RV *Southern Surveyor*

2007 program

MARINE
NATIONAL FACILITY

voyageplan
SS06-2007

Volcanism and Tectonism of the South Bismarck Microplate, Papua New Guinea

Itinerary

Depart Madang 1400hrs Wednesday July 25, 2007

Arrive Madang 0800hrs Tuesday 14 August, 2007

Principal Investigator(s)

Professor Richard J Arculus (Chief Scientist) – Department of Earth and Marine Sciences, Australian National University, Canberra ACT 0200

Phone: +61 02 6125 3778 **Fax:** +61 02 6125 5544

Email: Richard.Arculus@anu.edu.au **Mobile:** 0438 433 256

CSIRO

Scientific Objectives

1. The principal objective of the expedition is to build on background reconnaissance carried out by previous expeditions (most notably *RV Franklin* 02 in 2002 and RV Kilo Moana 0419 in 2004) in the submerged portions of the Bismarck Arc in order to characterise the petrogenesis and tectonic setting of previously unknown volcanic centres. Dredging and sticky wax coring will recover fresh glassy volcanic rock samples. Glasses and bulk rock samples will be analysed for major, trace and volatile elements together with isotopic (radiogenic and stable) abundances to determine the volatile contents and melting processes, identify mantle sources likely including "Indian"-type and possible Manus plume components, and hence obtain insights into upper mantle flows associated with arc-continent collision on the northern margin of the Australian Plate.

2. A secondary objective is to test young volcanic features for evidence of associated hydrothermal activity. This will be done using a similar plume-location and characterisation approach used on previous voyagers by the Chief Scientist and his collaborators.

Specific Objectives

1. 30 kHz swath mapping for detailed identification of volcanic targets located using available 12 kHz swath bathymetry from the KM0419 voyage, and previous voyages to the region.

2. 30 kHz swath traverses of two previously unmapped interpreted areas of the submerged Bismarck arc between Manam Island and Karkar Island and north of New Britain (Figure 1). Time constraints will preclude full swath mapping of these areas. However, the ship will be slowed on transit and care will be taken not to duplicate KM0419 tracks.

3. Sampling of submerged volcanic features using dredging, grab sampling and sticky wax coring.

4. Identification of hydrothermally active volcanic structures using CTD hydrocasts, plume water sampling, deep tow video, dredge and grab sampling.

Voyage Objectives

We seek to study the space – time distribution of the volcanic activity in order to investigate its relationships to the tectonic development of the South Bismarck Microplate, with the aim of understanding deviations from the normal patterns of volcanic activity associated with subduction and termination of subduction. The following are the objectives of the proposed research voyage and follow-up laboratory studies:

What are the characteristics and linkages between the magmatism and different tectonic variables in the South Bismarck Microplate?

In order to complete our understanding of the volcanic-tectonic relationships of the South Bismarck Microplate, we need to map at high resolution the distribution of deformation and principal stress directions in undersea parts of the Plate. Data are particularly needed in the region of the junction of the volcanic arc with the Bismarck Sea Seismic Zone, and along the strike of the Willaumez Peninsula-Witu Islands to address the following questions:

1. The occurrence and distribution of volcanic vents, including the orientations of elongated vents and aligned vent arrays that indicate principal horizontal stress directions. Swath and backscatter mapping by the 2004 *R/V Kilo Moana* voyage (*Silver et al.*, 2004; 2005) discovered a large number of volcanic features, including seamounts, small cones, lava flows and possible intrusions, and significant regional structures. While some of these had been serendipitously dredged by the FR02/02 voyage, most have not been sampled (the KM0419 voyage made few dredges). Some of the volcanic features and flows occur on the submarine flanks of known subaerial volcanoes, notably Lolobau, Garove, Dakatuau, Langilla, Crown and Karkar while others are discrete features well away from the submerged flanks of subaerial volcanoes. *Silver et al.* (2004) noted a N-S perpendicular elongation of "vents structures" close to the subaerial Bismarck volcanic arc, and a trend more E-W to the north around Witu Islands and near Lolobau, implying a complex variation in regional stress directions. They also noted the previously unknown wide zone of volcanism extending to the north of the subaerial volcanic arc.
2. The distributions and geometries of fault systems and fold structures, especially along and close to the boundaries of the three sections of the South Bismarck Sea Microplate defined above but also within these sections, and their relationships to the distributions and orientations of volcanic vent systems and drowned reefs.

What are the nature and source characteristics of the magmatism in the South Bismarck Microplate?

We know that the nature of the mantle wedge (intrinsic fertility), nature of slab inputs (fluids/melts), and extents of partial melting are linked in terms of arc magma characteristics. The magmatism distributed across the southern part of the South Bismarck Microplate provides a window into slab inputs and mantle variability over a wide range of subduction and possible rifting variables from post-collision uplift, through ongoing subduction to possible pre-backarc basin rifting west of the Manus Spreading Centre.

Does the Manus mantle plume penetrate beneath the South Bismarck Microplate?

