zone of the Pacific; Shallow submarine hydrothermal systems and their mineral potential in the SW Pacific; and in water depths under 500 m, include: A comparison of Shallow Seismic Reflection Profiling Systems for the Characterisation of Carbonate Sand Deposits. Other research in areas of exceptional Interest include: Underwater gravity separation and hydraulic classification of ocean minerals; Manganese tailings management; Mitigating an environmental problem for marine minerals processing by developing useful recycled building products; and Administration and coordination of the Underwater Mining Institute.

A comparison of Indian and Pacific Ocean manganese nodules and crusts

N.F. Exon

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Deepsea manganese nodules and crusts have long been of economic interest, mainly as potential sources of copper (Cu), nickel (Ni) and cobalt (Co). At present the costs of onshore mining for these metals are lower than those for offshore mining, and are likely to remain so for some time to come. The only thing that might change the economics of deepsea mining, in the short-term, would be the interruption of supplies to the industrial nations because of a crisis in one of the major countries of supply. Accordingly, international consortia and countries have split up the richest nodule mining areas between them, in conjunction with the United Nations, and are continuing to map nodule deposits with the aim of developing them eventually. However, very little new work is going into the development of nodule mining systems.

An alternative to manganese nodules, which generally lie as Ni+Cu rich carpets in the deep ocean (5000-6000 m deep) are Co rich manganese crusts, which generally form on seamounts and volcanic slopes (1000-2500 m deep). Although the crusts lie shallower, they will need to be separated from hard rock, whereas nodules need only be separated from soft sediments. The most interesting Mn nodule deposits known today (see Table) are in the northeast Pacific leases in international waters east of Hawaii (Ni+Cu), in the Indian lease in international waters in the Central Indian Basin (CIB; Ni+Cu), and in Cook Island waters (Co). The assessment of Co-rich manganese crusts is not as advanced as that of deepsea nodules, but the best of the known deposits are in the northwest Pacific Ocean, and probably in the Marshall Islands (Table).

Table: Mn nodule and crust data from various areas

Samples	No	Mn (%)	Fe (%)	Cu (%)	Ni (%)	Co (%)	Cu+Ni+Co (%)
Pacific Ocean crusts	319	22	15	0.08	0.44	0.63	1.15
Central Pacific crusts	311	23	15.7	0.47	0.12	0.79	1.38
Central Pacific outer crusts	102	25.05	14.2	0.06	0.51	1.02	1.59
Marshall Islands crusts		20.3	12.5	0.04	0.39	0.85	1.28
Christmas Island crusts	14	16.2	6.75	0.11	0.35	0.44	0.90
NE Pacific nodules	many	22.4	8.2	1.02	1.16	0.25	2.43
Best Cooks nodules	many	16	20	0.12	0.20	0.62	0.94
Average Cooks nodules	many	16	18	0.19	0.31	0.45	0.95
Indian Ocean nodules	324	15.4	14.8	0.27	0.46	0.23	0.96
CIB nodules (red clay)	44	22.2	10.7	0.68	0.92	0.21	1.81
CIB nodules (Si ooze)	45	26.1	7.7	1.19	1.22	0.14	2.55
Wharton Basin nodules	39	17.5	11.9	0.41	0.55	0.18	1.14
Christmas island nodules	24	19.7	4.6	0.49	0.51	0.12	1.12

At this stage the conditions for a potentially viable deepsea nodule mining site (Ni+Cu rich) are believed to be: cutoff abundance 5 kg/sq m; cutoff grade 1.8% Ni+Cu; topography not extreme; duration of recovery 20 years; annual recovery 3 million tonnes; efficiency of mining system 20 %. Areas in both the northeast pacific and the Central Indian Basin meet these requirements. For Co-rich manganese crusts two conditions are: cutoff thickness 4 cm; cutoff grade 0.8 % Co.

