ABSTRACTS OF PAPERS PRESENTED AT THE STAR* SESSION 2002

John Collen
Editor

SOPAC Miscellaneous Report 487

*** Science, Technology and Resources Network**

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FOREWORD

STAR (SOPAC's Science, Technology and Resources network) was founded in 1985 in collaboration with IOC. The first Chairman of STAR, Dr Charles Helsley, then Director of the Hawaii Institute of Geophysics, guided STAR until 1992. He was succeeded by Keith Crook from the Hawaii Undersea Research Laboratory. Keith served until the end of 1999 when John Collen from the School of Earth Sciences at Victoria University became Chair. STAR was formed as a vehicle to assist the international geoscience community to provide advice to SOPAC, particularly during the intervals between SOPAC International Workshops.

STAR meetings are not simply technical conferences at which individuals present scientific papers and discuss their 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 to the region. This advice, in the form of reports and recommendations from STAR Working Groups and reports on highlights of STAR technical presentations, is tendered to Council by way of an address in Plenary by the Chair of STAR and during the Governing Council/Technical Advisory Group (GC/TAG) segment of the Annual Session. 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 mobilize excellent and multidisciplinary 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 endeavor, 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. During the 1990's it supported the changes in SOPAC's scope and focus that are still continuing.

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 similarly so as to ensure that SOPAC's Work Program and its forward planning are influenced by international science that is both excellent and relevant. The wide scope of the work outlined by the abstracts in this volume is a clear indication that this evolution is continuing.

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September 2002

STAR Presentations at SOPAC Annual Session, 2002

PROGRAMME

Time	Theme	Authors & Speaker	Title
Wednesday September 25th			
09:00-09:15	OPENING	A. Simpson, Director, SOPAC & J. Collen, Chair, STAR	
09:15-09:45	Geology & development of Nauru	Howorth, R.	Pleasant Island: A product of sustainable development or a starting point for things to go wrong.
09:45-10:15		Kroenke, L.	Formation and deformation of the Ontong Java Plateau in the hotspot frame of reference: 122 Ma – Present.
10:15-10:35		Maharaj, R.	Evaluation of the impacts of harbour engineering in Anibare Bay, Republic of Nauru.
10:35-11:00	**Refreshment break**		
11:00-11:20	Geology & development of Nauru	Thaman, R.	The Nauru environment: issues and challenges for sustainable development.
11:20-11:40		Maharaj, R.	Recommendations for design of a shoreline protection system, Yaren District, Republic of Nauru.
11:40-12:00	Tectonics & Geology	Crook, K. & Felton, E. A.	Understanding the ups and downs of Lanai, Hawaii: integrating sedimentology, tectonics and geophysics.
12:00-12:20		Fisher, C.	The Ridge 2000 program and proposed integrated studies on the East Lau Basin spreading center.
12:20-13:30	**Lunch break**		
13:30-13:50	Tectonics & Geology	Nunn, P.D.	Late Cenozoic history of Niue Island: implications for understanding tectonics in areas of lithospheric flexure.
13:50-14:10		Suetsugu, D., Fukao, Y., Shiobara, H., & Inoue, H.	Broadband seismic observation in the South Pacific.
14:10-14:30		Rahiman, T.	Geology of the Ba and Vatia areas, northern Viti Levu: new stratigraphic relations within the Ba Volcanic Group.
14:30-14:50	Hazards	Tappin, D.R. Watts, P. & Matsumoto, T.	The 1998 PNG tsunami: an update on work carried out to understand the cause(s).
14:50-1510		Raj, R. & Kumar, A.	Rewa River flood forecasting system.
15:10-15:30	**Refreshment break**		
15:30-15:50	Hazards	Rahiman, T.	Rabi Island landslide hazard mapping project.
15:50-16:10	Non-living Resources	Lafoy, Y., Vially, R., Auzende, J.M., & France, R.	A contribution to geological knowledge and petroleum potential of New Caledonia: CADART1 well.
16:10-16:30		Heydon, D.	Why "----------" will be the first Pacific Island State to attract a $US multimillion investment in OFFSHORE MINING?
16:30-16:50		Okamoto, N.	Japan/SOPAC deep-sea mineral resources study programme – Stage II (2000-).
16:50-17:10		Raj, R. & Finiasi, F.	Interannual and seasonal rainfall distribution and storage behaviour on Viti Levu.
17:10-17:30	Human Resources	Penn, Ian E. & Stephenson M. H.	Business and Training Needs Analysis in geoscience organisations: focussing resources, improving the workforce, enabling change.
17:30-17:50	**STAR Business Meeting**		
Evening	Meetings of Working Groups – PJEP Training Rooms		

Thursday September 26th			
08:30-08:50	Sea Level & Oceans	Lal, A. & Turner, S.	Precise differential levelling survey, a major technique for monitoring sea level in the South Pacific.
08:50-09:10		Kaluwin C., Twilley, R., Yates, S. & Govind, R.	Implications of absolute and relative sea level changes monitoring in policy developments in the Pacific.
09:10-09:30		Kim, S.-P., Nam, S.-I., Chang J.-H. & Lee, S.-R.	Paleoenvironmental changes in the Korea Strait during the last deglaciation sea level rising: a case study from core SSDP-102.
09:30-09:50		McMurtry, G.M. & Smith, S.J	New mass spectrometer-based instrumentation for analysis of dissolved molecules and ions in coastal and deep-ocean environments.
09:50-10:10	Technology & Remote Sensing	Forstreuter, W., Tuivanuavou, S. & Lisati, P.	Production and application of multi temporal images.
10:10-10:40	**Refreshment break**		
10:40-11:00	Technology & Remote Sensing	Forstreuter, W.	Application of high-resolution satellite images in Pacific Islands Countries.
11:00-11:20		Lomani, E.	Creating MapInfo layers for vegetation change detection in Kosrae.
11:20-11:40		Ishoda, A. & Forstreuter, W.	Vegetation change detection, Majuro, RMI.
11:40-12:00		Tami, G. & Forstreuter, W.	Rapid lease boundary mapping in Fiji.
12:00-12:20		Chung, O. & Tuitai, T.	Creating a manageable database for the Pearl industry in Manihiki, Cook Islands.
12:20-13:30	**Lunch break**		
13:30-13:50	Habitats & Coastal	Smith, R. & Young, S.	High resolution, multibeam , shallow water surveys in the Pacific region in 2002.
13:50-14:10		Garimella, S. & Nand, N.R.	Sedimentation rate in Laucala Bay, Suva, Fiji, using the radioisotope ^{137}Cs as a tracer.
14:10-14:30		Terry, J.P., Kostaschuk, R.A. & Garimella, S.	Measuring floodplain sedimentation rates in the Rewa river basin, Fiji, using Caesium-137.
14:30-14:50		Harris, Peter T. & shipboard party.	Fly River sediment input to the northern Great Barrier Reef - relevance for regional marine planning.
14:50-15:30	**Refreshment break**		
	Joint Session 1		
15:30-15:50	Habitats & Coastal	Garton, D. & Collen, J.	Island carbonate sediment dynamics: assessing the role of foraminifera.
15:50-16:10		Tappin, D.R., Lal, A., Forstreuter, W. & Mafi, K.	Coastal erosion in western Tongatapu, Tonga – human impact, natural process or both?
16:10-16:30		Robinson, F.	Wetland Treatment Systems: a case study of the Wai Bulabula Project (Cuvu, Nadroga, Fiji).
16:30-16:50		Pearson, S.	The integration of geomorphological knowledge with sustainable shoreline management practice – an example of UK practice with potential application in other areas.
16:50-17:10		Chapman, J.	Sykes innovative solutions: pumping and aggregate supply within the Pacific region.
17:10-17:30		Erb, W.	The global ocean observing system
	Joint Session 2		
15:30-15:50	Energy	Bartmanovich, A.	Petroleum issues in the Pacific - gains through negotiation.
15:50-16:10		Madatov, A.	Installation of trial wave energy plant, Lifuka, Ha'apai Group, Kingdom of Tonga.
16:10-16:30		Naito, U., Uehara, H. & Ikegemi Y.	Ocean thermal energy conversion.
16:30-16:50		Mario, R.	Benchmarking commercial building electricity consumption in the Pacific islands.
16:50-17:10		Chandra, Y.	Results of the Earth Day 2002 competition convened by SOPAC.
17:10-17:30		Barram, F.	Significance of energy use and tourism in the South Pacific.
17:30:17:50		Woods, J.	Biomass Energy Research at ICCEPT, Imperial College, London.
Evening	Meetings of Working Groups – PJEP Training Rooms		

POSTERS	
Collen, J., Eagar, S. & McCulloch, M.	Dating the "Royal Society core" from Funafuti: Progress Report.
Eagar, S.	Ostracoda from Funafuti, Tuvalu : a progress report.
Kennedy, D.M.	A unifying model for the development of fringing reefs.
Khan, I.	Appliance labelling program for refrigerators and freezers – Fiji Islands.
Lafoy, Y., Sauvage, J.-F., Maurizot, P. & Devaux, L.	Mining industry in New Caledonia.
Lal, A.	South Pacific Sea Level & Climate Monitoring Project Phase III.
Maharaj, R.J.	Technology Transfer and Capacity Building in Earth Sciences for Development and Natural Hazards - SOPAC/USP Earth Sciences and Marine Geology (ESMG) 2001 Certificate Programme.
Maharaj, R.J.	Technology Transfer and Capacity Building in Hydrology and Hydrogeology- SOPAC/USP Earth Sciences and Marine Geology (ESMG) 2001 Certificate Programme.
Rahiman, T.	Geology and Petrology of the Dakuniba Peninsula, South East Vanua Levu, Fiji.
Rahiman, T.	Naboro Landfill geotechnical investigations, southeast Viti Levu, Fiji.
Rahiman, T.	Recent aggregate resource surveys by Mineral Resources Department, Fiji.
Stupenko, V.	Installation of trial wave energy plant, Lifuka, Ha'apai Group, Kingdom of Tonga.
Vially, R., Lafoy, Y. & Auzende, J.-M.	Petroleum potential of New Caledonia
Wren, C. & Barram, F.	Solar integration on commercial buildings.

ABSTRACTS OF PAPERS

Significance of energy use and tourism in the South Pacific

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Improving the operational efficiency of energy systems in isolated hotels in the South Pacific will be a key to the region's sustainable economic and environmental future. This paper outlines the data and the significance of energy use to hotels and nations in the South Pacific. Data is also presented on the significance of tourism in the region. Comparison is made of isolated South Pacific hotel energy costs as a percentage of total operating costs compared to standard Australian on-grid hotels. The paper demonstrates that the cost to supply energy to isolated hotels in the South Pacific has a significant impact on a hotel's financial and environmental sustainability. The current paradigm that pervades the design of energy systems for isolated hotels in the South Pacific has resulted in high energy-related operating costs. These unsustainable levels of emissions are predicted to contribute towards a permanent change in the global climate. High energy operating costs limit and constrain the potential for further tourism accommodation development. The paper concludes that further research into the efficient design and operation of energy systems in isolated hotels in the South Pacific is justified.

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Petroleum issues in the Pacific - gains through negotiation

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This paper will give a brief overview of the petroleum related issues in each of the forum island countries, as we have identified them, together with an indication of how each has been or is being addressed. Issues raised include exploring the benefits and limitations of fuel price regulation, the challenges of equitable, economic fuel supply to outer islands and the potential for increased industry competition through the independent ownership of fuel terminals.

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Results of the earth day 2002 competition convened by SOPAC: Schools Energy Conservation Project Competition "Energy Wizards of the 21st Century"

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Earth Day, April 22nd, is now widely celebrated around the world, as a collective expression of public will to create a sustainable society. Linking citizens' activities, Earth Day aims to educate and motivate people worldwide with the view to improving the environment.

The 2002 Earth Day Activity in the PICs, **"Energy Wizards of the 21st Century"**, focused on the importance of conserving and using energy (electricity) more efficiently in schools through an initiative that centred on an educational and awareness programme.

This paper focuses on the results of the Earth Day 2002 Competition and the change in attitude following implementation of the activity. The analysis of the reports received from the three schools (Mahatma Gandhi Memorial High School in Fji, KGV & EBS in Kiribati and Titikaueka College in the Cooks) is highlighted. Energy conservation and efficiency awareness was built among the students and the project was carried out successfully to "train" the students in good housekeeping practices.

The paper also highlights analysis of the questionnaire surveying the students' and teachers' understanding and knowledge on energy conservation and efficiency. The analysis revealed that, of 60 interviewed, 48% wanted to conserve electricity to save money, 35% to protect the environment and 27% to save fossil fuel. A keen interest was shown in saving electricity at home (97%). 70% thought most electricity could be saved through lighting, 22% from air conditioners and 18% from refrigerators. The survey revealed that people wanted to save electricity but were unaware of the simplicity of doing this.

The main observation from the "Energy Wizards of the 21st Century" programme was that there is a need in the Pacific for the effective delivery of basic education that includes and promotes the sustainable use and management of natural resources and the environment through energy conservation and efficiency.

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Sykes innovative solutions: pumping and aggregate supply within the Pacific region

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Sykes Pumps provides technical advice and equipment for sediment pumping and aggregate supply throughout Australia, New Zealand and the Pacific region. This presentation will discuss:

Dredging: sand recovery and establishment utilising hydraulic or electrical submersible dredging pumps;

Dewatering: sump pumping / wellpointing / snore operations utilising contractors' solids handling, auto-priming diesel and electric pumpsets;

Pumping: general high pressure applications - by-pass or overpumping applications;

Enviromental Applicatios: utilising quiet solution pumps - Sanivax marina installation, media filter & spill containment solutions; and

Pumps Selection: general guidance in pump selection and applications.

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Creating a manageable database for the pearl industry in Manihiki, Cook Islands

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In late 2000 and early 2001 a severe outbreak of pearl disease in Manihiki, Cook Islands, almost crippled the Manihiki black pearl industry. This disease occurred due to poor water circulation and the overpopulation of shells in farms. This and the pollution from shell maintenance and cleaning caused

a very poor environment in the lagoon. Manihiki lagoon is closed off to the ocean and its water only gets flushed out during storm conditions. This is the first time the disease has ever occurred in Manihiki and its source is still unknown.

Since this outbreak, the Manihiki Island Council has wanted a better management plan to help prevent this problem from recurring, by better understanding water circulation in the lagoon and by preventing farmers from overpopulating their farms.

The involvement of SOPAC began by obtaining a better understanding of the lagoon bathymetry. Bathymetric data was used to help in the referencing Ikonos imagery, by locating ground control points using reefs and small islands. The image was then enhanced to improve the colour. This was done by dividing the image into land and water areas and enhancing the colour separately. When both were improved, they were merged using the Erdas program. Next, the enhanced Ikonos image, annotated with layers of the bathymetry, farm boundaries, and island names, was used to produce a large-scale map that can be used by the Manihiki Island Council to better manage pearl farming.

The farm boundaries were surveyed to record the areas that each farm covers. After all were recorded correctly, they were related to the owner by introducing a code system and then put into a database. This database was produced to improve understanding of the practices that occur in each farm, reducing the chance of a fatal pearl disease occurring again.

The database for Manihiki pearl farms is produced as a management tool, so both the Council and the farmers can produce a clean environment for the pearls to grow in. They can also manage the sizes and number of farmers in the lagoon, where they can farm and how many shells they can have per farm. At the moment this database is in its infancy and the counting of shell per farm is still in process. However, the database makes it easier to see what each farm has, making management easier, and will hopefully improve the farming process in Manihiki and other atolls in the Pacific.

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Dating the “Royal Society core” from Funafuti: progress report

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In 1838, Charles Darwin proposed that atolls formed when coral reefs grew upwards in the shallow waters above subsiding volcanoes. As a result of the criticism that this concept received, he later (1881) begged that an atoll be bored to check the idea. In response, expeditions under the auspices of the Royal Society drilled several holes on Fongafale Island, Funafuti Atoll, Tuvalu between 1896 and 1898. The deepest reached 340 m and recovered core entirely of limestone, without reaching basalt. Despite the suggestion that some of the core may have been reef front talus deposits and thus from deep water, some coral was thought to be in growth position and thus to support Darwin’s ideas. Unfortunately, the results came some years after Darwin’s death.

Isotopic dating of rocks had not been developed in 1898 and there were no means of determining the age of the limestones in the core. Surprisingly, and despite the expedition being a high-profile one with the results mentioned in many textbooks, relatively little work has been done on the core since. The present study is an attempt to date the core using radiocarbon and uranium-series techniques and, if successful, could lead to a range of studies spanning a long time interval - the time range is unknown but is certain to extend beyond the last glaciation and may be much older. The core will probably include one or more unconformities (corresponding to dissolution during the low sea levels of glacial periods) and sufficient samples must be dated to delineate these. Ages plotted against the

global sea level curve will give a subsidence/time curve for Funafuti volcano and will aid the interpretation of reflectors seen in seismic profiles taken across the atoll.

The only other studies of material from deep within Pacific atolls are from Enewetak and Moruroa, where drilling during nuclear testing programmes found basalt at depth, and Midway. As these sites are more than 3000 km to the northwest and 4500 km to the east-southeast of Funafuti respectively, the results are of limited application to the SW Pacific.

Preliminary results for the Royal Society core suggest that the last glacial unconformity occurs between 23 and 30 m in the core. Ages from the overlying Holocene limestone indicate a net accretion rate for the coral of about 2.9-3.8 mm/year, with Holocene sediment accumulating in the lagoon at slightly lower rates.

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Understanding the ups and down of Lanai, Hawaii: integrating sedimentology, tectonics and geophysics

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Changing relative sea-levels observed on Pacific islands can result from several causes. Comparatively rapid (mm/yr) sea-level rise due to global warming is widely discussed. A rarely mentioned cause is the slowly increasing depth of the Pacific plate as it cools over time while moving westwards into the W. Pacific subduction zones. Some other causes of relative sea-level change are particularly well displayed by the island of Lanai, Hawaii.

Lanai, one of the smaller Hawaiian islands (Fig. 1), is a simple shield volcano that had ceased erupting by 1.28 Ma (Clague, 1998). It lies in the western strand of the duplex Hawaiian Islands chain, 135 km SE of the geographic center of Oahu, where Honolulu is located, and 195 km NW of the center of Hawaii island (a.k.a. the Big Island) where hot-spot volcanism is continuously active. In this location, Lanai has recorded vertical motions experienced by volcanic islands and seamounts as they are carried away from their magma sources.

Lanai's submerged western flank rises steeply from -4 km depth to a sharp slope break which deepens southwards from -1150 m to -1300m. This was a shoreline at the end of the Lanai volcano's shield-building phase (Moore & Campbell, 1987). Above this is a flight of seven submerged fringing reef terraces which also deepen southwards. Their ages are unknown; those assigned by Moore & Campbell (1987) rely on an invalid correlation with dated submerged reefs on the NW flank of the Big Island. The shallower seabed between Lanai and the adjacent islands of Maui and Kahoolawe is a drowned karst landscape developed in undated coral reef limestone (Grigg et al., 2002).

On Lanai's subaerial south flank, the Hulopoe Gravel (Moore and Moore, 1984) is widespread but patchy at elevations up to 190 m (Felton et al., 2000, Keating & Helsley, 2002). This consists primarily of rocky shoreline-related sedimentary facies that are variably cemented, 9m thick in the type section, and composed of basalt clasts, accompanied by fossiliferous limestone clasts in some beds (Felton et al., 2000, 2002). An outlier from higher on Lanai's south flank at 326 m a.s.l. was reported by Stearns (1936) as comprising "plenty of loose fragments and two places where fossiliferous limestone fills cracks in the bed rock.". We have confirmed that the fossils he collected are Hulopoe Gravel samples, not modern shells (Crook & Felton, 2002). Stearns (1940) interpreted soil stripping at elevations up to about 365 m as evidence for his Mahana high stand of sea level.

Isotopic dates reported from the Hulopoe Gravel are: >350,000 years at 170 m, by K. Osmond, using the ionium method (Stearns, 1966, p.21, footnote j); 173±15 ka to 235±33 ka from elevations between 10 and 74 m, with two outliers: 140±14 ka at 44 m and 37±11 ka at 40 m, (Grigg and Jones, 1997; using ESR); and two clusters, one at 130.9 -136.7 ka from elevations between 3.8 and 23.0 m and another at 196.2 - 258.2 ka from elevations between 2.3 and 58.9 m (Rubin et al., 2000; using TIMS). The fossils from 326 m have not been dated.

The TIMS data correspond to the last two glacial highstands, Marine Isotope Stages MIS 5e and 7 Rubin et al., (2000). We predict that the higher elevation Hulopoe Gravel outcrops at 170 - 190 m correspond to MIS 11 (ca. 400 ka) and the outcrop at 326 m corresponds to MIS 15 (ca. 575 ka).

From the foregoing we infer the following scenario. After cessation of volcanism at 1.28 Ma Lanai began to cool and sink, leading to the formation of seven fringing reef terraces corresponding to MIS 35, 33, 31, 29,27, 25 and 23, the youngest having formed ca. 0.95 Ma. Submergence continued during MIS 21, 19 and 17, but the growth of fringing reefs may have been inhibited by the steep slopes on what is now the subaerial south flank of the island; or the reefs may have been largely removed by subsequent subaerial erosion. Sinking of the island ceased after submergence to the present +365 m contour, at about 0.7 Ma, after which the island began to emerge, for reasons discussed below.

The growth of the five shield volcanoes that constitute the Big Island began sometime after 1 Ma. The oldest known lavas, dated at ca. 0.46 Ma (Clague, 1998), are part of the shield of Kohala volcano. A 0.26 ka drowned coral reef at -950 m on the slope break at the northern end of the Big Island (Jones, 1995), marks the end of Kohala's shield-building stage. The other four volcanoes are younger, and three (Hualalai, Mauna Loa, and Kilauea) are still active. As they have grown, the enormous mass of the Big Island has depressed the oceanic lithosphere, with concomitant uplift of the lithosphere to the northwest. Detailed geophysical treatment of this process, using a 3-D flexure model with curvature-dependent rigidity (Wessell, 1993a, b) has yet to be accomplished. Earlier studies (Moore, 1971; Watts & ten Brink, 1989) do not adequately model this phenomenon.

Thus, since ca. 1 Ma the south flank of Lanai between -120 m and + 365 m has been the site of repeated erosion and deposition, as a consequence of both glacio-eustasy and tectono-eustasy. Throughout, it has been primarily a rocky shoreline where terrigenous and bioclastic gravel has been generated, with an associated steep submarine slope where material moved offshore during storms has accumulated. The sedimentary facies present are distinctive, but they represent a deposystem and suite of environments that have hitherto not been studied systematically. These unrecognised circumstances have fueled the controversies about the nature and significance of the Hulopoe Gravel.

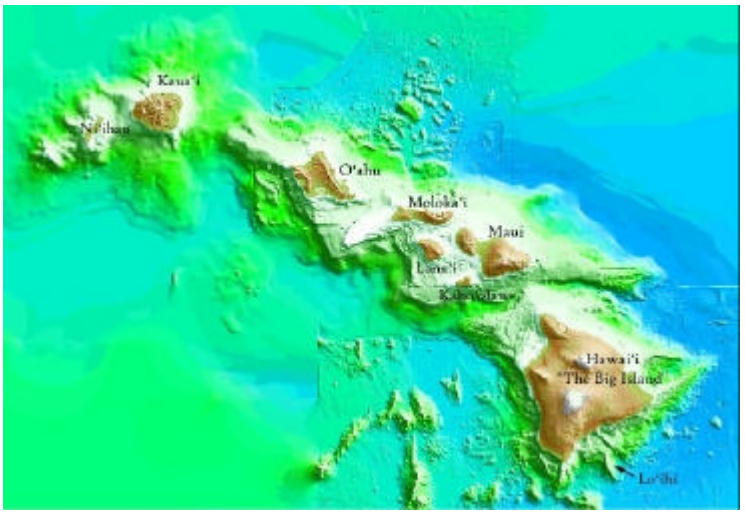

Figure 1: Topography and bathymentry of the Main Hawaiian Islands
http://www.soest.hawaii.edu/HURL/images/hawaii_map.jpg

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Ostracoda from Funafuti, Tuvalu : *a progress report*

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Ostracods are small, bivalved crustaceans that are found in many aquatic environments. Their microscopic nature means that even a small sample can yield many specimens. An important and historic collection of ostracods from Funafuti Atoll has been examined. Funafuti was first brought into scientific prominence with the testing of Darwin's theory on the formation of coral atolls by the drilling of the Royal Society boreholes in 1898 and subsequent years. Chapman (of Melbourne Museum) was asked to examine the microfauna, including the ostracods, from the various exploratory expeditions

and for the main borehole. His specimens are still in the collections of the Natural History Museum in London and provide a snapshot of the fauna of the nineteenth century. These historic samples provide supplementary material to the samples collected in 1984 by Bruce Radke (SOPAC) and in 1995/96 by Victoria University staff.

