ABSTRACTS OF PAPERS PRESENTED AT THE STAR* SESSION 2004

21st STAR Session is held in conjunction with the
SOPAC 33rd Session (17-24 September 2004)
Hosted at Warwick International Fiji, by the Government of Papua New Guinea

John Collen
Editor

SOPAC Miscellaneous Report 576
Revised Edition

October 2004

*Science, Technology and Resources Network

SOPAC

Copies can be obtained from the:

SOPAC Secretariat
Private Mail Bag
GPO, Suva
Fiji Islands
Phone: (679) 338 1377
Fax: (679) 337 0040
http://www.sopac.org

CONTENTS

FOREWORD

STAR (SOPAC's Science, Technology and Resources network) was founded in 1984 in collaboration with IOC. STAR was formed to assist the international geoscience community to provide advice to SOPAC, particularly during the intervals between SOPAC International Workshops.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 of Wellington, New Zealand became Chair.

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 also 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 led to the development of the of the three major work programmes and 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 similarly altered, partly reflecting changes in focus of international science but also 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.

John Collen
Chair, Science, Technology and Resources Network
School of Earth Sciences
Victoria University of Wellington
Wellington
New Zealand

September 2004

PROGRAMME FOR 21st STAR SESSION, 2004

Friday September 17th	
18:30-19:00	**STAR Opening** – J. Collen, Chair, STAR & C. Pratt, Director, SOPAC Coral Coast Conference Room, Warwick Hotel
19:00-19:30	**STAR Business Meeting** – Agenda to be distributed
19:30-	**ICEBREAKER**

TIME	THEME	AUTHORS & PRESENTER	TITLE
Saturday September 18th			
09:00-09:20	Geology & Geophysics	Anton, L. & McKee, C.	The great earthquake of 16 November 2000 and associated seismo-tectonic events near the Pacific-Solomon-South Bismark Plate triple junction in Papua New Guinea.
09:20-09:40		Kroenke, L.W. & Wessel, P.	Subduction zone development and accretionary processes in the Southwest Pacific.
09:40-10:00		Fisher, C.	Ridge 2000 expeditions to the East Lau Spreading Centre in 2004 and 2005 (with a short introduction to the biology of hydrothermal vent animals).
10:00-10:20		Martinez, F., Taylor, B., Resing, J., Walker, S., Vaiomo'unga, R., Vailea, A. & Wong, L.	Multi-scale mapping and hydrothermal survey of the Eastern Lau Spreading Centre.
10:20-10:50	**REFRESHMENT BREAK**		
10:50-11:10	Geology & Geophysics	Kilmer, F. & Kroenke, L.	The Sasa Fault: a major strike-slip fault in Guam.
11:10-11:30		Douillet, P., Ouillon, S., Schmied, L., Andréfouët, S., Chevillon, C., Jouon, A., Fichez, R.	Fine suspended sediment transport in the southwest lagoon of New Caledonia.
11:30-11:50		Stephen Booth – introduction to International Secondary School's bathymetric model of SE Viti Levu.	
11:50-12:10		Rahiman, T.	Morphologic and structural features of the offshore region of south eastern Viti Levu, Fiji, from high resolution multi-beam swath bathymetry and seismic reflection data.
12:30-14:00	**LUNCH BREAK**		
Joint Session A – Koral Coast Conference Centre			
14:00-14:20	Oceans & Coastal	Ramsay, D.	How can we improve the collection and effectiveness of beach profile datasets?
14:20-14:40		Tappin, D.R.	Coastal erosion on Tongatapu, Tonga, southwest Pacific Ocean – sea level rise or man's impact?
14:40-15:00		Terry, J.P. & Thaman, R.R.	Identifying and reducing the risks of beach and lagoon degradation in Cuvu Bay, southern Fiji.
15:00-15:20		Roemmich, D. & Willis, J.	The ARGO Floats – Observing the global oceans in near real-time for climate and other applications.
15:20-15:50	**REFRESHMENT BREAK**		
15:50-16:10	Oceans & Coastal	Pahalad, J.	Enhanced application of climate predictions in Pacific Island countries.
16:10-16:30		Henao, D. (Withdrawn)	Development of PNG's National Ocean Use policy and SOPAC involvement.
16:30-16:50		Erb, W.	Pacific Island GOOS update.
16:50-17:10			

TIME	THEME	AUTHORS & PRESENTER	TITLE
Joint Session B – Talanoa Room			
14:00-14:20	Hazards & Risk Management	Buleka, J.	Ramu River aggradation.
14:20-14:40		Jones, R.	Implementing a community risk management programme in the Pacific.
14:40-15:00		Matthews, A., Trustrum, N. & Campbell, G.	Natural Hazards NZ: using experience in New Zealand to help the Pacific.
15:00-15:20		Cowan, H.	Geological Hazard Monitoring in NZ: Opportunities and Issues for Enhanced Regional Collaboration.
15:20-15:50	**REFRESHMENT BREAK**		
15:50-16:10	Hazards & Risk Management	Johnson, R.W.	Geohazard monitoring, information management and risk assessment: new trends and drivers in Australian disaster management.
16:10-16:30		Newsome, P., Heron, D., Archbold, M., Glassey, P. & Malolo, T.	Tonga Cyclone Emergency Recovery and Management Project – Land and Risk component.
16:30-16:50		Melzner, S., Lagataki, S. & Bonte-Grapentin, M.	Large scale landslide hazard assessment in the Navua Catchment (SE Viti Levu, Fiji).
16:50-17:10	Cyclone Heta	Waqaicelua, A.	Meteorological aspects of TC Heta and its implications for disaster management.
17:10-17:30		Bonte-Grapentin, M., Oliver, S., Talangi, D. & Biukoto, L.	TC Heta – assessment of wave impacts on Niue and its implications for a coastal hazards zonation.
17:30-17:50		Goosby, S.	Cyclone Heta visualization and damage losses assessment.

Saturday 18th Evening	Meetings of Working Groups

Sunday 19th Morning	Meetings of Working Groups
Sunday 19th Afternoon	**Volleyball Tournament**
Sunday 19th Evening 18:00-	**Guest Lectures:** Andrew Matthews (National Institute of Water & Atmospheric Research, New Zealand): *What is sustainable development?* Alex Malahoff (Institute of Geological & Nuclear Sciences, New Zealand*): Oceans and their economic significance and opportunities for the Pacific.*

Monday September 20th			
Joint Session C – Koral Coast Conference Centre			
09:00-09:20	Tsunami	Kaloumaira, A. & Kong, L.S.L.	Developing Pacific Island regional strategies to reduce tsunami risks: *"South Pacific Tsunami Awareness Workshop 1-3rd July 2004".*
09:20-09:40		Kong, L.S.L. & Kaloumaira, A.	Regional tsunami warning services for the South Pacific.
09:40-10:00		McCreery, C.S.	Pacific Tsunami Warning Center: local/regional tsunami warning.
10:00-10:20		Cummins, P.R. & Kaluwin, C.	Feasibility study for a tsunami warning system in the SW Pacific.
10:20-10:50	**REFRESHMENT BREAK**		
10:50-11:10	Tsunami	Goosby, S.	Tsunami visualization and floods assessment methods.
11:10-11:30		Downes, G. & Cowan, H.	Historical tsunami data collection in the South West Pacific.
11:30-11:50		Chalapan K. & Lal, A.	Seaframe gauges potential for tsunami early warning systems in the Pacific region.
11:50-12:10		Anton, L.	Tsunami hazard research in Papua New Guinea.
12:10-12:30		Tappin, D.R., McMurtry, G.M., Sellwood, B.W., Williams, M., Wilkinson, I.,Fryer,G. & Watts, P.	Tsunami deposits from the submarine landslides of Hawaiian Giant – fact or fiction?
12:30-14:00	**LUNCH BREAK**		
14:00-14:20	Tsunami	Lus, W. & Davies, H. (Withdrawn)	Courses and research programmes at the Centre of Disaster Research, University of Papua New Guinea: an initiative for local and regional tsunami disaster mitigation.
14:20-14:40		Tappin, D.R., McMurtry, G.M.., Watts, P. & Matsumoto, T.	Dating submarine landslides – the July 17th 1998 Papua New Guinea Event.
14:40-15:00	Energy	Mario, R.	Ocean-based renewable energy prospects in the Pacific region.
15:00-15:20		Cloin, J.	Copra as a biofuel – challenges and opportunities.
15:20-15:50	**REFRESHMENT BREAK**		
15:50-16:10	Energy, mining &, petroleum	Mosusu, N.	Geothermal development in Papua New Guinea.
16:10-16:30		Heydon, D.	Likely directions in deep ocean mining to 2010.
16:30-16:50		Dau, I.	An overview of Fiji's new mining legislation.
16:50-17:10		Pawih, B.	Petroleum exploration & development in Papua New Guinea.

Joint Session D – Talanoa Room			
09:00-09:20		Gauna, S. & Canavanua, E.	Strengthening hydrological network capabilities in Fiji.
09:20-09:40		Singh, S.	Arsenic levels in drinking water on Fiji Islands.
09:40-10:00		Seruvatu, V.	Water and youth.
10:00-10:20		Terry, J.P.	The use of karstic depressions for surface water reservoirs on small limestone islands: case study of Yoron-to in sub-tropical southern Japan.
10:20-10:50	**REFRESHMENT BREAK**		
10:50-11:10	Water & Sanitation	Young, T. & Bower, R.	Sanitation Park.
11:10-11:30		Penaia, A.,	Disaster preparedness for Pacific water utilities.
11:30-11:50	Communities, development & capacity building	Grimes, S.	A history of environmental change and human impact since 3750 BP in the New Georgia Group, western Solomon Islands.
11:50-12:10		McKenzie, E.	A cost-benefit analysis of projects implemented to assist the black pearl industry in Manihiki Lagoon, northern Cook Islands.
12:10-12:30		Edsall, D., Bunnell, J.E. & Collen, J.D.	Medical geology and the health of SOPAC Member Nation populations: Is such an investigation of interest?
12:30-14:00	**LUNCH BREAK**		
14:00-14:20	Communities, development & capacity building	Forstreuter, W.	Mobile satellite image ground station for Pacific island countries.
14:20-14:40		Zann, L.	Capacity-building: the role of the Marine Studies Programme, University of the South Pacific.
14:40-15:00		Fortes, M.D.	Enhancing IOC/WESTPAC-SOPAC partnership through ocean sciences, ocean services, and capacity building.
15:00-15:20	Geophysics	Talia, L.	Seismicity of Samoa.

Monday 20th Evening	Meetings of Working Groups

POSTER PRESENTATIONS

AUTHOR(S)	POSTERS
Artack, E. & Lal, A.	Pacific Regional Maritime Delimitation Boundaries Project.
Bhikabhai, Y.	Renewable energy – save my island home.
Cameron, S., Tait, T., Shipper, L., & Anderson, G.	Denitrification by Design
Chand, S.S., Maamaatuaiahutapu, K. & Aung, T.	Geostrophic current in Fiji waters.
Chang, S.W., Kim, S.-P., Talia, L. & Smith, R.	Coastal morphology of Savai'i, Samoa.
Chevillotte, V., Chardon, D., Beauvais, A., Lagabrielle, Y., Maurizot, P. & Colin, F.	Uplift, erosion and the distribution of lateritic planation surfaces in southern New Caledonia.
Dymond, John R., Ausseil, Anne-Gaelle, Shepherd, James D., Buettner, Lars & Newsome, Peter F.	A region-wide model of landslide risk in the Manawatu/ Wanganui region of New Zealand.
Herbig, H.-G., Brentfuhrer, R. & Pohler, S. M.	Rolling stones from Korolevu Reef (Viti Levu, Fiji) – controls on composition and zonation.
Kaluwin, C. & Lal, A.	AusAID South Pacific Sea Level & Climate Monitoring Project Phase III.
Lafoy, Y., Brodien, I., Vially, R., & Buisson, D.	Structural style of offshore basins, western New Caledonia (southwest Pacific): implications for petroleum potential.
Lawedrau-Moroca, A.	Rainwater harvesting demonstration project in Vava'u, Tonga.
Massey, S.	Ground and airborne time domain electromagnetic methods, applications and case studies.
Mosusu, N., Anton, L., Walker, A. & Jordan, C.	Earthquake, geophysical and remote sensing data compilations: contributions to tectonic and mineral occurrence studies in Papua New Guinea.
Narain, S., Pohler, S. & Smith, R.	Stability of the reef to basin slope west of the Rewa Delta (southern Viti Levu).
Newsome, P. & Page, M.	Vegetation state and change, 1975-2002, Pohnpei, Federated States of Micronesia.
Parisot, J.-C., Paugam, A., Baeuvais, A., Savin, C. & Robineau, B.	Physical and chemical parameters controlling the electrical resistivity of ultramafic rocks weathering materials of New Caledonia.
Pelletier, B., Cabioch, G., Calmant, S., Ballu, V. & Perrier, J.	Bathymetry of the coastal areas of some islands of Vanuatu.
Pelletier, B. & Lagabrielle, Y.	The Futuna spreading center: an extensional relay zone along the North Fiji fracture zone.
Pohler, S.M.L. & Herbig, H.-G.	Distribution of sponges on a tropical intertidal flat near Suva (Viti Levu, Fiji) – the complex control of modern and inherited factors.
Rahiman, T. & Pettinga, J.	Geological structures related to seismicity in south eastern Viti Levu, Fiji, based on analysis of fracture lineaments.
Rau, S., Douillet, P. & Aung, T.	Hydrodynamic modelling in Suva Lagoon (Fiji).
Sharma, A., Pohler, S., Collen, J.D. & Langer, M.R.	Benthic foraminifera and their contribution to carbonate accumulation in Laucala Bay, Suva, Fiji.
Tawake, L.V., Pohler, S. & Maharaj, R.	Assessment of beach erosion: a case study of Tagaqe and Votua Villages on the Coral Coast near Sigatoka, Viti Levu Island.
Terri, J., Kaloumaira, A. & Pohler, S.	Can over-fishing influence coastal erosion?
Trustrum, N.	The role of Pohnpei forests in controlling landslides and water yield.

ABSTRACT OF PAPERS

ANTON

Tsunami hazard research in Papua New Guinea

Lawrence Anton
Port Moresby Geophysical Observatory, Geological Survey of Papua New Guinea, P.O. Box 323, Port Moresby, National Capital District, Papua New Guinea.
Email: pmgo@daltron.com.pg

Papua New Guinea (PNG) has the misfortune to be more exposed than most countries in the world to the effects of disaster-causing natural phenomena. Earthquakes have been the most common hazard. Tsunami hazard and others such as landslide have commonly accompanied earthquakes. PNG has experienced many devastating tsunamis in the recent past and is therefore vulnerable to future events. Our recent experiences are those related to the 1998 Aitape Tsunami. Tsunami hazard research, including analysis of these hazards and assessment of associated risks will enhance planning to mitigate the effects of natural disasters. However, in PNG, tsunami-related research programs by the Government have been limited to a few international programs such as those conducted by the USA and Japanese Governments. Effective mitigation strategies are attained through proper understanding of the natural phenomena and this is achieved through research. Palaeo-tsunami research helps uncover information on occurrence of past events and enhances understanding of how and where future events may occur.

Earthquake-related: seismic dislocation: In PNG, earthquakes having magnitude greater than 7 are relatively frequent. A significant number of these earthquakes was tsunamigenic. Most of the tsunamis were generated locally, but there have been some that originated from outside the region, for example, one generated by the Chilean magnitude 8.5 (Ms), earthquake of 1960.

Submarine slumping: earthquake-induced and spontaneous: Considered a common cause of tsunamis in PNG, submarine sediment slumping was indicated as the causative mechanism for the Madang 1970 tsunami on the basis of the coincidental breakages of the seafloor telecommunications cables immediately east of Madang. Two 1971 subduction earthquakes (magnitude 8.0) in the northern Solomon Sea occurred at depths of 50 km, too deep to cause surface rupture. The 1998 Aitape Tsunami was generated by slumping induced by an earthquake of magnitude 7.1. A spontaneous slumping event was reported in Lae in 1972.

Volcano related: caldera collapse and eruption: The Ritter Island event of 1888 produced one of the most damaging tsunamis in PNG's recorded history. No earthquakes or eruptive activity accompanied the event, and the tsunami waves were generated by the collapse of part of the volcano. Pyroclastic flows from the Vulcan cone are the probable cause of the tsunamis generated during the Rabaul volcanic eruptions in 1937 and 1994.

PNG has a fairly good historical record of past earthquakes and tsunamis, but no extensive study has been done to document tsunami hazard and risk in the PNG region. Events of the last decade, especially the 1994 Rabaul volcano eruptions and the 1998 Aitape Tsunami, had a very big impact on earth science in PNG. The 1998 event resulted in many onshore and offshore surveys with a lot of support from abroad and participation from within and abroad. Results from the Aitape Tsunami offshore surveys will enhance regional and local tsunami studies, which will help minimise loss that will result from future events. An immediate lesson from the 1998 Aitape Tsunami is that other coastlines of PNG may be considered highly vulnerable to tsunamis generated from offshore sediment slumping caused by earthquake shaking. Bathymetric data for all coastal areas of PNG must be collected before any better tsunami run-up and inundation modeling can be carried out. Routine research and post-event surveys to assess damage and collect tsunami run-up/inundation data are conducted by institutions from within and by others from abroad, invited for collaborative work.

Having established the risks, steps should be taken to ensure that they are minimised by the introduction of such measures as land-use legislation, seismic zoning and building codes. Effective disaster management should extend into the very process of national physical and economic planning. Preventive and warning

measures safeguard life and investment and are highly cost effective. The basic pre-requisite of such measures is scientific data, which is achieved through research programs.

PNG supports the set up of the Southwest Pacific Tsunami Warning System. PNG proposes to International Tsunami Information Centre and others to facilitate purchase of a number of SEAFRAME tide gauges for a local network. SEAFRAME tide gauges have proven to perform well in PNG. A local PNG network will fit in well with the proposed Southwest Pacific Tsunami Warning System regional network.

Seismic: Because most tsunamis of PNG were generated by earthquake, it is important to maintain and enhance existing earthquake monitoring capacity and capabilities for faster and more reliable location of earthquakes. The earthquake-monitoring network for local surveillance needs modernizing and expanding for quicker earthquake parameter determination.

Sea-level: PNG is the custodian of several instruments that are owned by agencies from abroad, and one tide gauge owned and operated by Rabaul Volcano Observatory. The existing sea-level monitoring capability should be upgraded and the viability of establishing a tsunami-monitoring network needs to be explored.

Conclusions:

- In coastal localities where tsunami awareness has been carried out, residents have been informed to move quickly to higher ground when they feel a strong earthquake. Residents are encouraged to live more than 3 metres above the high water level, and have been advised that special attention must be paid to the siting of public buildings and those housing essential services.
- Information programs and other means have been initiated to educate the public about the risks of earthquakes and related hazards such as tsunamis and landslides.
- Bathymetric data for the entire PNG coastal areas needs to be collected to conduct proper inundation modeling, evacuation mapping, etc.
- The country's current earthquake monitoring facility needs to be modernised, and must be upgraded.
- Sea-level monitoring equipment must be upgraded, expanded and the viability of a local tsunami monitoring/warning network must be assessed.
- PNG needs to develop policy and procedures for tsunami response that must be included in the overall Disasters Management Strategy for the country.
- Palaeo-tsunami and routine tsunami research must be fostered.

ANTON & McKEE

The great earthquake of 16 November 2000 and associated seismo-tectonic events near the Pacific-Solomon-South Bismarck Plate triple junction in Papua New Guinea

Lawrence Anton & Chris McKee
Geological Survey of Papua New Guinea, P.O. Box 323, Port Moresby, National Capital District, Papua New Guinea
Email: pmgo@daltron.com.pg

One of the largest earthquakes in the recorded history of Papua New Guinea (PNG), in fact the country's fifth known "great" earthquake, having measured magnitude values Ms 8.2 and Mw 8.0, with adopted magnitude 8.0, struck the eastern Bismarck Sea-New Ireland region at 0454 UTC on 16 November 2000. The large separation distance (110 km) between the hypocentre in the eastern Bismarck Sea and the centroid in southern New Ireland, and the length of the aftershock distribution field, indicated a rupture length of more than 200 km, from the eastern Bismarck Sea through southern New Ireland to the northern Solomon Sea. The earthquake focal mechanism indicated left-lateral strike-slip movement, consistent with observed left-lateral strike-slip ground displacement in the fault-controlled Weitin Valley of southern New Ireland.

The earthquake rupture involved huge stress release locally, and the consequent change to the stress pattern triggered other large earthquakes on neighbouring structures. A second large earthquake, having magnitude values Ms 7.8 and Mw 7.8, occurred offshore south of southern New Ireland less than three

hours after the initial earthquake, at 0742 UTC on 16 November. A third large earthquake, having magnitude values Ms 8.0 and Mw 7.8 occurred near Pomio eastern New Britain forty hours after the first earthquake, at 2101 UTC on 17 November. The second and third large earthquakes are not aftershocks of the first event as each earthquake affected separate parts of the region. Each event is regarded as a main earthquake.

The large earthquakes were felt strongly and caused damage on eastern New Britain, southern New Ireland and northwestern Bougainville. Effects of the first earthquake caused two human fatalities. Tsunami activity associated with the first earthquake caused damage to houses on southern New Ireland, western Bougainville and on Kaileuna Island in the Trobriand Islands, western Solomon Sea.

The large earthquakes caused aftershock sequences that continued into March 2001. The aftershock distribution clearly shows that a number of different tectono-structural elements were involved in the regional stress re-adjustment.

Several features of the earthquake sequence render it highly significant, locally, regionally, and globally. The rupture associated with the first main earthquake confirms that one component of the plate triple junction involves a dominantly strike-slip fault. The large magnitude of the first earthquake has forced a revision of the maximum credible earthquake magnitude of the eastern Bismarck Sea, eastern New Britain and southern New Ireland areas to 8.5. The tight clustering in time and space of one "great" and two "large" earthquakes represents one of the most energetic episodes of seismic stress release recorded in PNG. The broad, complex distribution of the main earthquakes, their aftershocks and other related earthquakes, the number of tectono-structural elements involved, and the diversity of earthquake dynamics in adjacent parts of the region are remarkable. These events encompass the triple junction of the South Bismarck, Pacific and Solomon Plates, and show that the whole region around the triple junction was involved in a chain reaction of events constituting a major regional tectonic re-adjustment. The impact of these events should not be surprising considering that this seismo-tectonic sequence was initiated by the largest earthquake in the world in the year 2000.

ARTACK & LAL

Pacific Regional Maritime Delimitation Boundaries Project

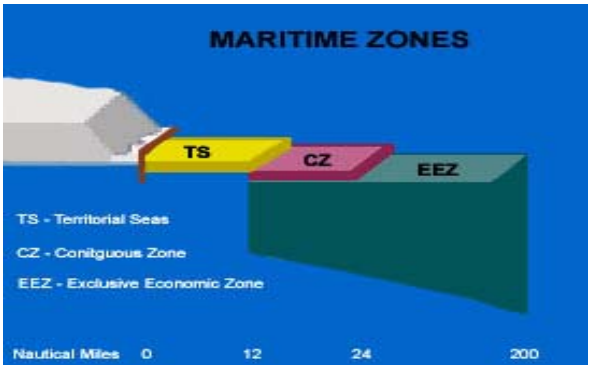
Emily Artack & Andrick Lal
SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands
Emails: emily@sopac.org, andrick@sopac.org

At the 28th Session of SOPAC held in October 1999, the Governing Council endorsed a proposal for the transfer of the Maritime Boundaries Delimitation Project from FFA to SOPAC. Similar endorsement was forthcoming from the Forum Fisheries Committee [FFC] at their 44th Meeting in May 2000, subject to preparation of a joint submission by FFA and SOPAC seeking approval from AusAID [Donor] for the Project and remaining funds to be transferred to SOPAC.

A review of the data and information collected during the FFA Maritime Boundaries Delimitation Project [1991-2000] and transferred to SOPAC in February 2002, was undertaken during the 2001/2002 SOPAC Work Programme. This activity relates to the specific task RT2000.048 in the 2001/2002 SOPAC Work Programme, approved and endorsed by the 30th SOPAC Governing Council Session, to design, develop and implement a Regional Maritime Boundaries Project initiative

The United Nations Convention on the Law of the Sea 1982 [UNCLOS] is accepted by an overwhelming majority of states, as a body of international law governing the broadest possible agenda of ocean issues. Under customary international law, as reflected in the United Nations Convention on the Law of the Sea 1982 [UNCLOS], each South Pacific Applied Geoscience Commission [SOPAC] member country is entitled to four maritime zones seaward of the territorial sea baselines. These are:

12 nautical mile [NM] territorial sea
Contiguous zone [CZ]
200 NM exclusive economic zone [EEZ]
Continental Shelf



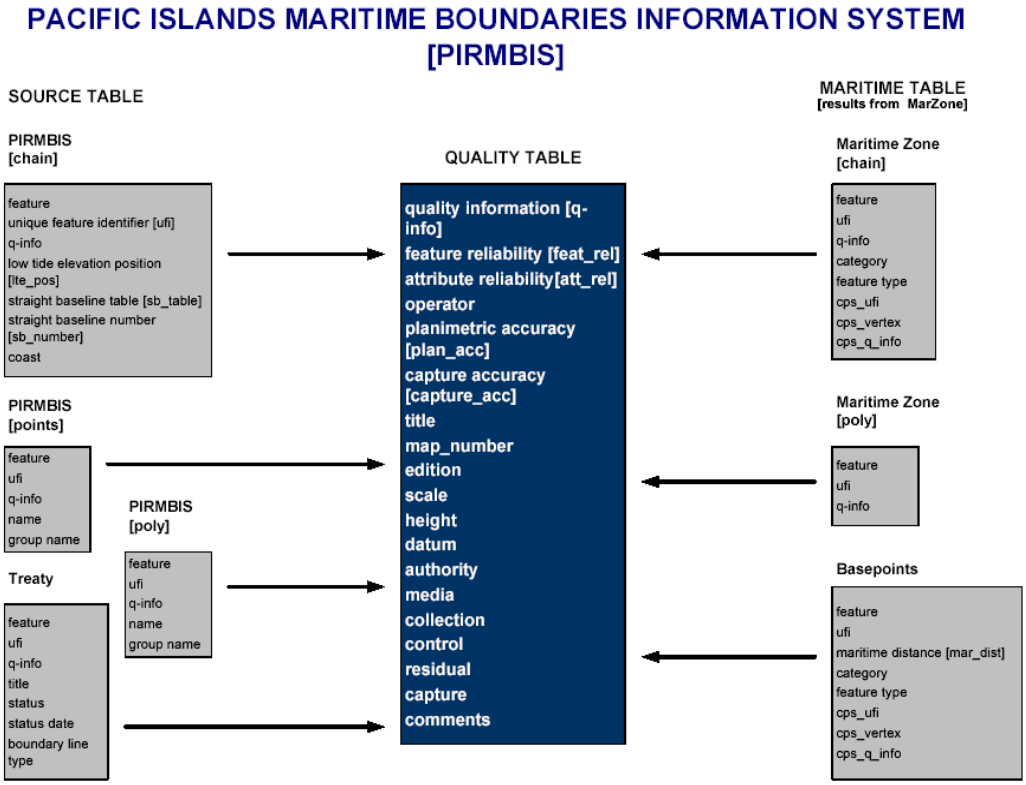
There is a need to determine a boundary between the zones of neighbouring countries where the potential maritime zones overlap. There are a total of 45-shared boundaries between SOPAC/Forum Fisheries Agency [FFA] member countries and neighbouring countries. The settlement of these boundaries helps regional stability and gives certainty to the ownership and management of maritime resources. In particular settled maritime boundaries provide a firm foundation for bilateral and regional resource management arrangements and for effective surveillance and enforcement.

The absence of an agreed maritime boundary, which is both binding at international law, and reflected in domestic legislation, may give rise to difficulties in enforcement. It may lead to a dispute with neighbouring countries over the ownership of resources either in the shorter or the longer term. For example, the absence of established boundaries may give rise to disputes with distant water fishing nations [DWFN].

In order to enhance the above tasks a comprehensive Geographic Information System [GIS] MapInfo database [Pacific Islands Maritime Boundaries Information System – PIRMBIS] is being designed, developed and maintained to validate and store datasets for the 14 countries in the SOPAC region.

These include Cook Islands, Fiji, Federated States of Micronesia (FSM), Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea (PNG), Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.

The Pacific Islands Regional Maritime Boundaries Information System [PIRMBIS] is a geographic information system [GIS], which contains a regional coverage of the maritime limits of Pacific Island coastal States. PIRMBIS is being designed, developed and maintained by SOPAC in consultation with its member countries and Geoscience Australia.



PIRM

- Data User Guide;
- Quality Information Files; and
- Data Files [contains the main tables that generate the maritime boundaries, using MarZone which has been customised to address specific technical issues in the Pacific Islands Region such as archipelagic straight baselines]

The components above will combine to give a comprehensive picture of the region's maritime boundaries and how they are derived. The schematic of the PIRMBIS explains the input, output and validation of the Maritime Boundaries Project

---

BHIKABHAI

Regional earth day 2004 – renewable energy awareness campaign: "Renewable Energy – Save My Island Home"

Yogita Bhikabhai
SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands
Email: yogita@sopac.org

The Regional Earth Day, April 22nd 2004 follows from the past three years' Regional Earth Day activities in helping build awareness on energy issues amongst school students throughout the region. The activity proposed for this years Regional Earth Day 2004 is a "Renewable Energy Awareness Campaign" targeting schools throughout the region with the theme: "Renewable Energy – Save My Island Home".

Most of the energy in the PICs today comes from fossil fuels. Coal, oil, and natural gas are all fossil fuels created several millions of years ago by the decay of plants and animals. These fuels lie buried between layers of earth and rock. While fossil fuels are still being created today by underground heat and pressure, they are being consumed much more rapidly than they are created. For that reason, fossil fuels are considered as non-renewable; that is, they are not replaced as soon as we use them. So, they will become depleted sometime in the future. Moreover burning fossil fuels also leads to pollution and many negative environmental impacts especially the emission of greenhouse gasses.

Because we depend so much on energy, we need to use sources of energy that will last and these are called renewable energy sources. These renewable energy sources are more environmentally friendly compared to fossil fuels. The "Renewable Energy Awareness Campaign", targeting Pacific region students is expected to raise awareness among students on what are the various potential sources of renewable energy and their importance to the Pacific. A flipchart has been creatively developed for the campaign illustrating various sources of renewable energy. The flipchart is expected to be used as a basic teaching aid for school teachers and assist with incorporating energy issues, especially renewable energy aspects into school curriculum. Further to this a video CD entitled "Saving Hieronymus" has been circulated along with the flipchart for use as educational tools.

BONTE-GRAPENTIN & others

TC Heta – assessment of wave impacts on Niue and its implications for a coastal hazard zonation

Michael Bonte-Grapentin[1], Steve Oliver[2], Dave Talangi[3] & Litea Biukoto[1]
[1]SOPAC Secretariat, Private Bag, GPO, Fiji Islands
Emails: michael@sopac.org; lite@sopac.org
[2]Global Environmental Modelling Systems GEMS, Hyatt Centre, Adelaide Terrace, Perth, Australia
Email: steve.oliver@gems-aus.com
[3]Ministry of Public Works, Niue
Email: pwd@mail.gov.nu

On 5th January 2004 Heta, a category 5 cyclone, hit Niue – an over 60 m raised limestone Atoll - and widely devastated its N to NW exposed coastlines from Uluvehi to Alofi (Figure 1). Thereby buildings in the capital Alofi and the villages of Makefu, Tuapa, Namukulu and Hikutavake, including the Niue Hotel and the hospital were destroyed by waves approaching unexpectedly over the Alofi terrace located some 20 m above present sea level (Figure 2). As part of the TC Heta Recovery Plan and as basis of building a "New Niue" there are strong considerations of relocating critical assets like the hospital and government ministries on higher ground as well as encouraging the civil society and the private sector to follow this example. Furthermore Niue government is developing a policy to discourage future development in hazardous prone coastal areas. SOPAC with partners has been requested to assist the identification of coastal hazard zones, to assess and model impacts of TC Heta to Niue's coastline.