Origin of massive dolomite, Leg 143, Hole 866A, Resolution Guyot, Mid-Pacific Mountains (Poster paper)

Peter G. Flood

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Dolomite is ubiquitous in Barremian age sediments at depths below 1200 mbsf in core from Hole 866A. Two distinct dolostones occur; one brown colored, the other white colored. The brown-colored dolomite occurs over a four hundred meter interval (1200 to 1620 mbsf), while the white-colored dolomite is restricted to a fifty meter interval (1250 to 1300 mbsf) enclosed within the brown-colored dolomite. Dolostone rock textures include unimodal planar-s type with non-mimically replaced to partially replaced allochems. The predominance of planar crystal boundaries indicates growth at low magnesium saturation and low temperatures. The dolomite is non-luminescent and it ranges from highly calcian (41 mole% MgCO₃) to nearly stoichiometric in

composition. Strontium, oxygen and carbon stable isotopic compositions reveal two distinct pulses of dolomitization both of which post date the depositional age of the shallow-water carbonate sediments. Pulse I dolomitization could have occurred during the early Aptian or late Albian after the shallow-water carbonate platform had subsided some 600 to 1200m. This dolomite displays δ_{OPDB} of -1.6 to +0.7 upcore; δ_{CPDB} value of +2.4 to +2.1 and an average $^{87}Sr/^{86}Sr$ value of 0.70735. Pulse II dolomite displays δ_{18OPDB} of +3.7, δ_{13CPDB} value of +3.4 and an average $^{87}Sr/^{86}Sr$ value of 0.70822. Pulse II is restricted to a very narrow stratigraphic interval. It is 100 m.y. younger than the depositional age and may correlate with events occurring about the time of the end of the Paleogene. Calculations, using the isotopic composition of seawater, of the temperature of the dolomite formation for pulse I, ranges from 15 to 30°C. During pulse II the temperature was 17°C. Marine waters percolating through the guyot may be responsible for both pulse I and II dolomitization events. Geothermal endo-upwelling is one possible mechanism driving the convective fluids through the subsiding carbonate platform thereby promoting dolomitization.

Recent advances in Canadian ocean mapping technologies

E. Carl Granter

*President, Canadian Ocean Resource Associates (CORA) Inc.
and a representative of the Canadian Hydrographic Service*

Canada manages one of the world's largest coastal zones, covering the Pacific, Atlantic, and Arctic regions. To manage these ocean resources, Canadians have developed a wide range of world-class technologies, including:

- data acquisition platforms including the autonomous underwater vehicle DOLPHIN and the SWATH vessel Frederick G. CREED
- a shipboard launch and recovery system for unmanned vehicles and towed bodies
- a marine motion sensor and positioning system using a gyro-based inertial platform integrated with DGPS
- airborne laser-base systems for shallow-water mapping
- data-cleaning software for acoustic multibeam systems
- water column and seabed acoustic classification hardware and software tools
- analytical and visualisation tools to effectively process large marine datasets

- multi-dimensional source database management systems
- information management technology to produce and disseminate digital marine data and products

The paper will describe the application of these technologies on a number of innovative seafloor mapping projects in Canada and internationally.

The paper will also describe the Ocean Mapping Initiative of Canada (OMIC), a partnership of Canadian Industry, universities and government which will provide complete coastal and ocean-mapping capabilities and expertise to domestic and international markets.

An outline of the resource of manganese nodules in the Cook Islands "EEZ"

*Stuart Kingan
Ministry of Marine Resources, Cook Islands*

This paper summarises the Manganese Nodule resource in the Cook Islands as determined by 14 SOPAC supported or assisted cruises in the Cook Islands EEZ over the last 20 years.