Only the shallow water fauna has been studied here. A selection from the many samples available was made, arranged into seven traverses from the beach into the lagoon west from Fongafale and the ostracods extracted. These were augmented with some spot samples from the ocean shore platform to check for any differences in the fauna from the more exposed environment. Thirty-eight species of ostracod are recorded, a greater number than for other atolls in the region. There is a core element in the fauna which has a similarities with those from Kiribati, French Polynesia and Fiji. The links are closer to the atolls than to the high islands.

Taxonomy is still a useful place to start any study of shallow-water Pacific ostracod faunas as it is important to correctly identify and establish the species present. In the past, it was assumed (through ignorance) that each atoll or area had its own fauna. It is now known that many species are more widely distributed than was first thought. By making studies from as many islands as possible, either through collection or by reference to publications, one can establish the distribution and plot the dispersal of individual species. However, it is important that one is confident of the identifications. This knowledge can then be used for more sophisticated studies of pan-biogeography using techniques such as DNA analysis on individual species.

Conclusions

There are more species of ostracod on the atoll of Funafuti, Tuvalu than on many other atolls in the southwest Pacific. The traverse that Chapman plotted is useful for establishing the distribution of the ostracods in the lagoon, but not for their relative abundances as there are only representative specimens preserved. No new species have been found to date, but more species were found than are recorded by Chapman. The ostracod numbers decrease close to the beach and increase towards the lagoon

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The Global Ocean Observing System

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The Global Ocean Observing System (GOOS) has been under development for about ten years and will be fully operational in about another 10-15 years. The Intergovernmental Oceanographic Commission (IOC) and the Government of Western Australia has established an Office in Perth, Australia, to assist in the development of GOOS in the South Pacific Ocean and Indian Ocean. This paper will describe some of the recent advances in general and address the development of GOOS in the Pacific region in more detail.

The Ridge 2000 program and proposed integrated studies on the East Lau Basin Spreading Center

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Ridge 2000 (R2K) is a new, US National Science Foundation-sponsored research initiative to understand Earth's spreading ridge system as an integrated whole, from its inception in the mantle to its manifestations in the biosphere and the water column. The R2K Program was conceived to promote an integrated approach towards the study of mid-ocean ridges. Emerging from community workshops over the past three years, R2K builds directly on the scientific and technological successes of a predecessor program, RIDGE (Ridge InterDisciplinary Global Experiments). The scientific motivation for the R2K Program is encapsulated in the phrase “from mantle to microbes” that expresses the inextricable linkages between processes of planetary renewal in the deep ocean and the origin, evolution and sustenance of life in the absence of sunlight. R2K is at the beginning of an anticipated 12-year program.

Research carried out under this new program will be structured within an integrated, whole-system approach that will encompass a wide range of disciplines. Specific geographic areas will be the focus of detailed studies to yield new insights into the linkages among the biological, chemical and geological processes that are involved in crustal accretion and subsequent ridge crest processes. The R2K Program will support two main research themes: Time-Critical Studies and Integrated Studies.

Time-Critical Studies

Under the R2K Program, Time-Critical Studies are dedicated to facilitating rapid-response missions that can observe, record and sample critical transient phenomena in the ocean above the mid-ocean ridge as well as on the seafloor itself immediately following a magmatic or tectonic event. In the initial phases of this element, the program will be restricted to the northeast Pacific where real time detection is possible through the US Navy SOSUS array and where the facilities are available for a rapid response. As detection and response facilities become available in other areas the R2K Steering Committee will consider expanding the geographic focus of this research theme.

Integrated Studies

The Integrated Studies theme of R2K is intended as a program of focused, whole system research of global mid-ocean ridge processes. This component addresses the complex, interlinked array of processes that support life at and beneath the seafloor as a consequence of the flow of energy and material from Earth’s deep mantle, through the volcanic and hydrothermal systems of the oceanic crust, to the overlying ocean. Moreover, this part of the program recognizes that the complex linkages between life and planetary processes at mid-ocean ridges can only be understood through coordinated studies that span a broad range of disciplines. Thus, Integrated Studies will consist of multidisciplinary research that is focused on a small number of pre-selected “type” areas that are designed to characterize segments of the mid-ocean ridge system. The objective of Integrated Studies is to develop quantitative, whole-system models through coordinated and interdisciplinary experiments. It will be necessary for R2K scientists to understand the interactions and linkages between the volcanic, tectonic, geochemical and biological systems to achieve this goal.

Program Status

The R2K Program officially began October 15, 2001, when the office opened at Penn State University. The Program is overseen by a Steering Committee of 15 scientists from the US and Canada. The chair of the Steering Committee also administers the program office with the assistance of three full time staff members: a post-doctoral Program Coordinator; a Program Assistant; and a Education and Outreach Coordinator.

To choose the initial sites for this research theme, proposals were solicited from the US research community and posted on a web site for comment. From the eight proposals, three initial Integrated Study sites were chosen through a community vote and review by a special Ridge 2000 Site Selection Panel (http://R2K.bio.psu.edu/ISPANELRPT.htm). One of the three sites chosen will center on a portion of the East Lau Spreading Center. Another will center within the 9-10°N segment of the East Pacific Rise off the Pacific coast of Mexico and the last on the Endeavour Segment of the Juan de Fuca Ridge in the Northeast Pacific.

Two open workshops were conducted in early 2002 to get the program rolling. The primary purpose of the first workshop (held in Long Beach, CA Feb. 25-27, 2002) was to provide a forum for community education and the sharing of data among all investigators wishing to write proposals for work at one of the Integrated Study sites. Speaker notes and figures, white papers, available data sets, maps, publications, and bibliographies from the workshop can be found at the R2K website (http://ridge2000.bio.psu.edu). Implementation plans for each of the initial Integrated Study sites were developed at the second workshop (April 7-8, 2002 in Albuquerque, NM). The three Implementation Plans were polished by teams of writers from the workshop and by the Ridge 2000 Steering Committee, and posted for community comment on the R2K website; the final versions are posted on the R2K website. These plans identify the geographic focus about which the nested components of each Integrated Study are centered and provide the guidelines for the components that will constitute the set of Integrated Studies necessary at each site.

The Lau Basin Integrated Study Site

The full text of the Implementation Plan for the Lau Basin Integrated Study Site is available on our web site (http://ridge2000.bio.psu.edu), along with a variety of other relevant information and contacts. Ridge 2000 scientists choose the East Lau Spreading Center for one of the initial Integrated Study Sites because it adds a variety of new elements to previous focus of US RIDGE research. For the first time the program will be encouraging a major research effort at a spreading center in a back-arc basin. The addition of this site to our efforts in the eastern Pacific greatly increases the range of biogeographic diversity, fluid and rock compositions, crustal structure and mantle dynamics that will be studied as an interrelated system by the program. We are all very excited about the possibility of a serious interdisciplinary research effort at this site. The Lau Spreading Center Implementation Plan calls for the first field season to begin with an ambitious series of research cruises sometime in 2004. These first cruises will serve to choose and characterize the “bull’s eye” about which the Integrated Studies research program will be centered, with the hopes of initiating contemporaneous and collocated interdisciplinary studies in the 2005-2006 time frame.

The Ridge 2000 program recognizes that much of the East Lau Spreading Center lies within Tongan Territorial waters and that our program can only go forward with the consent and support of the government of Tonga. The Implementation Plan also specifically states that: “Efforts must be made to collaborate with Tongan scientists to the maximum possible extent, both in the planning process and as active scientists and observers”. It is our hope that this presentation and visit will serve to facilitate a favorable start to this process.

To join the R2K mailing list, for timetables, data, upcoming meetings and workshops, contacts and other information about the R2K program, email us at ridge2000@psu.edu, see the R2K website at http://R2K.bio.psu.edu or call 814-865-RIDG.

Application of high-resolution satellite images in Pacific Islands Countries

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Many Pacific Island Countries still using maps produced during colonial times. This is due to the high cost of recording aerial photographs and even higher costs involved in their analysis. Today, satellites are recording high-resolution image data which has similar spatial resolution and better radiometric resolution than aerial photographs. In addition, this data is already in orthogonal projection and digital format. The data pre-processing is easy and the customer who is now able to add his field knowledge to the dataset can perform the data interpretation. Currently, high-resolution space-borne image data is replacing aerial photographs for most applications.

High-Resolution Image Data and its Applications

Currently there are four different sources of high-resolution image data available for Pacific Islands Countries. Different customers can use the same dataset and it is important to purchase jointly as there is a wide range of applications. The table below shows a comparison of different high-resolution image data sources and the approximately price per square kilometre.

Data Type	***Spatial Resol.***	***USD / km2***
QuickBird Pan	0.6m	30.00
IKONOS Pan	1m	21.00
EROS-A1 (only Pan) (archive)	1.8m	5.00
SPOT-5 Pan	2.5m	2.00
QuickBird MS	2.5m	30.00
IKONOS MS	4m	21.00
SPOT-5 MS	10m	1.00

Table 1: Spatial resolution and costs per square km for different high-resolution data available for Pacific Island Countries. No shipping costs included.

Application: vegetation change detection

During the past year SOPAC was involved in vegetation change detection in Majuro, RMI, in Kosrae, FSM and in Tonga, as part of the coastal investigations. In all cases, multispectral IKONOS images were used. For mapping landslides in Rabi Island, Fiji, SOPAC ordered QuickBird multi spectral data.

Application: shallow water bathymetry

In Manihiki, multispectral IKONOS image data was used for shallow water bathymetry as part of a pearl farm GIS developed with SOPAC. Further, shallow water application of multispectral IKONOS data was performed in Kosrae, where all mooring buoys around the island are GPS position recorded and displayed on a GIS backdrop. These buoys provide anchorage in the corals when taking tourists for diving and the image backdrop shows the bathymetry around the buoys. SOPAC ordered a large coverage of multispectral IKONOS images for the southern coast of Viti Levu, Fiji. Shallow water bathymetry is required for mapping of nearshore land-owning units for which management plans will be developed to avoid overexploitation. SOPAC ordered IKONOS multispectral data for the Suva reef to investigate its application for reef monitoring.

Application: general map replacement

SOPAC ordered IKONOS multispectral image data for the Suva peninsula, which is used for any kind of urban mapping. In addition SOPAC ordered EROS-A1 image data for the Suva peninsula to a) enhance the spatial resolution of the multispectral IKONOS image data through I H S transformation and b) to cover areas which were not included in the IKONOS dataset and are required by the Native

Land Trust Board for land use mapping. For Tonga, SOPAC ordered multispectral IKONOS data to complete the coverage of Tongatapu, where only the northern part was handed out as a GIS backdrop to the Tonga Electric Power Board. This utility utilises the image data to map and manage their assets.

SOPAC's role

SOPAC is the regional organisation with the mandate from member countries to assist in GIS and remote sensing. SOPAC is also the regional member of the international Society for Photogrammetry and Remote Sensing. SOPAC informs member countries, assists in data purchase and performs data processing where related hardware and software is not available in the corresponding country

A user working for a government or private institution in a member country is not able to overlook the latest development on market of space borne image data. He or she also cannot have an up-to-date picture of methods to employ image data. Here, SOPAC fulfils its role of a regional organisation. This year, there have been GIS & RS workshops in Kosrae, Vanuatu and Cook Islands, and remote sensing lectures and exercises at USP. The GIS and Remote Sensing newsletter, which informs about new data and analysis methods, is posted via air mail to member countries. Finally, the e-mail list GIS-PacNet regularly provides news about image data available, and data pricing and quality.

Currently SOPAC is dealing with five different companies selling image data for the Pacific. They are keen to communicate with a central point rather than with many customers. In addition, jointly with the Pacific Data Center in Hawaii, SOPAC gets a discount for Landsat, IKONOS and QuickBird images, which is fully forwarded to the customers in the member countries. SOPAC also avoids the difficulty arising when data is purchased with the ownership of one government institution only, which means that other government bodies in the same country have to pay a copy fee for the same data.

Some software and hardware is too expensive for small island countries. In this case SOPAC fulfils its role as a regional organisation and does the processing. This is the case for image analysis, where SOPAC has a full license and can do the pre-processing steps of geometric image correction, image stitching and conversion to GIS backdrops. SOPAC also has access to an A0 size scanner if production of a map backdrop is required. Some Pacific Island Countries do not have an A3 size scanner with the 600 BPI resolution necessary to scan aerial photographs.

Summary and recommendations

Joint purchase of space-borne image data reduces the cost of remote sensing information and provides a GIS basis where maps are not up-to-date or frequent image cover is necessary. It is necessary to change current procedures to:

> Provide joint and more frequent image data purchase for each country employing satellite data rather than aerial photographs;
>
> Delegate the image interpretation to operators who provide field knowledge; and
>
> Establish small, remote sensing centres in Pacific Island Countries to enable the countries to create image backdrops independently.

Sedimentation rate in the Laucala Bay, Suva, Fiji, using the radioisotope ^{137}Cs as a tracer

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Laucala Bay, a part of the Suva Lagoon and adjacent to Suva (the capital of Fiji), is enclosed by the Suva peninsula and several barrier reefs (which protect it from the Pacific Ocean). The average annual rainfall in Suva is about 3000 mm and the Bay receives major fresh water input from the Rewa River and some minor inputs from the Nasinu, Samabula and Watuwaqa Rivers. Further, Fiji is prone to repetitive tropical cyclones (about 40 since 1970), and large floods in the region are common. The waters of the Suva Lagoon are turbid throughout the year, and the rate of deposition of sediment in Laucala Bay is high.

The sedimentation rate in the Bay is measured using the ^{137}Cs technique. This radioisotope (half-life 30 y) was released into the environment through major atmospheric nuclear weapon tests during the period 1950-70 and was transferred to Earth's surface as dry fallout and washout in rainfall. It (^{137}Cs) is easily adsorbed onto soil particles and, through soil erosion, is transported into rivers and finally reaches the lagoon. By analysing the ^{137}Cs profile as a function of depth in a sediment core from the lagoon floor and by finding the depth at which ^{137}Cs is absent in the core, it is possible to date the lagoon sediment and to obtain a value for the average sedimentation rate. The ^{137}Cs technique not only gives accurate results but also has the advantage of requiring only a single visit to the test site to collect the sediment core.

In the present work, ^{137}Cs measurements on a sediment core from Laucala Bay were carried out using a high-resolution gamma-ray spectrometer at the University of the South Pacific. The measurements yielded an average sedimentation rate of 1.0 ± 0.1 cm/year.

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Island carbonate sediment dynamics: assessing the role of foraminifera

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Global climate change and the threat of sea level rise with associated increased coastal erosion presents immediate concerns to island nations worldwide. In the tropical Pacific Ocean islands are protected by reefs and beaches comprised of carbonates of biological origin. The distribution, transport and dissolution of carbonate particles are driven by geophysical processes; however, the production and composition of island coastal sediments results from predominantly biological processes. The stability and persistence of coastal sediments thus represents a balance between erosion/export and carbonate production/import processes. For islands and low-lying coastal regions to persist, endogenous sediment production must equal or exceed loss, assuming a static sea level. For a case of rising sea level, erosion/submergence may be mitigated by a corresponding increase in biological carbonate production and accretion into coastal sediments; conversely, reduction in carbonate production may exacerbate coastal erosion/subsidence.

Carbonate particle composition reflects the components of the biological community contributing to accumulating coastal sediments, and carbonate production rates reflect community composition and species' responses to environmental conditions. Prior studies have shown that composition of coastal sediments vary with location and depth, but are dominated by three major taxa: corals, calcareous

algae and foraminifera. Foraminifera, in particular, dominate sediments in shallow, calm waters (depositional environments) that are subsequently incorporated into island soils. Sediment samples often exceed 50% foraminiferan clasts, and this taxon clearly represents an important source of beach and reef matrix protecting low lying islands.

Compared to corals and calcareous algae, relatively little is known regarding the ecology of tropical species of foraminifera. Fundamental information on the population dynamics and carbonate production by foraminifera is critical in assessing potential impacts of global and local environmental change on coastal erosion of low-lying tropical islands. The usefulness of shallow-water foraminifera as indicators of climate change has already been identified (Hallock, 2000). Facilitating their study, species of foraminifera that contribute significantly to island sediments occur nearshore in shallow water, a direct result of the presence of photosynthetic symbiotic algae present within their cells. This provides ready access to foraminifera populations and their habitats, but likewise exposes these populations to the effects of human activity. Shallow-water species of foraminifera have declined markedly with eutrophication and increased turbidity in the Florida Keys during the past 50 years of development (Lidz & Hallock 2000). Hence, populations of foraminifera respond to local environmental changes, but factors driving these dynamic changes remain poorly studied.

Ideally, the responses of autotrophic foraminifera to environmental gradients (e.g. light intensity, depth, nutrient concentrations, current, etc.) are best studied in laboratory culture under well-controlled conditions. However, very few species have been successfully cultured and thus such data are limited (as well as labor intensive to generate). Field studies, although less controlled than laboratory studies, incorporate species interactions (density of algae used at substrate, degree of predation by fishes, wave energy, etc.) that are important to foraminifera population dynamics. Quantitative sampling and associated size-frequency distributions of foraminifera can provide reasonable estimates of population growth and carbonate production. These estimates may be extrapolated and incorporated into overall carbonate production/loss budgets for island and coastal regions.

Lack of fundamental data on the biology and ecology of tropical, shallow-water benthic foraminifera handicaps the ability to predict the time course and severity of the consequences of global environmental change for low-lying Pacific islands. To some extent, coastal reef systems have the capacity to increase carbonate production in response to rising sea level. However, reasonable estimates of realized versus potential rates of community carbonate production rely on a firm understanding of the biology and ecology of these shallow water organisms.

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Fly River Sediment Input to the Northern Great Barrier Reef - relevance for regional marine planning

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The Fly River, located in close proximity to the northern end of the Great Barrier Reef, discharges about 120 million tonnes/yr of sediment, equal to that all of Australia's rivers combined. Knowledge of the processes controlling the dispersal and deposition of this sediment is essential for effective

environmental management and the development of regional marine plans. Swath sonar mapping, seabed sediment samplers and underwater video equipment was deployed from the research vessel RV Franklin in Jan-Feb 2002, to improve our understanding of this area. The cruise discovered a series of channels up to 220 m deep that extend for more than 80km from eastern Torres Strait across the northern end of the Great Barrier Reef. Some channels in the north are clearly relict fluvial channels, exhibiting lateral accretion surfaces and incised channels that truncate underlying strata. Over-deepened channels in the south, however, appear to have formed by tidal current scour. They exhibit closed bathymetric contours and are floored with well-sorted carbonate gravely sand. The different channel types appear, therefore, to have played different roles in the dispersal of Fly River sediment through the Holocene.

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Why "----------" will be the first Pacific Island Nation to attract a $US multimillion investment in Offshore Mining?

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The STAR theme for this year is “Geosciences and Sustainable Development in Pacific Island States”

When it comes to “Sustainable Development” of Offshore Mining it begs the question - “What Development?” Is Development of Offshore Mining a topic worth discussing for it has been talked about for decades but no commercial activity is on the horizon – or is it not?

More than a quarter of a century of detailed scientific exploration by geoscientists has NOT led to any “Development”, sustainable or otherwise. Why is this so? Have the geoscientists helped or hindered, knowingly or otherwise, the process of development of offshore mining of natural resources in Pacific Island States.

We outline herein reasons why such development has to date not eventuated. We investigate why international mining companies have not taken over from the geoscientists and moved towards development of these offshore natural resources. What needs to change to attract investment and development of these resources?

In keeping with the theme of STAR 2002 we consider what in fact the geoscientists can do to more effectively assist in the process of “Sustainable Development in Pacific Island States” of offshore mineral resources. What is the role of Pacific Island governments and departments in this process? Have the policies (or lack of policies) of Pacific Island governments provided a framework for geoscientists to conduct exploration in a manner that unwittingly, or knowingly, hinders the process of development of offshore mining of natural resources in their Pacific Island State.

Since 1997, Nautilus Minerals Corporation [PNG] and Nautilus XPO Limited [Vanuatu] has been considering offshore mining for Seafloor Massive Sulphide [“SMS”] deposits of copper and zinc within the EEZ of several Pacific Island Nations.

After considering all the above issues, we conclude on a positive note and finally reveal in this paper why**:**
"----------" will be the first Pacific Island Nation to attract a $US multimillion investment to develop it’s OFFSHORE MINING resource.

Pleasant Island: a product of sustainable development or a starting point for things to go wrong. The role of geoscience in sustainable development in the Pacific over the next decade, based upon a reality for the past 100 years

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Almost exactly 100 years ago phosphate mining commenced on Nauru, a nation comprising a small, single island, raised atoll. Few will be aware that the name for Nauru in the 19th Century was Pleasant Island. On the other hand, many will be conversant with one or more elements of the environmental, social and economic problems the single island nation currently faces.

The phosphate resource, whilst starting life as a living entity in the guts of seabirds, was transformed over time into a non-living resource on Nauru. Its exploitation as a widely recognized, world-class, high grade deposit began from a small island with a "pleasant" environment with little input from geologists and ultimately raised major questions in the context of the current paradigm of sustainable development, coupled with vulnerability and poverty.

Today, a hundred years later, what would or should be the role of geoscience and the responsibility of geologists in such developments.

This paper will attempt to weave a web of linkages between the birds, Late Cenozoic plate tectonics, mega-landslides, ocean circulation, atoll geochemical processes, climate variability over the past 100 years, and the meaning of sustainable development on Pacifc small islands in order to arrive at an answer to the question "What is the future role of geoscience, and more specifically the geoscientist, in the Pacific?"

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Vegetation change detection, Majuro, RMI

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Growing population and possibly the first symptoms of sea level rise are expected to have an impact on vegetation cover in Majuro, Republic of the Marshall Islands. The vegetation cover was last recorded on aerial photographs taken in 1983. However, the vegetation never was mapped from these photographs and there has been no recent documentation of the vegetation cover. An AusAID-funded project based at the Environment Protection Authority (EPA) and carried out by SOPAC provided GIS, GPS and image analysis facilities. In addition, the project purchased high-resolution satellite image data, which after rectification were used as a reference for the historical aerial photographs. This allowed quantitative vegetation change detection.

Rectification of IKONOS multi spectral image data

For most parts of the atoll, IKONOS image data was rectified using a GPS road survey as reference. The GPS survey was essential because existing maps at 1:25,000 scale could not be referenced to the world-wide grid and not all map sheets joined exactly. For some ground control point establishment, expensive boat trips had to be undertaken to collect ground control points for isolated islands of the atoll, which were financed by EPA. The image rectification was performed with the image analysis software at EPA.

Rectification of historical aerial photographs

Aerial photographs taken in 1983 were first scanned at EPA. Then, the rectified IKONOS image was used as a reference for the geometric correction of aerial photographs. In this way, the identification of ground control points was not limited to road junctions; houses and even vegetation patterns were used. If the reference had been limited to the GPS road survey, there would have been insufficient ground control points for several photographs.

The vegetation change detection

Using the IKONOS image backdrop, onscreen delineation of the vegetation cover was performed for the northern (Rita) and southeastern (Laura) parts of Majuro where the island is wide enough to have reasonable vegetation. Two types of backdrop were available: a natural colour combination (blue, green, red) and a false colour infrared combination (green, red, near infrared). Field checks aided by GPS allowed detailed analysis and the elimination of shrub vegetation, which appeared in the near infrared as tree cover. After completing vegetation cover mapping for the satellite image data the activity was repeated for the coloured aerial photographs recorded in 1983. The photographs did not provide the spectral content of the IKONOS data set, but the spatial resolution allowed separation of tree vegetation from shrub cover by its different texture.

The area covered by trees was calculated for the years 1983 and 2000. To visualise the change the vegetation layer 2000 was displayed on top of the vegetation layer 1983 and vice versa. Areal analysis showed stable figures for Rita. The display, however, showed that much destruction of vegetation had taken place. However, palms were planted at the end of the island that was bare land in 1983. This simulates a stable situation and demonstrates the importance of the spatial display of areal figures. In Laura, the comparison showed a vegetation decrease of 25%, caused by the cutting of palms and other trees for agriculture and sporting facilities. A continuation of this trend could be critical as Laura has an important fresh water lens and vegetation ensures water infiltration during heavy rain and reduces the surface water run off. The display will allow EPA to show the change and encourage action by decision makers.