Eye-witness reports on the time of wave peaks are contradictory and range from 1-5 pm Niue time and according to Prime Añover, who was trapped in the waves, there were only a limited number of big waves, 10 to 20 swashing over the terrace and destroying the buildings. He estimates the frequency of these waves to be over 1 minute. Highest wind speeds were recorded at Niue airport between 4:30 to 5:10 pm (a power cut after 5:10 pm disabled further recording) with wind speeds around 130 km/h and gusts up to 200 km/h. The wind direction turned steadily from ENE at about 1 pm to N at 5 pm and according to witness reports further to NW – the general wave direction. Unfortunately there are no additional records, since the monitoring station in Alofi broke down and data could not be recovered.

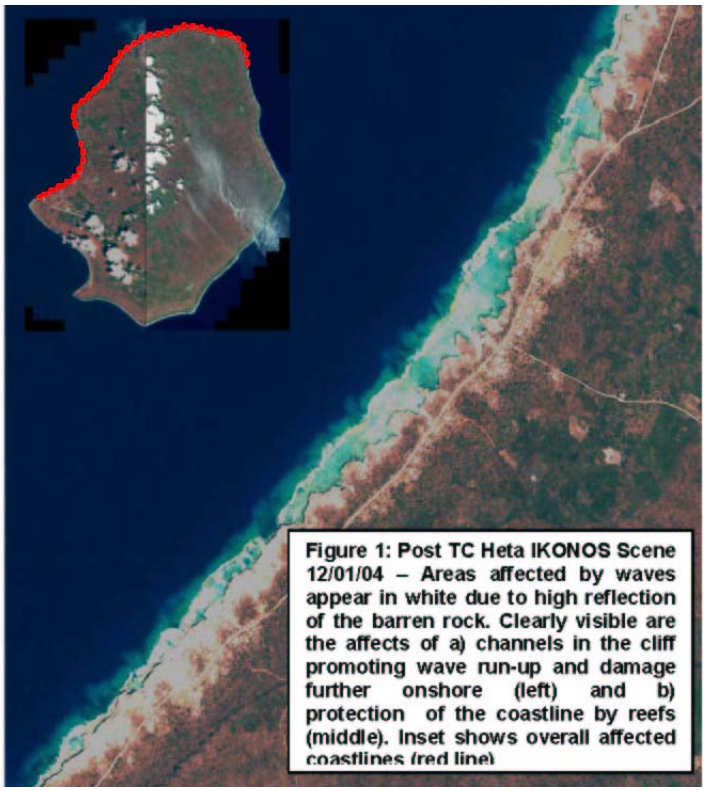


Figure 1: Post TC Heta IKONOS Scene 12/01/04 – Areas affected by waves appear in white due to high reflection of the barren rock. Clearly visible are the affects of a) channels in the cliff promoting wave run-up and damage further onshore (left) and b) protection of the coastline by reefs (middle). Inset shows overall affected coastlines (red line)

Evidence for wave impacts were found on sites up to 25 m a.s.l. and up to 200 m inland on the Alofi terrace. Areas affected by waves were delineated according to the post Heta IKONOS scene (Figure 1) and GPS mapping of coral rubble, several dm-m in size and other debris thrown onshore by the waves (see Figures 2 &3). The satellite image, taken 12 January one week after the cyclone stroke, shows a clear indication of affected areas, where vegetation was whipped out, barren rock exposed and coral rubble deposited (Figure 2). All these areas show a high reflection and appear in white.

Figure 2: Devastated Alofi-S – buildings and vegetation whipped out by waves. Note also fine structured cliff face. Photo by Min. of Fisheries Niue during RNZAF air surveillance

Major damage was observed behind channels/breaks in the cliff face, where waves were approaching further inland then elsewhere. Often houses on the landward side of the main road were affected. The waves (swash) might by concentrated in the channels, sea tracks and reached the Alofi terrace on the more gentle slopes with high energy. Neighbouring houses on the seaward side of the road, but on the ridges in between two channels were often not damaged. In Alofi South – the overall most severely affected area in terms of wave impacts (height/distance onshore) as well as values lost (hotel, hospital, houses and businesses) – the effects of the channel/breaks in the cliff face are not obvious, since the whole terrace seems similarly severely affected. But eyewitnesses reported waves (swash) running parallel to the coastline and inundating the terrace around 1-2 m. The coastline at Alofi-S is also marked by the lack of a fringing reef and comparable small, submerged terraces, whereas the area around Tuapa seemed to be protected by Niue's widest fringing reef of about 130 m and relatively wide submerged terraces (Figure 1).

Waves approaching far inland at the N coast did not cause major damage, because all settlements and infrastructure are located at the upper terrace.

Preliminary model results suggest significant wave heights of 24 m at about 5 pm. There might be some individual higher waves that were able to overtop the cliff at Alofi-S.

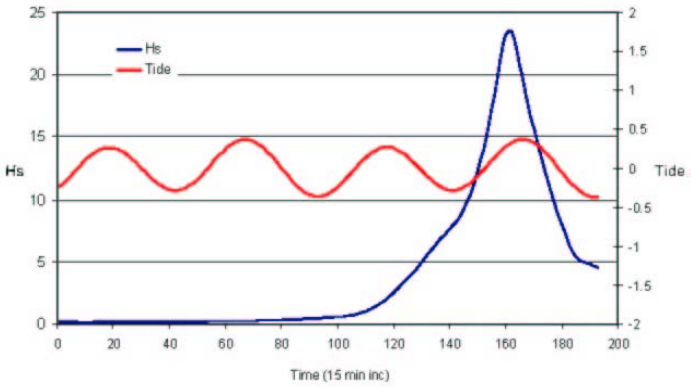


Figure 4: Modelled significant wave heights

Figure 3: Largest coral boulder (~3-4 t) transported some 50 m onshore

References:
Biukoto, L. & Bonte, M. 2004. Niue country mission report. Unpublished.
Forbes, D.L. 1996. Coastal geology and hazards of Niue. SOPAC Technical Report 233, 119 pp
Howorth, R., Bonte, M., Prasad, R., Goosby, S., Oliver, S., Elliot, M. & Biukoto, L. 2004. Impacts of tropical cyclone Heta to Niue. Proceedings AMOS Storm Conference, Brisbane 5-9 July, 2004.
Government of Niue, 2004. National impact assessment on Niue. 8pp.

BULEKA

Ramu River Aggradation

Joe Buleka
Geological Survey of PNG, Department of Mining, Private Mail Bag, Port Moresby, Papua New Guinea.
Email: joe_buleka@mineral.gov.pg

Papua New Guinea has a number of large rivers that parallel competent rock boundaries the result of prolonged tectonic interactions. Ramu and Markham Rivers are aligned and separate the Finisterre Range from the Mobile Belt to the northeast, and appear to imitate and form part of the boundary of the Australian and the South Solomon Plates. Many of the major earthquakes and the geohazards appear to be occurring in the northern part of the country including the New Guinea Islands.

The Ramu River in Madang Province aggregated in August 2003 and the River abandoned the 9km section and is now flowing into her tributary. This paper is reproduced for the SOPAC Annual Session and is aimed at addressing flooding as a form of geohazard in PNG. This paper explores the causes for the aggradation and the flooding from the Boku River in February 2004 prompted this study. The Ramu – Markham Valley is the surface expression of a major tectonic feature and large earthquakes are frequently experienced. Trigoning et al (1998) states that the collision between the Australian and the South Bismarck Plates is accommodated in the Adelbert Range in this part of the Ramu–Markham Valley. Assuming that the total collision is taken up on this fault, there should be displacement occurring as evidence and Terraces on the Huon Gulf testifies to such incremental uplift.

There are many reasons for Ramu River to meander and it appears that the siltation started sometime in 1987 and may be progressive and parallel development. It is natural for a river to migrate especially in a flat meandering valley but there has to be a direct link to the problem and a number of causes have been

proposed. Faults can occur in flat wide valleys with isolated small-localized faults are also expected to occur in this area. Faulting displacements in the flat river valleys are rarely observed as the source of faulting is at a great depth and rivers often obscure the details. Rivers respond to faulting by meandering as rivers flow away from the raised banks and affect the people and their properties. The New Ireland fault of 2002 had a vertical displacement of 0.56 m and horizontal displacement of 5.0 m.

Tectonic uplift can also be triggered with source at great depth. Uplift can be best noticed in the flat valley when one side of the valley is raised and affect the flow of the river but this has to include the whole region. In this case as the river shifted to the south it may be logical to assume that the Adelbert Range has undergone uplift due to tectonic movement. Sialum Terraces are good examples of tectonic uplift where coral terraces are being uplifted and the rate influences the whole Finisterre Range and not just the Ramu Valley. The 1993 Finisterre earthquake denuded many steep slopes in the Ramu and Markham headwaters. Sediments denuded from the hills may have reached this section and deposited as the gravity of the sediments supersedes the velocity of the Ramu River. The residual velocity measured at the upper part of the aggradation was 0.3 m/s and this may indicate that much of the river has diverted into the southeast. Boku River, a tributary of the Ramu River, has its headwaters in the Finisterre/Adelbert Range. JANT Company has been harvesting timber for pulpwood in this region since 1973. Increased devegetation exposures the soil to atmospheric degradation. Heavy rainfall increases the soil erosion and this contributes to debris flooding. Flooding was experienced in February of 2004 in which a major bridge in the Ramu Valley was rafted. The debris flooding in the area may also be partly responsible for aggradation of the Ramu River.

Ramu Bridge without water in the central part of the 9 km aggraded section.

CHAND & others

Geostrophic current in Fiji Waters

Savin S.Chand[1], Keitapu Maamaatuaiahutapu[2] & Than Aung[1]
[1]The University of the South Pacific, Suva, Fiji Islands
[2]The University of the French Polynesia, Tahiti
Email: chand_sv@usp.ac.fj

More than 95 % of ocean currents are geostrophic and their circulation in Fiji waters is calculated. The study area is between 10˚S to 25˚S latitude and 170˚E to 190˚E longitude. In our calculations, Topex / Poseidon and ERS 1/2 derived sea surface height anomaly (SSHA) data fields from October, 1992 to August, 2002 and available ARGO float data were appropriately used.

Geostrophic velocities were calculated combining SSHA and the Levitus climatological data. The geostrophic flow pattern shows that during ENSO cycle, the characteristic flow pattern is the major westward (eastward) flow in the northern (southern) part of the study region. During the La Nina phase, the flow pattern in the northern part of the study region, however, reverses and that in the southern part broadly remains eastward. On a seasonal time-scale, the dominant geostrophic flow in the northern part of the study region during the months of early summer is westward, unlike the eastward flow during early months

of winter. In the southern part of the region, the major flow is eastward regardless of winter and summer conditions. The variability of the circulation is also diagnosed with the Empirical Orthogonal Functions.

This general current pattern in Fiji waters during different seasons is believed to be a very useful tool for rescue missions in the area. The variability of this flow pattern on seasonal and inter-annual time scale was related to the steric changes caused by the movement of western equatorial Pacific "warm pool" and the associated movement of the South Pacific Convergence Zone (SPCZ).

CHANG & others

Coastal morphology of Savai'i, Samoa

S.W. Chang[1], S.-P. Kim[1], L. Talia[2] & R. Smith[3]
[1]Korea Institute of Geoscience and Mineral Resources (KIGAM), kajeong 30, Yuseong-Gu, Taejeon 305-350, Korea.
Emails: swchang@kigam.re.kr; spkim@kigam.re.kr
[2] Meteorology Division, Ministry of Agriculture, Forests, Fisheries and Meteorology, P.O. Box 3020, Apia, Samoa.
Email: geophysics@meteorology.gov.ws
[3]SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands
Email: robert@sopac.org

A field survey along the coasts on the Savai'i Island, Samoa was planned and undertaken to continue previous work based on task WS 1999.999, SOPAC during 14th to 21st April, 2004. The objective of the field survey was to classify the coastal morphological features around the island and check the coastal morphological features identified from the 1999 aerial orthophotos of the coastline from Saleologa to Pu'apu'a, Savai'i, Samoa (Fig. 1).

Fig. 1. Mosaic of 1999 aerial orthophotos from Saleologa to Pu'apu'a, Savai'i ,Samoa.

Firstly, the reconnaissance field survey was done to classify geomorphology and obtain GPS data for ground control positions around the island from 14th to 17th. During the reconnaissance field survey and mapping, classification of the coastal morphological features was done and compared with the former explanation for 1:25,000 coastal morphology maps of Upolu, Samoa (1991).

Next, leveling of the beach profile along the lines across the Faga beach (7 lines) and Falealupo beach (3 lines) and detailed mapping from Saleologa to Pu'apu'a was also performed from 19th to 21st. For this survey, SPOT image, 2000 topographic maps (1:50,000), geological map, 1999 aerial orthophotos(1:5,000) and 1990 aerial photographs(1:50,000) were used.

CHEVILLOTTE & others

Uplift, erosion and the distribution of lateritic planation surfaces in southern New Caledonia

Violaine Chevillotte[1,2], D. Chardon[1,2], A. Beauvais[1,2], Y. Lagabrielle[1], P. Maurizot[3] & F. Colin[1,2]
[1]IRD, BP A5, 98848 Nouméa, Nouvelle Calédonie
[2]CEREGE, UMR161, BP 80, Université Aix-Marseille 3, 13545- Aix-en-Provence, France
[3]Service des Mines, BP 465, 98845 Noumea, New Caledonia
Email: Violaine.Chevillotte@noumea.ird.nc

For 30 Ma, the ophiolite of New Caledonia underwent the combined effects of weathering and vertical tectonic movements. The uplift stages of the New Caledonian substratum allowed the relative downward movement of the base level that controlled the relief dissection and its mechanical erosion modalities by

the channel network incision. During the same time span, tropical climatic conditions have shaped very characteristic lateritic land surfaces, some of which were enriched in nickel ores. These surfaces are actually preserved at various altitudes (0-1600m) over the ophiolite.

In the northern part of the study area, two generations of the highest land surfaces have been developed between 600 and 1300 m. Those surfaces have a specific morphology and setting in the landscape. They have been developed on interfluves of limited lateral extent, and they are characterised by a very steep slope, and wide individual elevation range. Two steep channels also bound them laterally. Later, a subsequent glacis (pediment), bearing most of the nickel ore deposits, has been developed, especially along the piedmont of the ophiolite (from c.a. 100 to 500 m). The spatial relations of this glacis with the deltaic sequence seen along the shore of the island suggest that it could have been shaped before or during the mid-Miocene (16 – 24 Ma). In the southeastern part of the massif, a typical climatic sequence of three widespread land surfaces covered with thick ferricrete has been developed underneath the high surfaces, between 100 and 600 m in large karstic erosion alveoles. The last surface overlaps lacustrine and fluvial deposits that can reach 70 m in thickness.

Three main stages of landscape shaping have been distinguished. A first period dominated by uplift episodes led to the dismantling of the highest and oldest land surfaces. A second period marked by a stationary uplift allowed the development of thick lateritic weathering terrains on hill slope surfaces of relatively high altitudinal extension. A third period initiated when the magnitude and rate of the positive vertical movements decreased favoured the development of wide lateritic land surfaces bearing quite thick lateritic weathering mantles.

Our results suggest quite rapid late Oligocene to early Miocene uplift(s) during the setting of at least two planation systems contemporaneous with episodic or continuous intense incision that lead to specific drainage, morphological evolution, weathering and finite geometry of the surfaces. This early phase was followed by a period of moderate incision due to limited or low uplift, and by the setting of stepped, well-developed land surfaces within the peridotite massif and possibly polygenic glacis along its margins. The distribution and the type of land surfaces suggest that regional-scale tectonic uplift took place at least partly before normal faulting, which has shaped the actual horst geometry of the island. Our results further document the stepping of an early high-elevated tropical landscape primarily shaped by uplift and incisions, and a younger, lower elevation one in which the climatic imprint is dominant.

On the basis of morpho-tectonic observations, a metallogenetic model for the supergene nickel ore deposits can also be expected as well as a potential guide for prospecting in New Caledonia.

CLOIN

COPRA as a biofuel – challenges and opportunities

Jan Cloin
SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands
Email: jan@sopac.org

The use of biofuels is nearly as old as the diesel engine itself. In the Pacific, only recently has there been serious interest shown in the use of copra-oil as a biofuel. Through a combination of substitution for diesel imports, the safeguarding of the local agricultural industry and the impact of diesel exhaust on the environment, a range of initiatives using copra-oil as a biofuel have been carried out in the past 30 years.

In general, on the one hand there seems to be a market for raw, untreated copra-oil as a fuel for adapted generators. On the other hand there is the use of esterified, treated copra-oil as a fuel for large-scale automotive applications. This paper focuses on the use of raw copra-oil as a fuel for diesel gensets.

The initiatives undertaken in the Pacific to utilise raw copra-oil in generators have had different degrees of success. An overview is given on a range of projects carried out that utilised copra-oil as a biofuel in diesel generators and their current state of operation. Apart from the technical and economic aspects, both logistical and cultural factors are highlighted and found crucial for the future sustainable use copra-oil as a biofuel.

On the basis of these initial findings, conclusions are drawn of best practices and possible direction for the Pacific region. Recommendations with a focus on the long-term operation of remote electric power generation will elaborate on the opportunities for utilities to save money, local agriculture and the environment.

COWAN

Geological hazard monitoring in New Zealand: opportunities and issues for enhanced regional collaboration

Hugh Cowan
Institute of Geological & Nuclear Sciences, P.O. Box 30-368, Lower Hutt, New Zealand
Email: H.Cowan@gns.cri.nz

A major renewal of New Zealand's geological hazard monitoring system (GeoNet) is in its fourth year, providing more accurate and rapid information on earthquakes, volcanic unrest, land instability and geothermal activity. The goal is to ensure as the New Zealand economy and population grows, a wide range of agencies can respond effectively to future natural hazard events, to minimise damage, loss of life, and the cost of recovery.

The southwest Pacific encompasses many nations exposed to a variety of natural hazards, including earthquakes and volcanism. This region is the most seismically active on the planet, and a number of volcanoes pose potential ash plume threats to aircraft on trans-Pacific and regional flight paths. Monitoring is sparse and much could be gained from a wider network of local observers. Recent advances and investment in infrastructure and training, however, provide an improved context in which to integrate geophysical monitoring on a regional scale.

The Southwest Pacific Regional Integrated Network for GeophYsics (SPRINGY) initiative was launched in March 2003, with a statement of intent to facilitate rapid exchange of information from large, potentially damaging regional earthquakes. Some upgrading of infrastructure will be required to achieve this objective, recognising the practical constraints on rapid data exchange imposed by telecommunications bandwidth. Nevertheless, closer collaboration even among a network of observers with voice or limited data communications throughout the islands could enhance geological hazard detection, emergency response and, in particular, support for aviation forecasting during periods of volcanic unrest.

CUMMINS & KALUWIN

Feasibility study for a tsunami warning system in the SW Pacific

Phil R. Cummins[1] & Chalapan Kaluwin[2*]*
[1]Geohazards Division, Geoscience Australia, GPO Box 378 Canberra, Australia.
Email: Phil.Cummins@ga.gov.au
[2]South Pacific Sea Level & Climate Monitoring Project, Australian Marine Science & Technology Ltd, PO Box 17955, Suva, Fiji Islands
Email: amsatck@connect.com.fj

Tsunami comprise an important hazard for the southwest Pacific region, and this importance is likely to increase with population growth and development in coastal areas. Because the level of tsunami hazard is high, it seems worthwhile to consider establishing a regional tsunami warning system for the southwest Pacific. This issue was considered at the South Pacific Tsunami Awareness Workshop held in Suva in July 2004, and one of the main recommendations of this workshop was a study to test the technical feasibility of such a warning system. Such a study would attempt to answer the question: could a regional system issue reliable warnings rapidly enough to save lives in the event of a destructive tsunami?

One of the most difficult issues for a tsunami warning system in the southwest Pacific region is that of rapid communication with remote communities. Initiatives such as the RANET (Information Technology for Rural Communications using ***Ra***dio and the Inter***net***) Project may establish the required communications infrastructure in the Pacific. However, even if such a system cannot alert local communities in time to escape a tsunami, a tsunami warning system could provide rapid confirmation of a potentially destructive tsunami event, allowing disaster relief efforts to be mobilized quickly. Such rapid mobilization could save lives, especially if the affected area can be determined quickly via the data available from tide gauges and earthquake sensors. In this presentation, we will discuss some technical aspects of a proposed feasibility study designed to determine how rapidly and reliably tsunami warnings could be issued for the southwest Pacific region.

The basic technical components of a warning system are: (1) acquisition of continuous, real-time seismic data and its rapid analysis to determine potentially tsunamigenic events, and (2) event-triggered acquisition of near-real-time sea level data to verify whether a tsunami has actually occurred. For the seismic component, a substantial number of broadband stations, which provide data suitable for analysing signals from large earthquakes, are already deployed in the region by international agencies. An increasing number of these use satellite data telemetry, and the data are available in near-real-time over the internet. For the sea level component, a network of tide gauges have already been deployed in the region as part of the South Pacific Sea Level and Climate Monitoring Project (SPSLCMP, see Figure 1), and near-real-time access to the high sample rate data required for tsunami monitoring seems technically feasible, although some additional infrastructure may be required. The analysis required for sea-level data is much simpler than that required for seismic data.

*South Pacific Tsunami Awareness Workshop Participants

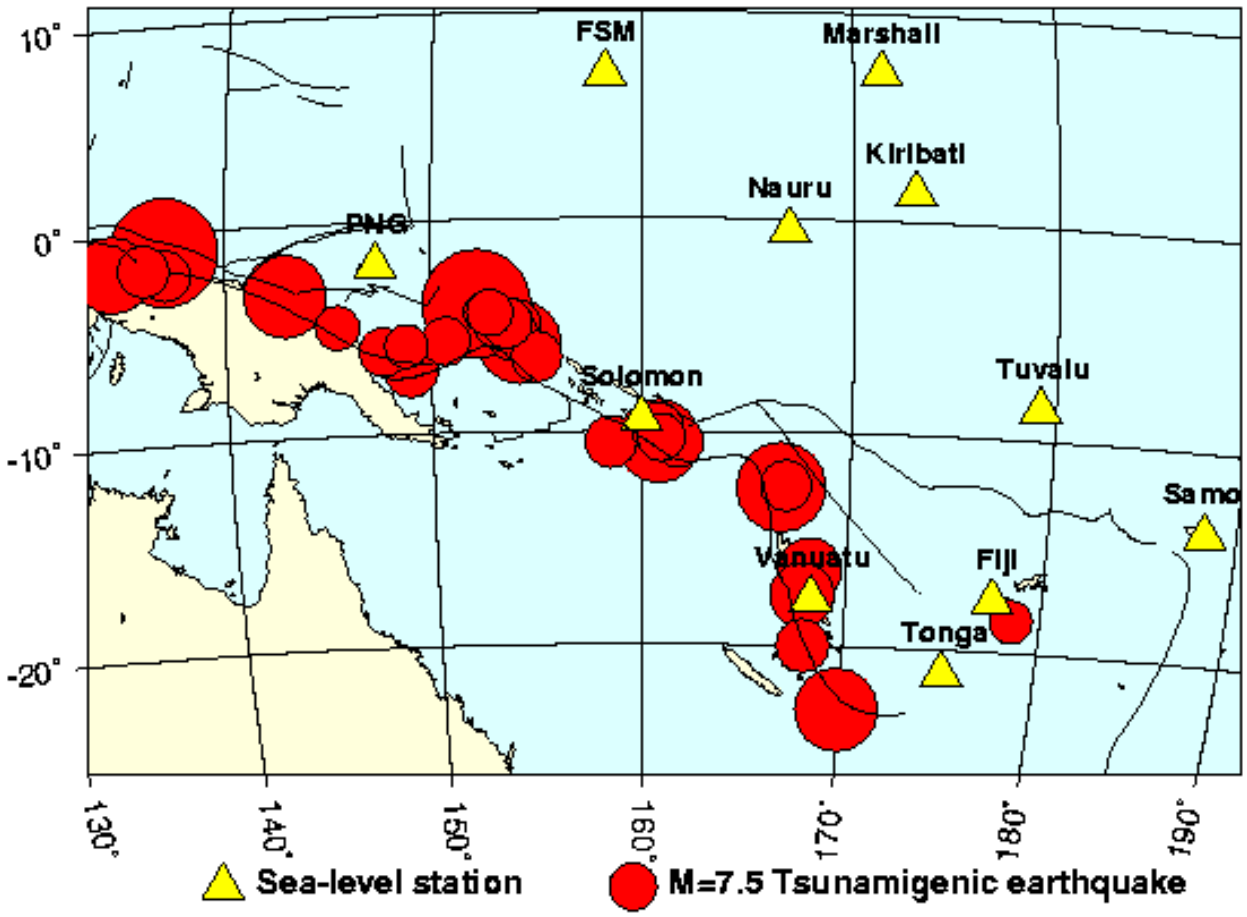


Figure 1. Sea-level stations of the South Pacific Sea level and Climate Monitoring Project, and large tsunamigenic earthquakes recorded since 1900 (from NOAA and NEIC databases). Solid lines indicate the boundaries of major tectonic plates where large earthquakes tend to occur.

A tsunami warning system for the SW Pacific would likely involve establishment of a regional center capable of acquiring and rapidly analysing both seismic and sea level data. This would require a reliable high-bandwidth internet connection as well as highly-trained staff, and would likely take several years to develop. However, our proposal is for a simple feasibility study that would, for a limited time, use earthquake alerts already produced by international agencies. A regional office would monitor only the sea level data from the SPSLCMP tide gauge network to verify whether a tsunami has actually occurred. This would have the advantage that the process of monitoring earthquake alerts and sea level data could be initiated at relatively modest cost, and potential for reliable and timely tsunami warnings could be assessed. If the results of the study were positive, suggesting that reliable warnings could be issued quickly, this may provide support for the establishment of a permanent tsunami warning system.

DAU

An overview of Fiji's new mining legislation

Ifereimi Dau
Fiji Mineral Resources Department, Suva, Fiji Islands
Email: dau@mrd.gov.fj

New mining legislation for Fiji is currently being drafted. The Bill, to be called the Mineral Exploration and Exploitation Bill, is expected to be presented to the Fiji Parliament in the early part of 2005. The new legislation will replace two current acts, the Mining and the Quarries Acts.

The Bill will have eleven parts. It will be based on six concepts, which include:

- Ownership of minerals
- Access to land and required authorization
- Social and economic impacts (including compensation and royalties)
- Environmental impacts
- Safety and Health in mines, quarries and petroleum exploration and exploitation activities
- Administration

When enacted, the new legislation is expected to bring more transparency into the governance of Fiji's mineral sector.

DOUILLET & others

Fine suspended sediment transport in the south-west lagoon of New-Caledonia

Douillet P.[1], Ouillon S.[1,2], Schmied L.[2], Andréfouët S.[3], Chevillon C.[1], Jouon A.[1] & Fichez R.[1]
[1] UR CAMELIA - IRD Nouméa – BP A5 – 98848 Noumea cedex – New Caledonia
Emails: ouillon@noumea.ird.nc, douillet@noumea.ird.nc, chevillc@noumea.ird.nc, jouon@noumea.ird.nc, fichez@com.univ-mrs.fr
[2] Laboratoire de Sondages Electromagnétiques de l'Environnement Terrestre,
UMR CNRS, Université Sud Toulon Var, BP 132, 83957 La Garde Cedex, France
Emails: ouillon@lseet.univ-tln.fr , Loys.Schmied@lseet.univ-tln.fr
[3] UR COREUS - IRD Nouméa – BP A5 – 98848 Noumea cedex – New Caledonia
Emails: andrefou@noumea.ird.nc

We present results on the integrated study of fine sediment dynamics in the southwest lagoon of New Caledonia, involving in situ measurements, numerical modelling and remote sensing. Coral reef lagoons of New Caledonia cover a total area of 23,400 km^2. The study area extended over an area of 2,000 km^2.

Wind, currents, CTD and turbidity profiles, water and sediment sampling, and hyperspectral reflectance have been regularly recorded so as to support the analysis of hydrodynamics and sediment transport, calibration and validation of the models, and satellite data inversion. The numerical models include a 3D

hydrodynamic model, the wave model Wavewatch III and a classical 3D numerical model for cohesive sediment transport. A 500-m grid size is used in the models. The fine sediment transport is modelled by use of several equations of transport, one per grain-size class. It involves the formulations of Krone and Partheniades for the exchange rates of particles through deposition and erosion, respectively. As bathymetry and sedimentology are highly variable throughout the lagoon, it was not efficient to calibrate the sediment transport model through local time-series. We calibrated the model using sedimentological characteristics and maps of turbidity obtained from OBS measurements and from Landsat7 ETM+ data. Parameters involved in the model are described and discussed.

Turbidity distribution and its variability were analyzed from data collected during 20 field campaigns (1997-2001) under non-storm conditions. Its temporal and spatial variations were analyzed against river discharges, wind stress and direction. It was shown that interannual variability in turbidity apply both to the mean turbidity level and to its vertical distribution. Sediment inputs by rivers were likely expected during La Niña or neutral periods. An increase in stratification in turbidity was observed during La Niña. Resuspension was enhanced by stronger winds during El Niño.

DOWNES & COWAN

Historical tsunami data collection in the South West Pacific

Gaye Downes & Hugh Cowan
Institute of Geological & Nuclear Sciences, PO Box 30-368, Lower Hutt, New Zealand
Emails: g.downes@gns.cri.nz; h.cowan@gns.cri.nz

The southwest Pacific is part of the highly active seismic zone that encircles the Pacific Ocean. Historically, earthquakes, submarine and coastal landslides as well as volcanic activity have caused disastrous local and regional tsunamis. The area has also been affected to a lesser, but still significant, degree by tsunamis generated at great distances. The historical record of tsunamis is almost certainly incomplete. At present, that is, until potential sources have been identified and comprehensive numerical modelling has been carried out, the historical record is the best and most easily obtained information for developing appropriate emergency management response and preparedness strategies for local and distant source tsunamis.

The historical record has many uses, including:

- It provides a first estimate of tsunami hazards and risks. Through a regional coordinator, it can be incorporated into the Integrated Tsunami Database* (ITDB), which provides excellent tools for developing hazard and risk models from historical earthquake and tsunami impact data, and when available, from numerically modelled tsunamis.
- Descriptive accounts of past tsunamis are invaluable for public education.
- It provides a set of scenarios that could form the basis of emergency management exercises.
- It provides essential data for calibration and validation of numerical tsunami propagation and inundation modelling, and for re-evaluating the magnitudes or sources of past events.
- It is useful for identifying sites suitable for paleotsunami investigation.

Collection of historical data is time-consuming, but not highly technical. It requires searching of historical newspapers, Government papers, possibly missionary, shipping, or other early written records, concentrating initially on known local and regional events as well as Pacific-wide tsunamis. Some material is available in New Zealand and Australia, but local resources should be investigated first. Oral history of relatively recent events should also be sought, as well as traditional knowledge and stories/legends, as these are very powerful resource for developing public education material.