Assessing the origins, age, and post-emplacement history of the Ontong-Java Plateau through basement drilling

L.W. Kroenke, J.J. Mahoney, A.D. Saunders

A basement drilling transect of the Ontong Java Plateau is proposed with the primary objectives of determining: 1) The age and duration of emplacement of the plateau; 2) Emplacement style; 3) Environment of eruption; 4) Range and diversity of magmatism; and magmatism; and, 5) Post-emplacement vertical tectonic history of the plateau. Nine sites are planned for a two-leg transect to address these objectives (including two possible reference sites adjacent to the OJP). As alternative, a four-site, one-leg transect is presented in case budgetary or time constraints do not permit the preferred two-leg program. A tenth site might also be targeted for drilling closely-spaced, multiple RDR's which are reported to occur on the plateau, if high-resolution digital, SCS or MCS grids were to become available in key areas. Although we propose to focus on basement

objectives at all of these sites, aimed at shedding light on fundamental processes governing the origin and emplacement of oceanic plateaus, considerable information would also be accrued bearing on the tectonism associated with plateau formation and subsequent deformation and the relationship of plateau emplacement to major paleoclimatic and biospheric changes and also on late Mesozoic - Cenozoic paleoceanography.

The morphostructural fabric of the Loyalty Ridge's southern extension

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The ZoNeCo 1 cruise represents the first phase of the multi-disciplinary ZoNeCo programme that aims to assess the living and non-living marine resources within the EEZ of New Caledonia. SIMRAD EM12 DUAL swath-bathymetry and acoustic imagery, seismic and magnetic data were collected on board IFREMER's R/V L'ATALANTE during the ZoNeCo 1 cruise (26 June-15 July, 1993).

NNW-SSE-trending, 120 miles-long profiles were carried out during the ZoNeCo 1 cruise that surveyed the southern ends of the New Caledonia and Loyalty ridges, between 23°-25°40'S and 167°20'-171°E.

The southern end of the Loyalty Ridge shows a succession of aligned seamounts and guyots characterised by an average depth of 1000 m and a N160°E trend. The discontinuous faulted ridge is bounded to the west, by the N160°E-trending southern extension of the Loyalty Basin, 2000-2500 m deep, and to the east, by the northwestern corner of the South Fiji Basin, characterised by an average depth of 4000 m and a smooth topography.

From the morphobathymetric data, a dive simulation has been realised by IFREMER's Information Processing Dpt (DITI/BREST) along the eastern part of the ZoNeCo 1 survey, on the Loyalty Ridge's southern extension. The video tape simulation consists of the superimposition of acoustic imagery data on the Digital Elevation Model (DEM) of the studied area. The dive starts

near 25'S on the eastern flank of the Loyalty Ridge, then heads eastward within the South Fiji Basin, crosses the Loyalty Ridge above the summit of the guyot-type structures, enters within the Loyalty Basin, crosscuts the western flank of the Loyalty Ridge before coming up to the surface near 25'30'S.

The dive simulation allows to identify two main volcanic phases. 1) The submarine basaltic phase that created the substratum of the Loyalty Ridge. The "guyot-type" volcanoes identified on the southern end of the Loyalty Ridge suggest a general uplift and an aerial erosion that probably occurred during the Pleistocene general uplift phase. 2) The recent volcanic phase, characterised by NNE-SSW-trending sharp seamounts, occurred after the Pleistocene uplift, probably when the "Loyalty - New-Hebrides" collision started.

The dive simulation also reveals that most of the volcanoes along the Loyalty Ridge are guyots. These guyots, interpreted as volcanic islands that were affected by a slow subsidence, represent potential fishery and mineral (FeMn crusts) targets.

The interpretation of the morphobathymetric data enables to precise the nature and the structural fabric of the Loyalty Ridge, an indispensable first step to define targets for future assessment of living and non-living marine resources.

Seismic reflection evidence for crustal uplift and volcanism along the Melanesian alkali volcanic island chain, Papua New Guinea

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The Melanesian Alkali Volcanic Island Chain (MAVIC) trends NW parallel to and NE of New Ireland, Papua New Guinea, and contains Tabar, Lihir, Tanga and Feni island groups. Each of the MAVIC island groups includes a series of small islands perched above a N-NE trending block of uplifted forearc crust. Interpretation of single channel seismic reflection data, dredge hauls and hydrosweep bathymetry acquired during R/V Sonne cruise 094 shows that these blocks are comprised of forearc sedimentary deposits, igneous intrusions, volcanic rocks, and post-uplift sedimentary cover.