Results and recommendations

The monitoring of vegetation cover is essential in small Pacific Island Countries as:

Vegetation cover reduces water run off and increases water infiltration in fresh water lenses;

Vegetation cover increases rainfall by reducing the Albedo;

Vegetation change can be an indicator of salt infiltration in fresh water lenses; and

The shortage of fresh water in particular becomes one of the most critical factors for life. The method of using GPS-rectified high-resolution satellite images as a reference for subsequent aerial photo rectification and analysis is transferable to other Pacific Island Countries. Vegetation cover could be monitored more intensively and vegetation could be replanted to improve fresh water supply.

Implications absolute and relative sea level changes monitoring in policy developments in the Pacific

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At the global and regional levels, there are still a lot of concerns of the climate change, variability and sea level rise impacts on countries and their various economic and environmental sectors.
In the Pacific and at regional level there are small number of scientific programmes being implemented to improve the understanding of climate variability, change and sea level rise, with the objectives to facilitate policy developments to mitigate these changes.

The South Pacific Sea Level and Climate Monitoring Project has been in operational since 1991 and continues to the end of 2005, funded the Australian Government, was designed to address the Pacific Islands Governments concerns on the global warming (greenhouse effect) in the region. The results and information from this project continues to be made available to the clients and stakeholders at regional and national level on relative sea level rise and variability.

From the 2001-2005, the project faces some new challenges include; determining the absolute and relative sea level changes, collect and archive long term sea level data, transfer of technology and facilitate adaptation policy developments.

Continuous Global Positioning System (CGPS) network linked to the tide gauge stations (known as Sea Level Fine Acoustic Measuring Equipment-SEAFRAME) have now being established. CGPS receivers are now being installed near the SEFRAME stations in the 12 Pacific Countries. Data and results from the respective sites and the region are now being collected with the objective to determining the absolute sea level changes.

This paper will attempt to provide and discuss the results from the project on the relative sea level changes from individual and regional perspective over the last 10years (1-2 mm per year) and compare this with the absolute sea level measurements currently underway in the region. In addition, discuss the linkages of science to policy and sectoral development especially for atoll states.

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A unifying model for the development of fringing reefs

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Fringing reefs are often described as simple veneers of coral growth along tropical shorelines. Extensive research over the past few decades, based on radiocarbon dating, has indicated that they in fact develop in a complex variety of ways even though their surface morphology may appear simple. Accommodation space is the principle determinate of the growth morphology of fringing reefs. Sea level is important primarily because it determines the absolute accommodation space available for a given reef. This means that a reef that is established during a period of sea-level rise will be able to accrete vertically as space is created above it. If, on the other hand, the reef is established close or grows to a stationary sea surface, thereby occupying the available vertical accommodation space, it is unable to grow upward and accretes laterally. From analysis of the morphology and chronostratigraphy of a range of Holocene fringing reefs, six growth models are

identified. In model A, the reef is established at depth and primarily grows vertically, while in model B the reef established at sea level and grows laterally. Model C is similar to model B, however the reef progrades over a non-reefal sediment wedge. Episodic lateral and vertical growth occurs in model D, where the reef front is characterized by a stepwise progradation. A seaward reef framework behind which unconsolidated sediments accumulate characterizes the remaining models. In model E the reef crest forms a barrier leading to the development of a backreef lagoon. Model F has a similar morphology to model E, except that the reef matrix is formed by hurricane-rubble accumulation rather than framework growth and is periodically reworked. These models provide a basis for investigation of ancient coral reefs, as well as providing a series of scenarios that may enable reef managers to forecast the likely trajectory of fringing-reef response to global climatic change.

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Appliance labelling program for refrigerators and freezers – Fiji Islands

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Energy use standards through the energy labelling of appliances targets end-users by changing the attitudes of manufacturers of electrical appliances towards energy efficiency. The introduction of an Energy Appliance Labelling Programme for refrigerators and freezers is an initial approach towards the application of Minimum Energy Performance Standards (MEPS) on electrical appliances in the Fiji Islands. Furthermore, the Fiji programme will also determine the appropriateness of introducing/replicating this in other Pacific Island Countries (PICs).

The process involves the introduction and promotion of the energy star rating labels on refrigerators and freezers, allowing consumers access to information to make energy-conscious decisions when purchasing electrical appliances.

The Fiji Department of Energy along with major distributors of household electrical appliances in the country and other stakeholders are involved in the distribution of flyers/brochures in the promotion of this programme. Stakeholder participation is a vital part of this programme and is being adhered to, as is the dissemination of information.

The poster presentation highlights the Fiji Energy Appliance Labelling Programme and Fiji's experience with energy labelling. It is anticipated that such programmes will initiate the expansion of regulations covering the importation of refrigerators and freezers to consider compulsory for retailers and suppliers to sell energy star rated refrigerators and freezers in the Fiji Islands.

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Paleoenvironmental changes in the Korea Strait during the last deglaciation sea level rising: a case study from core SSDP-102

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Consecutive Quaternary drilling projects have been undertaken by KIGAM in the Korean Sea shelves since 1995. The projects were focused on providing type sections to control the previously-established seismic stratigraphy, investigating sedimentary records in more details, and evaluating their relationship to the paleoclimate changes during the late Quaternary. Multidisciplinary analyses have been performed on all drilled cores and here we present a part of the results for the core SSDP-102, which is located on the thick mud deposit developed in the inner shelf adjacent to the Nakdong river mouth.

A 45 m-long sediment core from the site 102 of the South Sea Drilling Program (SSDP) was recovered from the South Sea inner shelf (ca. 40 m in water depth) off the northwestern coast of Korea Strait. According to ^{14}C dates, the entire units were presumably formed since the Last Glacial Maximum (LGM). The whole core can be divided into four lithologic units (I, II, III and IV in descending order), which are composed of homogeneous mud, massive muddy sand, laminated sandy mud and disorganized gravel, respectively. It shows a fining-upward trend except for the abrupt coarsening of unit II.

The depositional settings of the four units are interpreted as offshore (unit I), shoreface (unit II), estuarine (unit III) and fluvial (unit IV) environments, which are closely related to the Holocene marine transgression. The paleontologic (pollen and spore, and foraminifera) along with the $d^{18}O$ records of the benthic foraminiferan *E. advenum* reflect gradual warming patterns and increasing inflow of the warm and saline Tsushima Current, a branch of the Kuroshio western boundary current.

Our results reveal that the inner shelf of the Korean South Sea has preserved well the sedimentary records on the continuous marine transgression closely associated with the Holocene global sea-level rise. Therefore, we might expect that the methods and results of our study could be applied to understanding the environmental situation in the South Pacific regions.

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Formation and deformation of the Ontong Java Plateau in the hotspot frame of reference: 122 Ma – Present

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A new model of Pacific Plate motion between 140 and 0 Ma, generated in the Hotspot Frame of Reference, has been used to reconstruct paleogeographic positions of the Ontong Java Plateau (OJP) from the time of its formation, about 122 Ma, to its present day location. The resulting OJP flowline suggests that changes in Pacific plate motion, passage over hotspots, and Pacific rim tectonism all have influenced the continuing structural development and deformation of the Plateau. Gravity, bathymetric and tomographic mapping reveal the structural fabric of the OJP and adjoining Nauru Basin, including the orientation of probable fracture zones, location of possible fossil spreading centers, and the presence of a thick lithospheric root, as well as possible later hotspot modification of the fabric. The most recent phase of OJP deformation, which began about 6 Ma, is continuing today and is most likely responsible for triggering the ongoing uplift (and tilting) of Nauru and Banaba.

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A contribution to geological knowledge and petroleum potential of New Caledonia: CADART1 well

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Geological framework

New Caledonia's Mainland, the emerged part of the Norfolk Ridge, is a complex mosaic of volcanic, sedimentary and metamorphic terranes that were assembled during two main tectonic phases (Cluzel

et al., 2001): a Late Jurassic to Early Cretaceous tectonic collage, contemporaneous with the Rangitata Orogeny of New Zealand; and a late Eocene obduction/collision terrane. The geological history can be subdivided into four main periods:

Permian to Early Cretaceous: volcanogenic tuff and greywacke sedimentation overprinted by the Cretaceous Rangitata Orogeny;

Late Cretaceous to Late Eocene: transgressive marine sedimentation with associated continental facies (including coals) deposited during the late Cretaceous;

Middle to Late Eocene: deposition of calcareous, volcanogenic flysch sediments prior to and partly contemporaneous with the onset of the Alpine Orogeny; and

Late Eocene time: marked by intra-oceanic tectonism (Alpine Orogeny) characterised by the obduction of the New Caledonian ophiolitic sheet, sourced from the oceanic lithosphere of the Loyalty Basin to the east.

Petroleum potential

The potential for finding commercial reserves of hydrocarbons in New Caledonia is considered good (Vially and Mascle, 1994; Vially and Bénard, 2001) for the following reasons:

(a) New Caledonia is located in the favourable “Papuan Geosyncline”;
(b) Geochemical and radiometric surveys indicate hydrocarbons to be present along the western coastal basins;
(c) Surface and subsurface oil and gas shows are known within the West Coast basins;
(d) The Upper Cretaceous section shows significant gas-generating potential; and
(e) The active petroleum system is interpreted to consist of Cretaceous (Senonian) coals for the source rocks, and fractured Tertiary flysch for the reservoir and seal.

The petroleum potential of New Caledonia is directly linked to the general allochtony hypothesis of the late Eocene orogenic complex, suggesting that:

- the geographic extension of the underlying coal basins is likely greater than suggested by outcrop; and

- the overmaturity of the coals might be contemporaneous with, and/or slightly postdate, the structuring, allowing structural trapping of any hydrocarbons formed.

The Gouaro anticline potential prospect

The NW-SE trending Gouaro feature is located on the west coast of New Caledonia, 160 km northwest of Noumea. This area is affected by the Upper Eocene compressive phase related to emplacement of the ophiolitic thrust sheet eastward. The Gouaro anticline could have been sourced by the New Caledonia Basin in a similar fashion to the Taranaki Basin of New Zealand.

The subsurface structure of the Gouaro anticline was unveiled during a deep seismic survey undertaken by Victoria Petroleum NL in 1995. A possible « flat spot » suggested the presence of hypothetical gas cap with an oil leg scenario for the reservoirs (Blake, 1996). Arising from those seismic results, this play was recently explored. The CADART 1 well, drilled in 2000 by Victoria Petroleum NL in the PRA-436 exploration permit, encountered significant gas show.

CADART 1 borehole main results

The sedimentary section penetrated by the 1930 m-deep CADART 1 borehole is (France, 2000):

0-1420 mGL: Calcareous flysch, likely of Eocene age, providing an adequate lithological seal.

1420-1536.4 mGL: Aymes Creek Limestone equivalent, composed of calcareous siltstone/claystone.
1536.4-1595.9mGL: *Radiolaria*-bearing limestone, interpreted to be an equivalent of the targeted primary reservoir target, the Paleocene chert, which was not intersected.
1595.9-1930 mGL: Upper Cretaceous Coal Unit, made of shale, sandstones and coaly intervals. This unit was found to be both overmature (from carbonisation of palynomorphs), and bearing traces of liquid hydrocarbons.

Hydrocarbon shows in the core were encountered both in fractures and vugs within the Eocene flysch, and in shales and coals of the Upper Cretaceous section. Migrated dry gas (methane content averaging 99%) was produced on test from the Upper Cretaceous section.

Interpretation and conclusion

The overmaturity of the coals likely stems from the superpositional emplacement of the basalt nappe and peridotites, and may be contemporary with or slightly postdate the structuring, with potential structural trapping of the hydrocarbons thus formed. CADART1 results suggest that subsequent calcitic fracture annealing has enabled late-generated dry gas to be trapped within the Gouaro anticline. Therefore, according to the allochtonist hypothesis, any valid structural trap formed during the Alpine Orogeny should have been charged with hydrocarbons.

Moreover, if we interpret the Gouaro anticline as an overthrust with duplex formation (France, 2000), then the zone of gentle folding that is usually developed in front of such thrust zones should be located westward offshore, possibly within the Western Lagoon.

Dry gas production could have occurred (France, 2000; Lafoy, 2000):

from a highly mature to over-mature source rock,
from thermally cracked by continued high temperatures after migration,
contemporaneously with the ophiolite thrusting,
during the post-thrusting extensional phase with secondary cementation.

This allochtonist hypothesis could also explain the traces of liquid hydrocarbons present, with oil migration from a low-maturity area (oil window) such as the Western Lagoon or the New Caledonia Basin (Lafoy, 2000). Provided the Gouaro structure was undergoing folding at the time of maturation and expulsion of hydrocarbons from the coal beds, then the structure would have been charged with hydrocarbons. However, maintenance or diagenetic recovery of seal integrity before the final phase of hydrocarbon generation is critical for the accumulation of commercial gas deposits within the West Coast basins.

The drilling of CADART1 on the western coast has produced quantitative and qualitative information for the understanding of the petroleum potential of New Caledonia's mainland. New Caledonia's petroleum potential assessment has to be extended offshore, where a likely gas hydrates prospect (Bottom Simulating Reflector (BSR) associated with underlying diapirs?) has recently been identified 300 km west of the Mainland (Lafoy et al., 1998; Exon et al., 1998; Auzende et al., 2000). A new cruise, planned for 2003 within the frame of the ZoNéCo program, will be deploying multichannel and high resolution seismic to refine the underexplored petroleum potential of New Caledonian basins and to confirm the extension of the likely gas hydrates prospect.

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Mining industry in New Caledonia

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History and current situation

Garnierite nickel ore was discovered by Jules Garnier in 1864. Since then, New Caledonia became a mining country where 4,500 exploitation titles have been delivered. New Caledonia is the world's 4th largest producer of nickel, after Russia, Canada and Australia. New Caledonia nickel deposits are estimated to contain ¼ of global ore known resources. New Caledonia is preparing to build two major mining facilities through joint ventures with foreign investors to further enhance the territory's production capacity.

Geodynamical framework

The geology of New Caledonia was dominated at Late Eocene by the thrusting of the Ophiolite nappe over the autochthonous volcaniclastic substratum. These allocthonous Ultrabasic formations underwent isostatic movements, faulting and intense tropical weathering. Natural processes thus contribute to the weakening of the ultrabasic massives and are responsible for nickel mineralisation. Recently, the assessment of alternative resources (except Ni) has emphasized that the knowledge of superficial formations is of first importance (Co, Platinum-Group Element mineralisations). Consequently, a joint "New Caledonia-Bureau de Recherches Géologiques et Minières" pluriannual programme has been carried out since 1997.

Mineral resources

<u>*Substances*</u>

- Nickel, Cobalt, Chromite (50% Cr_2O_3), iron ore (55% Fe)
- Copper, Manganese, Antimony, Lead, Zinc, Gold

- Phosphates, Coal, Gypsum
- Hydrocarbons, Platinum-Group Element (PGE)
- Aggregates: carbonates (1.2 Mt/y) for pressure acid leach (PAL) process (effluents neutralisation)

Current situation

- 1785 on-going tenements
- 93 on-going mining licenses
- Exploration in New Caledonia mainly focuses on Nickel, Cobalt and also on :
  - hydrocarbons (both on land and offshore)
  - possible Gas Hydrates prospect offshore
  - platinum: PGE oxides (mainly Pt-Fe) in the ophiolite complex (strong lateritisation affecting a magmatic mineralisation associated with chromite seams)

Nickel industry (ore-type, nickel mining, environment, projects)

Ore-type

- Oxidised-type ores, resulting form the weathering of the peridotites
- Deposits are relic formations on plateaux and ridges crests saved from erosion

Nickel Mining: Operators and Organisation

Operators

- Four main mining operators :
- SLN (Société Le Nickel),
- SMSP Group (Société Minière du Sud Pacifique),
- SMT (Société des Mines de Tontouta),
- SMGM (Société Minière Georges Montagnat)

Organisation

- Geological surveying of potential sites
- Research surveys :
  - tracks opening
  - coring mostly used
- Exploitation opening :
- - stripping of the top soil and stockpilling
  - scrapping and storage of the sterile upper part
- - steriles storage
    - * downloaded on the flanks (before the 70's)
    - * monitored-storage on site (after the late 70's)
  - ore extraction : front shovels, dumpers
  - ore concentration: screening, wobblers
  - ore beneficiation (Népoui): slurrying & blending (limonite and saprolite)
  - ore haulage to sea-side : trucks, conveyor belt
  - ship loading : sea-front conveyors
  - processing plant : SLN's Nouméa-based Doniambo's smelting facility

Environmental concerns

Reclaiming programs are currently carried out including three main steps:

- mine remodelling
- water monitoring (water control facilities)
- revegetation

Revegetation is necessary to:

- reduce and repair environmental damage arising from mining
- re-establish self sustaining native ecosystems
- preserve the genetic diversity of rare species

A strategy of floristic inventory and species selection has been developed to ensure that the widest range of species are either used for revegetation or conserved. Revegetation techniques for ultramafic

landscapes are also developed in conjunction with local community training.

Production

- Between 1900 and 2001: 217 Mt of nickel ore grading 2.69%, 4.3 Mt of metal
- In 2001: 7.2 Mt of nickel ore grading 2.30%, 117,554 t of metal

Ore and Metallurgical products Export

France (processed ore), Japan, Australia, China, Taïwan

Projects

On-going: Two main projects

- **INCO** : Hydrometallurgy

  Goro project: largest and highest grade laterite deposit in the world
  Estimated resource: > 200 Mt grading 1.6% Ni, 0.18% Co
  2002-2004: building and set-up of a commercial plant
  End 2004: plant start-up - 20 yr - mine plan
  Nominal capacity: 54,000 t/y Ni & 5,400 t/y Co – Expandable to 120,000 t/y Ni
  On-shore tailings deposition
  Superior proprietary pressure acid leach (PAL) and solvent extraction processes
  Slurrying & blending of limonite and saprolite ore

- **SMSP / FALCONBRIDGE** : Pyrometallurgy

  Koniambo project: feasibility study due to be completed by the end of 2002
  for a decision to be taken in 2005 for the possible set-up of a smelter in the Northern Province
  Estimated resources: 151 Mt grading 2.58% Ni, 0.07% Co, SiO2/MgO ratio of 1.70
  60,000 tonnes / year nickel in ferronickel

Future

- SLN : increase of the Doniambo's smelter capacity (from 57 Kt/y to 75 Kt/y by 2004)
- Prony : Exploration Permit recently granted to INCO for prospecting rights
  - Estimated resource: 170 Mt grading 1.5% Ni
- Argosy (Joint Venture with Norilsk Nickel & SMT): bankable feasibility by 2004

Conclusions

New Caledonia is one of the key players in the global nickel production as it is estimated to hold about a quarter of the world resources, but has provided 10% of the nickel ore world production in 2001. Nickel mining in New Caledonia is recognised as the main driving force of the territory's industrial development and still remains the main development pole of the island. Nickel Mining (Mining activity and Metallurgy) in New Caledonia is a major contributor to Gross Domestic Product (11 % in 1997).

Regulatory regimes have been enforced to minimize the risks and likely impacts of mining allowing, through an environmentally sustainable way of mining, resources development and management to be undertaken without jeopardizing the environment. Currently, the major player in New Caledonia is still SLN (Société Le Nickel), a subsidiary of French group Eramet, with a yearly production of 57,000 tonnes of nickel per year, to be boost to 75,000 by 2004.

New Caledonia is preparing to build two major mining facilities through joint ventures with foreign investors to further enhance the territory's production capacity. The Canadian giant Inco's Goro prospect (a 1.4 billion US $ project in the South of the main island), shows potential to be one of the largest, long-term and cost-effective nickel projects in the world. The total, a combination of existing and upcoming plant projects could, by 2005, bring New Caledonia's nickel production capacity to a yearly 200,000 tonnes.

South Pacific Sea Level & Climate Monitoring Project Phase III

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There is a major concern that the sea level is rising in the world and as well in the South Pacific region. Every day regional countries are taking up issues related to sea level rise. These issues debate whether sea level is rising due to thermal expansions of seawater, tectonic movement of the sea floor or the contributions from melting land ice. The issue is important to the sustainable development of communities and to their very existence, which is threatened by inundation and damage to the fresh water supply.

Therefore the South Pacific Sea Level and Climate Monitoring Project is monitoring sea level change. It is funded by AusAID, managed by Australian Marine Science & Technology and coordinated by the National Tidal Facility at Flinders University. The project is now in its third 5-year phase [Phase III] of its 20-year span. The project started in October 1992 and Phases I and II are completed. SOPAC has been one of its regional partners in the project, contributing towards technical assistance and also being the regional data archive centre.

This project aims to provide quality meteorological and sea-level data through an array of the latest climate monitoring stations, backed by precise geodetic surveys to produce data, research and results upon which the South Pacific Countries can make future development plans. A series of high-resolution sea level recording stations has been established in twelve countries of the South Pacific Forum with data transmission via satellites.

The data collected by the project are in various form and are used by meteorological departments, lands and survey departments and by research scientists. The Sea Level Fine Resolution Acoustic Measuring Equipment (SEAFRAME) measures water levels, wind, atmospheric pressure, air and sea temperatures in twelve countries. The method of data collected is through Precise Differential Levelling surveys; vertical control stations are established with the survey data also being used by the surveyors for their land and geodetic surveys. Surveyors and navigators are also benefiting from the establishment of the Continuous Global Positioning Systems survey network by this project.

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Precise Differential Leveling Survey, a major technique for monitoring sea level in the South Pacific

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The South Pacific Sea Level and Climate Monitoring Project is being carried out in the following countries: Cook Islands, Fiji Islands, Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu and Samoa. High-resolution sea level stations have been established in these countries. Precise Differential Levelling (PDL) survey is the first order geodetic survey program, assisting in monitoring the stability of ground stations. The sea level stations are supported by a network of deep benchmark arrays established along the coast and inland. Repeated high-precision levelling with the Global Positioning Systems (GPS) survey connections on 18-month cycle monitors the stability of the sea level sensor.

Sea level rise is a major concern to the low-lying atolls. Therefore this (PDL survey) geodetic monitoring program enables sea level change to be determined. During this phase of the project there are installations of the real time GPS surveys to account for the absolute sea level rise, which separates eustatic change from the tectonic movement.

PDL survey is the conventional method of levelling for the proliferation of orthometric heights whereby all possible errors are identified and field procedures adopted. The use of equipment and field techniques should enable data collected to meet the requirements of CLASS A survey as recommended by the South Australian Lands Department, as far as standards of accuracy and the nature of equipment used with the vertical control stations established in the survey. The vertical control stations, also known as benchmarks, are of high importance to this project because the height is known from the positions where levelling and height determination is carried out. These benchmarks are driven deep into the ground and established in very stable rock. The survey equipment used maintains the standards and accuracy of the PDL survey carried out in the region.

This project is measuring the highest standards of accuracy of survey measurement. All the surveys carried out are within the specified limits of error (±2mmvk), where k is the distance levelled forward, measured in kilometres.

The objective of South Pacific Sea Level & Climate Monitoring Project is for the PDL surveys to be carried out by:

> Setting up high-resolution monitoring stations in the South Pacific region to compute relative motions of land and sea at each station in each of the twelve countries;
>
> Carrying out a geodetic survey program to measure movements of the crust in each country with respect to the reference station (vertical control stations); and
>
> Providing a measure of regional vertical controls and exchanging information and data with national, regional and international climate change centres in relation to the ongoing international geodetic programs, which incorporate satellite altimetry and radio astronomy.

From the surveys carried out and the data collected, the movement of land in terms tectonics can be determined and any sea level change assessed.

The results from surveys carried out to date in Tonga show that the benchmark (vertical control stations) TON2 did not move significantly (0.25 mm) from the surveys in 1993, while the same benchmark moved up by 1.33 mm compared to the 2000 surveys. In the Marshall Islands, the benchmark MAR3 has moved down by 1.49mm in 2001 compared to survey carried out in 1993 but risen by 0.09 mm compared to the 2000 surveys.

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Creating MapInfo layers for vegetation change detection in Kosrae

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Kosrae, like many other pacific island countries, has no map projection that fits to an international grid system. It is essential to monitor vegetation change and aerial photographs as well as old vegetation maps are available. However, the different sources of information are not comparable due to missing common projection.

AusAID provided the funds to provide high-resolution satellite data and a temporary GPS base station, which was used to create an image backdrop at 1:10,000 scale showing the vegetation cover recorded in 2000.

This GIS image backdrop was then used as a reference to geometrically rectify the existing vegetation map, which is now available as an additional backdrop. To produce a vector layer out of it, this vegetation map backdrop was on-screen digitized and linked to a tabular database. The polygon overlay over the satellite image backdrop allows a detailed vegetation change protection.