---

*The Integrated Tsunami DataBase (ITDB) has been developed by the Tsunami Laboratory, Russian Academy of Sciences, with funding support from the Intergovernmental Oceanographic Commission (UNESCO). It is available freely as a tool for scientists and others involved in tsunami hazard research, emergency management, land-use planning, education, etc. The ITDB consists of historical earthquake and tsunami databases, a geographical mapping subsystem, a data retrieval and analyzing subsystem, and a visualization subsystem. It incorporates many tools, including tsunami travel time and statistical data analysis modules.

EDSALL & others

Medical geology and the health of SOPAC member nation populations: is such an investigation of interest?

Doug Edsall[1], Joseph Bunnell [2] & John Collen[3]
[1]Physics Department, United States Naval Academy, Annapolis, Maryland 21402, USA
Email: edsall@usna.edu
[2]U.S. Geological Survey, MS 956 National Centre, 12201 Sunrise Valley Drive, Reston, VA 20192, USA
Email: jbunnell@usgs.gov
[3]School of Earth Sciences, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand
Email: john.collen@vuw.ac.nz

First mention of the link between medical conditions and geological materials and processes is found in the Greek literature. Only recently has interest in this field of investigation become the focus of geoscientists, medical and public health professionals.

We see an opportunity to investigate the potential links in the indigenous population of a member nation of SOPAC. The ideal candidate population for this study will be from a member nation with known mineral deposits containing one or more of the following elements: Au; Ag; Cu; Ni; Mn; or P. The presence in the soil, food and potable water of hypo- or hyper-concentrations of harmful trace elements associated with these mineral deposits will be determined and related to health problems bearing on the morbidity and mortality of the indigenous population.

We seek to establish a working relationship with professional scientists and administrators in this nation leading to the development of a proposal to fund a comprehensive medical geology investigation.

The purposes of this presentation are to:
- Increase awareness of this issue among STAR/SOPAC meeting attendees;
- Provide data on currently known linkages;
- Enumerate the benefits of the proposed study;
- Describe the data needs, collection methodology and identify local collaborators;
- Introduce the non-SOPAC based team members;
- Gauge SOPAC member interest; and
- Organize a team to develop a study proposal.

Our initiative focuses on one of the SOPAC mandates – the reduction of the vulnerability of its member nations by providing appropriate technologies, knowledge management, technical and policy advice, human resource development and advocacy through an applied geosciences approach

---

FISHER

Ridge 2000 Expeditions to the East Lau Spreading Center in 2004 and 2005 (with a short introduction to the biology of hydrothermal vent animals)

Charles Fisher
Ridge 2000 Program, 208 Mueller Laboratory, Penn State University, University Park, PA 16802, USA
Email: cfisher@psu.edu

Last year during the STAR sessions I reported that a multidisciplinary group of US scientists had successfully obtained a commitment of support from the US National Science Foundation for a series of research expeditions to the Lau Basin. The East Lau spreading center was chosen by the scientific community of the US Ridge 2000 program as the most desirable site for integrated studies designed to increase our understanding of Back-Arc Basin Spreading Centers. We had hoped to schedule a total of five research expeditions to this area in 2004, however due to ship scheduling conflicts 3 of these have been postponed to May and June of 2005. The first 2004 cruise was very successful, and Dr. Martinez will report on the results from that mapping and water sampling effort in the paper following this one. The second

cruise should be underway during this SOPAC meeting, and I will provide an update of the results from the first 10 days of work sampling water and imaging the sea floor. I will also provide an update on the early data from oceanographic monitoring instruments that have been deployed to characterize the currents in the area of the active ridge system. The three cruises scheduled for 2005 will use deep-sea remotely operated vehicles (ROVs) for detailed imaging and sampling of hydrothermal systems identified during the first two cruises. These cruises will identify the central hydrothermal vent site that will be the focus of additional future integrated and interdisciplinary studies. The cruises will also provide more detailed maps and inventories of the chemistry and biology of the hydrothermal systems.

Since I have reported on Ridge 2000 plans several times, I will use the remaining time to provide an introduction to the biology of animals adapted to the extreme environment of deep-sea hydrothermal vents. Although we will likely discover some new species over the course of the planned dives, we also can be confident that we will find giant tubeworms, mussels, and unique snails at the hydrothermal vents in this part of the world. All of these groups harbor chemoautotrophic bacterial symbionts that use the energy in dissolved gases to grow and provide the animals they live in with the bulk of their food. In fact the tubeworms have no mouth, gut or anus and get all of their nutrition from their symbionts. Their anatomy, blood, physiology and even life history are specially adapted to their extreme habitat and I will provide an overview the biology of both the tubeworms and the mussels we are likely to find at active sites on the East Lau Spreading Center.

The Ridge 2000 Program will continue to work with SOPAC and the Kingdom of Tonga to plan these research expeditions, associated education and outreach efforts, and to determine the best way to share all findings with the Kingdom of Tonga and SOPAC. The US Ridge 2000 Program has a data policy that dictates open sharing of data. All data collected will be provided to the Kingdom of Tonga along with the software necessary for accessing and visualizing the data. We will include local scientists in the research expeditions and have begun a significant outreach effort to communicate our findings to the general public and educators (both locally and in the US). You can follow the current cruise on our website.

More information on the plans and dreams for Ridge 2000 research in the Lau Basin is available on our Web site (http://www.ridge2000.com), including the Lau Basin Implementation Plan, a variety of background information, Letters of Intent for funded projects and proposals under consideration, and the newest results from ongoing cruises. 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://www.ridge2000.com) or call 814-865-7434.

FORSTREUTER

Mobile Satellite Image Ground Station for Pacific Island Countries?

Wolf Forstreuter
SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands
Email: wolf@sopac.org

Pacific Island Countries are outside the footprint of any ground antenna that can receive image data providing a special resolution usable for mapping at 1:50,000 or 1:10,000 scales. Space borne images used so far in the Pacific have been stored on onboard tape devices or transferred via relay satellites to ground receiving stations in USA.

IKONOS ground Antenna

European SpaceImaging, a company distributing IKONOS image data, is using a transportable ground receiving station housed in two shipping containers that controls the satellite during the over flight. Such a mobile station could also be temporary placed in the Pacific where it would be possible to receive images directly during the over flight. This has two advantages:

Pacific Island Countries do not depend on the onboard tape capacity, which is mostly booked out, as IKONOS data are also used for military purpose and there is a huge demand to record data all over

the world. The data recording could be used nearly every day when the satellite is in the area of the ground antenna.

The IKONOS satellite is able to move and look sideways. The target areas to be recorded can be programmed up to a few minutes before the satellite enters the Pacific region and having the latest satellite weather images from the geostationary satellites the tasking controller can optimise the recording.

This would enable the acquisition of more cloud free and timely images that can serve many applications that could include vessel monitoring, post disaster analysis and critical resource inventories.

After sufficient image recording from the region, the station could be moved to other areas and the station would be returned when new images are required.

The temporary installation could be financially viable if all Pacific Island Countries agree to jointly purchase the image data.

FORTES

Enhancing IOC/WESTPAC-SOPAC partnership through ocean sciences, ocean services and capacity building

Miguel D. Fortes
IOC Regional Secretariat for the Western Pacific (WESTPAC), 196 Phaholyothin Road, Chatujak, Bangkok 10900, Thailand
Emails: m.fortes@unescobkk.org; westpac@samart.co.th

The South Pacific is richly endowed with natural assets, high biodiversity, and aesthetic beauty. Human resources remain its most valuable resource, but these are not being utilized fully to effect a significant change in the slow pace of its development. This is primarily because the capacity to understand the surrounding oceans, their resources and factors affecting them, the fundamental knowledge to manage and protect them, has not been solidly built. This paper aims to build a solid and lasting foundation for the sustainability of the region's development by helping other initiatives reduce isolation and enhancing self-reliance. This strategy is premised on an enhanced and true partnership between IOC/WESTPAC and SOPAC in addressing three of the five priority issues facing especially the small islands in the South Pacific e.g. coastal and marine resources, climate change, natural and environmental disasters, and climate variability.

Organizations and programmes have played key roles in the development of the South Pacific region. This is through their activities that directly or indirectly address the above issues. Hence, AOSIS, through consultation and consensus, is shaping international policy on climate change. SIDSnet focuses on information management and networking, and CSI focuses on an integrated approach to the prevention and resolution of conflicts over resources and values in coastal regions and small islands. IOC/WESTPAC proposes to help in the development process through sharing and application of knowledge and skills in the ocean sciences, ocean services and capacity building in these domains. This strategy will be anchored on the five principles, which guide the region's ocean policy, e.g. improving our understanding of the ocean; sustainably developing and managing the use of its resources; maintaining its health; promoting its peaceful use; and creating partnerships and promoting cooperation. The results of these initiatives will provide more practical opportunities and options to understand better the Pacific Ocean, its components and processes, and how these affect its resources and people, their way of life, culture and tradition. Improved understanding will further identify other areas of investigation, increase capability to predict trends, improve policy and governance decisions, and benefit various stakeholders.

GAUNA & CANAVANUA

Strengthening hydrological network capabilities in Fiji

Sepesa Gauna[1] & Epineri Canavanua[2]
[1]Suva Water Supply, Public Works Department, P.O. Box 3740, Suva, Fiji Islands
Email: c/- alena@sopac.org
[2]Land & Water Resources Management Division, Ministry of Agriculture, P.O. Box 1292, Suva, Fiji Islands
Email: ecanavanua001@govnet.gov.fj

SOPAC in collaboration with UNESCO and WMO successfully secured funding to conduct the first course of a Hydrological Training Programme developed for hydrological technicians from the Pacific region. As a contribution to the implementation of the Regional Action Plan on Sustainable Water Management and the associated Type II Partnership Initiative, NZAID funded the first course on surface water, which included a mix of both theoretical and practical aspects of surface water hydrology.

The course consisted of 4 weeks of training provided by experienced hydrologists from the New Zealand National Institute of Water & Atmospheric Research (NIWA) and was held at the SOPAC Secretariat in Suva with attendance of hydrologists from the Cook Islands, Fiji, FSM, Papua New Guinea, Samoa, Solomon Islands and Vanuatu.

The presentation will outline the status of the hydrologiocal monitoring network in Fiji and highlight the benefits from the Hydrological Training Programme to Fiji's National Hydrological Service.

GOOSBY

Cyclone Heta visualization and damage losses assessment

Stan Goosby
Pacific Disaster Center, 590 Lipoa Parkway #259, Kihei, HI 9675, USA
Email: sgoosby@pdc.org

On Monday, 5th January, Cyclone Heta passed within of tens of kilometres to the west of Niue. The cyclone (with maximum sustained winds of more than 240km/h) caused major damage to the west coast of the island including Alofi, Niue's Capital. Alofi received significant devastation to both residential and commercial sectors.

One person was killed, several injured and some 200 people (more than 10% of the total population) were left homeless by Heta whose wind speeds rated the highest tropical cyclone ranking (the equivalent of a category five hurricane, or a super typhoon in the western Pacific). The severest damages to buildings and infrastructure were caused by the impacts of waves breaking over 30-meter high cliff where several villages were located.

To minimize future impacts and discuss risk reduction strategies, a joint effort of the South Pacific Applied Geoscience Commission (SOPAC), Global Environmental Modeling System (GEMS), and Pacific Disaster Center (PDC) was established. The goal of this effort is to simulate the impact of Cyclone Heta using numerical modeling of wave impacts, field surveying, scientific visualization, and GIS

The presentation will review the methodology and techniques for assessing damage losses, and show examples of visualization products depicting wave action damage.

Tsunami Visualization and Floods Assessment Methods

The Pacific Disaster Center (PDC) has been collaborating with the South Pacific Applied Geoscience Commission (SOPAC) to demonstrate a methodology for assessing and visualizing the impact of tsunami

inundation in island communities. This methodology was initially applied in Vanuatu to selected buildings in the Port Vila and Mele areas using computer modeling, scientific visualization, analysis tools, and GIS to demonstrate potential losses from a tsunami. The PDC also demonstrated this methodology to the Prime Minister of Fiji and his cabinet, showing how a tsunami would impact the modern Suva city and its facilities, based on the 1953 Suva earthquake-generated tsunami.

The presentation will review the methodology including techniques for assessing tsunami flood losses, as well as show examples of visualization products created for Decision and Policy makers. The presentation will be based on the PDC Vanuatu and Fiji tsunami impact studies.

GRIMES

A history of environmental change and human impact since 3750 BP in the New Georgia Group, western Solomon Islands

Sarah Grimes
School of Earth and Geographical Science, University of Western Australia, Nedlands, Western Australia 6009; and The New Georgia Archaeological Survey, Department of Anthropology, University of Auckland, Private Bag 92019, Auckland, New Zealand
Email: sgrimes@graduate.uwa.edu.au

A palaeo-environmental record for the Western Solomon Islands is presented, inferred from samples selected from modern vegetation, three lowland lake sites and one alluvial swamp in the New Georgia Group. The Group has an established prehistory of 2620 BP (Felgate 2001), which is younger than evidence from elsewhere in the tropical Pacific that suggests the region was initially colonised by an Austronesian-speaking Lapita culture between c 3500 and 2500 BP. The absence of archaeological sites indicating early Lapita groups closer to the apparent "homeland" in the Bismarck Archipelago or throughout the Western Solomons has highlighted a blank in the archaeological map for the Solomons and the Pacific. This thesis suggests human impact in the Western Solomons occurred approximately from 3500 BP, which predates the archaeological record and is in accordance with the more regional Pacific prehistory. As such, palaeo-environmental data by way of fossil pollen, charcoal, macrofossils, radiocarbon and sedimentary analyses provide an indirect method for establishing human presence in the Western Solomons.

Colonisation of the Western Solomons apparently occurred against a backdrop of dynamic environmental changes related to tectonic activities and eustatic movement. Probably, the Vona Vona and Roviana Lagoons, and some surrounding barrier and emergent reef islands were formed during uplift at about 3750 BP. A lake on Parara Island was also formed then. Differential uplift on Rendova Island seemingly formed a coral terrace along the Central Plateau at about 1830 BP and formation of a fresh to brackish lake. Falling relative sea level in the Roviana area probably reached present height at about 2660 BP and was influential in evolution of the lagoon coastline and the development of the Tamberamakoto Lake on Ndume Island. Sea level movement is in accordance with other evidence that suggests levels fell across the regional Pacific between 4000 and 2000 BP. It is suggested that sea level movement has probably obscured evidence for any earlier archaeological sites in the coastal zone. The evolution of the Roviana and Vona Vona Lagoons has set the stage against which early populations were able to colonise the Western Solomons, and subsequent development of the complex Roviana and Vona Vona chiefdoms in later centuries.

Apparently, human impact is associated with increased concentrations of micro and macro charcoal, a decline in tree pollen taxa, an abrupt increase in ferns and grasses, and sometimes episodes of erosion and deposition. Probably, early populations burned to remove forest to make way for settlement, gardens, agriculture and easy access to forest resources for gathering food, textiles and timber, integral to Melanesian subsistence. They may have also brought with them introduced domesticates including grass and breadfruit. The possibility that papaya was introduced to the Solomons, and the Pacific prior to the documented introduction in the 16th Century is entertained. Ferns, as a food source for prehistoric populations are also considered. Useful forest resources included large timber trees, coconut palms, pandanus, figs and woody shrubs such as *Pometia pinnata* and members of the Myrtaceae. Burning and human impact evidently intensified throughout the region after c 2500 until 1000 BP in association with increasing and more widespread population of the area, as documented in the archaeological record. Gardening and permanent settlements were probably established then and associated archaeologically and

anthropologically with the development of the Roviana social and political complex after approximately 1000 BP. Enhanced land capability and the sustained development of the Roviana religious and economic system in response to human impact are suggested.

The possibility of naturally induced catastrophic environmental changes related to ENSO, natural fires, tropical cyclones and associated flooding are considered. Low concentrations of charcoal are probably associated with the natural fire regime. There is evidence for erosion and sedimentation in response to forest clearance and this was exacerbated by heavy rainfall. The sedimentary sequences were too coarse for an indication of major, minor and interannular palaeo-climate reconstruction. As such, disentangling natural from human induced changes was not always clear. Other difficulties and issues in tropical lowland palaeo-environmental research were apparent, including interpretation of radiocarbon dates, and the lack of knowledge of Solomon's tropical flora and an inability to accurately identify many pollen types.

The research exemplifies the value of understanding the changing nature of past landscapes, the underlying causes and complexity of these changes, both natural and/or human, and how these factors contribute to a more accurate interpretation of prehistory and history of human impact in the tropical Pacific. The research extends the limited knowledge for the Solomons' environmental database and provides baseline scientific data against which to measure non-anthropogenic impacts and an analysis of how human impacts have contributed to changes in a lowland tropical environment over the last few millenia and into the present. This provides a framework for continued palaeo-environmental research there and in the Pacific, which assists in improving, and determination of, biological conservation and ecologically sustainable development in an area that has an urgent need for appropriate environmental planning and resource management.

HERBIG & others

Rolling stones from Korolevu Reef (Viti Levu, Fiji) – controls on composition and zonation

Hans-Georg Herbig[1], Ramon Brentführer[2] & Susanne M. Pohler[3]
[1]Institut für Geologie und Mineralogie, Universität zu Köln, Zülpicher Str. 49a, D-50674 Köln, Germany
[2]Institut für Geologie und Mineralogie, Universität zu Köln, Zülpicher Str. 49a, D-50674 Köln, Germany
[3]Marine Studies Programme, University of the South Pacific, Suva, Fiji Islands
Emails: herbig.paleont@uni-koeln.de; georam@gmx.de; pohler_s@usp.ac.fj

Carbonate secreting organism forming mobile encrustations, also termed macroids, oncoids or rolling stones, as well as immobile encrustations are known since Precambrian times. The modern association of predominating crustose red algae and associated secondary groups, like encrusting foraminifers, bryozoans and scleractinians evolved during the Late Cretaceous and flourishes since the beginning of the Cenozoic. Macroid formation is an important factor in formation of gravel-sized near-shore carbonates, and, together with immobile encrustations, in binding of sediment. Both processes contribute to formation and stabilisation of carbonate platforms and insular shelves. Biotic and environmental factors controlling composition, zonation and redistribution of modern mobile and immobile encrustations apparently remained poorly studied in the Pacific. They are crucial to understand sediment dynamics and fossil counterparts, which, vice versa, could give insight into (most probably interdependent) longer-term processes, e.g. changes in sealevel, predominating biota, productivity, and preservation potential.

Herein, we present results based on our study of two transects at the Korolevu fringing reef, situated about 80 km west of Suva at the Coral Coast of Viti Levu (Fig. 1).

Transect A, almost 600 m in length, is situated directly west of Korolevu Bay in a predominantly carbonate environment. It runs from the beach across the reef flat to the reef front. Three facies belts are discerned: (1) *Porites* microatoll belt. About 180 m wide, it forms a shallow channel parallel to the beach, with maximum water depth of 1,5 m during low tide (2) *Sargassum* belt. About 300 m wide, it extends across the reef flat, covered only by a thin film of water during low tide. In addition to extensive *Sargassum* covered areas, a second subfacies is characterized by irregular, shallow depressions without vegetation, filled with carbonate sand and reef rubble.(3) Coral reef belt. About 100 m wide, it includes the reef crest and ends at the seaward slope of the reef.

Transect B, about 150 m in length, was measured from the beach into Korolevu Bay. Due to fluviatile sediment input from two rivers, a mixed siliciclastic-carbonate environment developed in the peritidal zone. A almost 100 m wide seagrass belt is followed by a 50 m wide *Sargassum* belt with subfacies as known from transect A. The measured section ends at the subtidal lagoon, which is characterized by predominating siliciclastic sand and gravel.

Rolling stones of differing biotic composition and shape have been encountered in all facies, but are more common and more diverse in the pure carbonate environments of transect A. Dominating encrusters, in decreasing abundance, are crustose red algae, corals (mostly *Porites*, scarce *Siderastrea*) and foraminifers (*Homotrema rubrum*, Acervulinidae indet., *Carpenteria*). Serpulids and bryozoans occur only sporadically. Films of cyanobacteria seem to be important in the primary fouling of encrustable surfaces, i.e. mostly coral debris, but also of other bioclasts and siliciclastic cobbles.

Zonation of encrustations in transect A: Most spectacular are scattered *Porites* coralliths, which apparently remained unstudied in the Pacific except for Scoffin et al. (1985). Those globally poorly documented macroids grow on the seaward slope of the microatoll belt. Hemispherical growing crusts of *Porites* and intercalated thin laminae of crustose red algae prove restricted, episodic rotation of the macroids, but without measurable lateral transport along the microatoll belt into the adjacent Korolevu Bay, where coralliths were not observed. Episodic rotation seems to be mostly related to the activity of fishes, which are abundant during high tide. Bioturbation by other organisms, like crabs, cannot be excluded. After exceeding a size limit, the coralliths form the nucleus of the *Porites* microatolls. Associated are rare coral-crustose red algae-foraminifer-macroids, boxwork rhodoliths, and irregularly shaped multispecific rhodoliths characterized by patchy overgrowth of a delicate species. The development of this diverse macroid assemblage is related to the mostly unidirectional, constant flushing of water down from the reef flat into the microatoll belt, even during low tide. In the somewhat deeper water of the central microatoll belt immobile encrustations and protorhodoliths, i. e. rhodoliths consisting of thin crusts and still displaying the shape of the nucleus, are abundant. The restricted growth is tentatively related to increased bioerosion. Within the sand and rubble filled depressions of the *Sargassum* belt, well-developed mature rhodoliths with thick, concentric growing laminae and a bumpy surface predominate; rare foraminiferal macroids are associated. Concentric growth structure proves more or less continuous hydrodynamic rotation. The low diversity within and between the macroids points to elevated environmental stress, i. e. increased salinity, temperature and UV radiation. Quite abundant protorhodoliths probably have been derived from the coral reef belt by storms. In the latter, especially mm-thick encrustations and protorhodoliths occur because of the intensive hydrodynamic energy at the reef front.

Zonation of encrustations in transect B: Within the non-agitated waters of the seagrass belt, immobile, unidirectionally growing encrustations are abundant. However, mature rhodoliths are abundant as well. Those are interpreted to be washed in during periods of elevated wave energy from the *Sargassum* belt, i. e. from the zone of their main formation, as observed in transect A. Most probably, wave agitation enables their more or less continuous rotation at the transition from the subtidal waters of the lagoon to the intertidal *Sargassum* belt. In contrast to transect A boxwork rhodoliths are more frequent; serpulids and foraminifers are more abundant, and corals less abundant biota in encrustations. This is related to the increased siliciclastic component in Korolevu Bay.

In conclusion, studies of encrustations and their zonation can give important insight into the hydrodynamic regime within the fringing reef system and its complex interplay with sedimentary and biotic factors.

References:

Scoffin, T. P. et al., 1985, Rhodoliths and coralliths of Muri Lagoon, Rarotonga, Cook Islands, Coral Reefs, 4, 71-80.

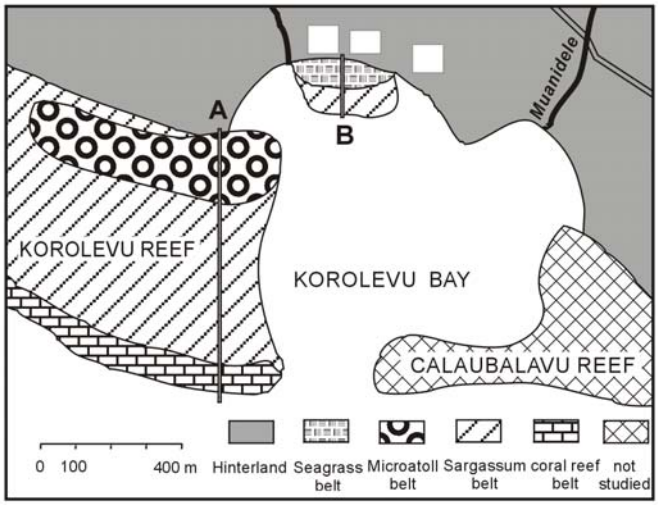


Figure 1. Facies map of the fringing reefs at Korolevu and position of the studied transects

---

HEYDON

Likely Directions in Deep Ocean Mining to 2010

David Heydon
Nautilus Minerals Limited, Level 7, 116 Miller Street, North Sydney, New South Wales 2060, Australia
Email: dheydon@NautilusMinerals.com

Given the interests by the likes of the Japanese, Korean and Indian government agencies, the big money appears to be backing both manganese nodules and manganese crusts as the most likely deep ocean mining development by 2010, but seafloor massive sulphides of copper/gold/zinc offer an alternative bet for a start-up by 2010. A study of the "form guide" or comparison of these resources provides direction on which resources are economic candidates for commercial deep ocean mining development by 2010.

This paper covers the commercial and technical issues of exploration, resource definition, drilling/sampling, sea bed mining options, mine plans, environmental issues, legal tenure and capital and operating costs (i.e., profitability) of these two mineral types.

Nautilus Minerals has just completed a pre-feasibility engineering study of mining sea floor massive copper/gold/zinc sulphides at 2,000 m depth. The Nautilus study reviewed a range of mining and lifting options, settling on tracked continuous drum cutter miners to produce 2 million tons per annum of high grade ore. Capital costs are shown to be at least 30% lower than a land based copper mine of the same production capacity. Likewise 75% of world's copper would be produced at a higher operating cost that the proposed seafloor mine. This paper then draws on the Nautilus study for comparison with earlier feasibility studies by others on manganese nodule mining to predict the likely directions in deep ocean mining to 2010.

Once it is determined which resource type is the most likely to be developed by 2010, the next question is where will such development take place. There are extensive manganese and sulphide mineral resources in both International waters and the EEZ of SOPAC island states. Accordingly, SOPAC island states are competing with the International Seabed Authority for the exploration dollar of those interested in such sea bed mineral resources. Evidence from the number of applications to explore granted by ISA compared to those granted by SOPAC island nations would suggest that the ISA is more competitive and attractive to exploration. We compare the competitiveness of both regimes and highlight areas that SOPAC member countries could address if they wish their sea bed mineral resources to be developed before, or many years after, those controlled by the ISA. It is clear therefore that the SOPAC island states by their own policy decisions can influence the "Likely Directions in Deep Ocean Mining to 2010".

JOHNSON

Geohazard monitoring, information management and risk assessment: new trends and drivers in Australian disaster mitigation

R. Wally Johnson
Geoscience Australia, GPO Box 378, Canberra, ACT 2601
Email: Wally.Johnson@ga.gov.au

A profound and inexorable trend has taken place in Australian disaster management over the last ten years from a position in the early 1990s dominated by hazard monitoring and disaster relief and recovery. A more integrated approach is emerging, characterised by a greater focus on natural-hazard *impacts*, rather than just the geophysics of the hazards themselves; on assessments of the vulnerability of the built environment, infrastructures, lifelines, and communities; on economic loss estimation and post-disaster loss assessment; and on the use of spatial information coupled with Geographic Information Systems (GIS) and risk assessment and modelling techniques.

The Geohazards Division in Geoscience Australia has been part of this trend. It now has a new skills profile that reflects the shift in emphasis. Our scientific staff still include geophysicists, but new fields of expertise include civil and software engineering, regolith and structural geology, applied mathematics, information management, economics, and social science. Staff work closely with counterparts in federal and State/Territory government agencies and in universities on a range of projects.

Four principle drivers are responsible for the paradigm shift towards a greater emphasis on disaster mitigation and risk:

(1) The International Disaster Decade for Natural Disaster Reduction (IDNDR) during the 1990s which succeeded in setting the scene for change.

(2) The Australia and New Zealand risk-management standard (AS/NZS 4390:1999 Risk Management) which now forms the fundamental framework for disaster-mitigation research.

(3) The 2002 Report to the Council of Australian Governments (COAG) entitled *Natural Disasters in Australia: reforming mitigation, relief and recovery arrangements* (published in 2004) which forms the high-level rationale for government funding for the Disaster Mitigation Australia Package (DMAP).

(4) Responses to the terrorist attacks on 11 September 2001 in the USA and on 12 October 2002 in Indonesia, including enhanced work by the National Counter Terrorism Committee (NCTC) and the Australian New Zealand Land Information Council (ANZLIC) and their focus on critical infrastructure protection (CIP). This counter-terrorism and CIP work is having a profound impact on disaster-mitigation research in general given that it adopts an 'all-hazards' approach.

Implications of these trends for the SOPAC work program are worth exploring.

JONES

Implementing a community risk management programme in the Pacific

Roger Jones
TEM Consultants P/L, P.O. Box 142, Mt Macedon, Victoria, Australia
Email: temcons@netcon.net.au

Earlier disaster management activities in the Pacific had followed the traditional approach in focussing primarily on natural and man-made *hazards* and on developing capacity for preparedness and response to *events*. This was the approach of early internationally-sponsored programmes, which assisted many island countries in developing national and local disaster management plans and supported the establishment of

National Disaster Management Offices (NDMOs) as key agencies. However, these activities gained only limited support from national governments and levels of community vulnerability have not decreased significantly.

In 2000, responsibility for such activities was accepted by SOPAC. SOPAC's small Disaster Management Unit (DMU) developed a new approach based on risk management concepts and principles. An early initiative of the DMU was the commissioning of a community risk management tool based on the recently-adopted Australian/New Zealand risk management standard, AS/NZS 4360 (CHARM, 'Comprehensive Hazard And Risk Management').

Trials and initial application of this tool rapidly demonstrated that disaster management programmes needed to be integrated with a wide range of national policies encompassing issues in the areas of sustainable development, sustainable living, poverty alleviation and environmental management. New approaches were needed.

In early 2003, the importance of SOPAC's community risk management activities was recognised by the establishment of the Community Risk Programme as one of the three key SOPAC programmes, with the goal of reducing community vulnerability and improving disaster management through hazard mitigation and disaster management activities. The Programme's three key component elements address Strengthening Resilience to Disasters, Mitigating the Effects of Hazards and Mainstreaming Disaster Risk Management.

This presentation briefly outlines the history of the Programme before detailing the concepts, principles and methodologies employed in assisting in the development of a comprehensive and integrated approach to community risk management in PICs.

KALOUMAIRA & KONG

Developing Pacific Islands Regional Strategies to Reduce Tsunami Risks: "*South Pacific Tsunami Awareness Workshop 1-3rd July 2004*"

Atunaisa Kaloumaira[1] & Laura S.L. Kong[2]
Co-convenors, South Pacific Tsunami Awareness Workshop
[1]SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji Islands
Email: atu@sopac.org
[2]UNESCO/IOC International Tsunami Information Centre, 737 Bishop St., Ste. 2200, Honolulu, HI 96813 USA
Email: laura.kong@noaa.gov

SOPAC co-convened with the assistance of the UNESCO/ Intergovernmental Oceanographic Commission and its International Tsunami Information Center (UNESCO/IOC-ITIC) a ***South Pacific Tsunami Awareness Workshop*** from 1-3rd July in Suva. It brought together technical experts and those in the disaster management fraternity from the countries of Papua New Guinea, Solomon Islands, Vanuatu, Tonga, Samoa, American Samoa, Cook Islands and Fiji. It has been useful for the region with the involvement of scientists resourced through UNESCO/IOC-ITIC.

Country responses to an end-user questionnaire survey identified as foremost of the many issues at stake are the inadequacies of national response systems, communication systems and education and awareness programmes. Countries currently receive international tsunami warnings but without the above remain very vulnerable. Further island countries have very little understanding of regional and local tsunamis hence no one country is really prepared. The events in Pentecost Island (1999 – 10 deaths) and Aitape (1999 – 2200+ deaths) are a sharp reminder of the tragic and destructive effects of local tsunamis. Other land mass-movement processes are now important in understanding local and regional tsunamis.