Based on the He, Sr, Nd, and Pb isotopic compositions of samples from Manus Island and vicinity, it has been proposed that a mantle plume is present (*Macpherson et al*, 1998). The strongest evidence for this hypothesis is high 3He/4He. We will obtain radiogenic isotope data for selected samples with which we should be able to detect plume input diminishing from north to south across the Microplate.

What are the characteristics of volatile distribution in the mantle sources of South Bismarck Microplate magmas?

Submarine-quenched samples are demonstrably superior to degassed subaerial arc magmas for studies of pristine volatile contents. The recycling of volatile elements and compounds such as H_2O, CO_2, S and halogen compounds from subducted slab to mantle and thence via arc and backarc basin magmatism to the hydrosphere and atmosphere is one of the first order geochemical processes. A major voyage objective will be to recover fresh glassy rock samples for detailed chemical analysis, particularly of volatile elements and compounds. Our overall primary objective with these (glassy) rock samples is to quantify the volatile fluxes in supra-subduction zone settings, and attempt to distinguish the components involved (mantle wedge, subducted crust, overriding arc lithosphere).

What is the incidence and distribution of tsunamigenic volcano collapses?

The KM0419 voyage identified a number of clearly tsunamigenic volcano collapses such as that of the flanks of Ritter. We also identified numerous similar volcano collapses in the Kermadec-Tonga Arc, and these features are generally significant both from the societal hazard point of view, as well as a major mode of redistribution of volcanic materials and arc crustal growth.

Voyage Track

From Madang, we will sail approximately 40 nautical miles north to the western side of Karkar Island, before turning northwest and carrying out an 90 mile EM300 multibeam echosounding transit to Target A (see Table 1) in the Shouten Islands (Area 1 on Figure 1). This structure is an apparently young volcanic feature mapped during KM0419 and is the first of a number of such targets identified from multibeam bathymetry for petrogenetic sampling and testing for hydrothermal activity (Table 1).

Following completion of testing of features of interest in Area 1, the vessel will proceed in a generally easterly direction, mapping and testing targets of interest in Area 2 and Area 3, as well as carrying out infill swath traverses during transits across the poorly mapped zones between Areas. Following testing of our final Target T in Area 3, the vessel will then return to Madang for the completion of the voyage.

Time Estimates

Action	Time (hours)	Time (days)
Transit Madang to Karkar	4	0.167
Swath mapping transits between mapped areas (300 Nm @ 8 knots)	40	1.583
Detailed swath mapping of targets (700 Nm @ 8 knots)	90	3.667
CTD casts (30 operations)	90	3.750
Rock sampling (50 operations)	140	5.833
Deep tow video (6 operations)	24	1.000
Transit Target T to Madang	30	1.250
Transits between Targets	45	1.875
Contingency	17	0.708
Total	**480**	**20.000**

Based on previous experience the following times in hours are estimated for operations other than swath mapping, including positioning and set-up

Operation	1000m	2000m	3000m
CTD single dip	2.0	2.5	3.0
Dredge	2.5	3.0	3.5
Grab/corer	1.5	2.0	2.5
Deep tow video	3.5	4.0	4.5

Southern Surveyor Equipment

Scientific Equipment

Smith-McIntyre sediment grab. 1
Seapath Seatex 200 – for accurate heading, pitch and roll and heave 1
Simrad EK500 sounder for biological research (12, 38 and 120 kHz) 1
Simrad EA500 sounder for bottom detection (12kHz) 1
ADCP - measures current vectors beneath the vessel 1

Laboratory and other Facilities

General purpose laboratory (includes fume hoods, fridge, freezer) 1
Hydrochemistry laboratory 1
Wet laboratory/CTD room 1
Fish laboratory/geoscience laboratory 1
Winches, A-frames and Crane . . . .
Trawl winches, port and starboard, with 4,500m of 24mm wire (trawling and dredging) 1
Coring winch with 7,000m of 19mm wire 1
CTD/Hydro winches each with 7,000m of 8mm single core conducting cable 1
Towed-body winch with 3,000m of 12mm 7-core conducting cable 1
Hydrographic A-frame 1
Stern A-frame (SWL 15 tonnes) 1
General purpose winch on stern A-frame (5 tonne) 1

Data Products

ADCP: standard data provided as 20 minute averages, default 8m or 16m bins 1
Underway data in netCDF format (10s sampling period) & CSV format
at user selected sampling period 1
Ship attitude – heave, pitch, roll and heading 1
Data from winch sensors (tension, winch speed and wire out) 1
Bridge log (photocopy) 1
Specialised Electronic Equipment . . . .
Acoustic Pinger – used for monitoring the altitude of underwater packages 1
Conductivity, Temperature and Depth Profiling (CTD) . . . .
CTD (Seabird SBE 911 plus). 1
Rosette (24 bottles up to 10 litres) 1
10 litre Niskin bottles 1
Other CTD Sensors . . . .
Transmissometer (to 6,000m depth) 1
Data Products Available on Request . . . .
CTD data. 1
CTD log (photocopy). 1
Echograms from the Simrad EK500 sounder
– readable with Sonardata Echoview software. 1
Echograms from the Simrad EA500 sounder
– readable with Sonardata Echoview software. 1