The described procedure should be applied to other Pacific Island Countries to monitor the vegetation cover, which is important for maintaining a sustainable fresh water supply and assisting coastal protection.

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Installation of trial wave energy plant, Lifuka, Ha'apai Group, Kingdom of Tonga

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Consumption of energy nowadays is about 1.7 kW per person in developed countries and 0.7 kW throughout the world, with an average annual increase of power consumption is 3-4 %. The total output of all power plants on Earth is more than 8.5 TW. Urbanization in developed countries leads to an increase of energy transport. Thus, the higher the energy consumption, the more expensive the energy.

Energy production on so large a scale requires the consumption of huge amount of natural resources. At the same time, the largest part of the energy is spent on the extraction and transportation of resources and energy, and the smallest part on direct consumption. Billions of tons of carbon dioxide and carbon monoxide enter the atmosphere, causing greenhouse effects. Mining spoils landscapes and pollutes rivers. Nuclear power plants produce highly radioactive waste that requires high-expensive utilization. As far as social impacts are concerned, millions of people work underground in mines and get doses of radiation. Narrow ways of energy transportation lead to urbanization and wars.

However, at the same time the sun sends billions of TW of heat energy to the Earth. Beam energy has very low density but it is concentrated into wind energy. Wind energy has low density too but is concentrated further into sea wave energy. Wave energy is 1000 times more concentrated than wind energy. Therefore, wave power devices can be 1000 times as cheaper than wind ones made from the same material.

The problem in harnessing satisfactory amounts of wave energy anywhere it is needed lie in the absence of suitable technology. During the past four decades a few wave power technologies have appeared but all are expensive. Existing wave technologies include the following:

Duck by Solter, made from concrete and has hydraulic transmission to the generator, has too large a minimum size and is too expensive;

Raft by Cokcerel is a very successful construction but has hydraulic transmission to the generator and is not reliable;

Sea snake has the same characteristics as the raft;

Oscillating column by Masuda is quite a successful device which has been introduced on an

industrial scale but contains an expensive air turbine what makes the energy too expensive;

Oscillating buoy is too expensive and has insufficient energy production;

Rotor by Wincranz is the most successful. It is the cheapest, simplest and most reliable device. We have developed and improved it with valves and pontoon;

Topchan has a quite simple construction but produces insufficient energy.

To decrease the individual costs of the unit and, therefore, make the project more attractive to investors, SEG:

- made the rotors from recycled plastic;
- made the entire construction floating and resistant to storm damage;
- made the work cells with valves which increase the efficiency of the unit;
- made transmission mechanical only, which allows increases in efficiency and reliability, and decrease unit costs and corrosion;
- made the minimum capacity of the unit 1 kW or less;
- made multi-rotor units with maximum capacity of up to 3-5 MW; and
- used Ukrainian aerospace technologies for wave power production.

SEG offers production at industrial scale of:

- small units 1-20 kW for autonomous consumers (cottage industries or fish refrigeration);
- middle-sized units 30-100 kW (grid connected or disconnected with accumulating);
- large-scale units 0.1-3 MW connected to grid; and
- the creation of new sea-shore energy infrastructure.

SEG seeks to find strategic partners for:

- international patenting, since our product is patentable;
- large-scale production of the product; and
- trading with the product throughout the world, since the units are very easily assembled from standard materials.

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Evaluation of the impacts of harbour engineering in Anibare Bay, Republic of Nauru

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This paper discusses a coastal engineering and environmental evaluation of design parameters for a fishing boat harbour facility at Anibare Channel, eastern Republic of Nauru. The Government of the Republic of Nauru (RON) requested SOPAC to evaluate the development; comment on the impacts on the harbour facility on sedimentation and erosion of the adjacent coastline; and advise on maintenance of the facility. An in-country site visit was made and a follow-up visit was done, which provided additional and new time-series observation data.

The developed coastline is t about 700 m north of the Mennen Hotel facility. Nauru received bi-lateral funding from the Government of Japan (GOJ), for the development of a port and harbour facility at Anibare Bay. The site is a former cut and excavated channel in Anibare Bay also used for fishing activities on the east coast. The facility is to provide Nauru with additional docking, launch and berthing facilities to support its offshore tuna fishing fleet.

Coastal infrastructure and development on a small island state can impact adversely on coastal processes. In addition, deleterious impacts can also result along the natural and built shorelines at

the site, and near the development. Consequently, it is important to monitor development activities and their impacts, both positive and negative. In this way, negative and deleterious impacts of the development can be captured immediately and remedied, where possible, in a timely and appropriate fashion. Further, information gained from such monitoring can be useful for future coastal development and engineering design of similar and related facilities on the island. Since RON plans to develop another harbour facility on the western side of the island, information gained from this monitoring study could be crucial to optimum planning and design of that facility The present study was indeed set-up with the objective of advising RON with timely and appropriate advice on the impacts of the harbour facility and strategies for addressing these impacts. Since RON is a small island with limited land area, the loss of any land or coastal property represents a significant one. In addition, developing economies can be seriously affected by damage to or loss of civil infrastructure and residential facilities from “silent” natural hazards, like coastal erosion.

Harbour development plans were consulted to assess the dimensions and quantities of the various components of the Anibare Harbour facility (Tetra, 1999). Environmental (including geological and geotechnical) information and data were collected during site visits. These included wave and littoral information, beach sediment characteristics, erosion characteristics, and documentation of damage to any critical facilities and infrastructure.

In summary, the coast is part of an emergent, Holocene reef-carbonate system, with the beach comprised entirely of carbonate sediments developed on phosphate-rich, cavernous, dolomite limestone bedrock. The coastline is partly rocky with classic karst limestone pinnacles found throughout the bay. The reef is a coral dominated system and is narrow and well-flushed, with many closely-spaced reef channels. The coastline at Anibare Bay is an active and dynamic one. The relatively coarse admixture of abraded sand and gravel and highly abraded karts pinnacles testify to this. The beach at the development site is moderately steep and has experienced erosion in the recent past. It shows signs of current erosion, with fresh erosion scarps. The harbour development appears to have increased this erosion at a local level at the adjacent, undeveloped coastal segments. The topographic elevation of the coastal land areas are relatively low with respect to CDL and MSL and under EHWST or during windy and low pressure systems, when large (3 m +) waves approach shore from the east, the beach, coastal road and adjacent areas are easily overtopped. The relatively narrow and almost flat backreef and reef flat, together with the numerous closely-spaced reef channels make it almost impossible to dissipitate significant wave energy and prevent overtopping during these conditions. In addition, the almost featureless backreef cannot trap sediments entrained in longshore currents and, therefore, sediments removed from the local areas can be completely lost from the coastal system in Anibare Bay.

The harbour development acts as a large groin, which breaks the continuity and smoothness of the concave Anibare Bay. Thus it interrupts southerly longshore currents and causes erosion of downdrift areas to the south. The harbour also acts as a headland protruding into the bay. As a result of this morphology, waves diffract around it and agitate and disturb beach sediments immediately north and south of the harbour. Therefore, the facility can cause erosion on both the north and south aspects of the harbour. With respect to the concrete breakwaters built to protect the harbour and mooring basin, these structures are already overtopped by 3 m high spring tide waves. While the design and construction firm (Tetra, 1999) indicated that a 50-year, of 5.34 m design wave was used to design the harbour, the fact that a 3 m high offshore wave, after undergoing decay over the reef crest, can overtop the main breakwater, raises concern as to what acceptable risks were allowed/selected for this facility. To that end, numerical analysis was performed for the facility.

For a 5.34 m, 1-in-50-year wave height proposed by Tetra (2000), wave period of 10 sec, a reef crest of about 12 m wide, a forereef slope of 1: 1.2, in fore reef water depth of about 10 m (seaward of the reef crest), under EHWST (freeboard level of -4.14 m; with the reef crest at –1.5 m below CDL) and under easterly (the modal) wave approach, the transformed wave computed was 3.7 m. This wave transformation corresponds to 30 % decay in wave height across the reef crest. Interestingly

enough, this is consistent with a wave that will run-up and overtop the coastal road under EHWST, and also that, which has been observed by residents, at the site, for more than a decade. For such a wave height, the size and density of boulders required to maintain stable structural conditions under the design/ and transformed wave, in the backreef, and on parts of the facility (e.g. on the groin and spending beach rip-rap), may be larger or more dense than those specified. For the local dolomite limestone used at the harbour site, which is dense, but porous, and with an estimated unit weight of 2650 kg/m³, and under a 3.7 m transformed wave, during EHWST, the nominal stone diameter required would be about 1 m. This is about 3-5 times the diameter specified by Tetra (2000). Tetra's (2000) diameter is 500-1000 kg/pc or about 18-35 % of that computed by the author (assuming a rock density of 2650 kg/m³). If a 3.7 m high transformed wave impacts on the vertical seaward face of the main breakwater, under an EHWST, overtopping of the structure will be about 0.457 m³/sec. At mean water level (1.57 m above CDL) overtopping will be 0.13 m³/sec.

In addition, the navigational channel will not cause significant wave decay, as would the adjacent intact reef crest. This is because it was dredged to –2.5 m below CDL (1 m deeper than the level of the existing reef crest), with a 30 m wide funnel-like entrance that narrows to 20 m. The freeboard height above EHWST level is therefore –5.14 m, estimated from Tetra (2000) designs, while these award channel slope is 1: 16. If a 5.34 m high wave break over the navigational access channel, the transformed wave will be about 4 m high or about 0.6 m higher than the transformed wave over the intact reef crest (3.4 m). This will then run-up on the spending beach rip-rap, and enter the mooring area, causing choppy conditions to develop within the harbour. Despite the fact that there is a spending beach of rip-rap, some reflection and refraction will occur on the landward side of the access channel.

It is therefore important and necessary to cater for routine and regular maintenance of the spending beach rip-rap so as to ensure that any rip-rap dislodgement, erosion or damage is repaired. Some numerical analysis was also performed for average wave climate for the same reef architecture and harbour design. For an average offshore non-broken wave height of 3 m (within a 1-year return interval computed by Tetra, 2000), with a 6 sec period, the transformed wave on EHWST, over the same reef morphology will be much smaller, at 2.4 m or 20 % decay. For such a transformed wave, the required rip-rap for the groin, under EHWST, should be at least 0.65 m diameter or 741 kg (assuming a rock density of 2650 kg/m³). The rip-rap required for stability at the spending beach should be 0.3 m or 60 kg, also assuming a rock density of 2650 kg/m³. Overtopping of the main breakwater by a 2.4 m transformed wave will be about 0.07 m³/sec, smaller, but nevertheless, noticeable.

Management of built shorelines, like those in Anibare Bay, is a dynamic process based on assessments and re-assessments. Shoreline management strategies and forecasting should be for the short-term, medium-term and long-term, and therefore, strategies must be developed which reflect these changing needs through time. However, management strategies must reflect site dynamics, which may be summarized as follows:

- The development site is part of a dynamic open-ocean coast;
- The beach is protected by a narrow (12 m wide) fringing coral reef, with many reef channels. The beach is narrow and of carbonate sand, with a moderate slope;
- The beach and shoreline has been subject to natural erosion in the past and recent years;
- Surf zone hydraulics show that on breaking waves run-up the backreef, onto the beach, without any further decay;
- Backwash is strong across the backreef and on mean or low tide drains the backreef;
- The entire harbour acts as a groin along Anibare bay and interrupts southerly longshore currents;
- The facility also diffract easterly approaching waves to the north and south;
- The harbour construction has therefore already caused alteration of surf zone hydraulics and caused local eddys to develop;

Eddys already cause local scouring at the toes of the various harbour structures;
The beach and shoreline has been affected by harbour construction and erosion has exacerbated, and scouring and erosion will continue in the immediate future;
Fine sediments (sand and silt) will become easily suspended and eroded from adjacent beaches, in response to scouring and eddying under wave attack;
Erosion is on both the updrift and downdrift aspect. Updrift erosion has resulted from wave diffraction around the structure from easterly waves, and downdrift erosion is due to interruption of longshore currents and sediment transport and sediment starvation;
The downdrift aspect is more eroded than the updrift side;
The beach on the updrift aspect has completely disappeared and the scoured underlying bedrock is exposed;
The main breakwater is overtopped by present EHWST and will continue to be overtopped;
It is expected that any waves generated by low-pressure systems and which affects the harbour site, will also overtop the harbour breakwater and run-up across the road;
Based on analysis of Tetra's (2000) design wave, their estimated transformed wave (1.9 m) over the reef crest is smaller than those wave heights observed by mariners in Nauru (3 m +);
Estimates of a transformed wave over the reef crest (modeled as a submerged breakwater) show a higher wave height (3.4 m) than that predicted by Tetra (2000), and is consistent with those observed by maritime personnel in Nauru;
The above suggests that there will be greater overtopping and run-up for the harbour site than those predicted by Tetra (2000);
The navigational channel access is deeper than the water over the reef crest and will therefore facilitate large waves to enter the harbour and mooring basin, especially under EHWST. Such waves will be larger than those north or south of the harbour facility; and
Larger waves entering the mooring basin will create choppy conditions within the harbour, even though some dissipitation will occur on the spending beach slope.

In relation to the above, and to prevent any further erosion or exacerbation of shoreline retreat, the following programmes will be needed at the site. Failure to implement these will allow erosion or damage to coastal facilities and infrastructure to go un-noticed, which may cause further negative impacts along the shorefront. Recommendations include:

Eroding sections of the coastline need to be protected immediately if erosion;
If eroding coasts are left un-protected, this will cause further loss of coastal soils, beach sediments and damage to the adjacent road or other infrastructure;
Protection strategies should be for the immediate and medium-long term;
A bio-engineering system of coastal protection should be employed;
To prevent overtopping of coastal areas, a rip-rap system could be utilized along the edge of the coastline, at the land-sea interface;
Biological protection can mean planting of locally adaptable coastal tree and shrub species. It would be best to select and plant species of flora which are adaptable to the existing coastal conditions;
I recommend the use of geotextile or erosion mats for erosion control, if available, as these can trap sediments within their structure Any geotextile selected should be appropriate for the hydraulic and tropical UV conditions;
Dolomite limestone rip-rap can also be used for coastal protection;
Limestone rip-rap is also recommended because it is cheap, available locally and easy to use. The local limestone is also of suitable density for coastal engineering protection structures;
Attempts should be made to select boulders without phosphate residue (to prevent eutrophication in coastal waters) and rip-rap should be sized based on wave and surf-zone hydraulics;
A coastal monitoring programme should be put in place to periodically assess any changes to

the coastline at the harbour site. This will facilitate rapid repair to damaged infrastructure, facilities and eroding coasts;

Monitoring should be beach profiling, beach sediment sampling and coastal littoral hydraulic assessment;

Visual inspection of failure characteristics and wave run-up/overtopping should be documented and photographed when it occurs;

This monitoring should be at least quarterly in the first 3 years, decreasing to twice yearly thereafter;

The coastal monitoring data should be reviewed as soon as possible and coastal management strategies modified/revised to reflect changes at the site;

All beach profiles and surveys should be leveled from Nauru's surveying benchmarks;

The data collected should be archived in a database for easy access and retrieval;

SOPAC Training Reports 84 should be consulted for details of set-up of a beach monitoring programme; and

Future coastal developments should be preceded by an environmental impact assessment (EIA). An EIA, if properly done, would identify problems and positive attributes of the development and would assist developers and project managers in planning for and decreasing any deleterious impacts at the project site.

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Technology transfer and capacity building in Earth Sciences for development and natural hazards - SOPAC/USP Earth Sciences and Marine Geology (ESMG) 2001 Certificate Programme

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This paper presents a summary of technology transfer course modules which were developed, planned and executed as part of the South Pacific Applied Geoscience Commission (SOPAC Secretariat) and the University of the South Pacific (USP) Joint Certificate in Earth Sciences and Marine Geology (ESMG) for the period November 2001 - 4th May 2002. This paper presents some details of the Course SCC24: Earth Sciences in Development Projects, Hazards, taught at the USP, Laucala Bay Campus, Suva, Fiji Islands, from November 2001 - 4th May 2002. The paper highlights the background, nature and objectives of the module, the student enrolment, the lecture outline, subjects and the results of examinations and assessment. This year's modular course formed part, and the final year of the three-year ESMG Programme offered jointly by SOPAC and the USP. The programme was entirely funded by the Commonwealth Secretariat (COMSEC), under the Commonwealth Fund for Technical Co-operation (CFTC).

This ESMG Certificate programme provides technology transfer and continuing professional development of practical skills and knowledge for those who are part of Geoscience survey teams or are laboratory geological technicians in Earth System Sciences and ancillary fields in the South Pacific region. This programme is open to candidates nominated by the South Pacific regional governments, and private sector/corporate entities. The USP, School of Pure and Applied Sciences (SPAS) approve the Certificate programme, and forms part of the Marine Sciences (MSP) approved modular programme, ensuring appropriate Quality Assurance and Control (QA & QC). The Certificate is also awarded by the USP after approval by the USP, SPAS. The Marine Studies Program (MSP), Lower Campus, of the School of Pure and Applied Sciences (SPAS) of the University of the South Pacific (USP), Laucala Bay, Suva, Fiji Islands, was the venue for the Certificate in Earth Science and Marine Geology Course (ESMG) programme this year.

The initial two years of this programme cycle were completed in 1999 (Year 1), and in 2000 (Year 2). The unforeseen circumstances of May 2000 in Fiji Islands and lack of funding of the Training Co-ordinator post, project funds and support staff pre-empted the timely completion of the ESMG programme in 2001. This resulted in the late completion of the programme.

This year's course had a smaller enrolment number (15) than Years 1 and 2 (17), as two students were absent. Mr. Nilesh Jit Kumar of Fiji Islands was unable to participate, and complete his final year, as he was abroad on a Fiji Islands - Japan bi-lateral Geoscience (Seismology) training course in Japan. Mr. Sitivi Kamu of Samoa opted to pursue a full-time B.Sc. programme in Earth Sciences, at USP, beginning 2002, after successfully gaining entry into the programme and securing financial support from the Government of Samoa.

The module included various aspects and elements of development planning, including the role and neglect of earth sciences in project planning, development, and maintenance and disaster management. Geological hazards examined include coastal erosion, earthquakes, liquefaction, volcanoes, tsunamis, landslides, flooding and tropical cyclones. The role of remote sensing and GIS was also presented and discussed. Fieldwork included coastal mapping, coastal erosion assessment, class project work and follow-up report writing. The coursework included lectures, tutorials/revision, and field and/or laboratory exercises/projects. All participants pursued SCC24. The course was run over 90 hours for a period of six continuous weeks. All teaching, review and examinations for each course was done within the six weeks of the instruction/teaching period. The coursework included lectures, tutorials/revision, and field and laboratory exercises/projects. Students were evaluated for each component of the coursework and by means of two separate, end-of-course written examinations, which were marked and graded. All students were successful in SCC24. The following are the results summary, in terms of grades and numbers of students attaining that grade: A+ - 3; A - 2; B+ - 2; B – 3; C+ - 4; C - 1.

The Cook Islands student performed best, securing an A+, even though he had no previous training in earth sciences or marine geology, and therefore had not done the Year 1 and Year 2 of the ESMG programme. The Fiji Islands students also performed extremely well, with two A+ and two A grades. One Solomon Islands and one Tongan student did very well, and obtained B+ grades. Two Tongan and one Samoan student obtained B's, while the remaining students performed satisfactorily, obtaining C's.

The performance of all students, based on their final grades, was consistent with their overall "classroom" performance throughout the course, and agrees well with their performance record for the first two years (Years 1 and 2) of this ESMG three-year programme cycle. Based on these final, Year 3 results; all students will be able to graduate with the Certificate in Earth Sciences and Marine Geology from the University of the South Pacific. Based on this assessment, the Certificate in Earth Sciences and Marine Geology programme was successful.

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Technology transfer and capacity building in hydrology and hydrogeology- SOPAC/USP Earth Sciences and Marine Geology (ESMG) 2001 Certificate Programme

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This paper presents a summary of technical training and capacity building, executed as part of the South Pacific Applied Geoscience Commission (SOPAC Secretariat) and the University of the South Pacific (USP) Joint Certificate in Earth Sciences and Marine Geology (ESMG) for the period November 2001 - 4th May 2002. This paper presents some details of the course, SCC25: Hydrology and

Hydrogeology, taught at the USP, Laucala Bay Campus, Suva, Fiji Islands, from 25th February to 5th April 2002. The paper highlights the background, nature and objectives of the course, the student enrolment, the lecture outline, subject areas covered and the results of in-course examinations and practical assessment.

This year's modular course formed part, and the final year of the three-year ESMG Programme offered by SOPAC and the USP. The programme was entirely funded by the Commonwealth Secretariat (COMSEC), under the Commonwealth Fund for Technical Co-operation (CFTC).

This ESMG Certificate programme provides technology transfer and continuing professional development of practical skills and knowledge for those who are part of Geoscience survey teams or are laboratory geological technicians in Earth System Sciences and ancillary fields in the South Pacific region. This programme is open to candidates nominated by the South Pacific regional governments, and private sector/corporate entities. The USP, School of Pure and Applied Sciences (SPAS) approve the Certificate programme, and forms part of the Marine Sciences (MSP) approved modular programme, ensuring appropriate Quality Assurance and Control (QA & QC). The Certificate is also awarded by the USP after approval by the USP, SPAS. The Marine Studies Program (MSP), Lower Campus, of the School of Pure and Applied Sciences (SPAS) of the University of the South Pacific (USP), Laucala Bay, Suva, Fiji Islands, was the venue for the Certificate in Earth Science and Marine Geology Course (ESMG) programme this year.

The initial two years of this programme cycle were completed in 1999 (Year 1), and in 2000 (Year 2). Unforeseen circumstances of May 2000 in Fiji Islands and lack of funding of the Training Co-ordinator post, project funds and support staff pre-empted the timely completion of the ESMG programme in 2001. This delay resulted in the untimely completion of the programme in 2001.

This year's course had a smaller enrolment number (15) than Years 1 and 2 (17), as two (2) students were absent. Mr. Nilesh Jit Kumar of Fiji Islands was unable to participate, and complete his final year, as he was abroad on a Fiji Islands- Japan bi-lateral Geoscience (Seismology) training course in Japan. Mr. Sitivi Kamu of Samoa decided to pursue a full-time B.Sc. programme in Earth Sciences at the USP, Fiji Islands, beginning 2002, after successfully gaining entry into the programme and securing financial support from the Government of Samoa.

The course provided an introduction to freshwater resources assessment in Pacific Island countries. The hydrological cycle was covered, including rainfall, evaporation, transpiration and runoff. Quantitative measurements of these hydrological parameters were also discussed. Quantification of stream flow and hydraulic gauging were described and discussed. Hydrogeological units, recharge boundaries, porous media and flow of groundwater were discussed. Water quality, contamination and pollution, and methods of processing, analysing and storing of water resources data were covered. Methods of groundwater resources assessment, including resistivity, seismic, electromagnetic and downhole logging techniques were discussed. Well drilling, completion and maintenance were also discussed at length. Methods for conducting and analysing pumping tests were discussed and presented. Fieldwork included water resources measurement techniques including resistivity surveys, well drilling and completion, water testing, well maintenance and technical report preparation.

The coursework included lectures, tutorials/revision, and field and laboratory exercises/projects. Students were examined for each component of the coursework and by means of two separate, end-of-course written examinations, which were marked and graded. All 15 students pursued SCC25. The course was run for 90 hours of instruction time, over a period of six continuous weeks. All teaching, review and examinations for each course was done within the six weeks of the instruction/teaching period. All students were successful in SCC25. The following are the results summary indicating grades and number of students obtaining the respective grade: A+ - 4; A - 1; B+ - 3; C+ - 1; C - 6.

The Cook Islands student performed best, securing an A+, even though he had no previous training

in earth sciences or marine geology, and therefore, had not done the Year 1 and Year 2 of the ESMG programme. The Fiji Islands students also performed extremely well, with three A+ and one B+. The Solomon Islands, Papua New Guinea and two Tongan students did very well, and obtained B+ grades. The Samoan, Tuvalu, Kiribati participants, one Tongan and one Solomon Islands student performed satisfactorily, obtaining C's.

The performance of all students, based on their final grades, was consistent with their overall "classroom" performance throughout the course, and agrees well with their performance record for the first two years (Years 1 and 2) of this ESMG three-year programme cycle. Based on these final, Year 3 result, all students will be able to graduate with Certificate in Earth Sciences and Marine Geology from the University of the South Pacific. Based on this assessment, the Certificate in Earth Sciences and Marine Geology programme was successful.