The Workshop discussed regional strategies and action plans to address the disparity across the region. A number of critical activities and the processes to facilitate implementation were identified, with SOPCA having the major coordinating role. Two key ones were the proposals to set-up a ***Tsunami Working Group-South Pacific (TWG-SP***) and secondly a feasibility study on ***Regional Tsunami Warning Services.*** Interest in better understanding tsunami hazards was further expressed on improving the

collection of local tsunami data and researching tsunamis, and technological collaboration, particularly amongst current regional programmes, to assist monitor and reduce tsunami risks.

Given the keen interest of STAR in addressing tsunami science, hazards and risks, the presentation seeks to gain greater support on the proposed activities. Consultation in STAR is important towards identifying the operational requirements to put these concepts successfully in operation, particularly a Regional Tsunami Warning Service, and to align process with the regional strategy and framework on disaster reduction that SOPAC is developing for presentation to the 2nd World Conference on Disaster Reduction in Kobe Jan 2005.

KALUWIN & LAL

AusAID South Pacific Sea Level & Climate Monitoring Project Phase III

Chalapan Kaluwin[1] & Andrick Lal[2]
[1]Australian Marine Science & Technology, Forum Secretariat Complex, Suva, Fiji Islands
E-mail: amsatck@connect.com.fj
[2]SOPAC Secretariat, Suva, Fiji Islands
E-mail: andrick@sopac.org

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 relay that sea level is rising due to the thermal expansions of the seawater or is it the tectonics movement of the sea floor or is it the contributions from the land ice. All of these contribute to the sustainable development of communities and their very existence, which is threatened by inundation and damage to their fresh water supply.

Therefore the South Pacific Sea Level and Climate Monitoring Project is monitoring sea level change. It is being funded by AusAID and is managed by Australian Marine Science & Technology and being coordinated by the National Tidal Centre Australia and Geoscience Australia. The project is now in its forth 5-year phase [Phase III] of its 20-year project. This project started in October 1992 where by Phase II and I are completed. The regional office of this project is based at the Forum Secretariat Building office in Suva, Fiji Islands. SOPAC has been approached as one of its regional partners in the project, contributing towards technical assistance and also being the regional data archive centre for the project.

This project aims to provide high quality meteorological and sea-level data through an array of latest climate monitoring stations, backed by the precise geodetic survey network in the region 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 they are used by the meteorological department, lands and survey department and by the 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 whereby vertical control stations are established with the survey data also being used by the surveyors for their land and geodetic surveys. The surveyors and the navigators are benefiting from the establishment of the Continuous Global Positioning Systems survey network by this project. Both the SEAFRAME and the CGPS stations are tied together using the precise differential levelling surveys.

The raw CGPS data is distributed and made available to the participating South Pacific Forum countries, and the global scientific community in the international standard Receiver Independent Exchange Format (RINEX). The data provides benefits to the national infrastructure of the participating countries with opportunities to undertake:

- Upgrading their geodetic survey network
- Unifying height datums, nationally and regionally
- Determining transformation parameters

- Cadastral and Engineering Surveys
- Digital Elevation Models (using kinematic GPS and geoids)
- Coastal Zone Management
- Mitigation

The project data and information are produced in various forms of fact sheets, SEAFRAME & CGPS data reports, six-monthly newsletters and tidal calendars.

KALUWIN & MITCHELL

Seaframe gauges potential for tsunami early warning systems in the Pacific region

Chalapan Kaluwin[1] & Bill Mitchell[2]
[1]Australian Marine Science and Technology Ltd, Suva, Fiji Islands
Email: amsatck@connect.com.fj
[2]National Tidal Centre, Bureau of Meteorology, Adelaide, Australia
Email: bill@pacific.ntf.flinders.edu.au

The South Pacific Sea Level & Climate Monitoring Project funded by the Australian Government (AusAID) was initiated and implemented in 1990 for the Forum Countries to improve their understanding over the potential impacts of an enhanced Greenhouse Effect (global warming) on Climate and Sea level Changes in South Pacific region. The challenge of the project is to measure absolute and relative sea level changes in countries and the region for a long term so that the data and information can be used to assist the PIC Governments develop policies and measures to mitigate the impacts of climate change, variability and sea level rise.

Sophisticated instruments such as the SEAFRAME (Sea Level Fine Resolution Acoustic Measuring Equipment) coupled to the Continuous Global Positioning System (CGPS) with sensitive sensors have a resolution and precision of + 0r – 1 mm for this monitoring and research programme.

However, whilst the SEAFRAME (Figure 1) can measure accurately the water level, wind speed, pressure, air and water temperature, the tool has a great potential and application to measure and monitor waves generated as a result of undersea earthquakes, landslides or volcanoes- "Tsunami waves". The SEAFRAME station has the capacity to operate with various, site-specific combinations of sensors, averaging and sampling intervals. These combinations can be adjusted or tailored to assist in the Tsunami warnings or strategy for the Forum countries as well.

Results of the work of the project and its application on issues like Tsunami and extreme events in the region and in countries like Papua New Guinea, Vanuatu and Fiji will be discussed in support of national and regional disaster management programmes.

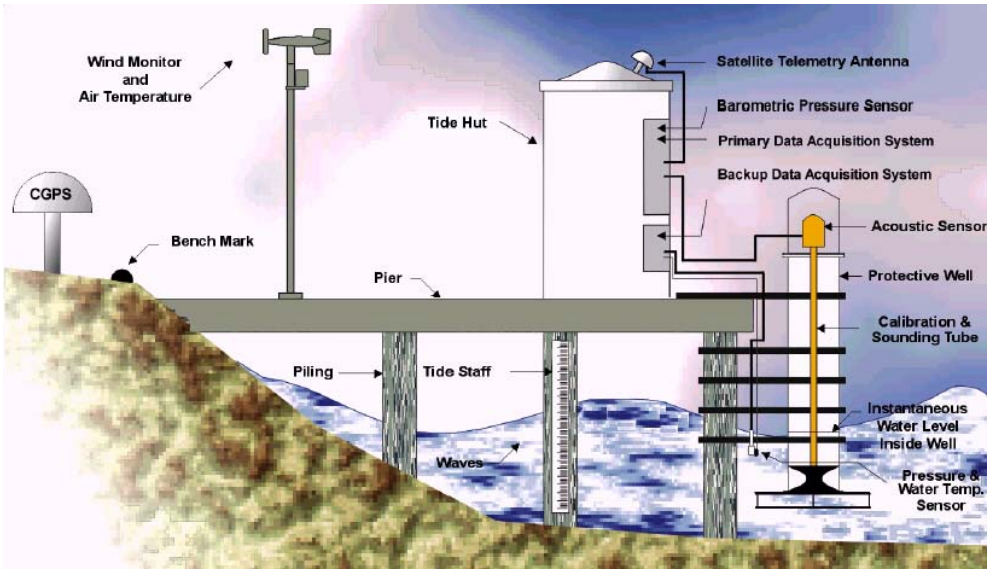


Figure 1. SEAFRAME Station.

KILMER & KROENKE

The Sasa Fault: A Major Strike-Slip Fault on Guam

Frank H. Kilmer[1] & Loren Kroenke[2]
[1]89456 Sutton Lake Road, Florence, Oregon 97439, USA
Email: officeco@oregonfast.net
[2]School of Ocean & Earth Science & Technology, University of Hawaii at Manoa, Honolulu, HI, 96822 USA
Email: kroenke@soest.hawaii.edu

Early Tertiary volcanogenic rocks (Facpi and Alutom formations) of Palau-Kyushu-Arc origin are exposed in central and southern Guam and are truncated by the northeast-trending Sasa Fault. The fault exhibits left-bending ridges, "left-offset" drainages, and juxtoposes markedly differing lithofacies. This evidence, coupled with the exposed fault length, suggests left-lateral motion in excess of 4 miles. The fault truncates early Oligocene strata (Alutom Fm;~32 Ma) and is bracketed by apparently unfaulted, late middle Miocene deposits (Alifan Fm; ~12 Ma).

Faulting along the Sasa Fault, accompanied by folding and uplift, took place within the original boundaries of the West Mariana Ridge, an elongate slab split-off from the PKA by initiation of spreading (~32 Ma) of the intervening Parece Vela Basin. The WMR, at this time, represented the "leading edge" of the Philippine Sea Plate which was undergoing subduction by the west-northwest directed Pacific Plate. The Mariana Ridge, a later rifted-off portion of the WMR carrying Guam geology, would not come into existence until late Miocene (~10 Ma).

Paleomagnetic studies by Koyama et al. (1992) show that the WMR "leading edge" had a roughly north-westerly orientation during the late Oligocene/early Miocene interval (25 Ma - 15 Ma). In this configuration, and during this approximate interval, it is postulated that deformation, resulting from oblique subduction stresses directed upward into the WMR by the under thrusting Pacific Plate caused the Sasa Fault to form accompanied by folding and uplift. Similar left-lateral strike-slip faulting along the Bonin Arc/Pacific Plate boundary (Oligocene) has been postulated by Karig (1975).

KONG & KALOUMAIRA

Regional tsunami warning services for the South Pacific

Laura S.L. Kong[1] & Atunaisa Kaloumaira[2]
Co-convenors, South Pacific Tsunami Awareness Workshop
[1]UNESCO/IOC International Tsunami Information Centre, 737 Bishop St., Ste. 2200, Honolulu, HI 96813 USA
Email: laura.kong@noaa.gov
[2]SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji Islands
Email: atu@sopac.org

Tsunamis are an underrated hazard that have and can have a major impact on Pacific island countries. Recent tsunami events in Papua New Guinea (1998, Aitape, magnitude 7.1, 2200 deaths) and Vanuatu (1999, magnitude 7.3, 5 deaths) demonstrate their vulnerability to the destructive nature of tsunamis. Currently, the Pacific Tsunami Warning Center provides international tsunami warnings to the Pacific for large earthquakes greater than magnitude 7.5 and tsunami information bulletins for earthquakes greater than magnitude 6.5, but is not able to monitor the regional seismicity occurring at lower magnitudes. Historical tsunami data for the region reveal the destructive tsunamis have been generated by smaller earthquakes measuring as low as magnitude M5.8 (1930, Bismarck Sea, 10 fatalities). During the first consultation on tsunami hazards, held July 1-3, 2004 in Suva, Fuji, disaster managers and technical experts agreed on number of important priorities, and made recommendations on Objectives, Outcomes, and Activities in the themes of Tsunami Hazard and Risk Identification, and Preparedness for Effective Response. Within the first theme, participants identified the urgency for better regional tsunami warning services, and recommended the formation of Tsunami Working Group for the South Pacific, and the conduct of a feasibility study that would assess the mitigation needs of each country, and the existing seismic and water level data and information technology and communications infrastructure that would be required to support such a regional tsunami warning centre for the South Pacific. In order to proceed, it is proposed to conduct the Feasibility Study in two phases, with Phase I addressing the collection of country information on tsunami mitigation needs, existing infrastructure, and the identification of the requirements for a tsunami warning service. Phase II would concentrate on the deployment of a pilot tsunami warning centre project to demonstrate at a smaller scale the data collection, seismic and water level evaluation, and the tsunami warning protocols and communication processes essential for the full implementation of a warning centre.

South Pacific Tsunami Awareness Workshop 1-3rd July
Strategic Recommendations for Addressing Tsunami Risks

EMERGING THEMES and MEASURES OF SUCCESS:

Involve all countries and national stakeholders to build capacity and develop human resources to support the data information needs in tsunami risk reduction.

Establish partnerships to integrate regional risk management tasks within the CHARM framework.
Build international and intra-regional cooperative relationships to support tsunami risk reduction activities (modeling, risk assessments, best management practices, data sharing, warning systems etc.).

Advocate to ensure Information Technology and Communication (ICT) infrastructure sufficiently supports regional and national requirements for tsunami warning services

THEME 1. TSUNAMI HAZARD AND RISK IDENTIFICATION

Objective	Expected Outcomes	Activities to achieve Objective
1. To establish a regional Tsunami Warning System (TWS) in order to provide early warning for regional earthquakes under PTWC magnitude threshold Basic components of the TWS: Data observation network (seismic and water level stations to monitor seismicity and sea levels) Data transmission and receiving systems for TWS evaluation, and data sharing amongst nations Data processing system at center for acquiring, archiving, and tsunamigenic evaluation (operating 24h/7d) Dissemination of warnings	**Expected Within 2 yrs:** Technical proposal for the creation of a Southwest and Central Pacific TWS. Coordinated by the TWG-SP **> 2 yrs:** Establishment of a Regional TWS capable of responding to Pacific needs All South Pacific countries become members of ICG/ITSU Clearinghouse for distribution of information/data	**< 2yrs:** Conduct Feasibility Study with existing observational data and communication infrastructures **> 2yrs:** SP countries establish networks and infrastructure for early warning system in the region SOPAC with support of ITIC to liase with countries in encouraging ICG/ITSU membership. PDC in coordination with SOPAC and ITIC to establish clearinghouse for distribution of information/data
2: To identify areas at risk and to develop hazard mitigation plan for each of these areas.	**Expected Within 2 yrs:** Historical earthquake and tsunami database for region based on international guidelines that would support early warning and tsunami risk management (Member countries of WG, GTDB Project, NZ, Australia, ITIC, PDC) **> 2 yrs** Production of maps/inventories on vulnerable sites/areas of the region National/Regional Reports on Tsunami risk assessment and management for the region Incorporate Tsunami Risk Assessment to National Disaster Mgmt Plans (Member govts with international support)	**< 2yrs** SP countries with support of SOPAC and GTDB Project, ITIC and PDC to collect data on historical seismicity, tsunami, and volcanic events. economics, population, critical infrastructure and lifelines, and other environmental hazards **> 2yrs** SP countries with support of SOPAC to assess potential tsunami impact and undertake modeling for at-risk areas

THEME 2. PREPAREDNESS FOR EFFECTVE RESPONSE

Objective	Expected Outcomes	Activities to achieve Objective
1. Develop Framework for Effective Response System for Preparedness and Emergency Response To Tsunamis	1.1 Guidelines available for developing plans	1.1.1 Conduct user questionnaire surveys 1.1.2 Develop guidelines for developing plans
	1.2 A timely response to tsunamis	1.2.1 Develop national tsunami response plans
	1.3 Tsunami-ready community	1.3.1 Develop partnership for acquiring educational material 1.3.2 Development of education programme and target key stakeholders (e.g. community, politicians, first responders). 1.3.3 Incorporation of training in formal and informal education 1.3.4 Develop national education strategy (tsunami)
2. Develop regional and national capacity (technical and management)	2.1 Provision of accurate and timely information	2.1.1 Raise tsunami awareness at national and community levels 2.1.2 Conduct table top exercises 2.1.3 Conduct an assessment on current capability of communication network 2.1.4 Communication / Media 2.1.5 Networking with national and regional partnership

---

KROENKE & WESSELL

Subduction zone development and accretionary processes in the Southwest Pacific

Loren W. Kroenke[1] & Paul Wessel[1]
School of Ocean & Earth Science & Technology, University of Hawaii at Manoa, Honolulu, HI, 96822 USA
Emails: kroenke@soest.hawaii.edu; pwessel@hawii.edu

The tectonic development of the Southwest Pacific entails a complex sequence of ocean basin and oceanic plateau formation, subduction zone development, island arc formation, back arc spreading, and arc and oceanic plateau accretion. Although much of the developmental history has been obscured by subduction zone ingress, it is clear that major events occurred at roughly 122, 96, 85, 76, 65, 55, 47, 34, 27, 23, 18, 12, 6, and 2.6 Ma. It is also clear that, for the most part, these events coincided with major changes in motion of the Pacific and Australia lithospheric plates. These events, among others, included: formation of the Ontong Java Plateau at 122 Ma, the beginning of Australia-Antarctic slow spreading ~96 Ma, spreading initiation in the Tasman Basin and along the Osbourn Trough at ~85 Ma, the end of spreading along the Osbourn Trough and the beginning of spreading in the New Caledonia Basin at ~76 Ma, the end of spreading in the New Caledonia Basin and the beginning of spreading in the Coral Sea Basin at ~65 Ma, the beginning of Papuan-New Caledonia-Norfolk trench subduction and the end of Tasman Basin spreading at ~55 Ma, beginning of Melanesian (Manus-Kilinailau-Vitiaz) Trench subduction and formation of the Louisiade Plateau over the Lord Howe Hotspot ~ 47 Ma, beginning of subduction along the Loyalty - Three Kings Ridges and spreading in the Caroline, D'entrecasteaux, and South Fiji basins at ~34 Ma, the collision of the Caroline Basin with the Manus Arc which stopped subduction along the Melanesian Trench and caused Caroline Basin spreading to end concomitant with the end of spreading in the D'entrecasteaux and South Fiji basins as subduction began along the Tonga Trench at 27 Ma, the beginning of Maramuni - Trobriand subduction at 23 Ma, increasing drag exerted by the accreting Sepik terrain which may be responsible for the extension occurring along the Maramuni Arc at 18 Ma, the beginning of South Solomon (New Britain-San Cristobal-New Hebrides) Trench subduction at 12 Ma, the opening of the Woodlark and Manus basins and the beginning of Lau Basin rifting as the Australia plate-Ontong Java collision begins and Viti Levu collides with the northern end of the Tonga Arc at 6 Ma, and finally the intensification of the Australia plate-Ontong Java collision as Ontong Java Plateau crust is folded and obducted in the Solomon Islands to form the Malaita Anticlinorium and the Island of Malaita.

LAFOY & others

Structural style of offshore basins, western New Caledonia (Southwest Pacific): implication for petroleum potential

Lafoy, Y.[1], Brodien, I.[2], Vially, R.[3], Buisson, D.[4]
[1]Direction de l'Industrie, des Mines et de l'Energie, BP 465 - 98 845 Nouméa, Nouvelle-Calédonie
[2]University of Utah, Salt Lake City, USA
[3]Institut Français du Pétrole, 1 & 4, av. de Bois Préau, 92853 Rueil-Malmaison, France
[4]Service des Méthodes Administratives et de l'Informatique, BP 8231 Nouméa Sud, Nouvelle-Calédonie
Emails: yves.lafoy@gouv.nc

Since Cretaceous times, the geodynamic history of the Southwest Pacific region has been dominated by the dismembering of Gondwana. Surprisingly, the Fairway Basin (FB) and the New Caledonia Basin (NCB), two key-features located between the Lord Howe Rise and the New Caledonia–Norfolk Ridge, remain poorly known and theirs origins still controversial.

Bathymetric, gravity, magnetic and Multichannel seismic data on both basins have been interpreted into a synthetic structural map which shows that:

i) a central "en echelon" SW-NE fault with a N-S relay-zone centred at 23°30'S, extends from the western edge of the FB to the southern segment of the NCB, south of 22°40'S;

ii) the FB trends NW-SE and NNW-SSE north and south of 24°30'S, respectively. Characterized by an average sedimentary infilling of 3 km, a BSR-like (Bottom Simulating Reflector) reflector, interpreted as the base of a possible gas hydrate layer, and diapir-like features (sedimentary and volcanic intrusions) within Cretaceous deposits, the FB is interpreted as a perched basins, with a thinned-continental substratum. Petroleum modelling has shown that both depth and thermal conditions are adequate for gas hydrate to be stable within the upper part (more than 500 m) of the sedimentary cover. However, further studies are necessary to unveil the origin of the likely gas hydrates;

iii) the NCB trends NW-SE and N-S north and south of 23°S, respectively. The northern segment basement shows an "horst and graben" structure with westward-tilted blocks filled by 8 km-thick sedimentary deposits. Within the deeper part of the NCB northern segment, modelling shows that the thickness of Cretaceous and Tertiary sediments is sufficient to generate liquid and gaseous hydrocarbons. As the basin's depocentres have migrated toward the west since Cretaceous time, the petroleum system described onshore can thus be extrapolated to the NCB northern segment, with Cretaceous tilted-blocks as structural traps.

The eastern end of the SW-NE "en echelon" fault is interpreted as a boundary fault zone that separates the NW-SE and N-S segments of the NCB characterized by a thinned-continental and an oceanic basement, respectively.

Considered as the western and eastern margins of the NCB, respectively, both the FB and the West Caledonia Basin (WCB) lie symmetric and equidistant from the NCB's N-S buried ridge, the latter being identified as the former basin's spreading center. The end of the continental stretching within FB and WCB is interpreted to be contemporaneous with the emplacement of an oceanic-like crust within the NCB's southern segment.

Based on existing gravity data, by extrapolation of our data toward the south, FB can be extended further south, down to Taranaki Basin. Therefore, NCB likely ends further north than previously thought, within the Reinga Basin that lies at 32°S, northwest of New Zealand.

One of the main objectives of the forthcoming ZoNéCo 11 Multichannel seismic cruise (sept.-oct., 2004 aboard R/V L'Atalante) will be to confirm: i) the likely thinned continental nature of WCB, northern NCB and FB, through a seismic refraction survey; and ii) the BSR-like reflector occurrence and extension within the FB and WCB.

LAWEDRAU-MOROCA

Rainwater Harvesting Demonstration Project in Vava'u, Tonga

Alena Lawedrau-Moroca
SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji Islands
Email: alena@sopac.org

In late 2001, SOPAC signed a Project Document Agreement with the United Nations Environmental Programme (UNEP) to implement a demonstration project on Rainwater Harvesting in the Pacific. The project was titled "Empowering Women in Rainwater Harvesting in Pacific Atoll Islands and its main purpose was to increase women's participation in implementation of rainwater harvesting systems and to increase quantity and quality of water for project communities.

Tonga was chosen as the study area after meeting the selection criteria set out in a decision matrix that had been developed to evaluate the suitability of each of the six prospective countries that were short listed. The Tonga Development Community Trust (TCDT) was contracted as the local partner to implement the project at the proposed field sites using the resources of its existing Village Women's Development Programme network (VWDP). A peri-urban and a rural site were chosen to house the project and both sites were based in Vava'u.

Following stakeholder consultations, the project has gotten underway and initial surveys were carried out when SOPAC personnel visited the peri-urban site in May, 2003. Two other visits have been done since the

inception of the project. A second visit to conduct more technical and social surveys at the first site and also inspect the second project site. The 3rd visit was to conduct community participation training workshops for the VWDP extension workers who would then run the community participation workshops in the two communities.

To date, 30 water tanks have been constructed at Utungake, the peri-urban site of the project and another 8 tanks are to be constructed at Matamaka, the outer island site. Knowledge gained from the project is being used to compile a Guideline on rainwater harvesting methods for use in the Pacific and a Manual for Participatory Training in rainwater harvesting in Tonga. A video on the project is also being produced.

LUS & DAVIES [Not presented]

Courses and research programs at the centre of disaster research, University of Papua New Guinea: an initiative for local & regional tsunami disaster mitigation

Wilfred Lus & Hugh Davies
Centre for Disaster Research, University of Papua New Guinea, P.O. Box 414, University Post Office, National Capital District, Papua New Guinea
Email: wlus@upng.ac.pg

The Centre for Disaster Research (CDR) was established in 2002 at University of Papua New Guinea (UPNG). The 1998 Aitape Tsunami proved that PNG has one of the highest rates of fatalities (i.e., lives lost per unit of population) from natural disasters in the world, and one of the CDR aims is to increase awareness and preparedness for disasters as a means of reducing fatalities and the impact of tsunamis through education, training and research.

The Centre runs a course in Geology & Disaster Reduction and initiated a number of research programs throughout Papua New Guinea Region with local and international collaborators into geohazards like tsunamis, volcanoes, earthquakes and landslides. The CDR's GIS and image analyses needs are serviced by UPNG GIS and Remote Sensing facility, which can also generate 'size 0' hazard maps.

A number of research projects related to the 1998 Aitape Tsunami have been completed through the CDR (e.g. Simeon and Davies, 2002; Davies et al., 2003). Current research projects (i) Uplift and hazard mapping of Kairiru Island associated with 2002 magnitude 7.4 Wewak earthquake and tsunami (Susan John); (ii) On land mapping of 1888 Rither Island Tsunami deposits has identified palaeo-tsunami deposits consisting of coral fragments of up to 6m across (Emmanuel David); (iii) Hazard mapping of Greater Kimbe area (Patricia Ila'ava); and (iv) Sociological survey of re-settled tsunami victims in Aitape West (Pascal Waisi). Similar tsunami research projects should be encouraged in other Pacific Island countries, and the two week course in Geology & Disaster Reduction is also available to our Pacific Island neighbours.

The CDR's educational and research activities were highlighted during the 1st South Pacific Tsunami Awareness Workshop in Fiji on 1-3 July 2004. Participants were encouraged to see such initiatives undertaken locally within the region's educational institutions and have resolved to support and strengthen tsunami education, research and training at UPNG and other Pacific Island countries.

MARIO

Ocean-based renewable energy prospects in the Pacific Region

Rupeni Mario
SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji Islands
Email: rupeni@sopac.org

The Pacific islands, with land area ranging from 21 km^2 to 28,000 km^2 (excluding PNG), are scattered over the world's largest ocean, the Pacific Ocean (an area of 165.384 million km^2, covers 28% of the global surface), which has supported generations of Pacific island communities – not only as a medium of transport but also as a source of food, tradition, culture and now energy.

The islands face a challenging situation with respect to energy for sustainable development. This is due largely to varying demographics between countries and markets that are difficult to serve and lack significant economies of scale.

To date, ocean-based energy resources in the Pacific region have not been fully explored. Resource evaluation carried out by the SOPAC Secretariat and other institutions only revealed a small portion of what energy potential is out there. In 1987, the SOPAC Secretariat with funding from the Government of Norway carried out a wave data collection programme with the primary objective of assisting the Pacific island countries to evaluate the potential for wave energy resource. Escalating interest resulted in the exploration of other ocean-based renewable energy technologies such as ocean thermal energy conversion (OTEC), deep ocean water applications (DOWA), wave energy and tidal energy. Various studies on ocean thermal energy conversion were carried out by American and Japanese researchers in Fiji Islands, French Polynesia, Hawaii, Kiribati, Marshall Islands, and Nauru. This was followed by two demonstration ocean-based renewable energy projects commissioned in Nauru (1980–82) and Hawaii with the latter also demonstrating DOWA.

There are specific engineering and technical challenges involved in the development of ocean-based renewable energy in the Pacific, as the region is prone to cyclones, hurricanes, Tsunamis and other natural hazards. Aspects such as mooring, foundations, installation, operation and maintenance of ocean-based renewable energy systems need to be considered carefully and are some of the challenges faced.

As yet, most ocean-based renewable energy options are not commercially proven. There are potential benefits, both for the further development of the technology and for the region, in having pilot projects in the Pacific Islands. Such projects should further the understanding of socio-economic and environmental impacts, engineering and technical issues, economic feasibility and operations and maintenance issues.

The paper presents some of the constraints and complications facing the development of ocean-based renewable energy in the Pacific region. It also makes reference to current regional initiatives that will set-up the necessary framework and structure needed if ocean-based renewable energy technologies are to become established as a sustainable energy source for the Pacific.

MARTINEZ & others

Multi-scale mapping and hydrothermal survey of the Eastern Lau Spreading Center

Fernando Martinez[1], Brian Taylor[1], Joseph Resing[2], Sharon Walkery[2], Rennie Vaiomo'unga[3], Akapei Vailea[3] & Luna Wong[4]
[1] *School of Ocean and Earth Science and Technology, University of Hawaii, Honolulu, HI 96822, USA*
Email: Fernando@hawaii.edu
[2] *NOAA/Pacific Marine Environmental Laboratory, Seattle, WA 98115, USA*
[3] *Ministry of Lands, Survey and Natural Resources, Nuku'alofa, Kingdom of Tonga*
[4] *Mineral Resources Department, Suva, Fiji Islands*

The motion of the Pacific plate as it descends into the mantle at the Tonga trench and pulls away from the Australian Plate creates the fastest plate tectonic motion on Earth today. This opening forms the Lau Basin above the subducted Pacific slab. The injection of the Pacific plate into the mantle, carrying with it water,

sediments, and crust, varyingly alters the mantle composition beneath the basin with distance from the trench. The Eastern Lau Spreading Center (ELSC) is one of the back-arc plate boundaries in the Lau Basin that take up the opening. Because this spreading center diagonally cuts across the basin above mantle with different effects from the subducted slab it produces varied styles, compositions, and thicknesses of volcanism and associated hydrothermal activity. Hydrothermal vents inhabited by deep-sea biological communities were known from the southern part of this system but most of the spreading center was unexplored.

In April-May 2004 the R/V Kilo Moana of the University of Hawaii conducted the first of four research cruises planned for this area, which has been selected as an Integrated Studies Site by the United States Ridge 2000 Program. The 34 day cruise mapped the entire 390 km length of the ELSC with two deep-towed sidescan sonar instruments and the multibeam system of the Kilo Moana, and carried out continuous near-bottom water column backscatter measurements and a series of CTD "tow-yos" and vertical casts to survey for hydrothermal venting. The survey found evidence of abundant hydrothermal activity along the axis and particularly in the previously unexplored northern ELSC. Multiple sites have been targeted for more detailed studies in the following cruises. The degree of hydrothermal activity appears to exceed that found on mid-ocean ridges and may result from the different character of the back-arc crust. The mapped volcanic forms of the spreading axis were found to differ from mid-ocean ridges, forming shallow (1600-1700 m) steep-sided volcanic ridges at the slower spreading southern end and becoming deeper, broader, faulted and lower relief axis to the north where spreading rates more than double. The overall character of this variation is opposite to that found at mid-ocean ridges. The degree of hydrothermal activity and changing volcanic character of the spreading axis suggest an environment favorable for varied and abundant mineralizations and biological communities.

MASSEY

Ground and airborne time domain electromagnetic methods, applications and case studies

S.G. Massey
Worley GeoSciences Group, Level 6, QV1Building, 250 St Georges Terrace, Perth WA 6000, Australia
Email: steve.massey@worleygpx.com.au),

Introduction:
In the last 5 years, geophysics in general has been used far more frequently and over a wider range of geoscience applications than in the past. Geophysics is now being applied routinely to engineering, groundwater and environmental geoscience studies, whereas traditionally geophysics has been established in the oil and minerals sectors The reasons for this are the development of advanced survey equipment, computer hardware and reliable processing and interpretation software that is relatively simple and proven. In addition, successful case studies are creating a wider interest and acceptance of the geophysical methods.

The Worley company, through its part-owned subsidiary Worley-GPX (WGPX), is actively developing time domain electromagnetic (TDEM) equipment and methods with applications to engineering, groundwater, environmental studies and to bathymetry. WGPX operates a helicopter mounted TDEM system known as the HoistEM, as well as ground based systems. Several case studies are presented, which illustrate the diverse applications of ground and airborne TDEM methods.

TDEM Method:
Time-Domain Electromagnetic (TDEM) methods utilize the principle of electromagnetic induction to create responses due to sub-surface variations in conductivity. Current flowing within a loop creates a primary magnetic field that collapses when the current is abruptly terminated. The collapsing primary magnetic field causes eddy currents to flow in conductive areas of the sub-surface and a secondary magnetic field is created and measured by a coil. The amplitude and decay rate of the secondary field is a function of the survey parameters, and the sub-surface conductivity structure. TDEM systems used in groundwater applications commonly employ the "in-loop" configuration, where a receiving coil at the centre of the loop measures the inductive responses as a time varying magnetic field amplitude. The receiver measures the

EM response during the transmitter off-time without the presence of the primary field. Electrical contact with the ground is not required. The method can be used to investigate the shallow and deep structure in the range of a few meters to 200-300 m. Measured TDEM responses are converted to apparent resistivity or conductivity values that vary with depth at each sounding site. The results of the model transformations are conductivity depth images, commonly known as CDI's. Modelling using 1D layered earth inversion (LEI) is also common practice.

The HoistEM System:
The HoistEM system uses an in-loop configuration that can be installed onto any suitable helicopter (Figure 1).

Figure 1. The HoistEM system mounted on an Emirates Air Force Squirrel Helicopter.