Uplift along each N-NE elongated group of islands has produced asymmetric arching of the crust, with steepened eastern flanks that appear to be more faulted than western flanks. Profiles across strike of the island groups show no evidence for existence of pull-apart basins near the islands, as has been previously suggested. On the basis of bathymetry and widely spaced seismic reflection profiles, steeply dipping faults along the flanks of the island groups are presumed to trend N-NE, and may have undergone strike-slip as well as normal dip-slip motion caused by footwall uplift. The timing of crustal uplift is marked by prominent angular unconformities, where younger sedimentary reflectors lap onto older, rotated sedimentary reflectors. Uplift and volcanism is suspected to have begun in the early Pliocene.

Bathymetric gullies on the southern flank of Lihir Island, previously suspected to be faults, are depositional features formed at the contacts between debris aprons and rotated sedimentary layers. Pre-uplift sediments here are folded into a NW striking antiform. Normal faulting, however, was identified in one profile crossing a WNW trending scarp (~500m high) identified using hydrosweep bathymetry near Luke Bay, Lihir. Crustal arching associated with clusters of small volcanic cones on the submerged, southern flank of Lihir Island may be the result of magmatic intrusion during the early stages of crustal uplift and volcano building, and may represent a nascent volcanic island forming above an intrusive complex.

NW trending profiles that cross valleys between island groups show evidence for transpressional and transtensional, strike-slip faulting along possibly N-NE trends. Between Feni and Tanga, a pull-apart basin has formed in the valley along one of the interpreted fault zones. Between Tanga and Lihir, a series of sedimentary blocks, having positive relief and thought to be thrust cored anticlines, show signs of transpressional faulting. Positive flower structures also are imaged in regional profiles crossing the valleys between island groups. At present we have no explanation for this strike-slip faulting, because seismic profiles are too widely spaced to give a clear picture.

Crustal arching and associated arc-like volcanism require that the tectonic evolution of the MAVIC be reconsidered in a framework of plutonic diapirism rather than extensional tectonism. This plutonic diapirism may have been initiated by northeastward subduction of young, Solomon microplate lithosphere along the eastern New Britain - northern Solomon Trench, prior to southward migration of the New Britain arc-trench system.

Frontiers of deep submergence research in the Western Pacific

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The techniques of deep submergence using submersibles for direct human observation of the ocean floor and sampling and in placement of instruments has allowed the detailed studies of the processes of hydrothermal venting along the mid-ocean ridge west and lately along the back-arc rifts of the western Pacific. These techniques, along with the use of companion remotely operated vehicles (ROV's), deep towed, ship-tethered acoustical, physical and optical devices, all used within well surveyed bathymetric grids and precise acoustic navigation of the deep submergence system, have allowed the precise sampling of deep ocean fauna and of rocks and minerals.

The use of these deep submergence systems has led to the direct observation of fish and crab population behaviour in important fisheries areas such as those of Alaska. These systems have allowed the detailed sampling and age dating of submerged coral reefs in Hawaii thus giving data on the rate of island sinking and the rate of sea-level changes in the Hawaiian Islands. Deep submergence based research has given quantitative data on the distribution and mineral content of cobalt rich ferromanganese crust located on Cretaceous seamounts near Hawaii. The use of submersibles for observation and precise collection of sessile benthic organisms such as gorgonians, for pharmaceutical extraction has opened new sources for antibiotic and anti viral compounds.

The Pacific Ocean Basin located west, northwest and southwest of the Hawaiian Islands is geologically unique in the presence of thousands of seamounts, atolls of the Pacific Basin and active volcanic Islands along the Western Pacific Island Arc system. In this area, research into the back-arc hydrothermal systems, their mineral deposits and fauna communities is in beginning stages. Our understanding of these systems is vital for our ability to predict the occurrence of renewable mineral resources and for our understanding of the distribution of the hydrothermal faunal communities.

In the Pacific Basin, the submerged portions of the thousands of atolls and seamounts have not as yet been studied or surveyed. Detailed mapping and sampling of the submerged slopes of the atolls will give an insight into past sea-level fluctuations and the climatic effect upon coral growth and mortality. The variety, distribution and physiology of the deep fauna associated with atolls and seamounts in the Western Pacific is unknown.