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Recommendations for design of a shoreline protection system, Yaren District, Republic of Nauru

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This paper presents the results of a technical study and design guidelines for a coastal protection system for a section of an eroding coastline in Yaren District, Republic of Nauru. Yaren District is located in the southwest part of Nauru and is the site of the capital of Nauru. The problem coastline is a segment of shorefront, just west and southwest of the airport runway and east of the Government buildings and Parliamentary complex. The residents in the District have also noticed significant erosion of the coastal areas, including loss of beach sand and loss of land over the past months.

Design information has been produced after numerical analysis with coastal engineering software CRESS and ACES. A multi-layered, free-draining rip-rap revetment is proposed for remediation of the erosion problem at the site. This structure will also protect the problem area from future erosion by wave attack under similar hydraulic conditions discussed. The rip-rap revetment should have the following design elements: two outer layers with a width of 10 m as the primary armor of the revetment; the revetment should be winged, that is, the ends of the revetment should not be open to wave attack, but should be built into the adjacent land or "closed"; the revetment should utilize natural dolomitic limestone rock from RON; it should consist of a granular filter layer or secondary armor layer, made up of 0.20-0.35 m diameter rocks; this underlies the primary armor; the revetment should have a 1:1.5 seaward slope; a geotextile filter fabric is also recommended for use in this structure; this fabric is a free draining artificial media; the geotextile fabric should have perforations with dimensions less that the diameter of the smallest boulders to which it is juxtaposed; two separate layers of the geotextile filter fabric should be used; one layer will underlie the primary armor of the revetment and overlie the granular filter media; the second liner should overlie the natural soil/land and underlie the secondary armor; the rock revetment should use 0.89 m nominal size dolomite limestone boulders obtained locally (from RON).

Boulders for the outer layers of the revetment should have the following dimensions: D_{50} of 1.04 m; D_N of 0.89 m; W_{50}/? of 1,745 kg; and Nauru's dolomite limestone with densities at 2500 kg/m^3. The above dimensions are suitable for hydraulic conditions associated with 3 m high (HS) plunging breakers, associated with wave periods of 6 sec (T), approaching the shore (?) at 015^0. Please note that we cannot design for nor do these dimensions cater for extreme oceanographic or weather events, like storms and cyclones, as that is beyond the scope of "normal engineering." It is noted that a qualified engineer should supervises all of this work to ensure Quality Assurance and Quality Control.

Benchmarking commercial building electricity consumption in the Pacific islands

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There are many opportunities for improving energy efficiency and conservation measures in electricity generation, in residential and commercial buildings, industry, transportation and the agricultural sectors.

This paper focuses on and highlights the importance of energy efficiency and conservation from a demand-side management perspective in commercial buildings. It demonstrates the derivation of the Energy Use Index (EUI) and is based on standard electricity consumption patterns determined from data and information collected from a large number of similar buildings in the Pacific region, and the use of the EUI that enables the comparison of electricity consumption with other similar buildings in the region. The other coordinate that links to electricity consumption is the Building Energy Index (BEI), which is based on the product of the EUI and the correction factor for actual operating hours.

In addition, the paper provides case studies from the Pacific region using the EUI and BEI to demonstrate potential savings and whether an energy management programme should be implemented to reduce energy consumption.

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New mass spectrometer-based instrumentation for analysis of dissolved molecules and ions in coastal and deep-ocean environments

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As analytical instruments, mass spectrometers have the capability of extremely high sensitivity, isotopic resolution and wide dynamic range. Field-portable units incorporating mass spectrometers could therefore revolutionize the ocean and earth sciences, replacing and complementing much present field equipment and expanding the analytical horizons for in situ geochemistry. We have built and are currently testing two miniature mass spectrometer-based systems specifically developed for the marine environment. These systems incorporate the Rotating Field Mass Spectrometer (RFMS) developed at JPL, which has very wide dynamic range and operates at modest vacuum levels. The Mass Spectrometer Using Rotating Fields for Exploratory Research (Mass SURFER) is housed within a 6.5-inch (16.5 cm) OD pressure vessel, 66 inches (1.68 m) long that is capable of 2500+ m deployments. Liquids such as seawater with their load of dissolved gases, ions and molecules are directly injected into the vacuum chamber via a novel sampler we developed that can in theory operate to water depths of >4500 m. Our direct liquid sampler approach, unique to this developing analytical field, uses an on-line capillary nano-electrospray interface (ESI) capable of high-sensitivity mass spectrometry at nanoliter per minute flow rates. The challenge for this type of interface is clogging by fine suspended particles (coarse particles can be screened) and salts build-up. Preliminary direct seawater injections have produced no significant deleterious effects. Mass SURFER vacuum levels need only be at the milli-torr level for a quality measurement, and the complete system nominally draws <10 watts. The RFMS mass resolution of 1 part in 1000 is comparable with the best of other small mass spectrometers. The extremely large analytical mass range of the RFMS (from 1 to

>100,000 amu) coupled with “soft” ionization techniques make this instrument capable of analyzing large dissolved organic compounds such as proteins and DNA fragments. We are also incorporating an on-line capillary electrophoresis column to aid spectral resolution of large organic compounds. Laboratory tests indicate detection limits below 1 ppb (part per billion) with the current prototypes. We are planning more sensitive versions with detection limits below 1 ppt (par per trillion) that will enable analysis of dissolved pesticides, biological/chemical agents, and heavy metals in fresh waters as well as the remote detection of life in extreme environments on Earth and on other planets. We present results from recent laboratory calibrations and initial field deployments in shallow and deep ocean environments off the Island of Oahu in Hawaii. The ongoing work is funded by the Defense Advanced Research Projects Agency (DARPA) through the National Defense Center of Excellence for Research in Ocean Sciences (CEROS).

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Ocean thermal energy conversion

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Research at the Saga University Institute of Ocean Thermal Energy

Research is being carried out on "ocean thermal energy conversion" (OTEC) as a new way to produce electric power without oil or nuclear energy. Two-thirds of the Earth's surface is ocean, which stores huge amounts of solar energy and can provide an inexhaustible energy resource for as long as the seas and the sun exist. This method of power generation is eco-friendly because only seawater is used and carbon dioxide emissions are exceedingly low. In addition to power generation, it also produces fresh water, hydrogen, lithium and so on. For the electricity in use today, we are reliant for the most part on thermal power and nuclear power. However, the reserves of oil and uranium, natural underground sources of energy, are limited and will one day run out.

OTEC is an innovative method of power generation for the 21st century to solve energy and environmental issues so crucial to human life. Research on such systems is taking place at Institute of Ocean Energy, Saga University, Japan. OTEC utilizes the temperature difference between cold deep water (10ºC) and warm surface seawater (30ºC). The principle of OTEC is to use warm surface seawater to heat and vaporize a working fluid and to use that vapor to turn a turbine to generate power. This is fundamentally the same mechanism used in other power generation with the major difference of the use of a working fluid such as ammonia, with a low boiling point, in OTEC.

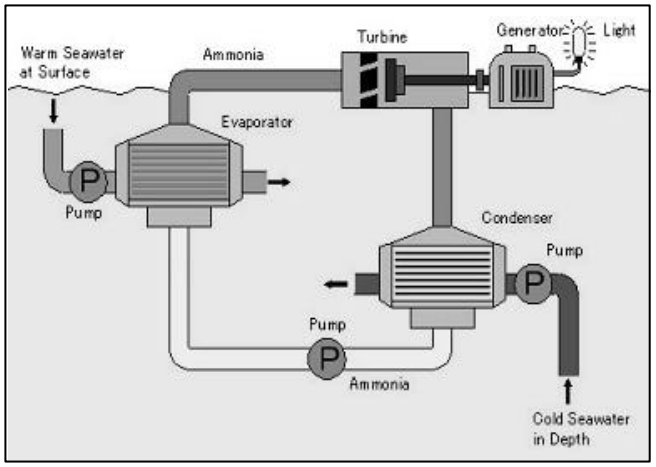

Figure 1 : Basic Theory of OTEC

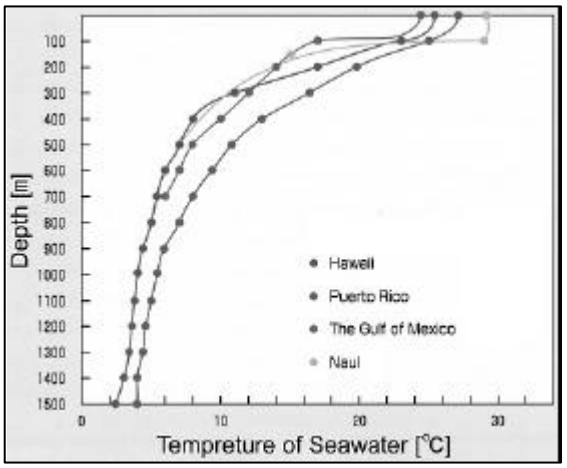

Figure 2 : Temperature Difference

OTEC was conceived theoretically 121 years ago. It was believed to be difficult to implement, however, because the energy used to pump up the deep and surface seawater would cancel out the energy produced through thermal conversion. Dr. Uehara developed a highly efficient OTEC system with low construction costs, known as the "Uehara Cycle," which has been researched for many years to make the system commercially viable. The key to lower the cost is that the fuel costs are free and therefore it is only necessary to make the cycle more efficient and reduce construction costs for the plant.

The main equipment in OTEC systems is evaporators, condensers, turbines, generators and pumps. To generate power, the working fluid is heated and vaporized, which turns the turbine. For OTEC, ammonia or other mixtures are used for the working fluid. Ammonia is used for its low boiling point, as surface seawater never gets warmer than about 35ºC. The cycle begins when the working fluid is pumped to the evaporator. There, the working fluid is vaporized by warm surface seawater. The vapor is expanded through the turbine, turning the turbine and generator to provide electricity. The vapor that comes out of the turbine is cooled by thermal contact with the cold, deep seawater flowing through the condenser and becomes liquid again. The condensate is then pumped back to the evaporator and the cycle repeats.

OTEC is possible in nearly 100 countries

The climatic conditions required for building OTEC plants are satisfied in more than 100 countries. OTEC is applicable to countries located within a range of 40º N latitude to 40º S latitude. The total production of electricity within the economic sea zone of Japan alone is estimated to be 10^{14} kWh annually, the equivalent of 8.6 billion tons of oil.

As the heat source is seawater, carbon dioxide emissions are extremely low compared to thermal or nuclear power generation, and the system is extremely eco-friendly and does not produce radioactive waste. As the thermal energy reserves in seawater are vast and the seawater can be recycled, it can provide a stable supply of electricity year round, unaffected by the weather and similar to other renewable energy such as wind and solar power.

The Uehara Cycle vastly reduces the intake volume of deep seawater

The Uehara Cycle has an additional turbine that reduces the load on the condenser by drawing vapor out of the first turbine. In addition, the fluid extracted and liquefied by the condenser is heated before it enters the regenerator, thereby increasing efficiency. The cycle also has an "after condenser," which liquefies vapor that could not be liquefied in the condenser.

In the Kalina Cycle, because of the heavy load on the evaporator and condenser, the intake volume of seawater can not be reduced. However, in the Uehara Cycle, the intake volume can be reduced, making it possible to reduce the diameter and weight of the intake pipe. A small condenser is also possible. As the result, total construction costs are vastly reduced.

The new research center is being built in the Imari city Saga, Japan, and is scheduled to open in March 2003. The scale of the experimental plant is 30 kW and the new plant will verify the on the Uehara Cycle. It will be the world's first research institute for OTEC.

Global efforts to commercialize the system: India and Palau

Construction of OTEC projects is already in progress in many countries. India, for example, is experimenting with a pilot plant with the full technical assistance of Saga University. The plant in India is a floating (barge-type) type with 1,000 kW power generating capacity. OTEC plants can be either floating or land-based. Floating plants might include a sea floor type, half-submerged or fully submerged. India plans to build 1,000 plants in the future, each with an output of 50,000 kW. This power output is equivalent to the energy produced by a nuclear power plant in Japan.

Besides India, 3,000 kW OTEC plant will be built in the Republic of Palau. Requests have reached Saga University for joint research and projects from other countries, including Korea, the Philippines, Sri Lanka, Papua New Guinea, and the State of Hawaii in the U.S.A. At present, over 50 countries are looking into building OTEC plants.

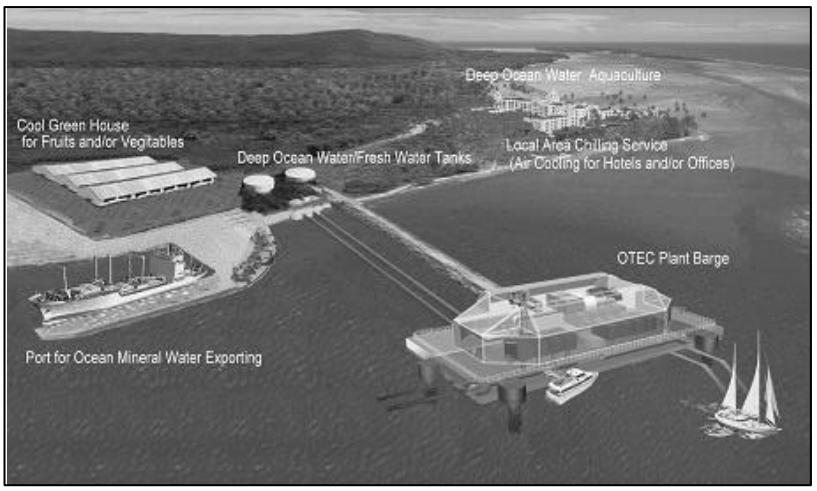

Figure 3 : Imaginary sketch of an OTEC plant in an island country

Palau has a particularly high interest in OTEC because it is located in the best site for OTEC and does not have fossil energy resources. Palau and other island countries also wish to be independent from the petroleum or gas so as to be eco-friendly countries and protect the environment.

Another major issue is the scarcity of fresh water. For this reason, a system that provides both energy and drinking water at the same time is highly sought. In the process of OTEC, deep seawater is pumped up and desalinated, and it is possible to produce large quantities of water in this manner.

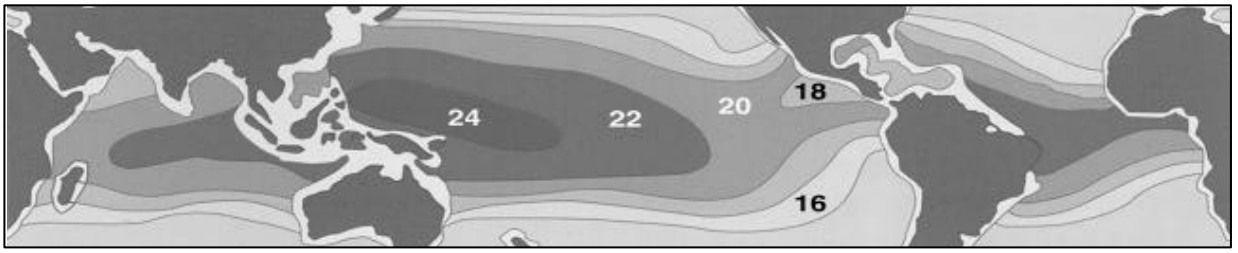

Figure 4 : Distribution of Temperature Difference between 1000 m Deep and Surface Seawater

Through OTEC, two types of fresh water are obtainable; mineral water produced by deep seawater and distilled water. Deep seawater circulates in the world's oceans for thousands years, so it contains many minerals including magnesium and calcium. Mineral water using the deep seawater can be sold as a drinking water and the distilled water can be used for industrial purposes. By so doing, it will be possible to engage in farming on land that could not be used before, such as desert and waste lands. India began early work on OTEC because of severe shortages of water and drinking water.

OTEC is a kind of oil field

OTEC can be used not only to generate power and produce fresh water, but for various purposes as well. For example, it is possible to produce a huge amount of hydrogen using the distilled water and electricity that are produced by OTEC plant itself.

Automotive makers today are scrambling to develop automobiles powered by fuel cells. Hydrogen is gaining attention as eco-friendly fuel can be replaced for diesel fuel and gasoline.

Additionally, deep seawater contains lithium and uranium. This is a vast energy source that can be

collected and used in nuclear power generation and in lithium batteries. The demand for lithium batteries in particular is rising rapidly with the spread of cellular phones and other mobile devices. Deep seawater can also be used in aquaculture to raise many types of fish and shellfish, and to improve the fertility of the ocean. Sea area that has a natural upwelling of deep seawater is fertile fishing ground as the ocean nearby Chili, South America. This is due to the voluminous propagation of phytoplankton from the purity of deep seawater and the inorganic eutrophication it promotes. If the deep seawater after power generation can be returned to the ocean skillfully, it might be possible to create new fishing grounds.
Other possible uses of deep seawater are in cosmetics, medicine, and other products, or cooling systems for houses and buildings. OTEC can thus be put to use in a various ways, and has the potential to solve problems related to the environment, energy, water, food, and human population. If you think of OTEC not only in terms of power generation but for its many other uses as well, its economicality rises dramatically. OTEC, which can solve many problems that we face, can be seen as an oil field of sorts. In addition to that, OTEC can support their social development in the developing countries nearby ocean and equator.

Imari, Saga: Becoming an OTEC Research Base

OTEC was once thought impossible to commercialize, but it is now becoming feasible and gaining attention around the world. It is also considered an ideal way to generate power, as its multiple utilizations can also solve various problems that humanity faces.
The new research center being built in Imari city will contain Uehara Cycle OTEC Experimental Pilot Plant along with the desalination pilot plant, hydrogen production and storage experimental pilot plant, and a lithium recovery experimental pilot plant. The Center's goal will be to establish high-performance power generation technologies and comprehensive-use technologies.
As a preparatory conference of the "3rd World Water Forum" held in Kyoto, Japan in March 2003, a pre-conference will be held in Palau and Saga with the participation of about 14 countries including India and Palau. At this forum, Saga University will try to promote the ocean utilization technologies and desalination technology using renewable energy to the world. In the future, the new research center will play a leading role in OTEC research, and hopes to become a focal point for international efforts to promote this new industry.

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Late Cenozoic history of Niue Island: implications for understanding tectonics in areas of lithospheric flexure

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The island Niue in the central South Pacific is an emerged atoll riding up the outer flank of the lithospheric flexure formed as a result of Pacific Plate convergence along the Tonga Trench 2-300 km west. The form of the atoll that existed around 500,000 years ago is preserved as a ring-reef (the Mutalau Reef), now reaching 70 m above the modern reef and enclosing the former lagoon. Fringing the Mutalau Reef are a series of 7 terraces marking fringing reefs that began growing at times of relative land-ocean stability. U/Th dates from these terraces show the broadest and most continuous - the 23 m Alofi Terrace - to be of Penultimate Interglacial age. The Last Interglacial terrace occurs around 18 m and the Holocene maximum sea level is recorded by an emerged notch 1.9-2.7 m above the modern shoreline. Questions remain as to whether late Quaternary uplift of Niue was continuous or episodic.

Japan/SOPAC Deep-sea Mineral Resources Study Programme – Stage II (2000-)-

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In response to a request by SOPAC member States, a co-operative programme between SOPAC and Japan, termed The Japan/SOPAC Deep-sea Mineral Resources Study Programme, commenced in 1985. Funded by the Government of Japan, the Programme uses the Research Vessel Hakurei-maru No.2 to conduct marine scientific research within the Exclusive Economic Zones (EEZ) of eleven SOPAC member countries[1].

The programme comprises two stages, with specific objectives established for the four phases that have been completed. Stage I of the Programme commenced in 1985 and ended in 1999, with Stage II starting in 2000, with planned completion in 2002. The objectives for the first fifteen years of the programme were to assess the potential of deep-sea mineral resources for manganese nodules, cobalt-rich manganese crusts and submarine massive sulfide deposits within the Exclusive Economic Zones (EEZ) of selected SOPAC member countries.

The objectives for Stage 2 of the programme, currently underway, are to conduct more detailed surveys of prospective areas discovered during Stage I. This has seen more detailed surveys being conducted within the EEZ's of the Cook Islands, Fiji and the Republic of the Marshall Islands. These detailed surveys have enabled preliminary estimates of ore reserves to be made, as well as initial environmental baseline surveys to be carried out. Such environmental data will be used for environmental assessments in the event of deepsea mining activities in the areas in question (Table 1).

Table 1: Summary of SOPAC member countries that have participated in the Japan/SOPAC Deep-sea Mineral Resources Study Programme.

Target	Stage I (Phase1, 2, 3)	Stage II (Phase 1)		
	1985-1999	2000	2001	2002
Manganese nodules	Cook Islands Kiribati Tuvalu Samoa	Cook Islands		
Cobalt-rich manganese crusts	Kiribati Tuvalu Samoa Marshall Islands FSM			Marshall Islands
Hydrothermal deposits	PNG Solomon Vanuatu Tonga Fiji Islands		Fiji Islands	

Summary results of first phase of Stage 2 of the programme follow:

Manganese nodules -2000 cruise in Cook Waters

Based on the results of Stage 1, detailed sampling to further estimate and confirm the resource potential of manganese nodules occurring within within the EEZ of the Cook Islands was conducted.

[1] *MSR cruises have been conducted within the EEZs of the following SOPAC member countries: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshal Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu.*

Bottom samples of manganese nodules were collected, with associated sediments, using free-fall grab, spade corer and/or large diameter gravity corer at 42 stations. The survey revealed an area covering approximately 2,400km^2, with an abundance of manganese nodules of over 30kg/m^2. Consequently, the resource in the area is estimated to be about 60,000 metric tones of manganese nodules.

Hydrothermal deposit -2001 cruise in Fiji Waters

Marine drilling, using the state-of-the-art Benthic Multi-coring System (BMS), was conducted at twenty-two sampling stations in the Triple Junction area of the Central Spreading Ridge, located in the central part of the North Fiji Basin, with poly-metallic massive sulfides being recovered from eight of the twenty-two cores. This is the first time that the third dimension of poly-metallic massive sulfide deposits in the North Fiji Basin has been physically established. Poly-metallic massive sulfides of up to 7 meters thickness were confirmed from one of the cores drilled on the mound.

The dimension of the mound that was drilled is estimated to be 100 m long and 30 m across, with a thickness of at least 7m. Therefore the ore reserve has been estimated to be 73,500 t with the grade of Cu 6.93%, Zn 0.61%, Au 0.85% and Ag 24.39%. The observations by deep-sea towed TV camera suggests that there are at least seven other polymetallic massive sulphide mounds in this site.

Cobalt-rich manganese crust –2002 cruise in Marshall Waters

Core sampling using the Benthic Multi-coring System (BMS) to get a more accurate estimate on the thickness of cobalt-rich manganese crusts was conducted on three (3) seamounts within the EEZ of the Marshall Islands. The thickness of crusts was decided from core samples collected by the BMS and the coring situations observed from high-resolution deep-sea video camera, which is mounted on the BMS.

A total of fifty-two (52) core samples from three seamounts, using the BMS, were collected during the June 2002 cruise. The data and samples collected during the survey cruise are currently being analysed in Japan and the final report with results of analysis will be available from the Government of Japan by June 2003.

Environmental baseline survey

Environmental baseline surveys for manganese nodules, cobalt-rich crusts and hydrothermal deposits have been conducted since 2000. The environmental surveys are an important element of the first phase of Stage II and will remain such if there is to be a continuation of the cooperative programme. These surveys using the multiple corer and the large gravity corer have obtained spatial chemical data of water and sediment conditions. It is intended that the data and information collected will be used -as baseline data and information in the event of marine mining in the areas in question.

Phase I of Stage II of the co-operative programme will end in March 2003. As there are other promising areas that require further research to elucidate their resources potential, within the EEZ's of selected SOPAC member countries, SOPAC is anxious to continue the longstanding cooperative initiative with Japan and is seeking an extension to the programme by requesting a second phase to Stage II.

The integration of geomorphological knowledge with sustainable shoreline management practice – an example of UK practice with potential application in other areas

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An understanding of the characteristics and formation processes of the morphological systems that make-up the fundamental structure of the coast is crucial to appreciating future shoreline changes. Some evolutionary processes and behavioural tendencies are only evident over very long timescales, and consequently, understanding geological and morphological controls can be equally as important as understanding hydrodynamic processes.

The Futurecoast project, funded by the UK government Department of Environment, Food and Rural Affairs (DEFRA), and led by Halcrow Group Ltd, was commissioned with the aim of providing a scientific baseline and framework for future shoreline management planning, through an improved understanding of coastal morphological systems and the major natural influences on their future evolution.