The in-loop geometry provides the optimum configuration for mapping purposes, with high spatial sampling (typically 10-12m) symmetric response obtained from any flight direction and increased signal strength due to the low flying height of the helicopter. The specifications of the system used are summarized in Table 1.

Table 1: HoistEM system specification.

Parameter	**Specification**
Configuration	In-Loop
Survey Height	Nominal 30-40 m
Transmitter Moment	120,000 Am^2
Transmitter Waveform	Periodic Square
Transmitter Current	330 Amps. (max)
Transmitter Area	375 m^2
Number Turns	1
Transmitter On time	5 milliseconds
Transmitter Switch off	40 microseconds
Duty Cycle	25%
Effective Receiver Area	10000 m^2
Receiver Turns	1
System Bandwidth	25 to 25,000 Hertz
Base Frequency	25 Hertz
Altitude Measurement	GPS and Laser
Measurement Interval	10-12m along line

Case Studies:

1. United Arab Emirates , HoistEM Pilot Study
In August 2003,Worley-GPX completed a hydrogeological mapping pilot study, surveying two areas of the UAE using the HoistEM system. This work was commissioned by the Department of Water Resource Studies (DWRS), UAE. One of the areas (Al Khazna) has an established borefield, that provides town water supplies. The other area (Al Razeen) has no borehole control. Both sites are covered by recent desert sand

dunes. The surveys were flown on N-S oriented lines spaced 200m apart. Production rates were typically 200 line km per day and processing was completed next day in the field, with final processing and interpretation in Perth.

The conductivity structure based on the CDI' and LEI models were interpreted in terms of hydrogeological structure and water quality. A good correlation between conductivity and water quality variations with depth was established where borehole control was available. The HoistEM survey led to an improved hydrogeological model. Groundwater distribution and quality were mapped in greater detail using the HoistEM results in combination with the borehole data rather than the borehole information alone.

2. Sydney Harbour Bathymetry .
Worley-GPX surveyed the "eastern part of Sydney Harbour using the HoistEM system to determine bathymetry and sub-bottom conductivity variations. The maximum water depth in the survey area was 38m below surface. The survey area was chosen to coincide with other shallow water datasets acquired by Australia's Defense and Science and Technology Organisation (DSTO).

The resistivity of seawater (0.32-0.35 ohm-m) at the survey location was determined using the bottom depth contraints provided by swath bathymetric sonar and Laser Airborne Depth Sounder (LADS) data. Seawater resistivity values were then used in modelling to determine bathymetry and sub-bottom resistivity variations throughout the survey area. At the present time and based on this single case study, the bathymetric depth determinations from HoistEM system data have an accuracy of approximately +/- 3-5m. Model studies indicate the hoistEM system can be used to determine bathymetry up to 70m-100m below surface.

3. Coastal Seawater Intrusion Mapping , Coral Bay Western Australia
Worley-GPX have used ground based TDEM surveys to map seawater intrusion in aquifers near the coast of the world renowned eco-tourism area of Coral Bay, Western Australia. The surveys used 50m loops with in-loop geometry and a transmitter base frequency of 8 Hertz. Conductivity depth images show high conductivity zones that are interpreted as the areas of seawater intrusion. In this area seawater intrusions extend up to 2 km inland from the coastline.

MATTHEWS

What is Sustainable Development?

W. Andrew Matthews
National Institute of Water and Atmospheric Research (NIWA), Greta Point, Wellington, New Zealand
Email: a.matthews@niwa.co.nz

The issue of sustainable development is a hot topic. Sustainability Science is a relatively new multi-disciplinary scientific field. However the measures used for the definitions of sustainability are only now starting to be defined or indeed paradigms are starting to be developed under which reasonable and consistent set measures could be applied.

As an example, the challenge of defining of what is meant by 'sustainable' is demonstrated by the problems surrounding the issue of enhanced greenhouse gas warming will increase the average surface temperature of the planet.

It raises the question 'What is the ideal temperature for planet Earth?' Is it for, example
- a comfortable temperature for those living at mid-latitudes?
- a temperature that minimises the incidence of extreme weather events?
- a temperature that on average maximises the production of protein and hence allows the planet to support of the greatest number of humans?

Should the paradigm include the use of non- renewable resources?
Over what time scales should such consideration apply
1 generation or 3?
1 hundred or 3 hundred years?

The most widely used definition of "sustainable development" is:

"That (humanity) meets the needs of the present without compromising the ability of future generations to meet their own needs." ("*Our Common future*", Report of Brundtland Commission, 1987.)

Some of the drivers of Global Change will be illustrated as will some of the challenges faced by policy makers charged with developing policies that are 'sustainable', particularly in the context that the issues span more than a single election cycle.

MATTHEWS & others

Natural Hazards NZ: using experience in New Zealand to help the Pacific

Andrew Matthews[1], Noel Trustrum[2] and Graeme Campbell[3]
Positively Wellington Business, Natural Hazards Cluster
[1]National Institute of Water and Atmospheric Research (NIWA), Greta Point, Wellington, New Zealand
Email: a.matthews@niwa.co.nz
[2]Institute of Geological & Nuclear Sciences, P.O. Box 30-368, Lower Hutt, New Zealand
Email: N.Trustrum@gns.cri.nz
[3]AC Consulting Group, Wellington, New Zealand
Email: graemec@acconsulting.co.nz

The New Zealand Natural Hazards Cluster is a group of 25 New Zealand-based research and consulting businesses that use their New Zealand experience to help Pacific communities manage their risk from natural hazards.

New Zealand's professional, technical and consultative hazard management practices are recognised internationally as innovative and have been shown to lead to sustainable solutions that meet the needs of affected communities and countries.

NHNZ is helping organisations and communities manage the risk of: cyclones, climate change, floods, drought, fires, landslides, slope instabilities, coastal erosion, ground deformations, earthquakes, tsunamis and volcanic eruptions

Examples of some of the work of NHNZ will be given.

McCREERY

Pacific Tsunami Warning Center: Local/Regional Tsunami Warning

Charles S. McCreery
Richard H. Hagemeyer Pacific Tsunami Warning Center, Ewa Beach, HI, USA
Email: charles.mccreery@noaa.gov

In addition to international and national teletsunami warning responsibilities, the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, serves as the local and regional tsunami warning center for Hawaii. Local tsunamis in 1868 and 1975 from magnitude 7+ earthquakes along the SE-facing coast of Hawaii's Big Island produced maximum runups near the epicenter of around 14m and both caused casualties and damage on that island. A handful of smaller local tsunamis are also known to have occurred on the Big Island, some likely produced by submarine landslides. Further, numerical models have demonstrated that tsunamis similar to those in 1868 and 1975, if generated on the SW-facing coast of the Big Island, would adversely affect all islands in the State in less than an hour. As coastal development continues to put more people and assets at risk, the need for effective mitigation for local and regional tsunamis, including rapid warning capabilities, has become ever more critical in Hawaii and elsewhere around the Pacific.

To fulfill its local/regional mission, PTWC operates an array of ten seismometers across Hawaii, and receives continuous waveform data from about 30 short-period and 3 broadband seismometers of the U.S. Geological Survey's (USGS) Hawaiian Volcano Observatory (HVO). It also receives continuous waveform data from two broadband seismometers of the Incorporated Research Institutes for Seismology (IRIS). With these seismic data, and using an automated seismic processing scheme based on the USGS Earthworm system, reliable hypocenters are routinely determined within about 45 seconds of the initial rupture. Analysts then use interactive processes to determine the magnitude, either a Richter ml or an Mwp – a moment magnitude based on the P wave. Messages with these earthquake parameters are issued to Hawaii's civil defense agencies typically within 2-4 minutes of the earthquake. An urgent local warning is issued to the closest counties if the earthquake magnitude exceeds 6.8. Based on the historical record, earthquakes of this size are expected only once or twice a century, and such a warning has never yet been issued by PTWC.

In the case of a local warning, the PTWC bulletin will immediately trigger the sounding of sirens by Civil Defense personnel. Automated messages on radio and television stations will advise the public of the situation and urge a rapid evacuation of coastal areas in the affected counties. PTWC will confirm the existence of the tsunami and measure its strength using real time sea level data from nearby coastal gauges as well as data from an array of coastal runup detectors. Should the sea level data warrant, the warning will be expanded to the entire state.

PTWC's local warnings can only be effective in areas located at least several minutes or more tsunami wave travel time from the source. Closest to the epicenter the tsunami will come onshore almost immediately since the most probable tsunami source in Hawaii is not an offshore seafloor movement but a movement of flank of the island itself including the coast. Programs of public education are essential to keep those at risk in these areas aware that any large earthquake is a natural tsunami warning. With this knowledge they will know to evacuate immediately on their own, without waiting for an official warning.

McKENZIE

A cost-benefit analysis of projects implemented to assist the black pearl industry in Manihiki Lagoon, Northern Cook Islands

Emily McKenzie
SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji Islands
Email: emilym@sopac.org

In November 2000 the black pearl industry in Manihiki Lagoon in the Northern Cook Islands was severely affected by an oyster disease, which, along with low international pearl prices, has caused a steep decline in pearl export earnings, falling from NZ$18.4 million in 2000 to $2.8 million in 2004.

Overstocking and poor handling of pearl oysters were found to be two major causes of the Manihiki disease outbreak in 2000. It is likely that better farm practices and lagoon management would have prevented the disease and subsequent decline in the quality and quantity of pearl production.

The Cook Islands Ministry of Marine Resources, with the assistance of other organisations, has implemented various projects in Manihiki, which aim to achieve sustainable development of the black pearl industry. These projects involve diverse activities, including monitoring the physical and chemical parameters in the lagoon; monitoring pearl oyster health; mapping the lagoon bathymetry and pearl farms; building local capacity in pearl farming and lagoon management skills, and drawing up a lagoon management plan.

The Cook Islands government and supporting organisations have invested considerable funds and resources in the various projects and activities in Manihiki. But will the projects reap economic returns greater than their costs? This paper develops a model of pearl production to estimate the economic benefits that the projects are likely to bring the Cook Islands. The technique of cost-benefit analysis is used to compare the estimated benefits with the total project costs over a fifteen year time period between 2004 and 2019.

The main finding of the Manihiki cost-benefit analysis is that, if the oyster stocking densities, maximum oyster stock, and farming practices in Manihiki Lagoon are regulated by a pearl farming management plan (currently in draft form), the projects will improve oyster health, and increase the yield and quality of pearls harvested. The present value of the resulting increase in pearl production revenue vastly exceeds the present value of the total project costs. The information and skills generated by the projects, however, will only translate in to large positive net benefits for the Cook Islands if there is an enforced system to ensure sustainable management practices in the pearl industry.

MELZNER

Large Scale Landslide Hazard Assessment in the Navua Catchment (SE-Viti Levu, Fiji)

Sandra Melzner[1], Samu Lagataki[2] & Michael Bonte-Grapentin[3]
[1]Dept of Geography, University of Bonn, Germany
Email: Sandra.Melzner@giub.uni-bonn.de
[2]Forest Management Service Division, Fiji Islands
Email: slagataki@forestry.gov.fj
[3]SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands
Email: michael@sopac.org

Gravitational mass movements are one of the major processes forming the landscape in large parts of Fiji, particularly in the Navua catchment. High precipitation rates throughout the year, deeply weathered soils, 'weak' sedimentary rocks of the Navua Basin, tectonic activity as well as a deeply incised relief are the dominant pre-disposition factors governing the occurrence of landslides in this area. The densely forested catchment is intensively used for Mahogany plantations and logging concession areas. Hence there is a need to incorporate landslide assessment into planning of future concession areas to assist sustainable forest management. Furthermore, most villages along the Upper Navua River are situated on the deposits of huge relict landslides and areas with recent landslide activity, which form a considerable hazard to them.

The overall aim of the study is to identify and map the different types of landslides and to relate them to their depositional, controlling and triggering factors. Parts of the Navua Catchment have been selected as training areas to represent the variety of landslide pre-disposition factors. Within the training areas the different landslide types are mapped by means of stereoscopic interpretation of large and small-scale aerial photos (1990 - 1:16.000; 1994 - 1:50.000) and GPS surveys. Based upon the mapping results in these training areas and associated geomorphic interpretation, a GIS-based, geo-statistical model will be developed to produce landslide susceptibility maps for major parts of the Navua catchment. The GIS analysis will focus on available maps and data or information easily generated from existing data sets, such as DTMs, geological, topographical, land-use and forest function maps.

Common landslide features observed are translational slides or slumps along extremely steep headwater areas of small creeks. These slides often rapidly develop into highly viscose flows when triggered by heavy rainfall. The forming of these steep valley head areas is progressive; this means during a major rainstorm (parts of) the valley head areas are likely to be reactivated by landsliding and cut deeper into the bordering interfluve ridges. This creates severe problems for logging roads located on these ridges, the only access for these remote areas. Debris flows with run-out distances of several hundreds of metres occur frequently in the catchment, as well as rockfalls at the cliffs along the deeply incised Navua gorges, especially within the volcanic rocks. Huge rockfalls within the gorges can result in a temporary blockage at a narrow intersection of the river and subsequently initiate the risk of flash flooding due to a catastrophic outburst of a damned lake. Such phenomena might have happened at least twice in the historical record of the Navua river system. But by far the most astonishing features are a series of huge relict landslides located around the confluence of the Upper Navua and the Wainikoroilevu River. These very deep-seated slides are developed along the rivers within the Navua Mudstone and involve up to several 10 millions m^3 of sliding masses. They are most probably a consequence of extreme river incision and 'weak' rock conditions. Their magnitude and concentration at a certain area might be an indication for a major local earthquake as trigger.

Preliminary results suggest a rather negligible influence of the actual land-use on landslide occurrence. Landslides occur everywhere within the catchment, regardless of the land use of the affected area. The occurrence of landslides and the type of movement are mainly dependent on rock-type, jointing, faults, relief, distance from major drainage and the landslide history, not to mention distribution of triggering factors such as heavy rainfall and/or seismicity.

MOSUSU

Geothermal development in Papua new Guinea

Nathan Mosusu
Geological Survey, Department of Mining, Private Mail Bag, Port Moresby, Papua New Guinea.
Emails: Nathan_mosusu@mineral.gov.pg

Recent developments in the geothermal industry in Papua New Guinea have propelled the country into an exciting era in the country's mining and petroleum sector. Indeed, the opening of the country's first geothermal power plant on the island of Lihir has seen a renewed interest in the geothermal industry, which promises to be a major energy supplier for the country.

Lihir island, host to a major gold project in Papua New Guinea, commissioned the country's first geothermal power plant in April 2003. The commissioning of the 6 MW power plant was immediately followed by the approval by Lihir Gold Limited to develop an additional 30 MW plant, which the company hopes to commission in 2005. Currently, Lihir Gold Limited is studying the possibility of further developing an extra 20-30 MW plant in addition to the current 6 (plus 30) MW plants.

Papua New Guinea, like any other Pacific Island Nations, has a lot of geothermal resources, mostly dotting the tectonic margins of the country. To the north, hot pools, solfataras and steaming mud ponds can be found on the islands stretching from Manus, along the Lihir-Tabar-Feni group of islands, to New Britain in the south, on to Bougainville in the east, and then to the D'Entrecasteaux Islands in the south east. These resources are mostly unexplored and undeveloped, except for primitive uses.

To ensure proper assessment of the viability of a geothermal resource, it is vital that necessary information about the resource be carefully evaluated. This includes tectonic structure, geological units, geophysical, geochemical, and temperature measurements. Therefore, the Department of Mining, through the Geological Survey, has begun initiatives to establish the Papua New Guinea Geothermal Database that it hopes will be the information system behind geothermal development in Papua New Guinea.

MOSUSU & others

Earthquake, geophysical and remote sensing data compilations: contributions to tectonic and mineral occurrence studies in Papua New Guinea

N. Mosusu[1], L. Anton[1], A. Walker[2] & C. Jordan[2]
[1]Geological Survey, Department of Mining, Private Mail Bag, Port Moresby, Papua New Guinea
Emails: Nathan_mosusu@mineral.gov.pg; pmgo@daltron.com.pg
[2]British Geological Survey, Keyworth, Nottingham NG12 5GG, United Kingdom
Emails: asdw@bgs.ac.uk; cjj@bgs.ac.uk

Recent advances in processing and interpretation of earthquake, geophysical and remote sensing data at the Geological Survey of Papua New Guinea (GSPNG), are allowing seismologists, geophysicists and geologists, a clearer view of the tectonic configuration and structural fabric of Papua New Guinea and its surrounds. This includes an improved understanding of the relationships between geological structure and mineral occurrence

Papua New Guinea lies along the collision zone of two major lithospheric plates, the Pacific Plate to the northeast and the India-Australia Plate to the southwest. The approach of the Pacific Plate is at 13cm per year on azimuth 316° determined by Tregoning et al. (1998). The India-Australia Plate has been calculated to have a motion of 6 cm per year, the third highest rate out of the 8 major tectonic plates in the world (http://www.hypertextbook.com/facts/ZhenHuang.shtml).

Within the collision zone exists minor plates. The Solomon Plate lies to the southeast, while the South Bismarck, North Bismarck and Caroline Plates lie to the northwest. Very low levels of earthquake activity prevail at the boundaries between the Pacific, North Bismarck and Caroline Plates, being remnants of the mid-Tertiary crustal activity, so that for present purposes the North Bismarck and Caroline Plates can be regarded as parts of the Pacific Plate. The plate configuration for Papua New Guinea is shown (see plate configuration and earthquake profile). Most earthquakes occur at plate boundaries; along subduction zones beneath New Britain and Bougainville, and along the Bismarck Sea and Solomon Sea spreading centers. Earthquakes beneath the Papuan Fold Belt (Southern New Guinea Highlands) are results of the collision (manifested by folding and thrusting) between the India-Australia Plate with the South Bismarck Plate.

Gravity data, as with earthquake data, provide a clear expression of the tectonic boundaries mapped in the region. These data are presently being interpreted together with images of remotely sensed (satellite) data to improve existing geological maps and the understanding of relationships between structure and mineral emplacement in Papua New Guinea. As can be seen in the figure, mineral occurrences, and thus, the emplacement of ore bodies, are controlled by earth processes that produce fold and fault systems.

In Papua New Guinea, compilations of such data are now being used effectively in geological mapping, including mineral district surveys and structural studies. Tectonically, it is clear that earthquake activity is not restricted solely to plate boundaries, but is prevalent in areas of deformation within plate fronts. The significance of this is that most major deposits of oil, gas and minerals reside within the Papuan Fold Belt, along the collision front of the India-Australia Plate.

References:

Tregoning, P., Lambeck, K., Stolz, A., Morgan, P., McCluskey, S.C., Van der Beek, P., McQueen, H., Jackson, R.R., Little, R.P., Laing, A. and Murphy, B., 1998. Estimation of current plate motions in Papua New Guinea from Global Positioning System observations. *Journal of Geophysical Research*, 103, 12181-12203.

NARAIN & others

Stability of the Reef to Basin Slope west of the Rewa Delta (Southern Viti Levu)

Sophia Narain[1], Susanne Pohler[1] & Robert Smith[2]
[1] Marine Studies Programme, University of the South Pacific, Suva, Fiji
Emails: fuelme_sn@yahoo.com; pohler_s@usp.ac.fj
[2]SOPAC Secretariat, Private Mail Bag, GPO, Suva, Fiji Islands
Email: robert@sopac.org

Sand sieve analyses of six sediment cores from the Suva Basin show interesting results as to nature and supply of sediment deposited on the basin slope. Of particular interest is the indication of potential submarine geo-hazards on the island slope.

The cores were taken in 2003 and 1999 in the vicinity of Suva and Kadavu with the help of the Japanese research vessel *Koyo Maru*. The sediment cores are predominantly classified as hemi-pelagic muds with the exception of a core retrieved from a depth of 260 m just south of Suva Barrier Reef off Nukubuco (18.2°S, 178.5°E). This core has a high coarse grained fraction which increases by weight to 90% down core. Microscopic examination of the sediment strews shows predominantly reef derived material, i.e. *Halimeda* plates and mollusc shells, which contrasts with sediment strews from the other five cores which contain planktonic foraminifera (*Globigerina*, *Orbulina* etc.), various pteropods and sponge spicules.

The hemi-pelagic muds found in the remaining five cores (18.3°S, 178.5°E and 18.37°S-19.07°S, 177.5°E) taken from depth ranging from 800-1990 m, probably comprise land-derived material largely supplied by the Rewa River. The dark terrigenous mud fraction was found to be significantly higher in the surface layers of the cores (0-5 cm deep) and to decrease measurably down core. Obviously the amount of fine-grained sediment delivered to the basin has increased dramatically over the past 10 years or so. This increase in the supply of fine sediments can most probably be related to an increased sediment load derived from the Rewa River. It may be the result of various causes, including bad farming practices in the catchment area, deforestation, shifting cultivation and most significantly the increase in tropical cyclone frequency (Terry *et al.*, 1999; 2002).

Major flooding of low lying coastal areas is known to cause submarine turbidity flows down island slopes and the buildup of reef derived sediment on the upper slope seen in the 260 m core poses a further threat to slope stabiliy. Two other cores from the Kadavu Waters (18.47°S, 177.54°E and 19.07°S, 177.54°E) from depths of 1981 m (basin bottom) and 1191 m (lower Kadavu slope) show high 63 micrometer and 125 micrometer fractions which partially consist of a dark magnetic mineral, possibly magnetite. These unusual fractions may be the aftermath of submarine debris avalanches triggered by seismic activity along the Hunter Fracture Zone (Cronin *et al.*, 1999).

Turbidity flows, slumping or debris flows can trigger or aggravate tsunami waves and pose a potential threat to populous areas in the coastal zone. The processes seen in operation on the Suva Basin slopes warrant further investigation in order to better understand and minimize the geo-hazards which could cause serious damage to the region.

References:

Cronin, S.J., Terry, J.P., and Ferland, M.A. 1999: Debris avalanches, seismic tsunami and volcanic hazards of Uluinabukalevu (Mt. Washington), Kadavu, Fiji. In: Crook, K.A., Rodda, P. (eds.) Abstracts of papers presented at the STAR session 1999. *SOPAC Miscellaneous Report* 355: 18.

Terry, J.P., Garimella, S. and Kostachuk, R.A. 2002: Rates of flood plain accretion in a tropical island river system impacted by cyclones and large floods. *Geomorphology* 42: 171-182.

Terry, J.P. and Raj, R. 1999: Island environment and landscapes responses to 1997 tropical cyclone in Fiji. *Pacific Science* 53/3: 257-272.

NEWSOME & PAGE

Vegetation state and change, 1975-2002, Pohnpei, Federated States of Micronesia

Peter Newsome & Mike Page
Landcare Research New Zealand Ltd, Private Bag 11052, Palmerston North, New Zealand
Emails: NewsomeP@LandcareResearch.co.nz; PageM@LandcareResearch.co.nz

Pohnpei is a forested volcanic island located in the North Pacific Ocean about 3000km east of the Philippines. Its size (354 km^2) equatorial location, elevation range and geographic isolation have led to high levels of endemism in both flora and fauna.

A long history of human habitation has modified the natural cover of tropical rain forest to grow tree and ground crops, initially in the coastal lowlands, but more recently in the foothills and rugged interior.

In 1995 and again in 2002, Landcare Research conducted vegetation surveys of the island. The results were analysed against an earlier survey done by the USDA in 1975.

Between 1975 and 2002, agro forestry has reduced the area of upland forest, from about 55% of the land area (18,800 ha) to about 30% of the land area (10,500 ha).

NEWSOME & others

Tonga Cyclone Emergency Recovery & Management Project – Land & Risk Information

Peter Newsome[1], David Heron[2], Malcolm Archbold[3], Phil Glassey[4] & Tevita Malolo[5]
[1]Landcare Research New Zealand Ltd, Private Bag 11052, Palmerston North, New Zealand.
Email: NewsomeP@LandcareResearch.co.nz
[2]Geological & Nuclear Sciences Ltd, P.O. Box 30368, Lower Hutt, New Zealand
Email: d.heron@gns.cri.nz
[3]BECA International, P O Box 6345, Auckland, New Zealand.
Email: marchbold@beca.co.nz
[4]Geological & Nuclear Sciences Ltd, Private Bag 1930, Dunedin, New Zealand.
Email: p.glassey@gns.cri.nz
[5]Ministry of Lands, Survey & Natural Resources, P O Box 5, Nuku'alofa, Kingdom of Tonga.
Email: minlands@kalianet.to

Tropical Cyclone Waka struck the Niua Fo'ou and Niua Toputapu island group late on December 30, 2001, and the Vava'u island group on December 31, 2001. Maximum sustained winds reached 100 knots with gusts to 140 knots (200 km/h). The affected population totalled about 26,500 persons or 4,600 households. On Vava'u sixty percent of buildings were damaged, with about twenty percent completely demolished or severely damaged. The government's report on damage assessment in January 2002 estimated losses of TOP 104.4 million (USD 48 m), and a relief and rehabilitation program of TOP 79.5 m (USD 36 m). The issues that required immediate attention included school repairs, replanting of crops, repairs to private buildings, and reconnecting domestic water supplies. Therefore, the first objective of the CERM Project was to assist in recovering the standard of living of the population affected by the cyclone through the rehabilitation of the social infrastructure in affected areas and to improve its resilience to natural hazards.

In addition to the immediate needs of restoration and rehabilitation, assistance was requested for strengthening the national emergency and risk management framework, including upgrading the information technology tools available. Therefore, the second objective of the CERM Project, and the focus of this presentation, is to strengthen and upgrade the emergency and risk management capacity of the country.

As well as strengthening emergency and risk management processes, the project provides for the upgrading of land and risk information, by establishing an updated high-resolution land information system. This system will include: (i) ortho-imagery and mapping of all main island groups; (ii) establishment of a geographic information system for national use; and (iii) development and implementation of a national risk mitigation strategy, including risk assessment of key hazards in vulnerable areas.

The CERMP – Land and Risk Information project team is an association of three New Zealand consultancies; Landcare Research, BECA International, and Geological & Nuclear Sciences, working in collaboration with the implementing agency, the Ministry of Lands, Survey & Natural Resources.

At the six month stage, of this 2-year project, the Team have:

1. Determined the nature of a new geodetic network and new geocentric coordinate system for Tonga
2. Recommended acquisition of land imagery and terrain data, the capture and updating of about 50 core spatial layers, the installation of a GIS system, and the production of topographic maps
3. Determined the requirements for hazard and risk modelling.

Over the coming 18 months the team will implement the work items above and collaborate with stakeholder agencies, including the National Disaster Management Office and Department of Environment, to ensure uptake from the strengthened emergency and risk management information system.

PAHALAD

Enhanced application of climate predictions in Pacific Island Countries

Janita Pahalad
Australian Bureau of Meteorology, GPO Box 1286K, Melbourne, Vic, 3001, Australia
Email: j.pahalad@bom.gov.au

In 2001 a needs analysis for strengthening Pacific Islands Meteorological Services found that the majority of National Meteorological Services (NMSs) in the region were struggling, and often failing, to provide basic services for the citizens and industries of their countries. The report identified the need for assistance programs in two clear priority areas, one of which was to enhance seasonal climate prediction services.

The needs analysis report included a project concept to expand and enhance the prudent use of climate predictions. The aim of the project would be to meet the general goals of improving weather and climate services and products to ensure the safety, security and general well-being of the people, and thereby to help achieve sustainable development. In response to this conceptual proposal, the Australian overseas aid and development agency, AusAID, in collaboration with the Australian Bureau of Meteorology developed a project proposal for establishing a climate prediction capacity in participating Pacific Island Countries (PICs). The project, now funded to the level of AUD2.2 million, emphasizes the need to develop a framework for incorporating climate prediction information into planning across a broad range of agencies and industries. To ensure a satisfactory level of confidence in the prediction scheme from the outset, it was seen as essential that it be based on sound science and proven techniques. For this reason the proposed scheme is based on the current operational seasonal climate prediction system used by the Bureau of Meteorology for Australia.

Objectives:
- Strengthen PICs capacity in climate prediction, through providing proven seasonal prediction system (based on Australian Bureau of Meteorology's operational system), and training in its prudent use.
- Enhance ability of PICs to provide a sustainable climate prediction service to meet needs of users in climate-sensitive industries, through in-country workshops involving NMSs and potential user representatives.

Outputs/Outcomes:
- At the end of the project implementation, the NMS of each participating country will have software tailored for use in its location, and a thorough understanding of how seasonal climate prediction services can be applied to support climate-sensitive industries.
- Key representatives of climate-sensitive activities (e.g. agriculture, water management, disaster mitigation) will have received training in the effective use of climate predictions in a risk management context.
- Once the information is incorporated into planning and decision-making across a number of agencies and organizations, the wider community will benefit from the improvements that should result.

Required Reading(s):
Pacific Meteorological Services: Meeting the Challenge, published in November 2001 by the South Pacific Regional Environment Programme (SPREP).

PARISOT & others

Physical and chemical parameters controlling the electrical resistivity of ultramafic rocks weathering materials of New Caledonia

J.-C. Parisot, A. Paugam, A. Beauvais, C. Savin & B. Robineau
IRD, UMR 161, BPA5, 98848 Nouméa, New Caledonia
Email : Anicet.Beauvais@noumea.ird.nc

In New Caledonia, huge nickel ore deposits have been formed from weathering processes of the ultramafic rocks. The geometry of these ores is difficult to define with classical methods such as mining drilling or geological mapping. The electrical resistivity tomography (ERT) is a modern geophysical method to treat this issue as it provides 2-D images of the resistivity values distribution in thick lateritic covers [1,2]. An ERT study has been carried out on the Nickel ore deposit of Tiebaghi in Northwestern New Caledonia. The main facies of saprolite have been sampled and analysed. Their respective resistivity and the conductivity of the saturation waters have been measured *in situ*. The low resistivities obtained in the Neo-Caledonian profiles are incompatible with the low clay content and the low water conductivity values of such terrains. The electrical current flows within the different terrain layers under an electrolytic form by ionic displacement, either in the interstitial water or at the surface of minerals as clays. The resistivity of a terrain can be empirically related to its physical and chemical properties such as the cationic exchange capacity (CEC), exchangeable bases, porosity, humidity and mineralogical composition [3,4]. The measurement of these different parameters has allowed appraising their influence on the weathering materials resistivity. An experimental study of the resistivity variation has been also done as a function of the saturation rate for a solution of known conductivity.

Goethite is the main component of the analysed samples. The saprolite at the bottom of profiles however have traces of sepiolite and serpentine. Those facies have also the lowest resistivity values and show noticeable concentrations of exchangeable cations as 95 % Mg^{2+}. Notice that small amount of amorphous manganiferous phases as asbolane could have also a non-negligible influence on the CEC of these facies. It however appears that an empirical function as $\rho = kHp^{-b}$ describes the relation between the resistivity and the water content, k and b being coefficients dependent on the facies type. The resistivity of the upper saprolite is essentially related to the water content variations whereas that of the lower saprolite is, rather, controlled by the cationic exchanges.