The extent of the ferromanganese crust coverage of the seamounts in this region has only been assessed through the use of crude ship-board techniques such as dredging. In order to begin a precise, quantitative repeatable documentation of deep ocean floor process, the fauna and the mineral deposits, deep submergence techniques must begin to be systematically used in the study of the Western Pacific seamounts, atolls and islands and their benthic resources.

Submarine hydrothermal activity in Izu-Ogasawara Arc area

Seizo Nakao
Geological Survey of Japan

The Geological Survey of Japan conducted a study on submarine hydrothermal activity in the Izu-Ogasawara (or Bonin) Arc and the northern most part of the Mariana Arc from 1984 through 1989. Hydrothermal products, both unequivocal and inferred, are divided into three categories: (1) manganese or iron enriched sediments, and Mn-Fe hydroxide and silica deposits (chimneys) in the back-arc basin (rift) area: (2) manganese and/or iron oxide deposits occurring in the mountainous areas of both the back-arc and the volcanic front areas: and (3) a veinlet of iron-copper-zinc sulfides in hydrothermally altered andesite on a wall of a submarine caldera along the volcanic front.

Geological structure suggests that the Sumisu Basin (or Sumisu Riff) is one of the most promising areas to find submarine hydrothermal activity, among the back-arc basins. Heat flow values and bacterial biomass in seawater support this prediction. Geochemical study of the Sumisu Basin sediments discloses that the contents of some metal elements, such as Mn, Fe, Ni, and Cu, are typical of hydrothermal metalliferous sediments. REE geochemical data support a hydrothermal interpretation. Submersible studies indicate that large chimneys composed Mn-Fe hydroxides and silica are ubiquitous near the summits of the dacite volcanoes in the Intra-Ridge area of the Sumisu Basin, though they are apparently not active.

Geological and geochemical studies of manganese and/or iron oxide deposits in the mountainous area of the volcanic front suggest recent hydrothermal activity because the oxide crusts are not covered with hydrogenous manganese oxides. Manganese crusts on a back-arc seamount

started to form in the Quaternary; they are now covered by a superficial hydrogenous ferromanganese (δ -MnO₂) layer, suggesting that hydrothermal activity has ceased.

Hydrothermal sulfides (pyrite, sphalerite, and possibly chalcopyrite) were found in a veinlet in a large mineralised block of two-pyroxene andesite on a submarine caldera wall (the Kaikata Caldera) along the volcanic front. The pyrite and quartz mixture with the veinlet has maximum gold and silver contents of 142 ppb and 1.8 ppm, respectively. This discovery implies that not only the back-arc spreading centre, but also the volcanic front may be an important site of mineralisation in an arc-trench system.

Submersible study of the Kaikata Caldera also disclosed some indications of submarine hydrothermal activity, such as reddish brown drifting particles (possible hydrothermal Fe-oxyhydroxide) and hydrothermally altered greenish volcanic rocks. Seawater temperature, bacterial biomass, dissolved methane, and heavy metal elements (Mn and Fe) in seawater also indicate possible hydrothermal activity in some calderas along the volcanic front.

We found the evidence for submarine hydrothermal activity in one back-arc basin (the Sumisu Basin) and one submarine caldera (the Kaikata Caldera) convincing. Analogy can be made between these areas and the paleo-setting of the "Kuroko" deposits, although almost all of the hydrothermal products in the marine areas are Mn and/or Fe oxides formed in a low temperature regime than that inferred for the "Kuroko" deposits.

Preliminary results of the recent Hakurei-Mar No.2 cruise in the Solomon Islands (partly Papua New Guinea) waters

*Jiro Osako**, *Seizo Nakao***
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The 1993 cruise of the Hakurei-Mar No. 2 for deep-sea minerals exploration in SOPAC region under the Technical Cooperation by Japan and SOPAC member countries, surveyed in the sea area of eastern Woodlark Basin, EEZ of Solomon Islands and partly Papua New Guinea of about 51,000 km from August 18, 1993 to October 24, 1993 (68 days).