The basic concepts adopted and applied by the Futurecoast project to the UK coast were: i) to provide a broad-scale geomorphology overview at a range of temporal and spatial scales; ii) to consider all aspects of the coastal system and how they might behave in the future, not simply focussing on littoral processes; and iii) to deliver consistency of approach, format and quality of information, such that it is readily understandable and useable. The research output was targeted at operating authorities (responsible for coastal defence management but often non-specialists), and coastal practitioners involved in developing future management plans on their behalf. It is hoped that the promotion of a greater appreciation of coastal systems and their behaviour to specialists and non-specialists alike will enable more informed decision making in the future.

This paper outlines the work undertaken for the Futurecoast project by a team of investigators, of which the Coastal Geoscience Programme of the British Geological Survey was a major contributor. This approach to shoreline management practice could be applied to other areas of the world's coastlines.

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Business and training needs analysis in geoscience organisations: focussing resources, improving the workforce, enabling change

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Public sector geoscience organisations are everywhere under pressure as they strive to respond to the great changes to their work programmes demanded by their governments who increasingly wish to harness increases in knowledge and in technology to serve their constituencies. At the same time governments are themselves under pressure to reduce taxation, and hence investment, in those very organisations. Further pressure to change organisational culture and ethos, has been exerted on the geoscience bodies by their governments requiring them to behave more like those in the private sector, alas commonly without private sector rates of pay, by generating income and reducing their perceived cost to government. Additional strain is then cast upon staff since these organisations were originally created as agencies of government and staffed with men and women brought up in the ethos of the public service, but are now required to deal directly with customers.

Directors and Top Management of the best of these organisations understand that good training programmes enable institutions to cope with change, and have invested their funds appropriately, recognising that staff are their most important resource. Optimum investment of training funds requires an understanding, however, that, just like the organisations themselves, training itself and especially the corporate organisation of training, has undergone significant changes in its own development over the past 50 years or so. It is vital that these changes are understood by Top Management since their understanding of training issues may have been formed at an early stage in their careers, perhaps arising from their experience of training as trainees, and perhaps even subsequently as trainers. Thus their views of training may have been formed or crystallised, or even fossilised, at an earlier stage in the development and growth of corporate training in geoscience organisations. If this is so, such Directors and managers, with the best of intentions, may be led unwittingly into funding training solutions that may be out-of-date and so not to make the best use of their resources.

Changes in the Development of Corporate Training

A number of distinct phases or stages in the development of corporate training can usually be recognised. They represent a transition from the days when specialist training was provided for specialists, through successive phases when various transferable (e.g. management, communication) skills were added to training programmes. Thus specialist skills were augmented first by personal development training, later by Information Technology training, to which were accreted Business Skills training and lately Health and Safety training. Simultaneously, the management of training evolved in a binary fashion. On the one hand it was believed that the 'specialist knows best', and that the scientist was in the best position to judge the merit of training need and provision. On the other hand, it was claimed that the rise of 'transferable skills' needs emphasised the priority of the non-specialist. Sometimes a compromise prevailed with the specialist manager deciding specialist issues and a non-specialist, the transferable skills issues. All geoscience organisations have undergone such changes, but at different rates resulting in a mosaic of states of development in their Training and Development programmes and their management. Individual organisations can usually work out their position within this matrix of training type versus managerial approach.

Shortcomings in Non-specialist –led and Specialist-led Corporate Training

The weakness of the non-specialist leadership lies and always will lie in the fact that the non-specialist is not equipped to make the key decisions in government geoscience organisations because the latter are predominately about, and predominately staffed by specialists. By and large, non-specialists do not understand the business. However, the old-fashioned, individual, specialist-knows-best approach to training is not well fitted, either, to deal with the nature and pace of change in the second half of the 20th century. As these organisations grew, the specialists had become the 'natural' managers, but as training and development diversified they were required to make many more decisions that were outside their range of experience and knowledge. In many cases, this resulted in staff being left to function as individuals to work out their own training need which they themselves were similarly ill-equipped to evaluate. Further, due to poor financial control and lack of training evaluation, the value and efficacy of training was not known. Staff, in their turn, did not know where they were in terms of training that they could expect to receive, or even had received. Nevertheless, although the training and development of an organisation's fundamental resource, its staff, was fragmented, unfair and chaotic, such a system had the outstanding merit of training being related to business need. The best managers were sometimes able to assess the business need correctly and were able to meet it successfully with the staff for whom they were responsible; poorer managers foundered. What is needed is a more general purpose, holistic solution.

A Solution for geoscience organisations

We suggest a solution that combines the strengths of the specialist, 'individual-knows-best' solution and the corporate, centralised approach. Our solution ensures maximum benefit to the business of the organisation, and fair but maximum career benefit to all staff. It ensures an evaluated, value-for-money spend on training activities, and addresses the individual, team and corporate levels of the

organisation. Perhaps most importantly it stipulates that training provision, at whatever level in the organisation, is firstly committed to by top management, then planned provided, evaluated and modified according to business need.

Practical application begins with a comprehensive 'snapshot' assessment of the training and business needs of the organisation. This is done by intensive data collection, including interviews of all staff, and as many customers and stakeholders as practicable, accompanied by analysis of staff records and business plans.

To address needs thus identified two broad areas of training are usually suggested:

Scientific-technical training. Focussed scientific and technical training usually through graduated series of short courses at MSc, graduate or even undergraduate levels. These commonly involve small numbers of staff at high cost

Non-specialist training. Mainly corporate, transferable skills including personal development skills such as report writing, presentation skills, management skills, possibly extending corporate culture and cultural change; IT skills such as MS Office applications; and H& S matters. These are applied across the whole organisation to minimise. These commonly include large numbers of staff at low individual cost

In the long run, to sustain progress, existing training systems, are examined and if necessary overhauled so that they can be implemented by local geoscientists and human resource personnel. The new system will allow institutions to monitor business need continually and tailor training to match these needs.

Thus our approach solves the immediate problems of a deficit in skills and knowledge but also installs a sustainable training system to carry geoscience institutions through future changes however great and howsoever imposed.

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Recent aggregate resource surveys by Mineral Resources Department, Fiji

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With new large development projects starting in Fiji, such as the Kings Road and Lodoni road upgrading, construction of the Rewa bridge, construction of the Naboro landfill and extension of the Fiji School of Medicine, there has been a need to identify sources of aggregate material of adequate volume and good quality. The need has been exacerbated by depletion of the resource at the hardrock quarries at Laqere (both government and private owned), that have been supplying aggregate for major projects for several years.

The Engineering Geology Section of the Mineral Resources Department of Fiji has recently been assisting other government departments and private companies in identifying and carrying out volume and quality assessment studies on hardrock and river-gravel aggregate sources. Examples of such projects over the last two years are Semo quarry (Sigatoka), Navua River (Navua) and Waivou creek (Sawakasa, Tailevu).

Site identification is done by referral to regional geological maps and databases on past and recent quarry and gravel-extraction sites around Fiji. Volume estimation is done by a combination of field-based surveys and office-based remote-sensing applications. The field-based work comprises geological mapping and sampling of site. At hardrock sites, shallow seismic-refraction surveys are

conducted with 12-channel seismograph and 60-m spreads for determining overburden thickness and bedrock characteristics. At river-gravel sites, Schlumberger resistivity soundings are used to determine thickness of gravel beds. Field data are compiled in GIS and integrated with aerial-photo interpretation.

Quality assessments are done by combination of mechanical, chemical and petrographic rock tests. Mechanical tests are done for grading, index properties, abrasion resistance and rock strengths to Australian Standard (AS1141, AS1289). Chemical tests are done for soluble salts (chloride and sulphates). Petrographic examinations are done to investigate secondary mineral content and presence of reactive silica and serpentine minerals.

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Geology of the Ba and Vatia areas, northern Viti Levu: new stratigraphic relations within the Ba Volcanic Group

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The Ba-Vatia area is one of the three areas selected by the Mineral Resources Department (MRD) for systematic remapping in the Vuda to Rakiraki mineralized structural corridor under the Regional Integrated Mapping Project (RIM). This corridor contains some of the most extensively mineralised ground in Fiji. The only operating mine in Fiji is at Vatukoula, Tavua, in the central part. Very little mapping has been done outside the Tavua Caldera in this corridor. New mapping has concentrated on the old Tavua 1:50 000 sheet, which is one of the oldest map sheets in the Viti Levu 1:50 000 series, and is currently out of print. There are major problems with mapping along the corridor, particularly inconsistencies in the geology units between adjacent sheets and the relationships between the young Pliocene stratovolcanoes.

The Ba-Vatia area occurs west and northwest of Vatukoula. Geological remapping of the Ba and Vatia areas was carried out from September 1999 to March 2000. The new mapping amplifies and updates the earlier regional mapping and has resulted in clarification of the geological boundaries and the establishment of new stratigraphic relationships within the Ba Volcanic Group (Figure 1). Rocks of the Ba and Vatia areas correlate with the Late Miocene to Early Pliocene? Koroimaivua Volcanic Group (Dickinson 1968), Late Miocene to Late Pliocene Ba Volcanic Group (Rodda and Band 1967), and other minor younger rock units, which have been correlated with the Pleistocene Ucuna Limestone - Y of Tokalau Limestone Group (Woodhall in prep.) and the Teidamu Boulder Conglomerate – SuT (Rao in prep.). Quaternary alluvium occurs in large quantities in the Ba River valley, mangrove mud in the Ba River delta and beach-sand deposits in a few places on the coast.

The Sabeto Volcanics – KmS (Rao in prep.) is the only formation of the Koroimavua Volcanic Group that occurs in the Ba-Vatia area. Most of the rocks are products derived from five volcanic centres (or zones) of the Ba Volcanic Group. These are, in approximate stratigraphic order, the Koroyanitu Volcano, Tavua Volcano, Karavi Volcano, Namosau Volcano and Vatia Volcano. Rocks in the mapped area have been correlated with seven previously distinguished formations of the Ba Volcanic Group. These are Vatukoro Greywacke – BVk (Hirst 1965), Saru Shoshonite – BS (Rao in prep.), Koroyanitu Breccia – BKo (Rao in prep.), Upper Vuda Beds – BVu (Dickinson 1968), Karavi Volcanics – BKa (Rao in prep.), Namosau Volcanics – BNm (Rao in prep.) and Vatia Andesite - BVt (Rodda and Band 1967). Two new formations of the Ba Volcanic Group have been identified on the basis of lithology, magma type and geographical separation. These are the Veisaru Basalt (BVs) and the Delaikoula Intrusives (BDk).

The type section of the Veisaru Basalt occurs at Vasavaruru trignometric station. Its distribution is to the northeast of Ba township, south of Vatia Peninsula, in the northeastern portion of sheet VIT 1. It comprises equal amounts of massive basalt lava flows and autoclastic breccia, with minor bedded tuff and basalt dikes. Thickness is not known, but is at least 330 m at Vasavaruru. By definition, the Vesisaru Basalt represents the subaerial lavas (absarokite at base and shoshonite on top) of the the Tavua Volcano to the west and northwest of the Tavua Caldera, about 10 km from the caldera edge. This formation is distinguished from the Namosau Volcanics by the larger proportion of massive flows, abundance of augite and olivine phenocrysts and fresher exposures. Rocks of the Namosau Volcanics have a deep weathering profile, often topped with ferricrete, followed downward by red oxidised clayey mud and then extremely weathered rock with well-preserved relict textures, which are absent in rocks of the Veisaru Basalt. The Veisaru Basalt overlies the lower strata of the Vatukoro Greywacke and interfingers with the upper strata of the Vatukoro Greywacke. It is overlain by the Vatia Andesite. Its upper limit is characterised by vesicular and oxidised shonshonitic lavas commonly interlayered with airfall tuff. K-Ar age from a shoshonite dike within the formation is 4.5 ? 0.30 Ma (Rodda 1981; Malahoff *et al.* 1982).

The Delaikoula Intrusives occur in the west and central west of the Vatia Peninsula, and also form Yanuca and Vatubuli islands in the northeast of sheet VIT 1. They comprise commonly massive and sometimes fragmented andesite and microdiorite, and also coarse andesitic breccia. By definition, the Delaikoula Intrusives is the collective name given to a series of small andesite to microdiorite stocks that intrude the Vatia Andesite. The intrusions can be divided into two groups, the northern intrusions and the southern intrusions. The southern intrusions represent volcanic stocks that are central to the Vatia Volcano, and the northern intrusions occur within the caldera structure, possibly representing volcanic stocks of the older northern eruptive centre. The name originates from “Delaikoula structure”, given to the largest of these intrusions (Fiji Map Series 31: M26/955529) by Ibbotson (1963). There is no direct evidence of age, except that it is younger than the Early Pliocene Vatia Andesite.

The overall relationship between the Veisaru Basalt and the Vatukoro Greywacke is inter-fingering as seen in outcrop south of Ba township, where Veisaru rocks overlie the Vatukoro rocks; south of Vatia Peninsula, where Vatukoro rocks overlie Veisaru rocks; and along the banks of the Ba River (Fiji Map Series 31: M27/873358) where basalt lavas of the Veisaru Basalt are intercalated with siltstone of the Vatukoro Greywacke. It is now clear from field evidence that the Vatia Andesite overlies the Vatukoro Greywacke and the Veisaru Basalt. The Koroyanitu Breccia overlies the Saru Shoshonite and grades laterally into the Upper Vuda Beds strata, which in turn grade laterally into the Vatukoro Greywacke. The Namosau Volcanics unconformably overlies the Koroyanitu Volcano to the south and the Karavi Volcanics to the north.

Rocks of the Vatia Andesite are petrographically different from the Karavi Volcanics. Geochemical analysis data still have to be checked for confirmation of difference in magma type. It is now confirmed that the Vatia Andesite was erupted from three eruptive centres located on the Vatia Peninsula, the largest known as the Vatia Volcano. The Vatia Volcano initially erupted magmas predominantly of pyroxene andesite composition. Next followed magmas of hornblende andesite composition, representing late stage of eruption and evolution of the Vatia Volcano.

New 1:25 000 geological map sheets for the Ba and Vatia areas will be available shortly from MRD in both hardcopy and digital formats. A bulletin containing detailed information on stratigraphy, structure, petrography, geochemistry, geophysics and economic geology, and summaries on aggregate sources, is currently under preparation. A digital database on the geology of the Ba/Vatia area, in GIS format, will also be available shortly. It will contain layers of information on new geology, traverse points, sample locations, photographs of outcrops, old geology, old geochemistry and radiometric age samples, drill-hole locations, digital elevation model and airborne geophysics (magnetic and radiometric).

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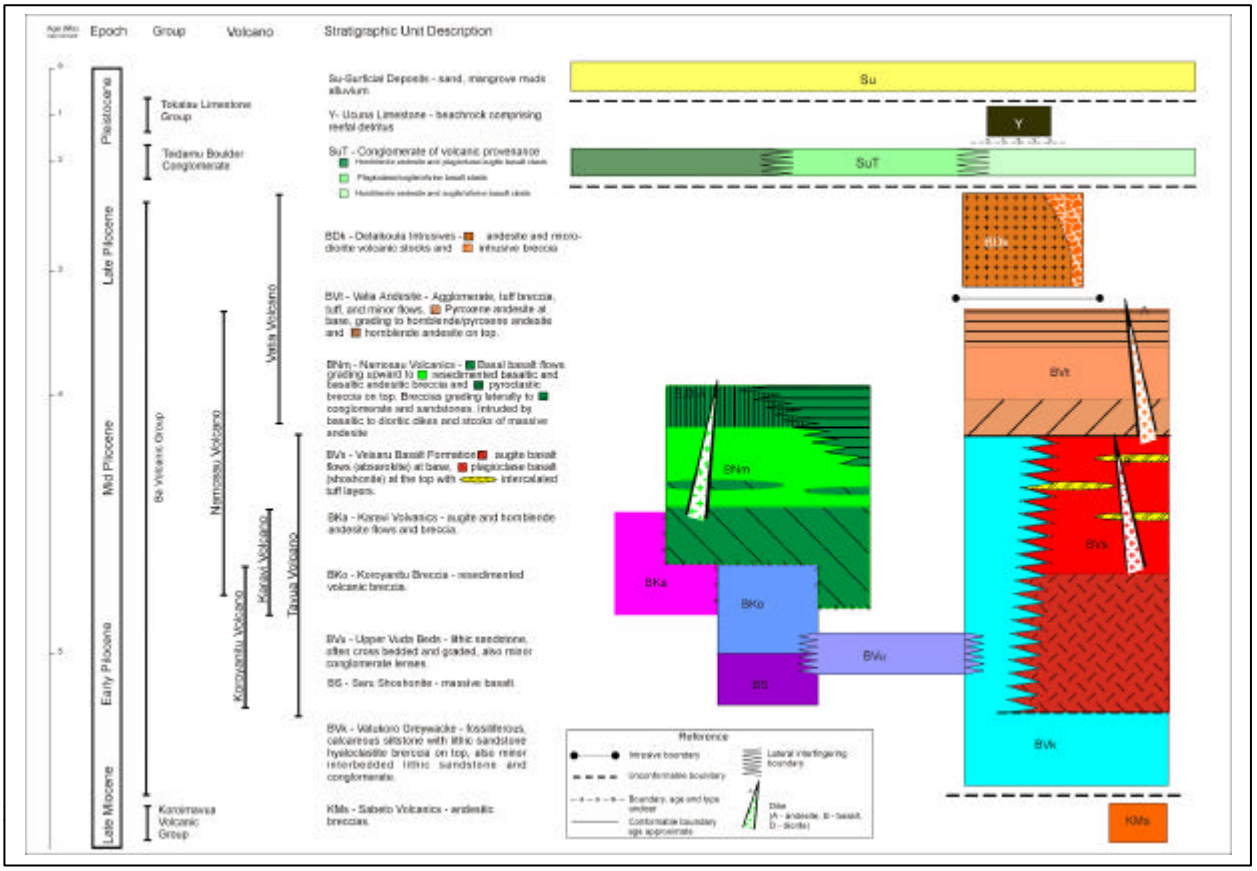

Figure 1: New stratigraphic relationships in the Ba and Vatia areas

Geology and Petrology of the Dakuniba Peninsula, South East Vanua Levu, Fiji

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Recent field and laboratory studies give new insight into the volcanic facies, geochemistry and petrogenesis of the Late Miocene to Early Pliocene (?) Dakuniba basalt province, in southeast Vanua Levu, Fiji.

There are several basaltic provinces recognised in Fiji, such as the shoshonites of the Ba Volcanic Group in north-eastern Viti Levu (Rodda & Band 1967; Gill 1970; Gill & Whelan 1989a) and ocean-island alkali basalts (OIB) of the Bua Volcanic Group on western Vanua Levu (Coulson 1971) and the Taveuni Volcanic Group on Taveuni island (Woodhall in prep; Gill & Whelan 1989b). Another basaltic province occurs on the Dakuniba Peninsula between latitudes 16°40'S and 16°47'S, and longitudes 179°45'E and 179°58'E, which also hosts the Dakuniba gold prospect. The Dakuniba Peninsula occurs on the south-eastern corner of Vanua Levu neighboring Taveuni across the Somosomo Strait. This basalt province has been mapped as the Dakuniba Basalt of the Natewa Volcanic Group by Woodrow (1976). Unlike the other basalt provinces in Fiji, very little was known about the nature of basalts on the Dakuniba Peninsula. The area has been of interest to several exploration companies and much of the geological work has concentrated around the gold prospect. Prior to this study much uncertainty existed regarding eruptive centres, mode of emplacement, geochemistry and petrogenesis of the basalts at Dakuniba.

The distribution of volcanic facies, and coincidence of volcanic centres defined by radially dipping flows with cone- and crater-like features on SLAR imagery, indicate that there are four centres of volcanic eruptions on the Dakuniba Peninsula. These centres are the Dakuniba Volcano, Naqaiqai Parasitic Cone, Navukana Volcano, and the Natuvu Fissure Ridge. The morphology and volcanic facies of the Dakuniba, Naqaiqai and Navukana eruptive centres are consistent with features that are observed in modern stratovolcanoes. The Natuvu eruptive centre, unlike the other centres on the Dakuniba Peninsula, is an elongate source of eruption. The relative ages of the eruptive centres on the Dakuniba Peninsula, as indicated by the degree of erosion, from oldest to youngest is: Dakuniba Volcano, Navukana Volcano, Naqaiqai Parasitic Cone, Natuvu Fissure Ridge.

High magnesium basalts (HMB) with olivine + clinopyroxene (? plagioclase) phenocrysts, and high alumina basalts (HAB) with plagioclase + clinopyroxene phenocryts, and basaltic andesites dominate the Dakuniba Peninsula. Minor andesite, dacite and gabbro also occur. Primitive HMBs have MgO contents greater than 9 weight percent, high *Mg#* (64 to 75), forsteritic olivine (Fo_{87}), and high Ni (140 to 190 ppm) and Cr (400 to 600 ppm) contents. The magma types subdivide into two principal suites based on major-element geochemistry. The suites are a low-potassium tholeiitic suite (LKT) comprising rocks restricted to the Natuvu eruptive centre, and a medium- to high-potassium calc-alkalic suite (MHKC) that comprise rocks from the Dakuniba, Navukana and Naqaiqai eruptive centres (Figure 1).

Differences in trace-element geochemistry, contrasting trends in major- and trace-element variation diagrams and association with eruptive centres in different structural settings indicate that the rocks from the LKT suite are not co-genetic with rocks of the MHKC suite. However, petrographic evidence and correlations in major- and trace-element qualitative variation diagrams indicate that the basaltic rocks in the MHKC suite are related through fractional crystallisation. This hypothesis is supported by least-squares modeling for major elements and Rayleigh fractionation calculation for trace elements, which shows that HABs are daughter magmas derived by fractionation of clinopyroxene, olivine and minor Fe-oxide phase and spinel from parental HMBs (Figure 2).

Processes such as fractional crystallisation and partial melting minimally affect incompatible- element ratios. Subtle differences in incompatible-trace-element ratios between the most primitive HMBs on the Dakuniba Peninsula imply small but significant changes in supra-subduction-zone (SSZ) processes and source components. Some important processes to be considered in the SSZ are different degrees of partial melting and influx of fluids from the subducted slab. Important source components to be considered are the subducting Pacific lithosphere (Pacific MORB) and oceanic sediment, mantle wedge and OIB-type source components.

Elevated LILE abundances (Figure 3) and enrichments of LILE over LREE (e.g. Chondrite-normalised Ba/La, Ba/Ce) are attributable to LILE-enriched hydrous fluids from the subducted Pacific plate fluxing a depleted mantle wedge. Contrasts in abundances of mantle-derived incompatible elements abundances indicate variable degrees of partial melting or additional source components (e.g. sediment ?). Oceanic-island-basalt (OIB) sources do not contribute to the petrogenesis of the Dakuniba basalts. Lower abundance of LILE and lower LILE/LREE ratios in primitive HMBs from the younger eruptive centres (Figure 4) reflect a reduction in the subduction component as a result of Fiji's rotation away from the subduction zone in the Pliocene.

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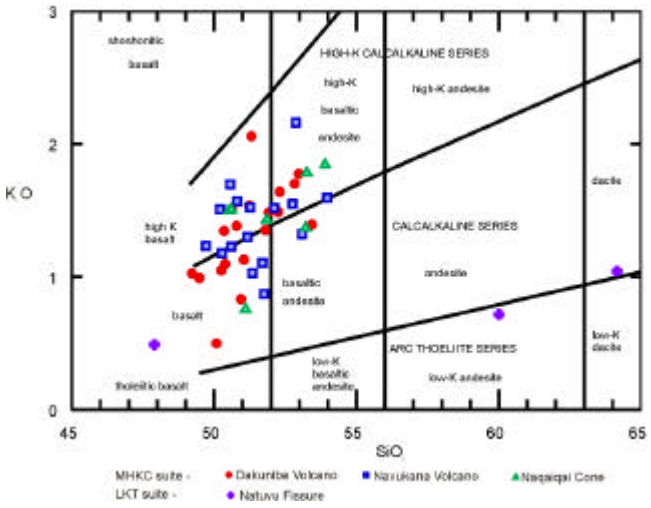

Figure 1: Classification of rocks on the Dakuniba Peninsula by K_2O vs SiO_2 (Peccerillo & Taylor 1976) into a medium to high potassium calc-alkalic suite and low potassium tholeiitic suite.