References:
[1] Beauvais et al., (1999) *Earth Planetary Science Letters*, **173**, 413-424.
[2] Beauvais et al., (2003) *Earth Surface Processes and Landforms* (in Press).
[3] Archie, G.E., (1942) *Trans. Am. Inst. Min. Metall. Pet. Eng.*, **146**, 54-62
[4] Chesnut, D.A., and Cox, D.O., (1978) *Trans. SPWLA Annu. Logging Symp.*, **19**, 1-15

PAWIH

Petroleum exploration & development in Papua New Guinea

Bernard Pawih
Deputy Secretary, Department of Petroleum & Energy, P.O. Box 1993, Port Moresby, Papua New Guinea
Email: bernard_pawhi@petroleum.gov.pg

Exploration for petroleum in Papua New Guinea began in 1911 and the first exploratory drilling was conducted in 1913. To date, more than 380 wells have been drilled resulting in twenty-six oil and gas discoveries. Four of the oil fields and one gas field have been brought into production. However, petroleum exploration in PNG today is at its all time low. Although the current oil price averaging US$25.00 per barrel is attractive enough, the future of our petroleum industry looks gloomy and unpredictable. No new major oil discoveries have been made since the Moran field was discovered in 1996. The oil production is currently around 50,000 barrels per day from the 140,000 barrels per day in 1993. A cumulative production of 320 million barrels of oil has been produced to date, from an estimated 2P reserves base of 500 million barrels. Similarly, the tax

revenue has been dwindling and is expected to decline further in response to declining oil production. These factors and the industry's concerns that the fiscal terms adopted in 2001 did little to improve the country's hydrocarbon fiscal regime the PNG Government introduced new fiscal incentives to rejuvenate petroleum exploration and production. These incentives are designed to provide a strong stimulus to oil and gas companies already established in PNG and internationally to potential investors to explore, develop and produce the country's petroleum resources. The new rates cover two vital elements of the petroleum fiscal regime including the abolition of Additional Profit Tax and reduction of the corporate tax from 45% to 30%. The new rates are applicable to petroleum projects arising from Petroleum Prospecting Licences granted in the period 1st January 2003 to 31st December 2007 and Petroleum Development Licences emanating from these prospecting licence granted on or before 31st December 2017. Positive developments have emerged since the introduction of these new incentives with the granting of over ten new exploration permits with a total of 34 exploration wells commitments and more than US$210 million to be expended from years 2003 to 2008.

PNG also has a vast undeveloped gas potential with an estimated 2P reserves of 15 trillion cubic feet. The Government of PNG is pursuing the commercialisation of key impact project and concepts that are currently envisaged to rejuvenate the downturn in exploration and investment in the sector. These key projects include Gas to Australia Project and other gas commercialisation option including liquid stripping from gas fields, compressed natural gas and gas pipeline construction from the Gulf of Papua to Port Moresby for gas fired power generation. Other major impact projects include the Napa Napa refinery, Moran Oil project and development of marginal oil fields such as Southeast Mananda, Saunders and Bilip. This paper presents an update on the trends and changes in the petroleum sector in PNG.

PELLETIER & LAGABRIELLE

The Futuna spreading center : an extensional relay zone along the North Fiji fracture zone

Bernard Pelletier[1] & Y. lagabrielle[2]
[1]IRD-UMR « Géosciences Azur », BP A5, Nouméa, Nouvelle-Calédonie
[2]UMR 5573, Laboratoire Dynamique de la Lithosphère, ISTEEM, Université de Montpellier
Email: Bernard.Pelletier@noumea.ird.nc

In March 2000, part of the North Fiji transform zone was swath mapped using the Simrad EM12dual echo sounder of the R/V L'Atalante. Three spreading centers or extensional zones (the North Cikobia Spreading Center, the Futuna Spreading Center and the Southeast Futuna Volcanic Zone) and a strike-slip fault zone (the Futuna Transform Fault) were discovered over a distance of 500 km along the eastern North Fiji transform zone, from the north of the Fiji platform to the east of the Futuna archipelago.

The Futuna Transform Fault, oriented 100° and surveyed over a distance of 250 km, must be considered as an important tectonic element of the North Fiji transform plate boundary. Pure strike-slip as well as transpression and transtension motions are responsible for the complex morphology of this feature. The uplifted Futuna-Alofi ridge represents a major compressional relay along the Futuna Transform Fault.

The Futuna Spreading Center extends over more than 200 km from 15°40'S at the northeastern tip of the Fiji platform to 13°35'S northwest of the Futuna-Alofi islands. Trending N20-30°E and deepening southward, it is composed of a series of en échelon left-stepping spreading segments, and can be divided into three parts.

The northern part, from 13°35'S to 14°25'S, is offset about 20 km westward relative to the central part. It consists of two main segments trending 35-40°, with pronounced axial ridge culminating at 600 m below sea level, 1300 m above the surrounding seafloor. Structural pattern suggests a recent ridge jump and a young emplacement of the northern part of the spreading center, at the time of the initiation of the Futuna Transform Fault.

The central part extends from 15°15'S to 14°15'S where it connects the Futuna Transform Fault. It is composed of three, 30 to 40 km-long, left-stepping, en échelon segments trending 25-30°. The lineations

of the magnetic anomalies parallel the sea-floor bathymetric fabric over a 110 km-wide zone. The anomalies are interpreted as anomalies 1, J and 2, giving a full spreading rate of 4 cm/yr.

The southern part, south of 15°15'S, includes the East Cikobia Volcanic Zone, partly mapped during previous survey. It consists of a spectacular V-shaped rift (deepest point at 3739 m depth) suggesting active southward propagation of the spreading center into older oceanic crust north of the Fiji platform. Basalts, dolerites and greenschist facies gabbros belonging to the rifted old oceanic lithosphere were recovered by dredging at the tip of the propagator.

Active spreading along the Futuna spreading Center is revealed by a 15 km-wide band of continuous strong acoustic reflectivity of the seafloor. Very fresh basaltic lavas (pillows and massive flows) have been recovered from 9 dredge hauls regularly spaced along the axis, thus confirming active spreading. The Futuna spreading center must be considered as a 200 km-long extensional relay between the Futuna transform fault and the western part of the North Fiji transform zone, the Fiji transform fault, which bounds the Fiji platform to the north.

PELLETIER & others

Bathymetry of the coastal areas of some islands of Vanuatu

Bernard Pelletier[1], G. Cabioch[2], S. Calmant[3], V. Ballu[4] & J. Perrier[1]
[1]IRD-UMR « Géosciences Azur », BP A5, Nouméa, Nouvelle-Calédonie
Email: Bernard.Pelletier@noumea.ird.nc
[2]IRD, UR 055 « Paléotropique », BP A5, Nouméa, Nouvelle-Calédonie
Email: cabioch@noumea.ird.nc
[3]IRD-UMR « Laboratoire d'Etudes en Géophysique et Océanographie Spatiales », Toulouse, France
Email: calmant@noumea.ird.nc
[4]Laboratoire de Gravimétrie et Géodynamique, IPG Paris
Email: ballu@ipgp.jussieu.fr

For scientific purposes three cruises have been conducted since May 2002 along the coasts of some of the Vanuatu islands, on board the IRD research vessel *Alis* (Nouméa, New Caledonia) equipped of a Kongsberg Simrad EM1002 multibeam echo sounder. This swath mapping system is designed for high resolution seabed mapping and acoustical imaging from the shoreline and down to a depth of 1000 m.

We present here some maps from the data collected during these cruises in May 2002, December 2003 and February-March 2004. The following coastal areas have been mapped : northwest and north of the northern part of Makakula, west, south and southeast of Santo, Wusi bank, west and south of Malo, Bougainville strait, south of Pentecote, Selwyn strait, north, east and southeast of Ambrym, west, south and east of Paama, west, south and east of Epi, De Chauliac bank, west of Efate (about from north Nguna to Narpow point) and Mele Bay.

One of the main objectives of two first cruises was to identified (by mapping, dredging and dating) paleo-sea level markers (platforms, notches, drowned reefs) and especially those related to the last maximum glacial stage and the melt water pulses during the subsequent deglaciation. The marker of the last maximum glacial stage, which was at about -120 m 20,000 years ago, should be now between -40 and -120 m depending on the uplift rate (from 0 to 3-4 mm/year) deduced from the125,000 year-old and Holocene emerged reefs of the islands. If identifiable, these markers will provide keys for the studies of the sea level variation and the vertical motion rates of the islands.

The last cruise in March 2004 was mainly focused on marine geoid and geodectic studies offshore Santo. Following the eruption of the Epi B submarine volcano between 16 and 24 February 2004, the opportunity of the presence of the *Alis* ship off Santo was taken to survey at the end of the cruise the area east of Epi island and to produce the first detailed bathymetric map of the Epi B and neighbouring submarine volcanoes.

PENAIA

Disaster Preparedness for Pacific Water Utilities

Amataga Penaia
Samoa Water Authority, P.O. Box 245, Apia, Samoa
Email: amataga@swa.gov.ws

As part of the "Building the Foundation Program", the East-West Center organised a Leadership Seminar for Pacific Island Water Managers from July 19 – 29 2004 in Honolulu, Hawaii. The course was organised with support from the U.S. Department of the Interior Office of Insular Affairs and NZAID, and was sponsored by the Pacific Water Association (PWA) and SOPAC.

The Leadership Seminar provided Pacific Island Water Managers with training in practical, applied tools and strategies designed to enhance leadership and team building capabilities, critical thinking, problem solving and decision making skills, and utilisation of strategic planning and job-task analysis techniques to further organisation goals and objectives.

The water managers applied these tools, strategies and skills to develop Disaster Preparedness and Mitigation Plans for their utilities or organisations specifically addressing Island Vulnerability, Theme 2 of the 2002 Pacific Regional Action Plan on Sustainable Water Management.

POHLER & HERBIG

Distribution of sponges on a tropical intertidal flat near Suva (Viti Levu, Fiji) – the complex control of modern and inherited factors

S. M.L Pohler[1] & H.-G. Herbig[2]
[1]Marine Studies Programme, University of the South Pacific, Suva, Fiji Islands
Email: pohler_s@usp.ac.fj
[2]Department of Geology and Mineralogy, University of Cologne, Zülpicher Str. 49, D-50674 Cologne, Germany
Email: herbig.paleont@uni-koeln.de

The Nasese intertidal platform near Suva (Viti Levu, Fiji) formed over a Holocene fringing reef complex which is in the process of being uplifted/tilted and eroded. The platform measures about one square kilometer in size and today is influenced by the prevailing wind direction from the southeast (trade winds), tidal currents and the sediment input from the major rivers that drain into the Suva Lagoon. On a larger time scale, distribution of sediments and fauna is additionally controlled by the young tectonic movements, lithology of the underlying rocks and Quaternary sea level history. Three lithofacies, each with a specific sponge community can be differentiated on the tidal flat. Facies 1 is an extinct fringing reef with thin mud and sand veneer, which surrounds the platform and is exposed at low tide. Facies 2 also formed on top of the Holocene reef complex, but is subtidal. Facies 3 is located in the central part of the tidal flat and is composed of muddy sand and tidal pools.

Facies 1 is characterized by the occurrence of the clionid sponge *Cervicornia cuspidifera* (Lamarck). *C. cuspidifera* is a massive excavating sponge which makes cavities into the underlying calcareous substrate provided by the extinct Holocene fringing reef. The sponges form large aggregates and cover considerable areas, where sedimentation rate is low and a very thin sand veneer overlies the hard limestone substrate (i.e. on the leeward side of the platform). The exhalant stolons of the sponges reach up to 30 cm deep into the substrate. The mode of excavation is thought to be the same as that employed by other clionid sponges. The size of the sponges and extent of cover on the platform margins imply that this taxon plays an important role in the bioerosion of the reef limestone. Also common in lithofacies 1 is a small tetillid sponge. This group is uniquely adapted to the harsh conditions characterizing the upper and middle intertidal zones of the platform, i. e. exposure to severe osmotic stress, heat stress and UV stress during low tide. The hemispherical golfball-sized sponge has a protective coating with grey-green mud and algae and is hence easily overlooked. At the seaward edge of the intertial platform a not yet identified clionid sponge is excavating the exposed reefrock. The brown sponge has a bark-like surface texture and forms

extensive anastomosing networks, which overgrow and invade the limestone substrate. It is less abundant than *Cervicornia* and restricted to the seaward side of the platform.

Lithofacies 2 is also located at the seaward side of the platform, but is submerged even at low tide. Ramose and digitate haplosclerid sponges are common that live attached to the old reef substrate and are intergrown with each other. They belong to the genera *Niphates* (mauve-coloured), *Haliclona* (turquoise-coloured) and *Haloclona* (black).

Lithofacies 3 is located in the centre of the platform where the Pliocene Suva Marl is exposed in the core of the anticline that is forming the spine of Suva peninsula and is jutting out into the lagoon. The marl is softer than the Holocene reefrock and hence the platform center is more deeply eroded than the limestone armoured fringes. It is covered with soft muddy sand; intertidal pools are frequent. Green-brown palmate to digitate sponges of the Order Halochondria, probably belonging to the genus *Amorphinopsis*, are most common in this facies zone.

The distribution of the sponges is intimately related to the sedimentary regimes on this complex platform. The fringing reef that was formed (directly on Suva Marl) by massive colonies of faviid corals, ramose *Acropora*, and Poritids is now deeply eroded by physical processes (e.g. by wave action) and bioerosion (e.g. by the excavating sponges). This Recent example of the development of an angular unconformity, a sedimentary gap in an island arc setting can aid in understanding fossil paleoenvironments and illustrates the importance of biofacies studies. Morevoer, the study of the Nasese intertidal platform shows that the distribution of fossil sediments still controls Recent environments, if intervening sediment production is lacking.

References:

Rützler, K. & Hooper, J.N.A. 2000: Two new genera of hadromerid sponges (Porifera, Demospongiae). *Zoosystema 22 (2):* 337-344. Publications Scientifiques du Muséum national d'Histoire naturelle, Paris.

RAHIMAN

Morphologic and structural features of the offshore region of south eastern Viti Levu, Fiji, from high resolution multi-beam swath bathymetry and seismic reflection data

Tariq Rahiman
Department of Geological Sciences, University of Canterbury, P.B. 4800, Christchurch, New Zealand
Email: tir14@student.canterbury.ac.nz

High resolution multi beam swath bathymetry and high resolution single channel seismic reflection profiling reveals the nature of morphological and structural features of the offshore region of south eastern Viti Levu. Two marginal basins occur off the southern coast of Viti Levu. Their floors are demarcated by the 2000 m bathymetric contour. These are the Suva Basin in the east and the Baravi Basin in the west. The marginal slope, which is defined as the sloping seafloor between the outer reef edge of the southern Viti Levu coast and the marginal basins, can be subdivided into a number of distinct morphological units. These units are the western slope, the eastern slope, the Beqa Lagoon slope and the Rewa Delta toe slope.

The eastern slope is the most structurally complex marginal slope unit. It comprises a shallow gradient seafloor (>10 degrees) between the Navua Delta and the Suva Harbour. This slope comes off a broad, 5 km wide, marginal shelf, which is covered by Holocene barrier reefs. This slope mimics the regional dip of the Medrausucu Group strata along the coast and may represent the dip slope of this strata. The surface of the eastern slope is scarred by a number of linear submarine canyons and submarine slumps. The most prominent canyon is the NNE trending Suva Canyon, the head of which is near the Suva Passage. It can be traced south westward for 23 km to the southern limit of the surveyed area. Near the head, it is 800 m wide and 300 m deep, but at the SW end, it widens to 2.4 km. The - 100 m contour lines on the Fiji 1:250 000 bathymetry map series Sheet 5 suggests that this canyon continues seaward and merges with the floor of the Suva Basin. Other smaller canyons are the NNW trending Namuka Canyon (~9 km long), the NW trending Naqara Canyon (~10 km), the curved Vunidoi Canyon (~4.5 km) and the NNE trending Vatuloa (~

6 km) and Togoru Canyons (~5 km). The Naqara, Vunidoi and Namuka Canyons are the western tributaries of the Suva Canyon. The Vatuloa and Togoru Canyons occur separately in the west, draining into the Beqa Channel, a bathymetric depression joining the Beqa Passage to the Suva Canyon. In the headward parts, the floor of the smaller canyons are also 300 m lower than the level of the adjacent seafloor. Cross sectional profiles across the canyons indicate that they are V shaped near the heads and U shaped at the seaward ends.

Seismic reflection profiles across the northern end of the Namuka, Vunidoi and Naqara canyons reveal that the axis of the canyons coincides with synclinal depressions in the basement rock. Downwarping of the seismic basement is shown to be accommodated by a number of normal faults that downthrow towards the axis of the syncline. In some profiles faulted grabens can be clearly seen near the axis of the synclines. The strike of the axes of synclines and normal faults are NNW trending. Downthrow of up to 75 m is inferred from the most seaward located profile across the Namuka Canyon. The canyons appear to represent bathymetric features, which are superimposed on structural depressions of the seismic basement. The structure observed in the basement rocks below the canyons is consistent with the style of deformation mapped along the coastal areas of south eastern Viti Levu and is also seen in seismic profiles conducted in the deeper areas of the marginal shelf. The canyons appear to be controlled by graben valleys, some of which can be correlated to structures mapped on land.

Two types of slumps are recognized on the eastern slope. There are those that occur at the edge of the marginal shelf and those that occur on the mid slope. The mid slope slumps occur below a very distinct slope break, which approximately follows the 500 m bathymetric contour. Above this slope break, the surface of the seafloor is smooth and beyond it, the seafloor has a rough surface and is associated with numerous slumps scars, slump debris and channels. The edge of the marginal shelf around Viti Levu and the Beqa Lagoon has high gradients, ranging from 20 to 30 degrees. A number of large slump scars occur at the edge of the marginal shelf at the seaward end of the Suva, Namuka, Naqara, Vatuloa and Togoru Passages. These slumps define the head scarps of the submarine canyons and are up to 2 km wide.

There are eyewitness accounts of disturbance at the reef edge near the southern end of the Suva Passage during the 1953 Suva earthquake (Houtz 1962). Numerous cracks appeared at the reef edge. Sections of the reef were dislodged by a submarine slump. This slump was responsible for a tsunami which, threw up large blocks of dislodged reef on to the reef platform. The swath data clearly shows the geometry of a failure surface at this location. This failure surface appears to be a composite feature of many seismically induced slumping events. During the 1953 earthquake there were also reports of submarine cable damage 50 to 60 km seaward of the reef edge and along the Suva Canyon. The way the cables were damaged (tangled and bunched up) suggested damage by turbidity currents (Houtz & Wellman 1962). A large deposit of sandy debris was found at the base of the Suva Canyon near the edge of the Suva Basin. The lack of a debris field at the base of the slump scar in the swath data suggests that the slump initiated turbidity currents, which carried the slump debris for many kilometres along the Suva Canyon. Other slump scars at the edge of the marginal shelf may have formed during earthquake events prior to 1953.

The location trend and shape of the submarine canyons on the eastern slope are structurally controlled. Headward erosion and axial cutting appear to be occurring by seismically induced basinward sliding of unconsolidated surficial deposits and lithified basement rocks at the head scarp. These slumps generate turbidity currents, which keep the canyons clear of sedimentation. The close association of seismically induced slumping with the canyon heads suggests that faults controlling the canyons may be potential sources of seismic events in south eastern Viti Levu.

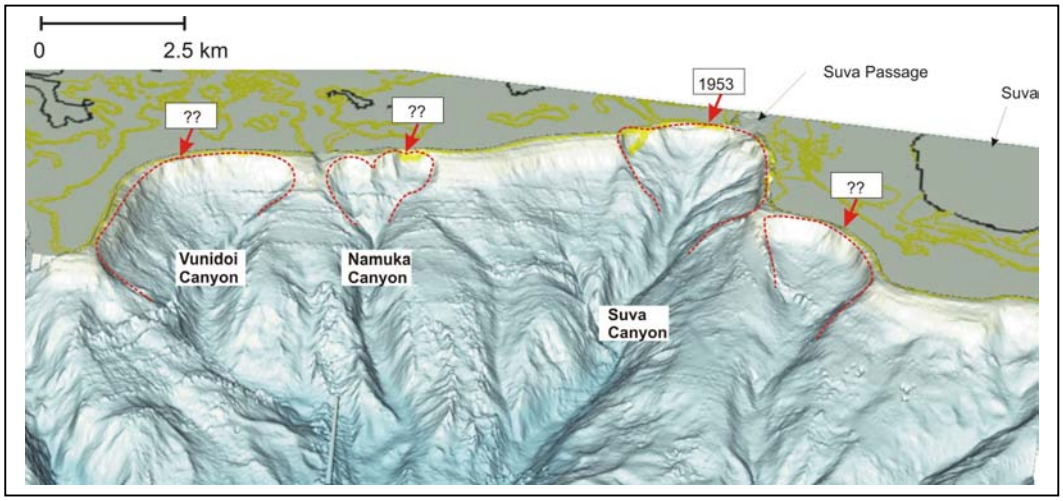


Figure 1. Part of the eastern slope near Suva showing the locations of submarine canyons and seismically induced slope failures.

References:

Houtz, R.E. 1962, The 1953 Suva earthquake and tsunami, *Bulletin of the Seismological Society of America* **52, No. 1**: 1-12.

Houtz, R.E. & Wellman, H.W. 1962, Turbidity current at Kadavu Passage, Fiji, *Geological Magazine* **99**, 1: 57-62.

RAHIMAN & PETTINGA

Geological structures related to seismicity in south eastern Viti Levu, Fiji, based on analysis of fracture lineaments

Tariq Rahiman & Jarg Pettinga
Department of Geological Sciences, University of Canterbury, P.B. 4800, Christchurch, New Zealand
Emails: tir14@student.canterbury.ac.nz; jarg.pettinga@canterbury.ac.nz

A study of lineament and fracture patterns was carried in the seismically active south eastern Viti Levu region of Fiji. The objectives were to ascertain the nature and history of deformation, and to delineate areas of crustal weakness to define potential seismic sources. Lineaments are naturally occurring, linear features on the earth's surface of topography, drainage, soil tones and vegetation. They are assumed to represent subsurface phenomena such as fracture zones, and other linear geological discontinuities such as faults and geologic contacts in the bedrock. Lineaments were mapped using a variety of remote imagery of south eastern Viti Levu. These included images of side looking airborne radar (SLAR), first vertical derivative of total magnetic intensity (1VD), digital terrain model (DEM) and aerial photographs.

Two trial maps of regional lineaments for DTM, SLAR and 1VD images were made digitally in GIS, six months apart, each with over 400 lineaments. A total of 5488 large-scale lineaments were mapped from stereoscopic aerial photographs. A quantitative analysis was carried out to determine the orientation patterns of the lineaments using Gaussian peak fitted, normalised and smoothed linear azimuth frequency histograms and rose plots. Six distinct sets of lineaments trends are defined in south eastern Viti Levu. They are NW, NE, NNE, ENE, WNW, E-W and N-S. The NW, NE, NNE and ENE trends are the major trends, which are reproducible in multiple trials, multiple images and at regional and large scales. The others are minor trends; the WNW and E-W trends are only reproducible in multiple trials and multiple images at the regional scale, and the N-S trend only appears at the large-scale.

Spatial density distributions maps of the lineaments trends were made to define swarms of lineaments. Lineament swarms are closely spaced sub-parallel lineaments that have geographic continuity and appear to represent related fractures. The distribution patterns of the NE and NNE lineament swarms suggest that

some of these lineaments may be part of the same set of curved fractures. The NW, NE, and ENE lineament swarms show good spatial correlation between the two scales. Most of the lineament swarms are parallel to and associated with high angle faults observed in outcrop. These observations support the interpretation that the lineament swarms are the surface expression of faults. In most cases the fault-correlated lineament swarms extend beyond the mapped limits of the faults. It is likely that the fault-correlated lineament swarms, which extend beyond the mapped limits of the fault, represent the continuation of the fault as zones of erosion-prone, closely spaced and intense jointing and fracturing. A number of small faults are seen to occur parallel to and at a number of locations along the strike of the lineament swarms. These lineament swarms indicate that a number of small faults, previously unrelated, are actually segments of larger fault zones.

Detailed mapping of faults along the south eastern coast of Viti Levu show a systematic change in slip character from strike-slip domination along WNW (and probably ENE trends) to almost pure dip-slip on N trends. The intervening NE, NW and NNW striking faults shows equal amounts of strike-slip and dip-slip character. The predominant faults in the area are NW and NNW striking normal faults.

The lineament trends correlate to well known structural grains in Viti Levu and in other parts of Fiji. The E-W trend correlates with the strike of the axes of folding in the Lower Oligocene to Middle Miocene Wainimala strata and may reflect the oldest phase of deformation in the study area. The majority of the ENE lineaments and WNW lineaments appear to be associated with Late Miocene to Pliocene subduction-related volcanism and extension. The ENE lineaments are parallel to the locus of Pliocene volcanoes along the Viti Levu Lineament in northern Viti Levu and the Beqa-Vatulele Lineament to the south of Viti Levu. Additionally, the ENE and WNW lineaments control the location of Miocene to Pliocene Ra, Navua, Rewa and Suva sedimentary basins. These basins may have formed by strike-slip and dip-slip faulting during the early phase of rotation of the Fiji Platform in the Late Miocene. The NE and NW lineament trends are much younger than the WNW and ENE trends. The NW trend is associated with the Rewarani-Yarawa fault system, which offsets the WNW faults. This trend is associated with the pervasive pattern of normal faulting which imparts an excellent control on the geomorphic expression of bays, peninsulas and nearshore islands of the south eastern Viti Levu coast. This trend is also associated with the Medrausucu Fault, which displaces young, possibly Pleistocene strata. The NE trend correlates with the strike of Pliocene-Quaternary basins (e.g. Suva graben and Savusavu Bay) and the axis Quaternary volcanism on Taveuni island. These younger structures may be related to a change in stress field at the cessation of anticlockwise rotation of the Fiji Platform.

The NE and NW trends follow patterns of seismicity and define the trends of two potential seismic source zones (SSZ), which pass through and overlap in south eastern Viti Levu. The NW trending lineaments define a NW SSZ that is closely associated with a broad zone of shallow seismicity 50 km wide that extends from offshore south eastern Viti Levu to the northern coast of the island. Focal mechanism solutions and isoseismal lines of large earthquakes in south eastern Viti Levu implicate activity along the NW trend, correlating with the location and strike of the NW SSZ. A number of active (Holocene) NW and NNW faults occur within the boundaries of the NW SSZ in south eastern Viti Levu. The NE trending lineaments in south eastern Viti Levu represent fractures associated with a NE trending seismo-tectonic source zone. The entire structure extends from north eastern Vanua Levu (Taveuni), near the plate boundary elements of the north western Lau Basin, and passes through the Koro Sea in central Fiji and south eastern Viti Levu, and terminates in western Kadavu in the south west, near the Hunter Fracture Zone. Earthquakes from the two seismic source zones frequently affect south eastern Viti Levu.

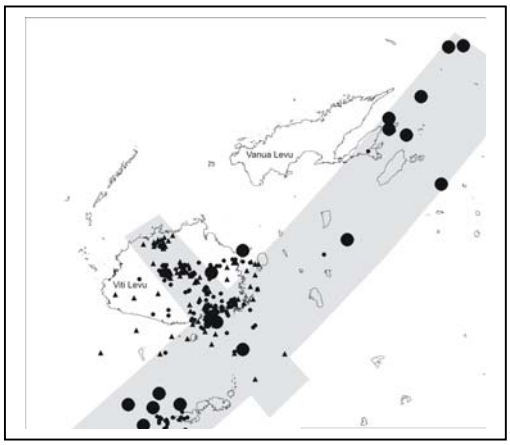


Figure 1. Location of NW and NE seismic source zones.

RAMSAY

How can we improve the collection and effectiveness of beach profile datasets?

Doug Ramsay
National Institute of Water & Atmospheric Research, PO Box 11115, Hamilton, New Zealand
Email: d.ramsay@niwa.co.nz

A common trend over the last decade in many parts of the world, including New Zealand and many Pacific Islands, has been the increasing use of high-technology equipment for the measurement of beach profiles. However, in many cases this has not improved the temporal and spatial collection of beach profile data. Typically this is due to a number of factors including limited staff resources with the necessary technical skills and time within the responsible organisations, scare resources for equipment maintenance or replacement, and issues relating to the data entry, analysis and effective dissemination of such data. As a result there are few countries in the Pacific region where beach profile datasets are adequate enough to reliably inform the long-term planning or decision-making processes.

The use of local community groups to help collect beach profile data is one approach that can assist with such data collection. Two be effective this requires two fundamental components:

- A simple and inexpensive, but reliable, method for collecting beach profile data;
- An accessible and user-friendly system for entering, storing and analysing beach profile data.

Over the next year a framework for facilitating community beach profiling activities is being developed based on a number of demonstration studies with community groups in New Zealand, including Maori, Coastcare Groups and schools. To facilitate measurement a beach profiling tool kit has been developed based on the Emery method. This method has been proven to be a reliable method and is now commonly used in New Zealand replacing the use of more technical methods in many areas. As part of NIWA's Foundation for Research Science and Technology research programme, a Beach Profile Analysis Tool box (BPAT) is also being developed for the storage and analysis of beach profile data. This project will demonstrate how these components can link together to allow communities to carry out beach profiling in a reliable and consistent manner, how they can use the data to provide information on beach changes on "their" beach, and how these dataset can ultimately increase the coverage and frequency of beach profile measurements to improve understanding and decision making by the relevant authorities. It is an approach that could fit just as well in the Pacific region.

RAO & others

Hydrodynamical Modelling in Suva Lagoon (Fiji)

Shivanesh Rao[1], Pascal Douillet[2] & Than Aung[1]
[1]University of the South Pacific, P.O. Box 1168, Suva, Fiji Islands
[2]Institute of Research and Development, Noumea, New Caledonea
Email: rao_s@usp.ac.fj

To determine the shallow water circulation in the Suva lagoon of Fiji Islands, a 3-D model developed in IRD-Noumea was used during 2004. The study area covers approximately 500 km^2 and the average depth is 25 m. The effects of major tidal constituents, M_2, S_2, K_1 and O_1, wind and major river-runoff are included in the model calculations. The model was tested and verified using field data collected in the Laucala Bay area of Suva Lagoon during 2003 and 2004. The verification procedure involves comparing salinity profile measurements and model output.

In the absence of direct current meter measurements, model prediction is the only major source of information in shallow water circulation in the lagoon. The model is run for the period of flooding and ebbing tides for a specific month. Model results show the formation of two-layer movement, the surface layer going seaward and the inflow along the bottom layer. Water flowing along the coast flows through

the Nasese channel to enter Suva Harbour, subsequently going out through the Suva passage. The current speed for most of Laucala Bay is 15 cm s^{-1} while the current speed in the harbour is mostly below 10 cms^{-1}.

The water entering through Nukubuco Passage flows northeast then turns counterclockwise and flows along the coast and through Nasese Channel. Similarly for Suva Passage, water enters the harbour in the bottom layer, flowing into Nasese Channel. The bottom current speeds range from 5–11 cm s^{-1} for Laucala Bay and less than 5 cm s^{-1} for the harbor. Results for the ebbing tide show that the bulk of the surface water flows seaward through Nukubuco Passage and Nasese Channel, whereas the bottom water layer flows landward, primarily entering through the Nukubuco and Suva passages.

ROEMMICH & WILLIS

The Argo Project: observing the global oceans in near real-time for climate and other applications

Dean Roemmich & Josh Willis
Scripps Institution of Oceanography, University of California San Diego, San Diego, U.S.A. Email: droemmich@ucsd.edu

The international Argo Project (http://www.argo.ucsd.edu) provides measurements of temperature, salinity, and ocean current in the upper 1-2 km of the global oceans using autonomous profiling floats. The fundamental elements of the coupled climate system are heat and freshwater, and Argo data reveals the oceanic branch of the heat and freshwater balance on global scales for the first time. There are presently 1278 Argo floats spread over all oceans (Figure 1), building toward the planned 3000 float array to be completed in 2007. Major float deployments are being carried out in the southern Pacific in 2004, filling the largest gaps in the global array. All Argo data are freely available to anyone via the internet within about 24 hours of collection.