Other Equipment and Facilities

User Equipment

- He water sampling crimping gear (as used on SS11/2004) from NOAA (Newport, Oregon)
- Equipment for filtering and analysing hydrocast samples
- Microscopes.
- A specially designed “glass-chipping head” for the small gravity corer.
- Small gravity corer
- Spare dredges from Geoscience Australia of the same design (and deployment routine) as those belonging to the National Facility
- Rock sampling equipment (hammers)
- Deep tow video camera

Personnel List

Name	Affiliation	Position
Richard Arculus	ANU	Petrology/Tectonics/Chief Scientist
Sarah O'Callaghan	ANU	Petrology/Tectonics
Tarum Whan	ANU	Student
Heather Cunningham	Macquarie Uni.	Geochemistry
Simon Day	Uni of California	Tectonics
Chris Yeats	CSIRO E&M	Ore Deposit Geology
Shannon Johns	CSIRO E&M	Ore Deposit Geology
Camilla Stark	CSIRO E&M	Water Column Sampling
David Fuentes	CSIRO Petroleum	Water Column Sampling
To be confirmed	To be confirmed	Swath mapping
Drew Mills	CMAR/MNF	Electronics Support
Bob Beattie	CMAR/MNF	Voyage Manager/Computing
PNG Observer – to be confirmed		PNG Observer

ANU – Australian National University
CSIRO E&M – CSIRO Exploration and Mining
CMAR – CSIRO Marine and Atmospheric Research
MNF – Marine National Facility

Richard Arculus
Chief Scientist

Tables and Figures

Table 1: Coordinates of specific targets.

Target (Zone)	Latitude (S)	Longitude (E)
A (1)	3° 33′	144° 50′
B (1)	3° 32′	144° 56′
C (1)	3° 26′	144° 50′
D (1)	3° 28′	144° 36′
E (1) – Manam Island	4° 05′	145° 02′
F (2)	4° 25′	146° 12′
G (2)	4° 54′	146° 08′
H (2)	4° 35′	146° 41′
I (2)	4° 39′	146° 50′
J (2)	5° 05′	147° 06′
K (2)	5° 06′	147° 11′
L (2)	4° 52′	147° 22′
M (3)	4° 48′	148° 48′
N (3)	4° 54′	148° 51′
O (3)	4° 39′	149° 04′
P (3)	4° 38′	149° 08′
Q (3)	5° 02′	149° 51′
R (3)	5° 08′	149° 55′
S (3)	4° 46′	151° 02′
T (3)	4° 47′	151° 25′

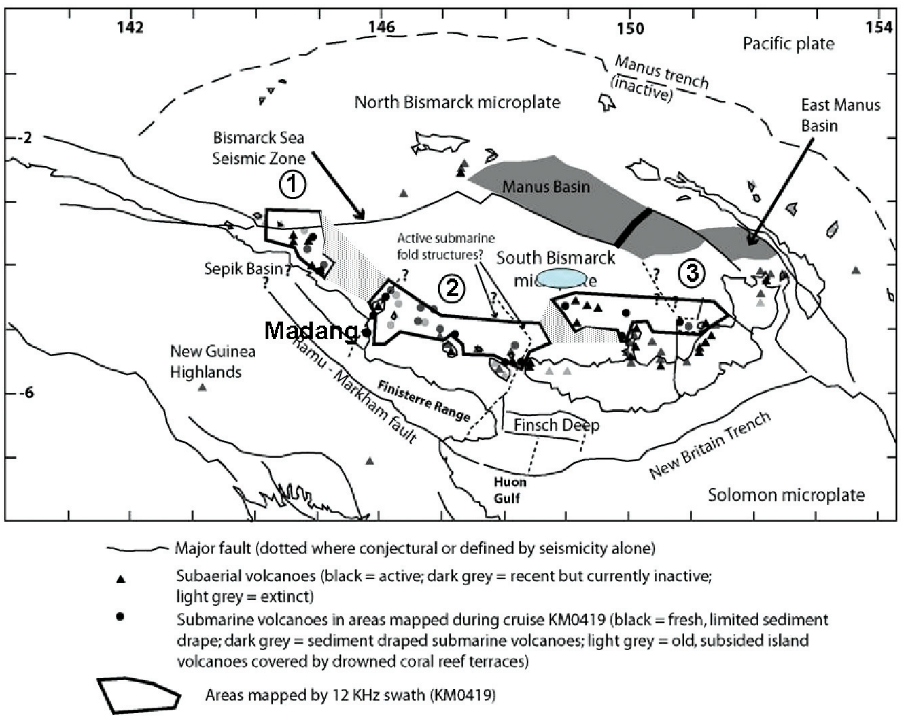

Figure 1: Bismarck Arc in regional context showing the location of active and inactive plate boundaries, other major geographical and tectonic features, known volcanoes, the target areas swath mapped by the KM0419 research voyage (Areas 1 to 3), and the gaps in coverage which will be reconnaissance mapped by this expedition (light stipple).