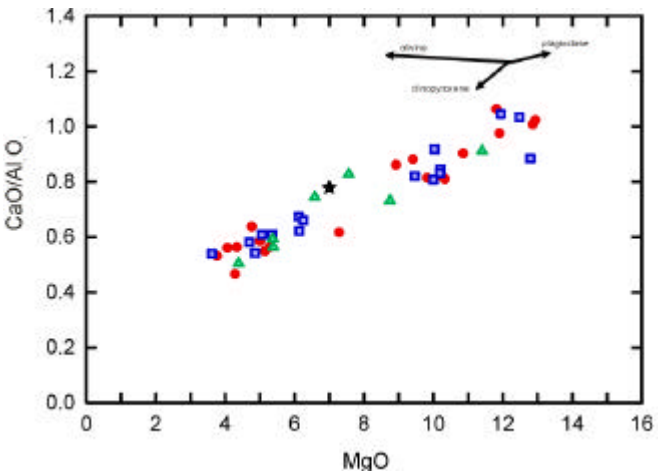

Figure 2: Plot of CaO/Al_2O_3 vs MgO showing MHKC suite rocks consistent with fractionation of olivine and clinocpyroxene. Vectors showing effects of removing 10 wt% olivine, clinopyroxene and plagioclase (from Gust & Perfit 1987).

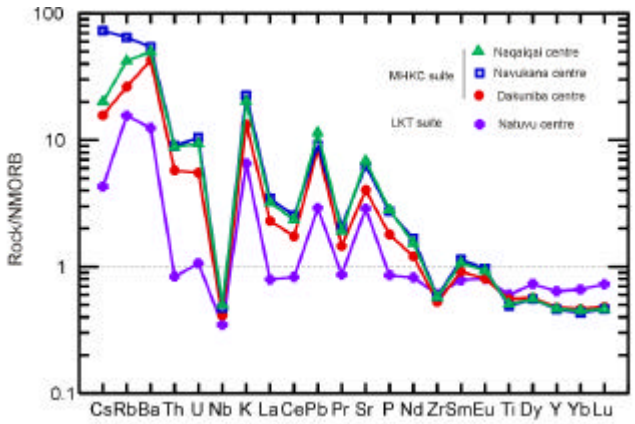

Figure 3: N-type MORB normalised multi-element plot (Sun & McDonough 1989) showing elevated abundance of LILE in representative samples from the MHKC and LKT suites.

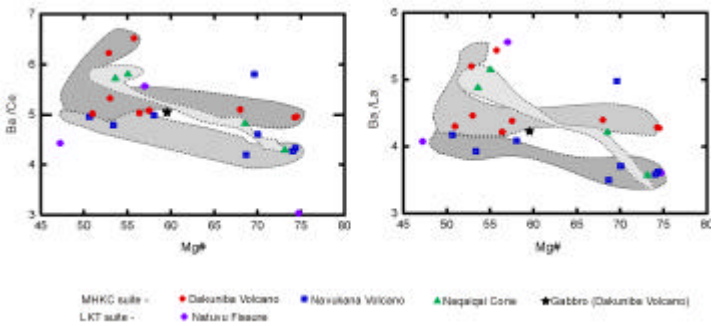

Figure 4: Variation diagrams for selected chondrite normalised (Wood et al 1979) trace element ratios showing lower values in primitive HMBs from younger eruptive centres.

Rabi Island landslide hazard mapping project

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The Mineral Resources Department (MRD) of Fiji is carrying out an investigation on landslide hazard on Rabi island. The aim of the survey is to produce a landslide hazard map that will help prepare for, and mitigate against, the effects of landsliding on the communities and infrastructure on Rabi, and to avoid or minimise the risks associated with new developments. Rabi is located 235 km north east of Suva and 5-10 km from the tip of the Cakaudrove Peninsula on Vanua Levu. The main areas of population and development on Rabi are along the northwestern and southern coasts. The central and northern parts of the island are barren of human settlement and development.

On the 22nd of April 2002, a landslide at Bokanikai settlement in the south of Rabi killed six people after a prolonged period of rainfall in early to mid April. Following a request from the Ministry of Regional Development for a landslide assessment report, a reconnaissance field survey was conducted by MRD on Rabi from 15th to 18th of May 2002. This reconnaissance survey highlighted several important issues of concern that were previously unknown about the situation on Rabi. The issues highlighted by the survey are:

Apart from the landslide that killed six people, a large number of landslides occurred on Rabi in late April and caused considerable damage to property. Landslides damaged roads and landslide debris blocked roads for several weeks. Schools had to be closed and access to the local health centre was cut off. Landslide debris caused silting up of creeks and affected water supply to households. Damaging landslide debris closely missed several houses in the settlements of Levuka, Fatima and Farm, and a primary school near Bokonikai. Over-steepened slopes on new landslide scars above the settlements will act as funnels that will concentrate infiltration of rainwater and increase the possibility of recurrence of landslides at these locations.

Landslides occurred close to developed areas where some form of excavation had taken place, especially cut-and-fill platforms on slopes for house building, and in areas where cultivation had taken place on slopes, including the one responsible for the fatal incident at Bokonikai. Several old landslide scars on the hills at Bokonikai suggests that the hills are unstable. The instability is due to a thick layer of residual soil cover and low-strength weathered bedrock, removal of native forest and cultivation.

Landslides are restricted to the south and western areas of the island (Figure1). Reconnaissance geological mapping suggest that the northern end of the island is younger than the southern end. Petrographic studies reveal that rocks in the northern part of the island are hornblende andesites (Rabi Breccia of the Naroro Volcanic Group on Vanua Levu – Rickard 1966) and rocks in the southern part of the island are basalts (equivalent to the older Natewa Volcanic Group - Rickard 1966). The total-magnetic-intensity image also reveals a continuous magnetic high in the north relative to the south, an indication of possibly a younger volcanic centre. The greater age of the southern rocks would explain the deep residual weathering profiles and the subsequent landslides that occurred in them.

The above issues highlighted by reconnaissance survey justify the quick production of a hazard map that will highlight areas prone to landslides and where they may occur in future. The map can be also used to assess locations of evacuation centres for communities at risk from landslides.

Landslide hazards maps for large areas base on ground geotechnical studies are costly and time consuming and require expertise and resources that are not available in a developing country like Fiji. The alternative cheaper and quicker approach is to use remote sensing and data analysis using geographic information systems (GIS). The methodology will include interpretation and digitising of

past and recent landslides from corrected aerial photos, satellite (Quick Bird) image and field survey, generation of digital elevation model (DEM) from topographic spot heights, production of slope and aspect maps from DEM, and digital compilation of other parameters such as soils, geology and lineaments. Finally, GIS analysis will be used to establish spatial relationships between parameters, and the occurrence of landslides for generation of landslide hazard maps. Use of GIS and remote sensing in landslide hazard mapping was investigated in a previous study in south east Viti Levu by Greenbaum et al. (1995).

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Figure 1: Red stars represent locations of landslides mapped on Rabi from reconnaissance field survey

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Naboro Landfill geotechnical investigations, southeast Viti Levu, Fiji

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The Mineral Resources Department recently completed a geological/geotechnical survey at Naboro landfill site in south east Viti Levu. The Naboro landfill site is located approximately 23 kilometres along the Queens Road from central Suva towards Navua. The survey was carried out at the request of the Ministry of Local Government, Housing and Environment, to provide the consultant engineers (HydroPlan) with landfill design parameters. The aim of the survey was to determine character and thickness of overburden soil and bedrock levels.

Suva City currently has a major-waste disposal problem. The current waste-disposal site outside the city, at Lami, is full and no longer can cater for the increasing supply of waste and is becoming a health hazard. A new fully engineered landfill at Naboro is being designed to cater for wastes from the capital city as well as the towns of Nausori and Navua in south eastern Viti Levu.

The investigations comprised field geological mapping, seismic-refraction profiling using an OYO McSEIS -170 12-channel seismograph and augering using 10-m auger. Laboratory testing for index properties (Atterberg Limits), particle size and permeability were done to Australian Standards 1289. Integration and analyses of collected data were done in a Geographical Information System (GIS). The Trimble GeoExplorer 1 Global Positioning System (GPS) was used to record co-ordinate bcations of survey points.

The landfill site is blanketed by residual soil composed of red/orange, moist, stiff and high-plasticity silt at the top and very stiff, mottled red/white silt towards the base. The residual soil classifies as an inorganic high-plasticity silt (MH) on the Unified Soil Classification table. Figure 1 shows the Atterberg Limit plot of the residual soil. Minor amounts of sandy silt, silty sand, sand and gravel also occur within the residual soil profile (Figure 2). Odeometer permeability tests results show that this residual soil has permeability in the order of 10^{-8} m/s at depths of 1.5 m and increases to 10^{-6} m/s at depths between 3 and 5 m. Seismic-refraction and borehole data reveal that the residual soil layer varies in thickness from 2 to 14 m above bedrock. The layer is thicker closer to creeks.

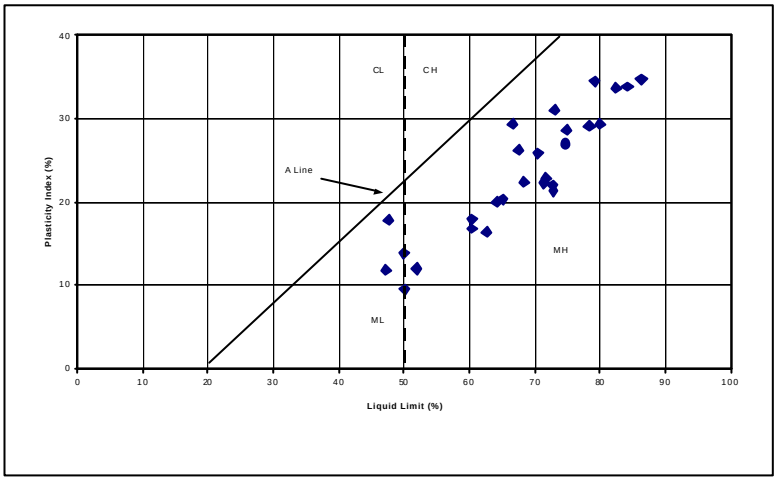

Figure 1: Atterberg Limit plot of residual soil cover from Naboro landfill site

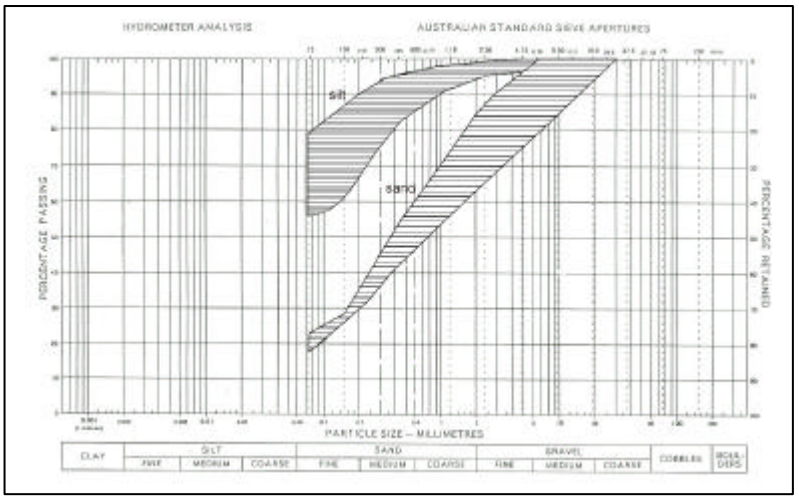

Figure 2: Summary of particle size analyses

The bedrock is composed of grey, fossiliferous siltstone and minor sandstone and resistant conglomerate beds of moderate dip (14° to 20° SSE). Seismic velocities reveal that bedrock is moderately weathered (1100 m/s to 1900 m/s) and slightly weathered to fresh (2200 m/s to 2700 m/s) below the residual soil cover. The bedrock is barren of joint or fault planes and acts as an impermeable layer relative to the residual soil cover.

A three-dimensional topographic model and a bedrock-level contour map were produced for the landfill site. To produce the three-dimensional topographic model, topographic data (X, Y, Z coordinates) acquired from topographic surveys (done by Wood and Jepsen and the Survey Department) were imported into GIS to produce a layer of points representing topography. Interpolation by the triangulation method was applied to the layer of points to create the three dimensional topographic model of the landfill site (Figure 3).

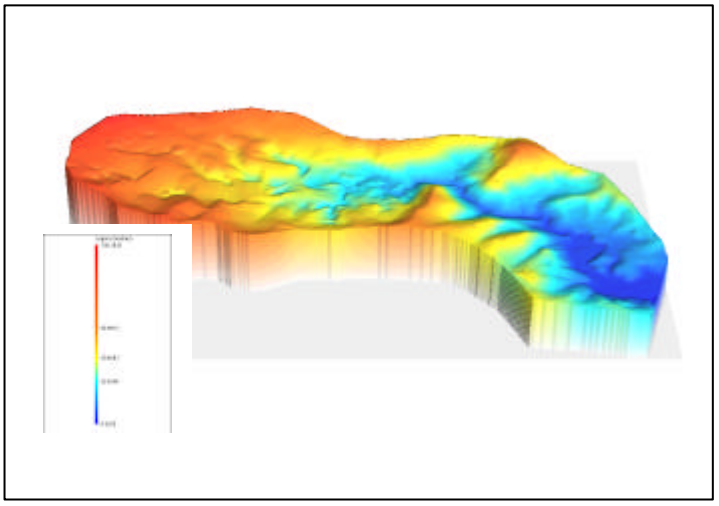

Figure 3: Three dimensional topographic model for the Naboro

Bedrock-level data from seismic-refraction profiles and drill holes were extracted in the X, Y co-ordinate and Z (for bedrock elevation) format and entered into separate GIS layers. These separate layers were combined into a single layer containing points representing bedrock level. Points were then interpolated by the triangulation method to produce a contour map of bedrock levels (Figure 4).

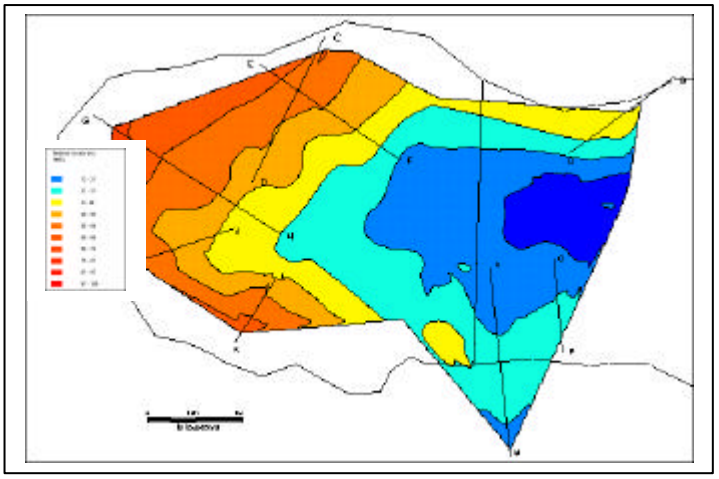

Figure 4: Bedrock level contour map

The topographic surface layer was overlaid on the bedrock-level contour map and was used to create surface and bedrock-level cross-sections at various places in the landfill site (Figure 5).

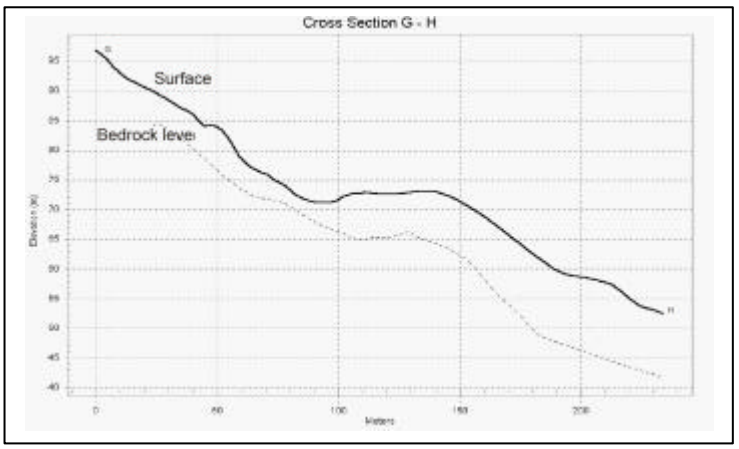

Figure 5: An example of a cross-section generated from overlay of topographic surface over bedrock level

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Interannual and seasonal rainfall distribution and storage behavior on Viti Levu

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Fiji is blessed with abundant water during the wet season, with high intensity rainfall and damaging floods from November to April. On the other hand, rainfall deficiencies are apparent during the dry season from May to October. Up to 80% of the annual rainfall may occur in the wet season. During the dry season the 20% of the annual rainfall is non-homogeneously distributed over time and space. High seasonal and interannual rainfall variation has been of considerable concern in recent years. Potential increases in climate variation and climate change induced through global warming are threatening.

The Intergovernmental Panel on Climate Change (IPCC) in its third assessment report indicates that the intensity of extreme events is likely to increase. It says that precipitation patterns have changed with some areas becoming wetter and others drier accompanied by heavy precipitation in some regions. Further the magnitude, frequency and persistence of ENSO phenomena appear to have increased last few decades.

This does not augur well when we already have difficulty in meeting our water requirements. While on average Fiji receives around 30 x 10^9 m^3 of rain annually there are still periods of deficiency. High intensity short duration rainfall produces runoff that runs out to sea and is ineffective in recharging ground water.

The bulk of electricity needs for Fiji has been met from hydropower since 1984, and this currently meets 70% of energy demands. The capacity of the dam has remained constant. Over this period there has been increase in demand and increased electricity generation. During the same period there have been periods when the water in the dam has been inadequate for running the turbines. Use of imported diesel fuel for energy is a drain on the national economy.

This paper examines the rainfall pattern, rain-causing mechanisms, water shortages and climate events that affect rainfall over the western part of Viti Levu. The behavior of Vaturu and Monasavu storage dams on Viti Levu is significant.

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Rewa River flood forecasting system

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Effective flood forecasting in small island countries in the tropical Pacific is difficult. The catchments are invariably small and steep, with short streams. High intensity tropical rain storms are common. The effect of tropical cyclones even in the developing and approaching stages influence rainfall patterns, intensity and duration. Quantitative rainfall forecasts on the scale of the catchments are not available. Flash floods are common. Although damage and losses caused by flash floods are mounting, flash flood forecasting techniques and technology are lacking in Fiji and the region. Standard techniques for flood forecasting in sizeable catchments have worked successfully.

The Rewa River is Fiji's largest catchment and stretches from the southeastern coast of Viti Levu to the central highlands with a total catchment area of approximately 3000 km^2 and the merging of four river systems. A simple flood forecasting system has been used successfully since 1986. A network of six real time river level and rainfall monitoring stations are equipped with VHS radios powered

through solar energy and capture real time data. Normal data capture is on a daily basis but can be interrogated as frequently as desired. It can be manual or automated.

Computer-generated flood forecasts are based on linear propagation of the flood wave from the upper reaches of the river to the lower, flood-prone and densely populated delta. With a lead-time of around six hours and timely forecasts, losses can be significantly reduced. Perishable goods and moveable property such as farm animals and vehicles can be moved to safety.

This paper demonstrates the success of a simple and robust flood forecasting system in a tropical environment.

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Wetland Treatment Systems: a case study of the Wai Bulabula Project (Cuvu, Nadroga, Fiji)

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The Wai Bulabula project successfully constructed an artificial wetlands treatment system in December, 2001 at the Shangri La's Fijian Resort, Sigatoka, Fiji. These treatment ponds were designed to treat sewerage effluent to a higher quality using biological means.

The wetlands consist of 3 ponds each 60 m x 8 m. Effluent enters the first pond and flows to the next under the influence of gravity, as they are built along a slope. Even though sewerage is treated primarily at the sewerage treatment plant, it still contains a significant amount of nutrients such as nitrates and phosphates. Such nutrients are present in marine and aquatic ecosystems but in elevated levels they cause eutrophication leading to reduced growth and reproduction of coral. The 3 ponds are planted with a variety of local and introduced species that consume nitrates and phosphates. Therefore wastewaters are treated to a higher quality through biological means.

Wetlands have been constructed in many other nations. However, these treatment ponds at the Shangri la's Fijian Resort are the first in Fiji and perhaps the South Pacific. Therefore the Wai Bulabula wetlands are a pilot project. Whilst a number of lessons have been learnt a lot more can be learnt about wetland treatment systems.

The Wai Bulabula project was implemented by the Foundation for the Peoples of the South Pacific (FSP Fiji), a non-governmental organisation. This project is implemented in the Cuvu district, Nadroga, and its objective is the conservation of coral reefs. The community component aims to empower villagers of Cuvu district to manage and/or treat their land-based sources of pollution. A second component of the project worked with the resort to construct the artificial wetland treatment system. The Wai Bulabula project was coordinated laterally with another FSP project, Coral Gardens, that aims to empower resource owners restore their degraded coral reefs.

The Wai Bulabula project is coordinated by a landowners district environmental committee that also includes government ministries, provincial authorities, NGO's such as FSP Fiji, the Shangri La's Fijian Resort and other relevant stakeholders .The wetlands treatment system is an example of how the private sector (e.g. resort), government and civil society (i.e. FSP & villagers) can promote economic development whilst simultaneously implementing initiatives that aim to reduce environmental impacts and conservation.

High resolution, multibeam shallow water surveys in the Pacific region in 2002

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During the period January to August 2002, SOPAC completed 8 multibeam mapping surveys in 4 member states: Samoa, Fiji, Federated States of Micronesia and Marshall Islands. Each of these surveys was for a different end user. This indicates the level and variety of demand on the resources of our shallow water environment. Information from multibeam mapping assists in a very useful and unique way in decision making in the following areas:

- aquaculture – development desired by government to generate employment and income in rural communities;
- port and harbour development – increase in number of vessels competing for the same wharf space and the problems of siltation are better characterized;
- locating seabed wrecks which are an environmental threat but could also be turned into divers' attractions;
- coastal reclamation – the demand for land requires the identification of lagoon and offshore aggregates for fill; and
- last but not least, the delineation of fishing grounds and other marine habitats.

The challenges and opportunities of these high-resolution surveys is not so much in the surveying and the handling of the large data sets but in realizing the magnitude of applications one such data set can benefit. We only identify four or so end users in this paper. However, a multitude of other applications can be immediately identified as extended use of the datasets already collected during these surveys. The tool has more than revolutionized SOPAC's interventions within its ocean and island program in member countries that contribute to the development and management of our coastal and ocean resources.

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Installation of trial wave energy plant, Lifuka, Ha'apai Group, Kingdom of Tonga

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Consumption of energy nowadays is about 1.7 kW per person in developed countries and 0.7 kW throughout the world, with an average annual increase of power consumption is 3-4 %. The total output of all power plants on Earth is more than 8.5 TW. Urbanization in developed countries leads to an increase of energy transport. Thus, the higher the energy consumption, the more expensive the energy.

Energy production on so large a scale requires the consumption of huge amount of natural resources. At the same time, the largest part of the energy is spent on the extraction and transportation of resources and energy, and the smallest part on direct consumption. Billions of tons of carbon dioxide and carbon monoxide enter the atmosphere, causing greenhouse effects. Mining spoils landscapes and pollutes rivers. Nuclear power plants produce highly radioactive waste that requires high-expensive utilization. As far as social impacts are concerned, millions of people work underground in mines and get doses of radiation. Narrow ways of energy transportation lead to urbanization and wars.

However, at the same time the sun sends billions of TW of heat energy to the Earth. Beam energy has very low density but it is concentrated into wind energy. Wind energy has low density too but is concentrated further into sea wave energy. Wave energy is 1000 times more concentrated than wind energy. Therefore, wave power devices can be 1000 times as cheaper than wind ones made from the same material.

The problem in harnessing satisfactory amounts of wave energy anywhere it is needed lie in the absence of suitable technology. During the past four decades a few wave power technologies have appeared but all are expensive. Existing wave technologies include the following:

Duck by Solter, made from concrete and has hydraulic transmission to the generator, has too large a minimum size and is too expensive;

Raft by Cokcerel is a very successful construction but has hydraulic transmission to the generator and is not reliable;

Sea snake has the same characteristics as the raft;

Oscillating column by Masuda is quite a successful device which has been introduced on an industrial scale but contains an expensive air turbine what makes the energy too expensive;

Oscillating buoy is too expensive and has insufficient energy production;

Rotor by Wincranz is the most successful. It is the cheapest, simplest and most reliable device. We have developed and improved it with valves and pontoon;

Topchan has a quite simple construction but produces insufficient energy.

To decrease the individual costs of the unit and, therefore, make the project more attractive to investors, SEG:

- made the rotors from recycled plastic;
- made the entire construction floating and resistant to storm damage;
- made the work cells with valves which increase the efficiency of the unit;
- made transmission mechanical only, which allows increases in efficiency and reliability, and decrease unit costs and corrosion;
- made the minimum capacity of the unit 1 kW or less;
- made multi-rotor units with maximum capacity of up to 3-5 MW; and
- used Ukrainian aerospace technologies for wave power production.