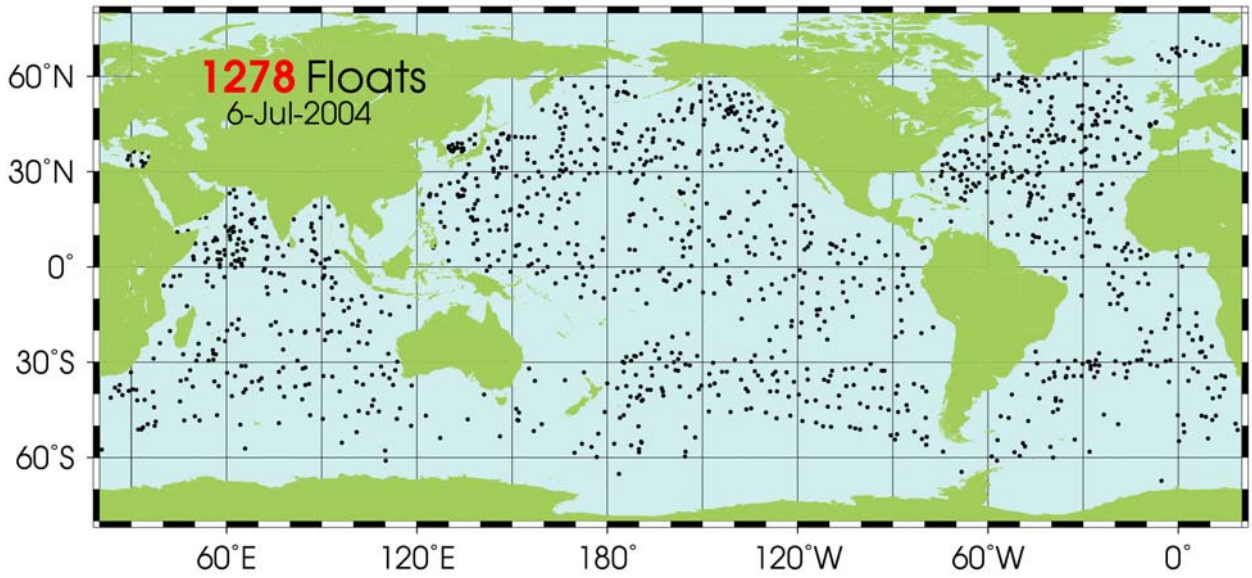


Figure 1. Location of 1278 Argo floats as of July 6, 2004.

Argo is a central component of the Global Ocean Observing System (GOOS), which has a wide variety of research and operational applications. These were reviewed in a regional workshop on Potential Applications of Ocean Observations for the Pacific Islands (co-sponsored by SOPAC), held in Fiji in October 2002. The workshop focused on application areas including climate, coastal and marine resources, fisheries, protection of life and property, and research and education. Knowledge of the physical state of the oceans has many potential benefits, especially for island nations. An Argo Science Workshop was held in Tokyo in November 2003, to review the basic oceanographic research being carried out with floats.

This presentation highlights climate-relevant research using Argo and other elements of the ocean observing system. Recent work by Willis *et al (2004)*, combined temperature profile data and sea surface height (SSH) measurements from satellite altimeters, revealing a steady heating of the global oceans averaging 1 W/m^2 (Figure 2) during the period 1992 - 2003. The heating rate was regionally variable, with the strongest heating of 4 W/m^2 occurring at 40^{o}S, and extending to more than 1 km depth. Overall, the tropical oceans showed little net change in heat content from 1992 – 1998, but warmed strongly in the past 5 years. In the tropical Pacific, all of the sea level increase from 1992 to 2003, more than 2 cm on average, is attributable to ocean warming (thermosteric expansion, Figure 2). From previous work (Levitus *et al, 2001*), over 90% of the heating of the air/sea/land climate system in the past 50 years has occurred in the oceans. Increased sampling of the oceans with Argo floats allows ocean heat content to be accurately measured, including the contribution of thermosteric expansion to sea level change.

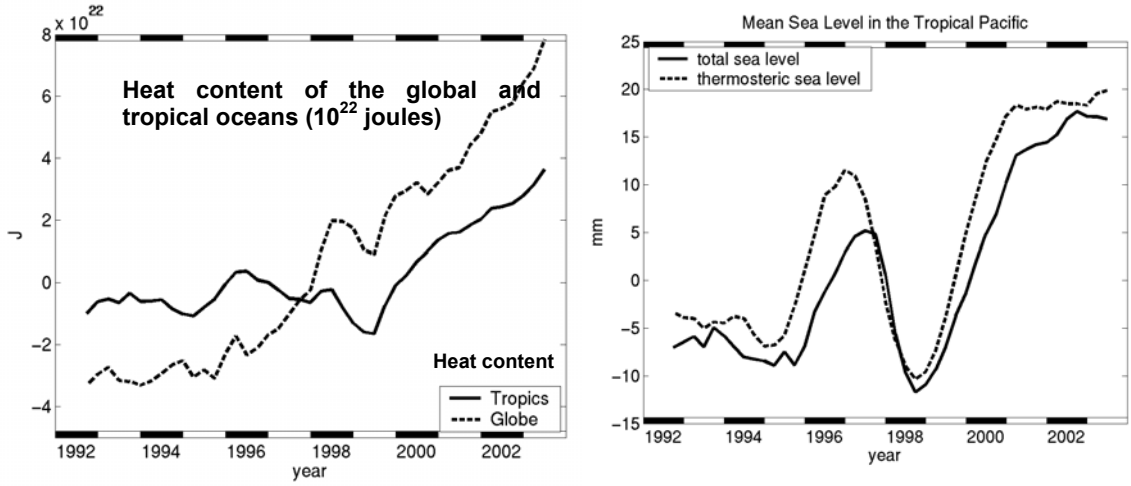


Figure 2. (Left panel) Interannual variability in heat content of the global oceans (dashed line) and of the tropical oceans (solid line). Units are 10^{22} joules; data from Willis et al (2004). (Right panel) Interannual variability in tropical Pacific spatial-mean sea level (solid line) measured by satellite altimeter, compared with sea surface height changes due to ocean warming in the same region.

During early 2004, 85 Argo floats were deployed in the southern Pacific (27^{o}S – 55^{o}S), with an additional 110 instruments being deployed in July – October, mostly in the southern tropics. Early Argo results from the southern Pacific add support to previous suggestions (e.g. Curry *et al, 2003*) of acceleration in the global hydrological cycle, with anomalously fresh sub-surface waters caused by increased rainfall at high latitudes. Continuing analysis will reveal the interannual variability in the precipitation/evaporation balance of the entire Pacific. By measuring temperature, salinity, and ocean circulation, Argo will observe the oceanic storage of heat and freshwater, their transport by ocean currents, and their exchange with the atmosphere.

References:

Curry, R, R. Dickson, and I. Yashayaev, 2003. A change in the freshwater balance of the Atlantic Ocean over the past four decades. *Nature, 426*: 826 – 829.

Levitus, S., J. Antonov, J. Wang, T. Delworth, K. Dixon and A. Broccoli, 2001. Anthropogenic warming of the Earth's climate system. *Science, 292:* 267 – 270.

Willis, J., D. Roemmich, and B. Cornuelle, 2004. Interannual variability in upper-ocean heat content, temperature and thermosteric expansion on global scales. Submitted to the *Journal of Geophysical Research.*

SERUVATU

Water and youth

Vasiti Seruvatu
Live & Learn Environmental Education, 2 Denison Road, Suva, Fiji Islands
Email: watered@livelearn.org.fj
Web: http://liveandlearn.idea.org.au

In August 2003 DFID (through SOPAC) approved a small grant to Live & Learn Environmental Education to carry out a water education pilot project. The project aims to support the outcomes from the *"From Vision to Action towards Sustainable Water Management in the Pacific"* High-Level consultation in Sigatoka in Fiji from the 29th July to 3rd August 2002. Live & Learn Environmental Education was particularly involved with Theme 3 of this consultation that focused on awareness.

Build the competency and capacity of young people in the South Pacific to engage in dialogue and debate regarding water, human rights and reduction of poverty and to mobilize communities to action towards sustainable water use and equality of access to water.

Project Achievements:

Rapid assessment of opportunities for youth participation and education within the Action Plan established by the High Level Consultation in Sigatoka;

Research of current resources available to youth in the Pacific on participation in sustainable water management;

Design and development of resources for training and capacity building purposes. This includes Water & Youth training manual (in progress) and educational flipcharts.

Pre-testing (2) of methodologies and methods proposed in the learning resources. The preliminary was carried out with a targeted audience at University of the South Pacific and the Fiji Institute of Technology. These were the first of 3 pre-tests. The pre-testing is considered an important component to the success of the development of the learning resources and training methods.

Establishment of a Water & Youth network in Honiara (Solomon Islands), Mele Catchment (Vanuatu), Kimbe Bay (Papua New Guinea) Training Team in Honiara in the Solomon Islands. This team will assist in carrying out training of other youth locally once the learning resources have been developed. It is envisaged there will be similar team in the other target countries. The Water and Youth trainers are listed below.

SHARMA & others

Benthic Foraminifera and their Contribution to Carbonate Accumulation in Laucala Bay, Suva, Fiji

Ashishika Sharma[1], Susanne Pohler[1], John Collen [2] & M.R. Langer[3]
[1]Marine Studies Programme, University of the South Pacific, Suva, Fiji
Emails: pohler_s@usp.ac.fj; S00007435@student.usp.ac.fj
[2]School of Earth Sciences, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand
Email: John.Collen@vuw.ac.nz
[3]Institut für Paläontologie, Rheinische Friedrich-Wilhelms-Universität Bonn, Nussallee 8, 53115 Bonn, Germany
Email: martin.langer@uni-bonn.de

The skeletal remains of foraminifera form an important part of carbonate sediments in the Pacific region. These organisms are capable of generating 2 kg of carbonate skeletons/m^{-2}/$year^{-1}$ (Harney, J.N. *et al.*, 1999). Langer *et al.* (1997) estimated that reef foraminifera contribute approximately 43 million tons of

calcium carbonate per year, 34 million tons of which accumulate in reef sediments. Because of their abundance and ubiquity in reefal and lagoonal habitats, foraminifera have often been referred to as "living sands" (Langer *et al.*, 1997). Living and fossil benthic foraminifera species represent a unique set of tools in understanding temporal and spatial variability, and more importantly, the implications of positive and negative anthropogenic impacts (Eade, 1988). They are good ecosystem monitors because they are usually the last organisms to disappear completely at sites heavily impacted by contamination (Murray, 1973). Laucala Bay is situated on the southeastern side of Viti Levu, Fiji Islands. It is a shallow triangular estuarine bay bordered by Suva's suburbs along its northwest shore, the mangrove forests and the Rewa River on the eastern side, and the coral reefs of the Suva Reef (Sosoikula Reef) and the Nukubuco Reef to the south.

The aim of this on-going research project is to study a series of sand samples from within Laucala Bay to determine the total foraminiferan fauna present and the relative abundance of the forams compared to other sand grains at each site. Sediment samples of about 1kg dry weight were collected from 8 sites within the Bay (Table 1). The samples were washed in dilute bleach and left overnight to soak. Each sediment sample was then washed with water over a 63μm sieve to remove all the clay and mud components. The sample was then dried in the oven at 60-80°C and subsequently sieved in a series of sieves ranging from 2mm, 1mm, 500μm, 250μm, 125μm, and 63μm. The different species of foraminifera present in each sample were picked under a binocular microscope until no new species could be found. The abundance of foraminifera compared to other components was determined by examining 100 grains of the original, unsieved sediment and counting the number of foraminifera in the sample. There were three replicates (i.e. 300 grains) to get an average percentage.

The fauna of the Bay, represented by the eight samples from within the lagoon and the reef flats, is characterized by large numbers of *Marginopora vertebralis*, *Amphistegina* spp., *Calcarina* sp., and *Quinqueloculina* spp. (Table 2). Other genera determined so far were *Neorotalia* sp., *Elphidium* spp., *Ammonia* sp., *Pitella* sp., *Textularia* spp., *Peneroplis* spp., *Rectobolivina* sp., *Millettiana* sp., *Spiroloculina* spp. and *Monalysidium* sp.

Table 1: Sampled sites within Laucala Bay and abundance of foraminifera per 100 grains of sample.

Sample No.	Location	Description of Location	No. of Forams per 100 sand grains	Approximate abundance
1	Nukubuco Reef	1/2 way to reef margin in micro-atoll zone	7	7%
2	Nukubuco Reef	NW tip	7	7%
3	Makuluva Island	Eastern side	10	10%
4	Makuluva Island	Northern tip	13	13%
5	Makuluva Island	Western side - toward open ocean	20	20%
6	Makuluva Island	Southern side - near passage	12	12%
7	Fish Patch	Due south from Nasese tidal flat	9	9%
8	Nasese Tidal Platform	Outer edge of platform	2	2%

Table 2. Generic composition of foraminiferids from Laucala Bay.

Sample No.	Environment	Genera present
1 – Nukubuco Reef	Suva Barrier reef on bayward side. No corals but algae. Fine to coarse grains.	*Marginopora, Amphistegina, Calcarina, Quinqueloculina, Neorotalia, Textularia, Rectobolivina, Spiroloculina*
2 – Nukubuco Reef (NW tip)	Suva Barrier reef on bayward side. No corals but algae. Fine to coarse grains.	*Marginopora, Amphistegina, Calcarina, Quinqueloculina, Neorotalia, Elphidium, Ammonia, Textularia, Peneroplis, Millettiana, Spiroloculina, Dorothia*
3 – Makuluva Island (East)	Suva Barrier reef on seaward side. Low energy area. Finer grains.	*Marginopora, Amphistegina, Calcarina, Quinqueloculina, Neorotalia, Elphidium, Ammonia, Pitella, Textularia, Peneroplis, Millettiana, Spiroloculina, Dorothia*
4 – Makuluva Island (North)	Suva Barrier reef on seaward side. Medium energy area, fine grains	*Marginopora, Amphistegina, Calcarina, Quinqueloculina, Neorotalia, Ammonia, Pitella, Peneroplis, Millettiana, Spiroloculina, Dorothia*
5 – Makuluva Island (West)	Suva Barrier reef on seaward side. High energy environment, open ocean water	*Marginopora, Amphistegina, Calcarina, Quinqueloculina, Neorotalia, Elphidium, Textularia, Peneroplis, Millettiana, Dorothia*
6 – Makuluva Island (South)	Suva Barrier reef on seaward side. High energy environment, very fast water flow	*Marginopora, Amphistegina, Calcarina, Quinqueloculina, Neorotalia, Elphidium, Ammonia, Pitella, Textularia, Peneroplis, Rectobolivina, Millettiana, Spiroloculina, Dorothia*
7 – Fish Patch	Suva Barrier reef on bayward side. Medium energy environment. Very clear water. Many corals in area.	*Marginopora, Amphistegina, Calcarina, Quinqueloculina, Neorotalia, Elphidium, Ammonia, Pitella, Textularia, Peneroplis, Rectobolivina, Millettiana, Monalysidium, Spiroloculina, Dorothia*
8 – Nasese Tidal Flat	Low energy environment. Extinct fringing reef now covered with silty clayey sand	*Amphistegina, Calcarina, Quinqueloculina, Neorotalia, Elphidium, Pitella, Textularia, Rectobolivina, Spiroloculina*

Samples 1 and 2 from the Nukubuco Reef had a large number and a whole range of sizes of *Marginopora vertebralis*. Also abundant were *Amphistegina* spp., *Calcarina* sp., *Quinqueloculina* spp. and *Textularia* spp. There were few *Neorotalia* sp or *Peneroplis* spp. Hence, few species were abundant but diversity was low.

Samples 3 and 4, from the low energy areas on Makuluva Island, were dominated by large numbers of *Peneroplis* spp, and *Quinqueloculina* spp.

Sample 5 faced the open ocean on Makuluva Island and was a very high energy area. It consisted of *Neorotalia* sp. and *Calcarina* sp. in large numbers along with *Textularia* spp.

Sample 6 from toward the passage near Makuluva Island had a high abundance and diversity. The water at this location was clear and fast flowing, and replenished from the open ocean. Foraminifera of the genus *Monalysidium* were exclusively found at that site.

Sample 7 from the Fish Patch had high abundance and diversity. All the species determined so far were found at this site in large numbers.

Sample 8 from the Nasese Tidal flat consisted of very few foraminifera and those were mostly abraded specimen, which can be assumed to have been transported from the reef. Only a few *Elphidium* spp. were found intact at this site.

It appears that sands from Makuluva Island contain the greatest abundance of foraminifera. Between 10% and 20% of the sand from that location is composed of foraminifera. The area is a well protected and less polluted than the rest of the Bay due to tidal flushing with water from the open Pacific Ocean. The fish patch opposite Nasese tidal platform contains almost 10% foraminifera which is surprisingly healthy considering the closeness to Suva Harbour and coastal run-off. Nasese tidal flat has very few forams and those found were dead and eroded. This sample consisted mostly of siliciclastic mud and clay, and although a few corals can be found in the murky water, the area is generally not an environment where foraminifera thrive.

References:
Eade, J.V. 1988. *Geographic Distribution of Living Planktonic Foraminifera in the South West Pacific,* New Zealand Oceanic Institute, Wellington.
Harney, J.N., Hallock, P., Fletcher III, C.H., Richmond, B.M. 1999. Standing crop and sediment production of reef-dwelling foraminifera on Oahu, Hawaii. *Pacific Science* 53: 61-73.
Langer, M.R., Silk, M.T. and Lipps, J.H. 1997. Global ocean carbonate production: the role of reef foraminifera, *Journal of Foraminiferal Research*, 27.
Murray, J.W. (1973) *Distribution and Ecology of Living Benthic Foraminiferids,* Heinemann Educational Books Ltd, London.

SINGH

Arsenic levels in drinking water on Fiji Islands

Sarabjeet Singh
SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands
Email: sarabjee@sopac.org

The Institute of Applied Sciences (IAS) of the University of the South Pacific have been involved in a study assessing arsenic (As) in drinking water in Fiji. Drinking water samples were collected from several major water source intakes on Fiji Islands and analysed for As content. The objective of the study was to determine if As concentration was above the recommended levels specified in the World Health Organisation (WHO) guidelines (10μg/L). The concentrations of As were determined by hydride generation using a Perkin Elmer 3100 atomic absorption spectrophotometer with FIAS 100 and adopting an accepted method from American Public Health Association (APHA, 1998). In the source waters, concentration of As were generally very low (<0.5 μg/L) indicating that there is very low input of arsenic from anthropogenic or natural sources. All of samples were below WHO guidelines indicating that drinking water in Fiji is safe for drinking from an arsenic content perspective. A relatively high value for As (6.6 μg/L) was found in Nasivi River in Tavua which was located downstream of a gold mine tailings pond discharge and more than 500m below Tavua Water Supply intake. The level of As downstream of pond discharge would depend on the quality and volume of the discharge being put in the river at any time and the present data are not adequate to validate if the As level is above or within WHO guideline and is safe for people who probably extract drinking water from directly downstream of the discharge.

TALIA

Seismicity of Samoa

Lameko Talia
Meteorology Division, Ministry of Agriculture, Forestry, Fisheries and Meteorology, P.O. Box 3020, Apia, Samoa
Email: geophysics@meteorology.gov.ws; ltalia@meteorology.gov.ws

Our earthquake recordings dated back to the year 1917. Very large earthquakes of the order of magnitude 7 on the Richter Scale were recorded however in those early days little or no records of the damages were recorded locally. Most of the recorded seismic activities in the Samoa Region originated from the nearby Tonga Trench to the southwest of Apia. Our instruments were updated from the old Digital World Wide Standardized Seismograph System Network (DWWSSN) to a much more recent Incorporated Research Institutes for Seismology (IRIS II) System under the Global Seismology Network (GSN).

TAPPIN

Coastal erosion on Tongatapu, Tonga, southwest Pacific Ocean – sea level rise or man's impact?

David R Tappin
British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham, NG12 5GG, United Kingdom
E-mail: drta@exchange.keyworth.bgs.ac.uk;

A comprehensive dataset including published literature, time series aerial photographs and satellite images, detailed survey levelling and field observation have been utilized to investigate an area of severe flooding in northwest Tongatapu, Tonga, southwest Pacific Ocean. The area is low-lying, with much of the region below sea level. It has been intermittently flooded since the mid-1970's. A major breach in the coastal barrier resulted in further flooding in 1983 and was repaired in 1984. The coastal barrier was again breached in 1997, and again repaired in 2003. If the coastal barrier is permanently breached a large land area will ultimately be lost to the sea, two land areas on the coast will become islands and coastal villages will be lost.

The flooding is attributed to human causes. The low-lying coastal barrier was most probably weakened in the mid-1970's by beach sand mining in an adjacent area and subsequently further damaged by human clearance of coastal vegetation. Severe storm conditions in the mid 1970's led to overtopping by the sea with the formation of a coastal breach in the north. After remedial action and the construction of a bund in northern breach, a second breach in the central area was created by storm conditions in 1997, resulting in further flooding. The predicted rise of global temperatures and associated eustatic sea level through global warming will increase the vulnerability of the area.

To repair and rehabilitate the area, construction of improved coastal defences using 'soft' engineering techniques is required. Additionally, access routes to the coast, such as footpaths, that are resulting in coastal erosion, require repair and the coastal vegetation in their vicinity rehabilitated. To promote recovery in the flooded hinterland and a return to agriculture, a programme of rehabilitation is required with restocking by suitable plants.

TAPPIN & others

Tsunami deposits from the submarine landslides of Hawaiian Giant – fact or fiction?

David R. Tappin[1], Gary M. McMurtry[2], Bruce W. Sellwood[3], Mark Williams[1], Ian P. Wilkinson[1], Gerard J. Fryer[2] & Philip Watts[4]
[1]British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham, NG12 5GG, UK
E-mail: drta@exchange.keyworth.bgs.ac.uk;
[2]School of Ocean and Earth Science and Technology, University of Hawaii, Honolulu, HI 96822, USA
E-mail: garym@soest.hawaii.edu, gerard@hawaii.edu
[3]School of Human and Environmental Sciences, University of Reading, Whiteknights, PO Box 2277, Reading, RG6 6AB, UK
Email: b.w.sellwood@reading.ac.uk
[4]Applied Fluids Engineering, Inc., Mail Box #237, 5710 E 7th Street, Long Beach, CA 90803, USA
E-mail: phil.watts@appliedfluids.com

On the Hawaiian islands of Lanai and Molokai, on the coast and at higher elevations, marine sediments, mainly volcanic conglomerates with a high biogenic component and calcareous cements, have been the subject of controversy since their identification in the 1930's. Initially interpreted as deposited during sealevel highstands, the sediments were reinterpreted during the 1980's as the result of megatsunamis created by massive volcanic sector collapses of the Hawaiian islands that created Giant Submarine Landslides (GSL's) 100's to 1000's of km^3 in volume. During the last decade the sediments on Lanai were reinterpreted again as shoreline deposits, laid down during interglacial sea level highstands.

Since their original discovery, constraints in the interpretation of the deposits has been the uncertainty of what constitutes a tsunami deposit in this environment as well as uncertainties in the subsidence history of

these islands, due to their relationship with the peripheral bulge created by the effects of the main island of Hawaii. Additionally, discrimination between the two possible origins of the sediments has been complicated by the GSL's themselves forming during interglacial periods when sealevels were also high.

Most recently, modelling of the tsunamigenic potential of the GSL's shows runups on the adjacent Hawaiian islands of up to 800 metres. This new work, in combination with the rediscovery on the main island of Hawaii of marine conglomerates comparable with those on Lanai and Molokai and a re-evaluation of the subsidence history of the Hawaiian islands, has resulted in a further reassessment of the likely origin of the sediments, that we consider to be due to tsunami runup.

In this talk we present the main facies characteristics of the sediments rediscovered on Hawaii Island based on field mapping and environmental analysis using the faunas in the sediments and their petrography. We compare this data to that from other Hawaiian islands. The sediments on Hawaii are located in the north of the island on Kohala volcano where they are exposed between the coast at 1.5m above present sea level to an altitude of 61 m. They comprise calcareous boulder conglomerates with a microfauna quite distinctive to that of present day beach deposits. The petrography is complex with cements of various affinities present. U-series dates from corals within the sediment are 100 to 120 ka. Ar/Ar dating of lava immediately underlying the conglomerate provides additional support for this age. Assuming the coral ages reflect the age of the enclosing sediment the subsidence rate of the island, established at 2.6 mm/year, indicates deposition well above the present sea level at elevations of ~300-400 m. The present depth of the 120-ka shoreline implies that the deposit was laid down by a tsunami, the runup of which at 6 km inland from the shore was 400 to 500 m. Based on the age of the corals in the sediment, the time of deposition correlates with that of the Alika 2 GSL from nearby Mauna Loa volcano, located offshore to the southwest of Kohala.

Dating Submarine Landslides – the July 17th 1998 Papua New Guinea Event

David R Tappin[1], Gary M. McMurtry[2], Philip Watts[3] & Takeshi Matsumoto[4]
[1]British Geological Survey, Kingsley Dunham Centre, Keyworth, Nottingham, NG12 5GG, UK
E-mail: drta@exchange.keyworth.bgs.ac.uk
[2]School of Ocean and Earth Science and Technology, University of Hawaii, Honolulu, HI 96822, USA
E-mails: garym@soest.hawaii.edu, gerard@hawaii.edu
[3]Applied Fluids Engineering, Inc., Mail Box #237, 5710 E 7th Street, Long Beach, CA 90803, USA
E-mail: phil.watts@appliedfluids.com
[4]Japan Marine Science and Technology Center, 2-15 Natsushima-cho, Yokosuka, Kanagewa, 237-0061, Japan

Identification, using seabed morphology and seismic, of a suitably located cohesive sedimentary slump offshore off the north coast of Papua New Guinea, mathematical modelling of which provided appropriate run-ups compared with onshore measurements, might have been expected to provide compelling evidence for the source of the registered tsunami in the context of an alternative hypothesis based on a shallow dipping thrust source. However, notwithstanding the evidence, alternative slump source mechanisms, as well as those attributed to a thrust fault, are still considered by some investigators as a likely alternative. In this context evidence is presented on the relative dating of the slump by observational and biological methods that supports the slump as the source of the tsunami.

The observational data from Remote and Manned Submersibles shows that seabed features, such as fissures and fractured limestone, on the surface of the slump, to be relatively fresher in appearance and thus more recently deformed than those located in other areas located outside the slump area. Chemosynthetic limestone was only observed on the slump surface, as was active fluid expulsion from the seabed. Additionally, seabed chemosynthetic cold water faunas, such as mussels and tubeworms, as well as bacterial mats that are intimately associated with sulphide rich fluids and seabed sediment, are much more common on the slump surface than elsewhere. Their presence is interpreted to indicate active expulsion of sulphide and methane rich pore fluids.

The combination of relatively fresh looking seabed features, active venting and intense biological activity on the surface of the slump, in the wider context of the limited presence of these in the surrounding area, is interpreted to indicate that this area was the source location of the slump that caused the July 1998 tsunami.

TAWAKE & others

Assesment of beach erosion: a case study of Tagaqe and Votua villages on the Coral Coast near Sigatoka, Viti Levu Island

Lavenia Volavola Tawake[1], Susanne Pohler[2] & Russell Maharaj[3]
[1] *Institute of Applied Sciences, University of the South Pacific,*
Email: lavenia_v@yahoo.com
[2] *Marine Studies Program, University of the South Pacific*
Email: pohler_s@usp.ac.fj
[3] *South Pacific Applied Geoscience Commission (SOPAC)*
Email: RussellM@sopac.org

The purpose of this research is to assess beach erosion along the Coral Coast of Viti Levu in the Fiji Islands. Tagaqe and Votua are two of the villages along the Coral Coast where beach erosion is a threat to housing and infrastructure such as seawalls. The Coral Coast has intensified in coastal population with increasing tourism development and population growth resulting in conflicts for coastal managers in dealing with beach erosion. Analysis of shoreline change by monthly beach profiling and analyses of aerial photographs, in relation to sediment composition and distribution, longshore and inshore currents, sea-level oscillations and climate and weather, will help in the assessment of chronic and acute erosion. Information gathered from this study will form part of the baseline data for further beach monitoring and optimum management of the beach environment.

Beach erosion is currently recognized as presenting a grave threat to many settlements in the Southwest Pacific including the Coral Coast of Viti Levu. About 86% of the coast lies at elevations that are less than 5m above sea-level and some villages have reported shoreline retreats of 15 to 20m over the past few decades (Mimura and Nunn, 1998). Natural beach systems are in a state of dynamic equilibrium and coastal processes cause changes to the beach equilibrium conditions (Gillie, 1997). Apart from these natural processes, human activity can usually start and even increase the rates of beach erosion occurring.

The Coral Coast on the south coast of Viti Levu is protected by fringing reefs but subject to rapid changes during frequent storm surges and cyclones. Ocean swells observed on these southern shores are predicted to present 70% of wave energy, with significant periods between 6 to 12 seconds. The trade winds from the southeast generally create longshore drifts from the southeast to the northwest. Inshore current patterns are governed by the tides, average wind speeds and direction, and reef structure and channels in the area. Past natural hazards like coastal floods and cyclones, extreme changes in weather, possible threats due to sea-level rise, and tectonic uplift have also been responsible for shoreline change along the Coral Coast.

The research methodology includes collection of monthly averages of wind velocities and wind directions, sea-level (mm), and water temperature of the Coral Coast area from the Nadi Meteorological records and the Australian National Tidal Facility. Extreme values of these climatological variables are being identified and assessed to explain observed changes of the village beaches and rates of shoreline changes. Longshore and inshore current patterns are also being assessed and mapped out using current drogues for the deeper areas, and hand-held current meters for the shallower areas. Sediment in the inshore areas is being collected to determine the composition, textural properties and possible transport patterns. In addition, six detailed beach profiles at each village site using a Leica automatic level kit are being conducted on a monthly basis to determine the short-term rates of shoreline change in the area. Oblique photographs are also taken on every trip to keep record of other changes that occur along the eroding beach. Aerial photograph analysis using the ERDAS and MAPINFO GIS software is being done to calculate the shoreline changes over the past fifty years, and to determine possible reasons for shoreline change. Interviews with the villagers are conducted simultaneously to gather information from non-historical documentation.

Three months of observation and beach profiling data collection have been conducted for both villages and data have been analyzed in Microsoft Excel. Analyses of aerial photographs from the 1950's have shown dramatic shoreline erosion in some areas. In both villages more beach erosion occurs to the west of the villages as currents move sediments to channels in the eastern part of the concave beaches. Observation and photographs have also revealed sediment migration in the river mouth and changes in the sediment

distribution and composition in different sections of the beaches. Unusually high rainfall in the month of June, the dry season would have increased the amount of coarser sediment transported from the rivers to the shoreline area thus reducing the rates of beach erosion. On the other hand, the short-term event of heavy rainfall can also cause erosion to occur.

Both villages have large amounts of beach rock, approximately 50m to 90m offshore suggesting that the beach might have once been in these locations. Rock and sediment samples are being dated to verify this. The size and orientation of this beach rock formation has probably affected the longshore current and sediment transport patterns that may also be contributing factor to the rates of erosion in front of the villages.

Wave energy that is generally dissipated along the fringing reefs increased dramatically in June, 2001 as strong southerly winds generated freak waves that caused a lot of damage and erosion along the shoreline. This may have been an indirect result of a deteriorating fringing reef as a result of eutrophication by pollution. Surveys of the inshore areas showed severe deterioration of micro-atolls and blooms of *Sargassum* and other soft algae.

The understanding of the significant coastal processes that occur in these two sites are important to describe the erosional problems that are present. It is hoped that beach erosion monitoring will elucidate which coastal processes are operating in these two areas and that the results of this project will help establishing management strategies.

References:

Gillie, R. D. 1997. Coastal Processes and Causes of Coastal Erosion on Pacific Islands.In: *Workshop on Coastal Processes in the South Pacific Island Nations. SOPAC Technical Bulletin, 9*, pp 11-23.