The survey was composed of topographical cruising for making bathymetric maps and geological/geochemical regional detail survey. To help estimate geological structure, magnetic survey was also conducted.

The result of the investigation indicate that the area can be divided into two parts by the Simbo Ridge located in the center of the area, where a N-S transform fault is located. The western side of the Simbo Ridge is characterised by a combination of seafloor spreading center with E-W depression and a N-S transform fault, which crosses the spreading center orthogonally. The interpretation of magnetic anomalies also indicate this structure very clearly.

The eastern part consists of trenches, submarine volcanoes and relatively flat seafloor. Geochemical anomalies were detected by multivariate statistical analysis of geochemical samples. Continuous Deep Sea Camera with Finder (FDC) was used for detailed observation of geology in the areas of the spreading center and some submarine volcanoes. Many rock samples were obtained by chain Budget and Finder-mounted Power Grab.

Rock samples of light grey clay and siliceous rocks taken at the crest of Kana Keoki Seamount shows hydrothermal mineralisation. By laboratory study, pyrite, gold and small amount of chalcopyrite, tetrahedrite and sphalerite were observed.

Sericite was also detected. In addition to these mineralised and altered rocks, a small "chimney-like" sample composed of powdered galena and gypsum was collected.

Progress on SOPAC Atlas on deepsea minerals

Jiro Osako Seizo Nakao***

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Technical cooperation on deep sea mineral resources investigation between the Metal Mining Agency of Japan (MMAJ/Japan International) Cooperation Agency (JICA) and SOPAC member countries had started in 1985.

The Phase I, or the First Five Year Plan, and the Phase II, or the Second Year Plan have already covered the Exclusive Economic Zone (EEZ) of Cook Islands, Tuvalu, Western Samoa, Republic of Kiribati, Papua New Guinea, Solomon Islands and Vanuatu.

This year, 1994 is the last year of the Second Five Year Plan and the 10th year of the survey. During this period Hakurei-Maru No.2 has been conducted for exploration of manganese nodules, cobalt-rich crust and hydrothermal multi-mineral deposits as well as for making detail topographic maps.

Significant amount of scientifically important and valuable data were accumulated during this 10 year period. In order to disseminate, to summarise and to index, compiling cruise data on deep sea minerals in SOPAC area on the Atlas were agreed between Japan and SOPAC.

The ATLAS will be completed coming February 1, 1995.

Niufo'ou, Tonga: volcanic hazard and the risk from future activity

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Niufo'ou Island, located within the northern Lau Basin is Tonga's most active volcano. Hazard/risk rating scales indicate that Niufo'ou is considered to be both an "active" and "hazardous" volcano. Both effusive and explosive activity has occurred through-out the development of the island. At least 10 periods of activity have occurred since 1800 producing extensive lava flows and tephra deposits. Among the hazards, lava flows have been the most frequent and have had the most direct effect on the islands population, resulting in at least 25 deaths in 1853 and the complete evacuation of the island following the 1946 eruption. Tephra falls, although being less frequent, have also resulted in considerable damage to both buildings and vegetation and have indirectly caused a number of deaths. Other phenomena, including pyroclastic surges, volcanic gases, ground fracturing and earthquakes have had only a minor effect on the island's population. Based on the frequency of recorded eruptions and the distribution of the resultant products, preliminary hazard maps for lava flows and tephra falls have been constructed. The zone of highest risk from lava flows is confined to the lower seaward flanks of the volcano, ie.. below the 50 metre topographic contour. Although the entire island is at risk

from a tephra fall produced during explosive activity, the western quadrants of the island are at highest risk.

Perception of the risk from volcanic activity is sometimes complex and in the case of Niuafou'ou this is true. The degree of perception varies considerably. The older generation, ie.. those who have experienced an eruption, have a definite perception of the risk. In contrast, the younger generation, although being aware of the hazards associated with an eruption have a somewhat lesser perception of the risk to life and property. Because of the strong cultural traits of the Niuafou'ouans they have accepted the high risk from future activity and it appears that the ties to family and traditional land have overridden the high risk. There is, however, still a fear evident in the population that can be attributed to the risk of future activity.