SEG offers production at industrial scale of:

- small units 1-20 kW for autonomous consumers (cottage industries or fish refrigeration);
- middle-sized units 30-100 kW (grid connected or disconnected with accumulating);
- large-scale units 0.1-3 MW connected to grid; and
- the creation of new sea-shore energy infrastructure.

SEG seeks to find strategic partners for:

- international patenting, since our product is patentable;
- large-scale production of the product; and
- trading with the product throughout the world, since the units are very easily assembled from standard materials.

Broadband seismic observation in the South Pacific

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The mantle structure beneath the South Pacific has been less studied seismologically than continental areas in the world in spite of its geoscientific significance as a likely site of a large upwelling of mantle material. The main reason for the lack of extensive studies on the region is that there are not enough seismic stations and earthquakes here to be analyzed. To fill this gap in seismological observation, we deployed a broadband network dubbed SPANET (South PAcific broadband seismic NETwork). The deployment was performed as part of the Superplume Project which started in 1996 and finished in 2001, with funding provided by the Science and Technology Agency of Japan (STA) (Ishida et al., 1999). We have deployed 10 broadband seismic stations on oceanic islands, of which 6 sites were constructed under Japanese initiative (called SPANET stations hereafter) and 4 stations were constructed through a STA-IRIS collaboration (called SPANET/IRIS stations hereafter) as part of the IRIS Global Seismographic Network (GSN). All of the SPANET stations were constructed in 1997 and 1998, and the SPANET/IRIS stations are still being deployed. These stations cover the Central and South Pacific (from Midway in the north to Kermadec in the south, and from Pitcairn in the east to Tarawa in the west (Fig. 1). The sites were selected so as to surround the South Pacific Superswell as well as possible under logistic constraints such as the availability of scheduled air services. Since the Superplume Project was completed in March 2001, the National Research Institute of Earth Science and Disaster Prevention has taken over the operation of the SPANET.

The next step for seismic observations in the South Pacific should be to perform seismic observations on the ocean bottom. Two year-long broadband ocean bottom seismic observation (BBOBS) is planed in late 2002 in the French Polynesia area where huge scale uprising mantle flow (plume) is expected. This work (Fig. 2) is a cooperative effort with ERI (University of Tokyo) for the ocean bottom and with French scientists for the contemporary land observations which have already started. Due to the sparse land observatories in this area, it is difficult to construct a fine image of the plume and the detail of the core mantle boundary. The main targets of the project are: (a) How is the mega low-velocity anomaly found by previous tomographic studies extended into the mantle transition zone?; (b)How do low-velocity plumes rise up to the surface hot spots in the French Polynesia?; and (c)What is the origin of the uprising plumes - thermal, chemical, or both?

Seismic data from both projects are, after a period of quality control of data and research work, made available to the geoscience community and are used for monitoring local earthquake activity. Two SPANET stations in Tonga are supplemented by JICA-funded seismic stations to form the first permanent national seismic network of Tonga, which could be a great contribution to the earthquake monitoring there.

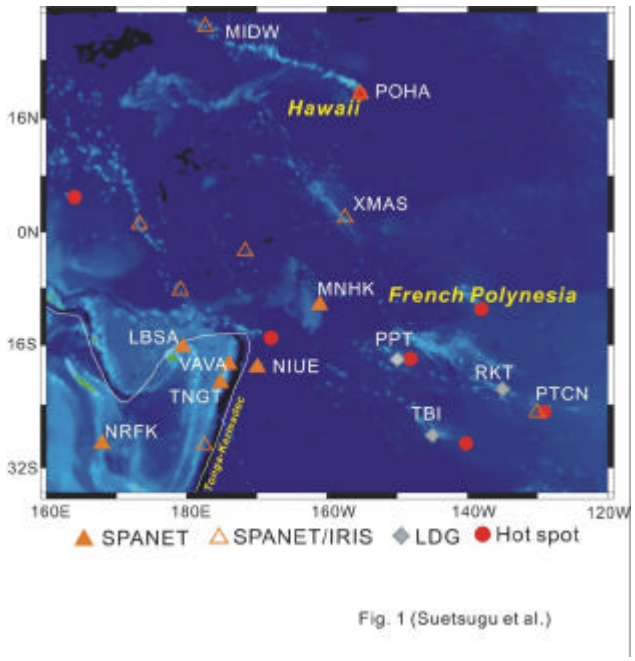

Figure 1: Map of SPANET and SPANET / IRIS stations. Symbol convention is shown below the map.

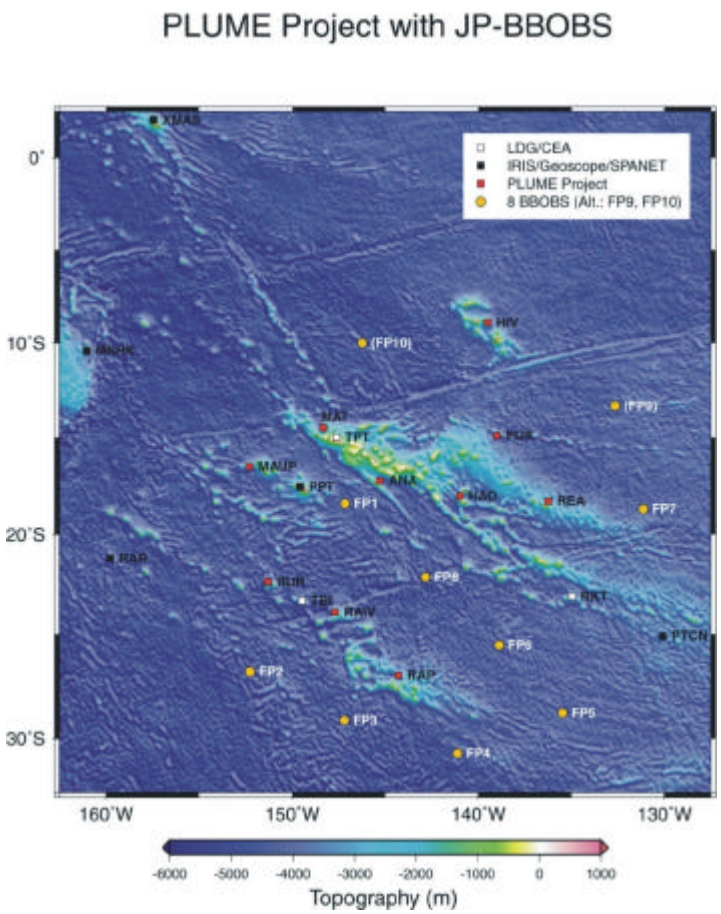

Figure 2: Site Location Map

Rapid lease boundary mapping in Fiji

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In Fiji, the Native Lands Trust Board (NLTB) is responsible for leasing native land, which is more than 90% of Fiji's land area. During the past few years, many agricultural leases have expired but the tenants wanted to stay in their houses. This requires that the area around the houses is given out as a residential lease. To be able to proceed with a lease arrangements NLTB requires a map showing the area of the residential lease and the position and approximate outline of the house. The NLTB has many field teams; however, they were equipped with measurement tape, inclinometer and compass only, which resulted in long waiting times after tenants applied for a lease and in some cases led to land disputes between different tenants. An Asian Development Bank-financed project carried out by SOPAC changed the mapping method.

The old NLTB mapping procedure

The conventional survey at NLTB not only required more time in the field but also needed much more time to prepare maps and reports later in the office. The first step of a lease survey was the preparation of a locality map. The team had to draft a sketch map from available resources such as 1:50,000 topographic maps or historical land ownership maps at a scale of 2 inch to 16 chain. As a next step, a "point of origin" had to be identified for which map coordinates were known. From this point a survey line was created to the first boundary point of the lease area before the team could start to survey the other corners of the lease boundary. The survey required noting compass bearings, distance and slope for every line segment in order to calculate the horizontal distance later. A sketch map and all recordings were then handed to the draftsman in the office who calculated a polygon in the horizontal plane.

The new introduced mapping procedure

The Asian Development Bank-financed project provided GPS equipment, GIS software and training. Now, the team does not have to identify a point of origin. The GPS recorded points not only automatically have X and Y coordinates but also annotation recoded in the field such as type of peg, type of road, type of lease boundary. Compass bearings, distance measurement and subsequent recording of inclination is not necessary. Now, a normal residential plot requires about 8 to 10 minutes. In addition, the surveyor also records the outline of the houses within a plot, which takes an average of 12 minutes per house.

To reach the target of speeding up the mapping of all NLTB field teams, compromises had to be made. It was not possible to purchase survey grade GPS hand held receivers and it was also impracticable to wait at every survey point 20 minutes to be able to average recordings to high accuracy. To survey houses the GPS operators survey points always staying away a minimum distance of 15m to avoid multipathing of the satellite signal.

Back in the office the surveyor and not a third person does the area calculation and computerised drawing. The area calculation and the calculation of distances from plot to plot is handled by the GIS software. In addition to the traditional mapping procedure the field staff a) calculates the position for every peg, and b) displays the lease area on 1:50,000 backdrop, which allows an easy identification of their location.

A field report, the edited map and the original GPS data are kept in one directory named with data and area name, which is a) stored on CD and b) send via e-mail attachment to NLTB head quarters in Suva.

Results and Recommendation

This rapid mapping method does not create a legal document, because the lease areas have to be surveyed with conventional method employing conventional mapping instruments and a certified surveyor. However, the new mapping procedure is sufficient to provide maps allowing proceeding with the lease document and the new procedure increases the mapping speed for by approximately a factor of ten. The latter reduces the time tenants have to wait for the leases and will reduce land disputes. In addition, the new mapping method creates spatial data in digital format, which easily can be stored, monitored, send via e-mail and further processed to a countrywide lease area layer.

Land ownership is an important issue in Pacific Island Countries and not only Fiji is facing problems solving land disputes. The method could be transferred to other countries.

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Coastal erosion in western Tongatapu, Tonga – human impact, natural process or both?

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Two years ago the villagers of the Hihifo (western) District of Tongatapu called in their parliamentary representatives to show them the flooding that was taking place in the west of the island and that was threatening their villages. They demanded action to help find out why the flooding was taking place and how it could be stopped. The western (Hihifo) area of Tongatapu has been suffering periods of inundation for at least 20 years resulting, at the present time, in the loss of 10-12 hectares of agricultural land and threatening villages located in the vicinity of the flooded area. As a result of the villager's representations, in April/May 2002 a detailed survey of he affected area by a joint team from the British Geological Survey, SOPAC and the Tonga Ministry of Lands, Surveys and Natural Resources was carried out.

2000 Ikonos image of flooded area west of Kanokupolo village

SOPAC had already carried out a previous survey of the area in 1983, when Russell Howarth investigated the problem and recommended remedial action that for some time proved effective. However, at some point between 1990 and 2000 the coastal defences were breached again and this time the flooding was so severe that an area in excess of 40 hectares is threatened with complete erosion that will result in permanent inundation by the sea.

To assess the threat to the Hihifo area, the island of Tongatapu is fortunate in having a sound database of information on the problem. There are aerial photographs and satellite images providing time series data over a 30-year timescale. The SOPAC survey of 1983 provides benchmark survey data. In addition and most interestingly there is anecdotal data provided by local newspapers and from local inhabitants. There are also several enigmatic reports.

In April/May 2002 the threatened area was surveyed in detail by the BGS/SOPAC/Tonga team and an in-depth appraisal made of the possible causes of the flooding and what remedial action is necessary to reclaim the flooded area. There is no doubt that the area is low-lying and during storm surges may be temporarily flooded. Because of the sediment transport regime operating in the area, removal of sand from one (western) side of the island may have a significant impact on the opposite (eastern) shore. Human impact is not negligible and the coastal defences proximal to villages are most denuded of coastal vegetation. Roads and foot-trails to the coast further remove protecting vegetation and beach berms. The activities of free-ranging pigs destroy both the vegetation and erode the soil, thereby preventing rehabilitation. Most intriguing is the possible negative impact of recently constructed large-sale coastal defences along the nearby Nuku'alofa waterfront, that may have resulted in focussing wave-power onto the low-lying Hihifo shoreline.

In this talk, the results of the Hihifo study are presented and highlight the sensitivity of vulnerable coastal areas on low-lying carbonate islands to the complex interaction of natural and human processes over decadal timescales. Sensitivities are not only of the 'natural' type but extend to human perceptions of the problem. To realise a long-term solution to problems of coastal flooding, it is essential to address both 'natural' and human impacts in a constructive and interactive manner.

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The 1998 PNG tsunami: an update on work carried out to understand the cause(s).

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The recent 7.5 magnitude earthquake of September 8th 2002 located WNW of Wewak reminds us once again of the vulnerability of the north coast of Papua New Guinea to earthquake and tsunami threat. In this instance it is fortunate that early reports suggest that there is little loss of life. However, the earthquake is a reminder of the devastating tsunami of July 1998 that killed 2,000 people in the Aitape area. This contribution to the STAR meeting of 2002 is an update on the research that continues on the July 1998 event and includes a recently compiled movie simulation of the tsunami.

After considerable controversy over the alternative origins of the 1998 PNG tsunami, there is now a body of evidence that supports a cause by sediment slumping offshore of the devastated area. In association with onshore run-up measurements, acquired by the field survey teams, four surveys carried out between 1999 and 2001 offshore of the most affected area resulted in a composite suite

of marine data, comprising: multibeam bathymetry, high resolution 3.5kHz data, multichannel seismic, and piston cores in association with ROV and submersible images and direct seabed observation. Using this data the morphology and tectonics of the area offshore has been elucidated, as well as imaging of the slump causing the 1998 tsunami as well as its geotechnical properties.

In early 2001 the original offshore data-set was complemented and improved by the acquisition of a closely spaced grid of single channel seismic data in the area of the multibeam bathymetry acquired in 1999, using the JAMSTEC vessel *Natsushima*. Better definition of the slump is now possible for use in describing the slump architecture as well as in future modelling.

As noted in previous publications (Tappin et. al., 1999; Tappin et. al., 2001; Synolakis et. al., 2002; Sweet and Silver; in press) the tectonics of the area north of PNG is complex, but dominated by transpressional plate convergence along the New Guinea Trench. It was on the landward wall of the trench that the sediment slump was created and failed. Using the multibeam bathymetry and multichannel seismic the slump is measured at ~6 km^3 in volume and 750 m in thickness.

The newly acquired single channel data set now allows the detailed mapping of the slump architecture and confirms interpretations made previously. Its also provides the basis for a better understanding of the regional structure of the New Guinea Trench. For the future, it is planned to carry out further modelling analysis that will be based on the regional tectonic setting, combined with the slump geometry. The new modelling will use a novel type of stability analysis performed with a 1D-consolidation code. The simulation results will help constrain slump motion following failure. The geologic, bathymetric and soil mechanic data will be employed in new simulations of fully 3D tsunami generation by the slump as newly defined. The result is a more definite assessment of the susceptibility to slumping of the area offshore of northern PNG.

In the wider context the interpretations and analyses employed in the PNG study may contribute to the identification of other regions susceptible to comparable offshore slumping and tsunami generation. It is well recognised that it is still problematic to address the threat of tsunami prediction from local slumps. To generate realistic models of tsunami generation and run-up simulations need to be validated by direct evidence provided from offshore surveying. Case studies are therefore required and a seminal example is the Papua New Guinea tsunami of 1998.

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Measuring floodplain sedimentation rates in the Rewa river basin, Fiji, using Caesium-137

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Processes and rates of river valley sedimentation are less well understood in the humid tropics than in other environments. In our project the caesium-137 (^{137}Cs) method was used to examine recent historical sediment accumulation in the Wainimala River valley. This lies in the basin of the Rewa River, the largest fluvial system in the Fiji Islands. Floodplain stratigraphy showed a well defined profile of ^{137}Cs activity, with a clear peak at 115 cm depth. Our measured accretion rate of 3.2 cm per year over the last half century exceeds rates in humid regions elsewhere. This is explained by the high frequency of tropical cyclones near Fiji (40 since 1970), which often produce torrential rainfalls and extreme floods. Since hydrological records began, overbank floods have occurred every two years on average in the study area. The largest floods had peak flows exceeding 7000 $m^3 s^{-1}$, or six times the channel bankfull discharge. Concentrations of suspended sediments at such times are very high (maximum 200-500 g l^{1}), delivered mainly by channel bank erosion. In the future, climate change in the South Pacific may be associated with greater tropical cyclone intensities. This will probably increase the magnitude of floods in tropical island river basins, with clear consequences for sediment delivery and accumulation on low lying floodplain areas.

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Production and application of multi temporal images

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Introduction

Nasinu, a recently declared town is located along the Kings Road between Suva City and Nausori town. The population of Nasinu has grown intensively in the past 20 years due to low cost housing built within the area. As a result, the Nasinu Town Council requested for the visualisation and mapping of squatter settlements growth over the township.

Method

Black and white aerial photographs were selected of Nasinu recorded during the years, 1973, 1986 and 1998. These photographs are of different scales and subsequent different resolution, but the only image source available.

The photos were first scanned with is 600 dots per inch and then geometrically rectified. The rectification process employed ERDAS rubbersheeting module. This allows rectifying the central perspective of an aerial photograph in one rectification process to Fiji Map Grid, the common projection in Fiji. Cadastral layers of the Fiji's Lands Department were used as reference, which were available as DXF files and displayed as ERDAS annotation layer. After rectification of the different photographs ERDAS module Mosaic stitched them together to one layer for each of the three years. The next step was the combination of the three image layers to one three-layer image file. The 1973 layer was assigned the blue band, the 1986 layer was assigned the green band and the 1998 layer was assigned the red, the colour of the display, see figure 1.

Finally the multi temporal image and the three black and white image layers were imported to MapInfo. This allows an operator to carry out the analysis work in MapInfo environment. This again makes it easy to attach Access database storing the analysis results during the on screen digitising.

Results

The multi temporal image visualises the change of housing area. Based on the fact that a) vegetation absorbs sunlight and b) clearings and corrugated iron roofs reflects sunlight, both of the latter can be easily separated from "un-touched" and vegetation covered areas. Linking the layers to different colour displays, these areas show the colour intensive while vegetation-covered areas are shown dark. A roof, which was built between 1986 and 1998 will be shown intensive in the red channel, while this place is shown dark in the blue and in the green channel. The result is red in the multi temporal image. A roof which was built in or before 1973 will have a white colour because it has high reflection in all three colour layers which then add up to white. A roof built between 1973 and 1986 will have a high reflection in both the green and the red layer and will have a mixed colour from both layers.

Areas where the vegetation is cleared have a high reflection, however, the vegetation will cover the area again after a few years. This results in high reflection in the specific channel only related to one period only. Areas in green colour therefore are cleared between 1973 and 1986, areas in blue colour before 1973 and areas in red between 1986 and 1998 see figure 2.
The result is a product, which can be analysed with MapInfo software. If all single layers including the multi temporal image are loaded, an operator can screen the multi temporal image and switch to any single year layer. He is able to perform on-screen digitising and can create a clear picture of development in time.

Recommendations

Urbanisation will increase in Pacific Island Countries and analysis of controlled or uncontrolled area development will help improve planning. Multi temporal images allow quantitative analysis to be carried out with simple software. Other areas besides Nasinu should be analysed where multi temporal images will be an essential tool.

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Petroleum potential of New Caledonia

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Since 1994, new assessment of the petroleum potential of the New Caledonia basins has been carried out by the Institut Français du Pétrole (IFP), in collaboration with the Service des Mines de Nouvelle-Calédonie. These studies have synthetised recent seismic data carried out within the frame of the marine ZoNéCo (resources assessment of New Caledonia's Economic Zone) and FAUST (French Australian Seismic Transect) scientific programmes.

Several plays have been defined:

Grande Terre western onshore basins

Oil and gas shows are known since the beginning of the 20th century in the western part of the Grande Terre. The petroleum systems consists in Cretaceous coal and coaly shales for the source-rocks, and fractured tertiary flysch for the reservoirs. This area is affected by an Upper Eocene compressive phase in relation with the emplacement of the ophiolitic thrust sheet eastward which is responsible of roughly NW-SE anticlines. This play has been recently explored and the Cadart-1 well (2000) encountered significant gas show.

New-Caledonia Basin

Located immediately westward of the Grande-Terre, this deep offshore basin was not affected by the Eocene compressive phase. The FAUST 1 deep-seismic survey (1998) has shown that the basin, the basement of which shows huge tilted-blocks, is filled by sedimentary deposits that can reach up to 8 km in thickness. According to new geodynamical interpretations based on the FAUST seismic lines, a thinned continental crust can be inferred for the basement. Consequently, the petroleum system described onshore can be extrapolated offshore, with Cretaceous tilted-blocks as structural traps.

Fairway Basin and Ridge

The western border of the New-Caledonia basin consists in the Fairway Ridge, the origin of which still remains controversial. Westward, the NW-SE trending Fairway Basin shows a sedimentary thickness compatible with production of liquid and gaseous hydrocarbons. Good Cretaceous and Lower Tertiary reservoir can be expected in the prograding wedges fed by the erosion of the Fairway Ridge.

A "Bottom Simulating Reflector" (BSR), interpreted as the base of a gas hydrate layer was evidenced during the FAUST 1 seismic campaign (1998). During the ZoNéCo 5 (1999) survey, the BSR's geographic extension has been confirmed over an area of 80 000 sq. km within New Caledonia's Economic Zone. Moreover, the presence of diapir-like features (both sedimentary and volcanic intrusions) associated with the BSR's extension was unveiled. More recently, the FAUST 3 cruise (2001) enabled to clarify the structural style (eastward-tilted half-grabens) and the sedimentary infilling (3 km in average) of the Fairway Basin.

Within the Fairway Basin and at the eastern border of the Fairway Ridge, both the depth and thermal conditions are adequate for gas hydrate to be stable within the upper part (more than 500 m) of the sedimentary cover. Although the origin of the methane trapped in the gas hydrates still remains unknown (biogenic or thermogenic), the Fairway Basin can be considered as a long-term petroleum prospect.

The almost totally unexplored New-Caledonia deep offshore basins appear to have a likely petroleum potential, and consequently, can be considered as frontier basins for the 21st century's oil the exploration.

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Biomass energy research at ICCEPT, Imperial College, London

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For over a decade it has been realised that the potential for biomass to be exploited for energy purposes is theoretically very large indeed. There are two categories of biomass when considering the potential for energy production:

Residues:
- Agricultural (straw, husks, shells, cobs, etc);
- Forestry (branches, leaves, off-cuts, etc); and
- Animal (dung and abattoir wastes).

Dedicated growth of biomass i.e. 'energy crops':
- Sugar, starch and / or 'oil' rich crops (often annual, e.g. cereals, oil seed rape (canola) and sugarbeet); and
- Ligno-cellulosic rich crops (often perennial e.g. short rotation coppice (SRC)).

Global energy scenarios indicate a projected requirement for between 52 and 280 EJ from biomass by 2050, compared to current global primary energy consumption of about 400 EJ when traditional biomass use is included. Estimates of current biomass use for energy are uncertain but is approximately 40 to 55 EJ per year. However, there is currently little consensus as to the 'best way forward' for developing a sustainable, modern, biomass energy sector at the scales envisaged by the global scenarios.

Our research at ICCEPT is evaluating the interplay between the modern biomass conversion technologies and the policies (and incentives) that are required to establish bioenergy as a significant supplier of modern energy services. As part of this work we have three current areas of research:

Electricity from Biomass in OECD countries (WWF funded);
Liquid fuels from biomass in the UK transport Sector (UK-DTI and DoT funded); and
Liquid fuel production in developing countries e.g. Brazil and southern Africa (CFC and EU funded).

A summary of this work is provided and its relevance to WSSD and the Kyoto protocol are evaluated.

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Solar integration on commercial buildings

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Commercial high-rise buildings use up to 30% of all electrical energy from Australia's power grid. This is a major contributor to Australia's greenhouse gas emissions and fossil fuel use. Forrester Kurts, currently developing a 21 storey commercial building at 120 Edward Street in the Brisbane CBD realised the economic, environmental and marketing advantages in showcasing building integrated solar and cost effective improvements in building energy consumption. The design philosophy was to reduce the use of energy and produce green electricity to offset the need for polluting coal generated electricity. This paper discusses the Solar Integration System proposed to be installed at a 21 story commercial development at 120 Edward Street, Brisbane, Queensland. The project will contribute to the transformation of the photovoltaic industry in Australia through the resolution of design issues for roof and glazing solar building products suitable for a commercial development. In addition the project is determining the market's interest in novel power conditioning solutions aimed at reducing the cost of converting the solar DC output to useful AC power.

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