Mimura, N. and Nunn, P. D. 1998. Trends of Beach Erosion and Shoreline Protection in the Rural Fiji. In: *Journal of Coastal Research,* 14, pp 37-46.

TERI & others

Can over-fishing influence coastal erosion?

James Teri, Aisea Kaloumaira & Susanne Pohler
Marine Studies Programme, University of the South Pacific, Suva, Fiji
Email: pohler_s@usp.ac.fj

Fish are thought to generate up to 50% of the sand- and rubble sized carbonate fraction which completely or partially build many tropical beaches (Mark Hay, pers. Com., 2004). The break-down of calcified materials within a coral reef system plays an important role in sediment generation and beach nourishment particularly in low lying coral islands. A coral reef generally teeters on the balance between bioconstruction (accretion) and erosion. Bioerosion of carbonate substrates can be categorized as either external or internal depending on the nature of the process. The myriad of bioeroding organisms include reef fish (external bioerosion) that grind away on reef corals. This mode of external bioerosion is caused by direct grazing and feeding and contributes to sediment accumulation (Sammarco et al., 1987). In the process of grazing and coral consumption, coral reef fish can display preference for either live or dead corals depending on their diet. They are known as biolithophagic and contribute to bioerosion of coral reefs at an average rate of 0.1-1.15 kg m^{-2} yr^{-1} and release 1.9 m^3 of unconsolidated carbonate sediment anually with mechanical erosion (coral breakage) at 3.15 kg m^{-2} yr^{-1} (Harney & Fletcher; Mc Lean, 1974).

The sediment produced by herbivorous fish can be comprised of newly bioeroded materials and/or reworked sediments (Bellwood, 1995, 1996). "Coral eaters" constitute 20% (by weight) of all fishes seen on a coral reef and another 20% are classified as herbivores (Bruggemann et al., 1996) and they derive some of their food by eating substratum containing endolithic algae (Bruggemann et al., 1996). The fish families Acanthuridae (surgeon fish) and Scaridae (parrotfish) make up a major component of tropical herbivorous fish guilds (Lewis and Wainwright, 1985) and are responsible for high rates of carbonate degradation on different reef zones. Pari et al (1998) found $CaCO_3$ accretion in Tahiti between 0.03 to 24.4 kg m^{-2} yr^{-1} with total carbonate removal (bioerosion) by grazing found between 0.03 - 25.4 kg m^{-2} yr^{-1}.

Butterflyfish (Chaetodontidae) are primarily reef fishes and corals form part of their diet (Warren, 1978). Some chaetodontidae feed exclusively on corals (e.g., *Chaetodon ornatissimus*) while others (e.g., *C. punctatofasciatus*) utilize a variety of additional food sources. Most gut content analysis of *Chaetodon* spp. has shown that the diet consisted of coral polyps with no skeletal material admixed. *Montipora* sp., *Pocillopora* sp. and *Porites* sp. are preferred targets of chaetodonts.

The rabbitfish (Siganidae) are herbivores and graze mostly on encrusting algae. Though they are not really known for mass carbonate production they are capable of producing sediments through erosion and and fragmentation of algae (Milliman 1973).

Another, probably even larger, group of fish are omnivors or predators with varied diets which include calcareous organisms such as molluscs, echinoderms, and coralline red algae. These include pufferfish, porcupine fish, emperor fish, filefish, trunkfish, triggerfish, picasso fish, coris and unicorn fish. The break-down of invertebrates with calcified skeletons adds significant amounts of sand-sized carbonate sediment to the carbonate budget.

Our study of gut contents and aquarium fish showed that there is a positive correlation between fish size and amount of sediment produced and that some of the rarely considered fish such as porcupine fish are significant sediment producers.

The number of fish species that generate carbonate sediment through predation on corals, molluscs, echinoderm, coralline red algae and endolithic algae is very large and many of these fish, particularly the larger species, are targeted food fish in artisanal and subsistence fishery. Some of these fish species are locally depleted possibly due to overfishing (e.g. the humphead wrasse). In addition, some fish species lost their habitat due to eutrophication which kills many corals in fringing reef environments (seen in many areas along the coral coast). This combination of factors can, without doubt significantly reduce the amount of fish-generated sand and rubble and, as a consequence negatively impact beach nourishment. Beach erosion is an on-going process on many beaches, however, it is balanced by nourishment from various sources such as terrestrial input from rivers and marine input from reefs and lagoons (erosion = nourishment). If nourishment is higher than erosion then it is not commonly a reason for concern. But if part of the sediment that is nourishing the beach is not renewed than the balance will tilt to the erosional side of the equation, a grave concern for many island beaches. The important role that reef fish play in the production of carbonate sand, particularly on islands completely composed of recently formed carbonates, obviously needs to be assessed in more detail. Very little is known to date about the contribution of reef fish that predate on carbonate-producing organisms such as molluscs, echinoderms and red coralline algae.

References:

Bellwood, D.R. 1995: Direct estimates of bioerosion by two parrotfish species *Chlorurus gibbus* and *C. sordidus*, on the Great Barrier Reef, Australia. *Marine Biology,* 121: 419-429.

Bellwood, D.R. 1996: Production and reworking of sediments by parrotfish (Family Scaridae) on the Great Barrier Reef, Australia. *Marine Biology*, 125: 795-800.

Bruggemann. J.H., Van Kessel, A.M., Van Rooij, J.M. and Breeman, A.M. 1996: Bioerosion and sediment ingestion by Caribbean parrotfish *Scarus vetula* and *Sparisoma viride*: Implications of fish size, feeding mode and habitat use. *Marine Ecology Progress Series* ,134: 59-71.

Harney, J.N. and Fletcher, C.H. n.d.: A budget of carbonate framework and sediment production, Kailua Bay, Oahu, Hawaii, U.S.A. (Internet Source).

Lewis, S.M. and Wainwright, P.C. 1985: Herbivore abundance and grazing intensity on a Caribbean coral reef. *Journal of Experimental Marine Biology and Ecology,* 87: 215-228.

Mc Lean, R.F. 1974: Geologic significance of bioerosion of beachrock. *Proceedings of the second International Coral Reef Symposium 2*, Great Barrier Reef Committee, Brisbane.

Milliman, J.D. 1973: Marine carbonates: *Recent sedimentary carbonates*, Part I. H. Sturtz A.G., Würzburg, West Germany.

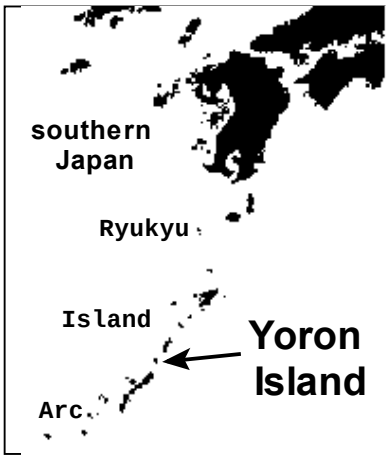
Sammarco, P.W., Risk, M. J. and Carrianiryij, J.D. 1987: Effect of grazing and damselfish territoriality on internal bioerosion of dead corals: indirect effects. - *Journal of Experimental Marine Biology and Ecology* 112:185-199.

TERRY

The use of karstic depressions for surface water reservoirs on small limestone islands: case study of Yoron-to in sub-tropical southern Japan

James P. Terry
Geography Department, The University of the South Pacific, Suva, Fiji Islands
Email: terry_j@usp.ac.fj

Yoron-jima is a small carbonate island 21 km^2 in area, located 27°01'N, 128°24'E in the central Ryukyu Island Arc of southern Japan. The island was raised above sea level in the Quaternary period and the sub-aerial geology comprises fossil coral reefs, rhodolith (algal ball) limestone and partly cemented Holocene coralline sands and gravels. The western peninsula and the northern segment are low relief coral limestone terraces, 10-30 m in elevation. Traversing NNW to SSE across the southern part of the island is an escarpment guided by a parallel pair of normal faults. The scarp slope rises to 50-97 m, east of which is an undulating area of low hills gradually losing height towards the east coast.



Yoron's landscape is partly karstified, characterised by many solution depressions of the doline type. The distribution of dolines is uneven, controlled by spatial changes in carbonate bedrock type, permeability, proximity with the fault escarpment, and tidal effects on coastal water table fluctuations. Concentrated swarms of doline depressions occur in two main areas. On the western peninsular low-lying coral limestone platform, where structural deformation has been minimal, dolines are generally small, shallow saucer-shaped features with simple elliptical plans, and are densely clustered. The other important doline cluster is in the north of Yoron, where dolines are larger, deeper and occur more often with irregular or star-shaped plans, clustered at lower density in association with the fault escarpment or outcrops of rhodolith limestone (Table 1). Aggressive dissolution has also produced large elongated dolines in coastal positions, where tidal fluctuations control the salinity and surface height of the water table within the bedrock.

Table 1. Doline characteristics on Yoron Island.

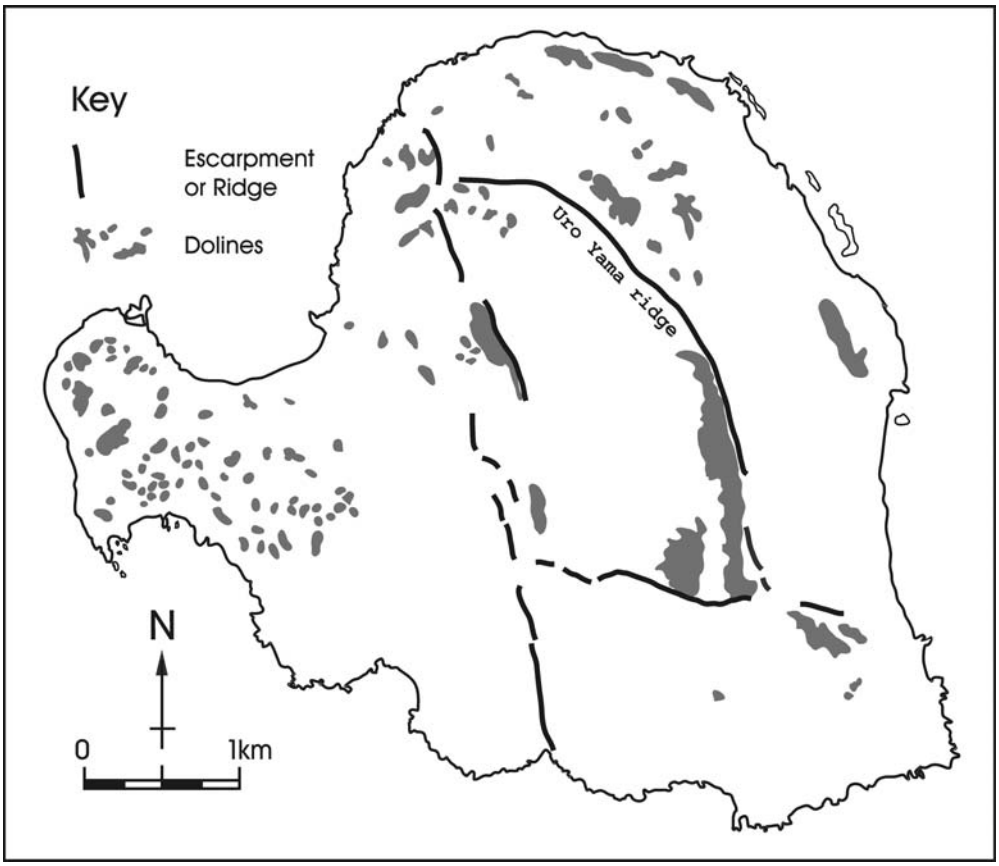
	Western Peninsula	**Northern Area**
Number	71	39
Mean diameter of enclosing contour	89 m	158 m
Standard Deviation	42 m	138 m
Clustering density	27 per km^2	7 per km^2

Yoron island's resident population numbers around 6000. The climate is subtropical with approximately 2200 mm mean annual precipitation. Typhoons often bring torrential rain from July to September. Domestic water needs are supplied from a large freshwater aquifer 30-40 m thick within the limestone bedrock. Published data on the hydrological balance estimates evapotranspiration 45%, runoff 15% and groundwater recharge 40% (Momii *et al.* 2001). Most of the native sub-tropical forest cover has been cleared and sugar cane farming and beef cattle grazing are now the two predominant agricultural land uses. Because of the permeable carbonate geology, there are no permanent surface watercourses, only small ephemeral streams draining the area below the fault escarpment. However, in the absence of streams as a resource for agricultural irrigation, the karst geomorphology has been utilized for surface water storage. Shallow dolines have been deepened mechanically, and lined to be used for reservoirs. This technique may be suitable for water storage on small limestone islands in the tropical South Pacific.

Reference:

Momii, K., Shoji, J., Jinno, K. and Nakagawa, K. 2001 Application of sharp interface approach to seawater intrusion and groundwater analysis in a small island, Japan. *Proceedings of the 3rd International Conference on Future Groundwater Resources at Risk*, 25-27 June 2001, Lisbon, Portugal, p649-656.

Top left: *Oblique aerial photo of Yoron Island; photograph by Kihachiro Kaneko.* ***Top right:*** *Typical small shallow doline on Yoron, used for agriculture.* ***Bottom:*** *Excavated and lined doline (left) to be used as a water reservoir for sugarcane irrigation (right).*



Map of surface doline depressions on Yoron

TERRY & THAMAN

Identifying and reducing the risks of beach and lagoon degradation in Cuvu Bay, southern Fiji

James P. Terry and Randolph R. Thaman
Geography Department, The University of the South Pacific, Suva, Fiji Islands
Email: terry_j@usp.ac.fj; thaman_r@usp.ac.fj

In Cuvu Bay, on the southwest coast of Viti Levu in Fiji, lies Yanuca Island, a 50 hectare low emerged limestone island (Figure 1). Developed on the island is one of Fiji's biggest international resort complexes, Shangri-La's Fijian Resort, which employs large numbers of people and is important for the local economy. A narrow marine lagoon, Yanuca Channel, separates the island from the mainland. Local Fijian chiefs and land owners who live in adjacent villages, and long-serving resort staff, give anecdotal accounts of beach erosion on the island and deteriorating environmental conditions in the lagoon over recent years.

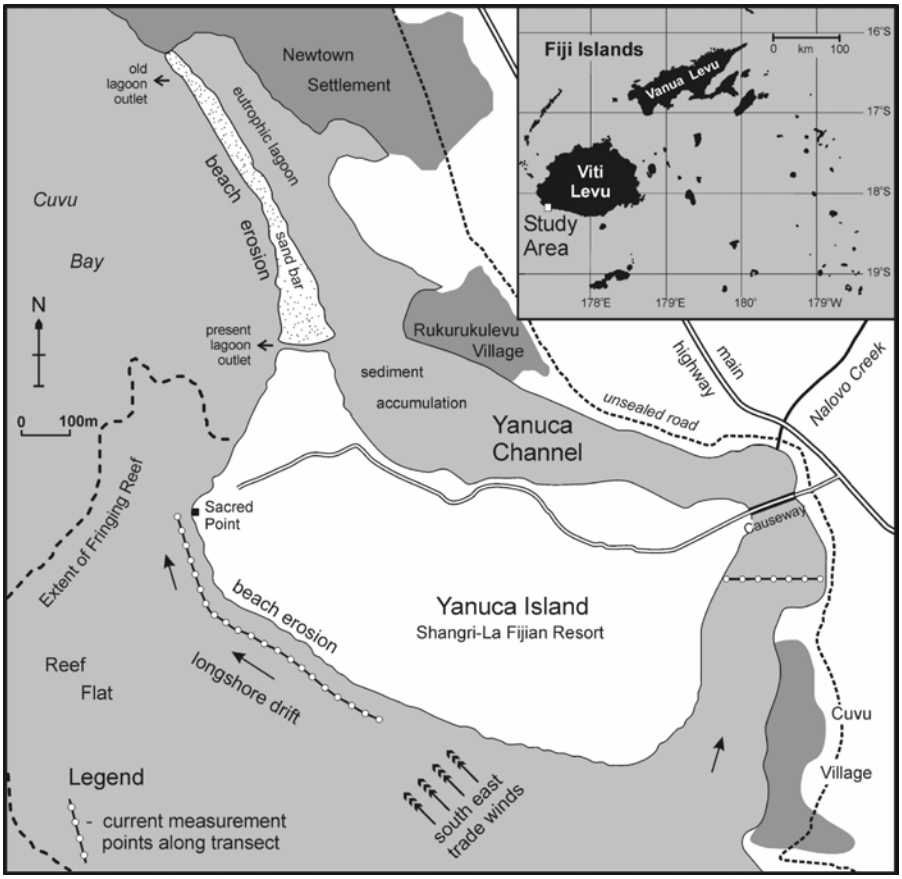
Figure 1:

An investigation into the processes responsible for these problems identified a number of causes for the degradation. Examination of the 50-year air photo record indicated coastal geomorphic evolution and associated adjustment to the drainage configuration of Yanuca Channel. Specifically, anthropogenic disturbance caused by sand mining and coastal vegetation clearance, beginning in the 1980s, led to sediment mobility and narrowing of a coastal sand bar attached to the north end of the island. As a result, a former lagoon outlet into Cuvu Bay became blocked, resulting in sediment infilling and eutrophication in the lagoon (Figure 2). Several small creeks discharge high sediment concentrations (e.g. >2000 mg/l) into the lagoon during storms. Sediment production is linked to land clearing for agriculture in the catchments, the erodible nature of the soils and marl bedrock, and the removal of mangroves in the lagoon estuaries of these creeks. Another factor is the resort causeway, built in the mid-1960s across the narrowest part of Yanuca Channel. This structure dampens wave power and impedes the flow of currents generated by the prevailing South East Trade Winds through the lagoon. Previously, periodic scouring of loose sediments from the lagoon floor by large waves, especially during storm surges, prevented long-term aggradation. The partial dam effect of the causeway now contributes to lagoon floor sedimentation. Along the ocean coasts of Yanuca Island, recent tropical cyclones have been largely responsible for the removal of beach deposits and the resulting exposure of cemented beachrock. Beach loss is probably exacerbated by a reduction in biogenic sand supply from nearby fringing reefs, due to over-fishing, crown-of-thorns starfish damage, coral bleaching and an overall decline in reef biodiversity.

Deteriorating lagoon conditions in Yanuca Channel and beach erosion on Yanuca Island represent a loss of natural resources vital for maintaining the aesthetic value of the tourist resort. This threatens tourist numbers and the employment of local people. It also heavily impacts on the productivity of the lagoon as an important source of subsistence fisheries products for the villages bordering the lagoon. In response, several adaptation actions involving partnership between the resort management, NGOs, The University of

the South Pacific, Fiji government representatives, and nearby Fijian villages, have been implemented. Some of these techniques promote traditional coastal management systems such as tabu (taboo) reserve designation, as well as coral garden planting, and coastal and riparian revegetation with ethnobotanically and ecologically important species.

Figure 2:



TRUSTRUM

The role of Pohnpei forests in controlling landslides and water yield

Noel Trustrum
Institute of Geological & Nuclear Sciences, P.O. Box 30-368, Lower Hutt, New Zealand
Email: N.Trustrum@gns.cri.nz

The upland forests of Pohnpei are relatively pristine, yet their watershed is extremely fragile given the high rainfall, steep topography and consequent potential for landslide erosion.

The removal of forest, increases runoff and erosion, and thereby; thins topsoils making them more drought prone, increases sediment loading of streams, and deposits sediment in lagoons and damages reef habitats.

In 2002, a survey of historic landslide events identified three types of landslide characterised by their depth and hazard and their relationship to environmental factors such as land cover, topography and rainfall events.

VUETIBAU & WONG

Tsunami mitigation activities in Fiji

Lasarusa Vuetibau & Loona Wong
Mineral Resources Department, Private Mail Bag, Suva, Fiji Islands
Email: lasarusa@mrd.gov.fj; l_wong@mrd.gov.fj

The tsunami generated by the M6.8 earthquake off the coast of Navua, Fiji, struck the coast of Suva within eight minutes, generating waves of 5 m in height. In Suva, eyewitnesses along the sea wall observed the ocean receding from the shore to beyond the reef, exposing the sea bottom and fish. The earthquake killed 3 people and the tsunami killed 5 people off the coast of Suva and Kadavu Island who were caught on the reef when the tsunami waves struck. Since the 1990's, the Fiji Mineral Resources Department (MRD) has steadily increased its efforts to monitor earthquake seismicity, document earthquake and tsunami hazards and assess their risks to Fiji, carry out tsunami awareness and outreach to local communities, and conduct research aimed at better understanding the regional tectonic and geological processes responsible for tsunamis.

Detailed coastal bathymetry collected by SOPAC with the assistance of the European Union, and in coordination with MRD off the southwestern to southeastern coast of Viti Levu in 1999 is providing new insights into the generation of tsunamis near island coasts. The data show a massive feature, interpreted as a slump or landslide, which overlays the submarine canyon topography caused by coastal river drainage into the ocean. The feature is very close to the epicenter of the 1953 earthquake, suggesting that the earthquake could have triggered a landslide, which in turn generated the destructive tsunami. The tsunami-generating mechanism would be similar to that which caused the 1998 Aitape tsunami which killed over 2200 people in Papua New Guinea, thus providing more evidence that earthquake-initiated landslides occurring along steep submarine slopes may be common sources for the generation of tsunamis in the South Pacific.

To better assess the potential risk, detailed high-resolution bathymetry surveys of coastal regions where moderate to large earthquakes are occurring are needed to identify potential landslide source areas, and to then numerically model the potential inundation and flooding of at-risk communities from the tsunami.

WAQAICELUA

Meteorological aspects of TC Heta and its implications for Disaster Management

Alipate Waqaicelua
Regional Specialised Meteorological Centre, Nadi-Tropical Cyclone Centre (RSMC Nadi-TCC), Fiji Meteorological Service, Private Mail Bag NAP0351, Nadi Airport, Fiji Islands
E-mail: Alipate.Waqaicelua@met.gov.fj

Heta was an intense category 5 tropical cyclone that devastated Niue on January 5th 2004 (Niue Local Time). It had an estimated maximum 10-minute average intensity of 115 knots (213 km/hr) with gusts to 160 knots (~300 km/hr). Tropical Cyclone *Heta* possessed a relatively large surface circulation, extending to about 20 degrees of latitude (1200 nautical miles or 2,200 km) across the centre. Of the centre of the cyclone, hurricane force winds (above 63 knots) were estimated to within 30 nautical miles, storm (48 – 63 knots), 50 nautical miles and gales (33 – 47 knots), 180 nautical miles. As far as track and development rate were concerned, *Heta* was generally well-behaved. Before hitting Niue, *Heta* "snaked" its way slowly close to five other countries, namely, Tokelau, Samoa, American Samoa, Wallis & Futuna and Tonga. Southern Cooks was the seventh country affected by Tropical Cyclone *Heta,* but indirectly. In this presentation, only the meteorological aspects of *Heta* are highlighted with some analogies against other severe tropical cyclones that had affected Niue. Additionally, some useful lessons on disaster management are drawn.

YOUNG & BOWER

Sanitation Park

Timothy Young[1] & Rhonda Bower[2]
[1]Pollution Control, Ministry of Health, 223 Government Buildings, Suva, Fiji Islands
Email: tyoung@health.gov.fj
[2]SOPAC Secretariat, Private Bag, GPO, Suva, Fiji Islands
Email: rhonda@sopac.org

A regional initiative to increase participatory approaches in the sanitation sector, Government bodies and the public give little attention to sanitation issues in the Pacific. This complacency and subsequent lack of investment has led to inadequate development in the sanitation sector. The result is an absence of good training facilities for Health Workers and technicians, with health education in the community suffering in particular. Ultimately, there have been serious health consequences for the community. The lack of awareness of the importance of appropriate excreta disposal leads to little or poor maintenance of existing sanitation facilities, resulting in low standard waste disposal systems. As a result of the above, sanitation related diseases are prevalent in the community, predominantly in rural areas and squatter settlements, where poverty is rife. Ultimately the marine environment, water resources and sub-soil suffer due to dangerously high levels of fecal contamination.

A genuinely grassroots undertaking with full community involvement, the Sanitation Park project supports communities in Fiji to identify and solve their sanitation problems by examining and selecting from a range of appropriate, affordable options wastewater treatment options housed at a demonstration park at the Fiji School of Medicine, Tamavua campus. The project Team inclusive of the World Health Organisation, Fiji Ministry of Health, Fiji School of Medicine and SOPAC worked together to implement the project with funding provided by WHO and NZAID.

Three communities, namely Keiyasi (Sigatoka), Balevuto (Ba) and Nadelei (Tavua), were selected through pre-project surveys to carry out community training, which included a hands-on composting toilet construction training in May 2004 involving district health workers and community members and also 3 community workshops under the "Healthy Islands Initiative" in the three selected communities. Project reports are currently being finalised.

ZANN

Capacity-building: the role of the Marine Studies Programme, University of the South Pacific

Leon Zann
Marine Studies Programme, University of the South Pacific, Suva, Fiji Islands
Email: zann_l@usp.ac.fj

The University of the South Pacific (USP) is the premier provider of tertiary education in the region, and services the needs of 12 Pacific island countries. The Marine Studies Programme (MSP) at USP was established to aid in the understanding, conservation, development, management and utilization their living and non-living resources; provide opportunities for research, education, training and employment in the marine sector; and provide for improved collaboration between USP island nations, regional and international bodies in their common goals in the marine sector.

The structure and function of both the University and MSP are currently being revised. USP's top priorities in its new Vision 2020 are: good governance, sustainable development and marine studies. The needs of the region in the areas of coastal and marine resources management are now being examined, with the intention of MSP better meeting the region's needs in this fast-changing world. New focus areas are to be fisheries, coral reef and coastal management. Closer working relationships are being developed with CROP agencies, including SOPAC, and new teaching programs and research directions are planned. In this STAR session USP is seeking advice from SOPAC and Pacific governments on priority issues in coastal/marine resource management, and training and research needs.

LATE ABSTRACTS

CAMERON & others

Denitrification by Design

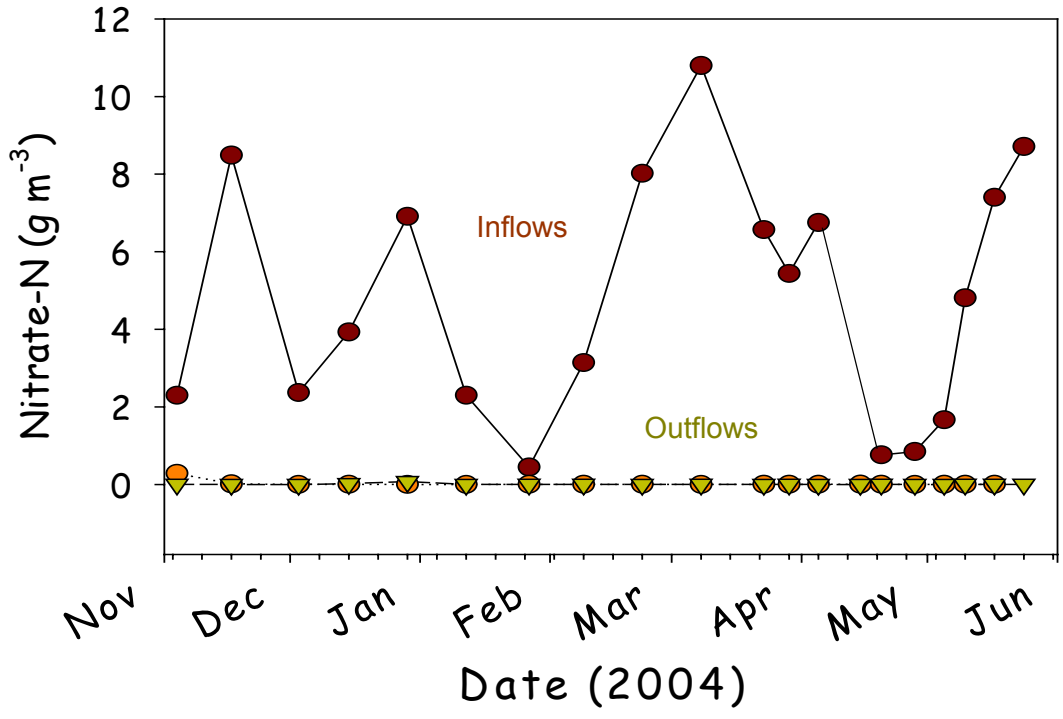
Stewart Cameron[1], Tamara Tait[1], Louis Shipper[2] & Graeme Anderson[2]
[1]Institute of Geological & Nuclear Research Ltd, Geological & Nuclear Sciences
Wairakei Research Centre, Private Bag 2000, Taupo, New Zealand
Emails: s.cameron@gns.cri.nz; t.tait@gns.cri.nz
[2]LandCare Research, Private Bag 3127, Hamilton, New Zealand
Emails: SchipperL@landcareresearch.co.nz; AndersonG@landcareresearch.co.nz

Wastewater treatment plants have been designed to remove nitrogen, however removing the last bit of nitrogen from wastewaters before discharge has proved to be difficult.

Denitrification beds, a recent development, achieve impressive nitrogen removal from wastewater. These denitrification beds are constructed using bulk carbon-based material and are designed to assist the conversion of nitrate to nitrogen gas.

GNS and Landcare in conjunction with Taupo District Council, New Zealand have a working system of beds currently in place at Kinloch on the shore of Lake Taupo. Measurement of nitrate entering and leaving the denitrification beds, depicted in the figure below, shows nearly complete nitrate removal.

Kinloch Denitrification System



The performance of the denitrification beds at Kinloch is in line with similar systems in place overseas. These systems have effectively removed nitrogen on a continuous basis for up to 6 years.

The beds are a highly cost-effective means of achieving the environmental benefits of nitrogen removal, sought after by councils and industry.

The success of the Kinloch venture has prompted the creation of XN solutions

a joint venture between GNS and Landcare Research charged with working with councils and industry to minimise nitrogen release into the environment.

XN solutions can provide:

- An assessment of your waste stream by recognised scientific personnel
- Design of a denitrification bed in line with current working systems
- Providing data to assist resource consents
- Assistance with engaging engineering firms with system experience
- Design of a performance or compliance monitoring programme
- Accredited analytical laboratories to fulfil your monitoring requirements.

Further information is available from the GNS staff at the conference or you may like to contact the authors directly.

DYMOND & others

A region-wide model of landslide risk in the Manawatu/Wanganui region of New Zealand

John R. Dymond[1], Anne-Gaelle Ausseil[1] James D. Shepherd[1], Lars Buettner[2] & Peter F. Newsome[1]
[1]Landcare Research, Private Bag 11052, Palmerston North, New Zealand
Emails: DymondJ@LandcareResearch.co.nz, AusseilA@LandcareResearch.con.nz, ShepherdJ@LandcareResearch.con.nz, NewsomeP@LandcareResearch.con.nz
[2]Centre for Environmental Research, Leipzig, Germany
Email: Ibuettner@web.de

Since the arrival of Europeans in New Zealand 160 years ago, much of the indigenous forest on hill country has been cleared for pastoral agriculure, resulting in increased erosion and sedimentation. In order to prioritise soil conservation work in the Manawatu/Wanganui region, a model of landslide risk has been used to identify steep land without the protection of woody vegetation. A major storm that occurred in the region on the 15th and 16th February, 2004, and produced many landslides, has been used to validate the model. The model predicted hills at risk to landsliding with moderate accuracy: 58% of erosion scars in the February storm occurred on hillsides considered to be at risk from landsliding. The model concept of slope thresholds, above which the probability of landsliding is high and below which the probability is low, is inadequate as the probability of landsliding is linearly related to slope below 30 degrees. Thus reforestation of steep slopes will need to be combined with improved vegetation management for soil conservation on moderate slopes to significantly reduce the future incidence of landsliding.