Because of Niuafou'ou's remoteness and the high risk accepted by the population, the only effective and realistic form of mitigation against the hazard, particularly lava flows, is the strict control of village location, ie.. being based on the zones outlined in the hazard maps. This has been accomplished by the fact that all villages are now located on or above the 50 metre contour and within the eastern quadrants of the volcano.

Thus, steps must be taken by the authorities to enhance the native population's knowledge of the hazard. This could be achieved by an education program and the implementation of a volcano monitoring program involving both seismic monitoring and periodic observations of the volcano by trained personnel. Interpretation of the data collected during this program will allow more precise forecasts of future activity to be made.

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Papers:

"Preliminary studies for setting a groyne on the coral island of Amedee Lighthouse, New Caledonia, South West Pacific" by M. Allenbach [abstract provided]

"Presentation and objectives of the impact study for construction of the littoral motorway by-pass Noumea-Mont Dore, New Caledonia, South West Pacific" by M. Allenbach P. Thollot, C. Chauvet [abstract provided]

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Paper: "Relation between tectonic, magmatic and hydrothermal activity on the EPR at 17°-19°S: NAUDUR cruise (Nadir-Nautile)" by J.M. Auzende, Y. Fouquet, V. Ballu, R. Batiza, D. Bideau, H-H. Cormier, P. Geistdoerfer, Y. Lagabrielle, J. Sinton, P. Spadea [abstract provided]

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Paper: "OR-shore seafloor mapping from satellite altimetry: results of surveys within Tuvalu and Papua New Guinea EEZs" by Nicolas Baudry [abstract provided]

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Paper: "Global seismographic network coverage of the Pacific" by Rhett Butler (Oral and Poster) [abstract provided]

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Paper: "The occurrences of Todorokite and Buserite in deep-sea manganese nodules" by Se-Won Chang and Chan Hee Lee [abstract provided]

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Paper: "Current research activities at the Marine Minerals Technology Center" by Michael Cruickshank **[abstract provided]**

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Paper: "A comparison of Indian and Pacific Ocean manganese nodules and crusts" by Neville F. Exon **[abstract provided]**

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Paper: "Origin of Massive Dolomite, Leg 143, Hole 866A, Resolution Guyot, Mid-Pacific Mountains" by Peter G. Flood **(poster) [abstract provided]**

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Paper: "Recent advances in Canadian ocean mapping technologies" by E. Carl Granter **[abstract provided]**

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Paper: "An outline of the manganese nodule resource of the Cook Islands." by Stuart Kingan **[abstract provided]**

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Paper: "Assessing the origins, age, and Post-emplacement history of the Ontong Java Plateau through basement drilling" by L.W. Kroenke, J.J. Mahoney, A.D. Saunders [abstract provided]

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Paper: "The morphostructural fabric of the Loyalty Ridge's southern extension" by Y. Lafoy, Jacques Dupont, Raymond Le Suave, Guy Pautot [abstract provided]

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Paper: "Frontiers of deep submergence research in the Western Pacific" by A. Malahoff [abstract provided]

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Paper: "Seismic reflection evidence for crustal uplift and volcanism along the Melanesian Alkali Volcanic Island Chain, Papua New Guinea" by Jayson Meyers, Heiner Villinger, Andreas Rosenberger, Hans Gennerich [abstract provided]

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Paper: "Submarine hydrothermal activity in Izu-Ogasawara arc area" by Seizo Nakao [abstract provided]

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Paper: "Progress of SOPAC Atlas on Deep-sea Minerals" by Jiro Osako [abstract provided]

Paper: "Preliminary results of the recent Hakurei-Maru No. 2 cruise in the Solomon Islands waters" by Jiro Osako and Seizo Nakao [abstract provided]

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Paper: "Niuafu'ou, Tonga: Volcanic hazards and the risk from future activity" by Paul Taylor [abstract provided]

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