VOYAGE PLAN SS06/2004

Title
COTROVE-2004 (Coriolis Troughs Vents Expedition)
Submarine volcanic and hydrothermal activity in the New Hebrides arc-backarc system.

Itinerary
Depart Noumea 1000 hrs, Monday 31 May, 2004
Arrive Sydney 1000 hrs, Sunday 27 June, 2004

Principal Investigator
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Scientific Objectives
1. to swath-map the Coriolis Troughs (Vanuatu) (Fig. 1) with multibeam sonar, in order to identify areas of exposed lavas, including coverage of the known occurrences in the northern end of the Futuna Basin and the Nifonea Ridge in the Vate Trough;
2. to explore for and map the distribution of active hydrothermal venting systems of the Coriolis Troughs;
3. To revisit the Nifonea Ridge hydrothermal vent system discovered on RV Franklin (FR08/2001), and determined whether changes have occurred in the intervening 3 years;
4. to recover fresh igneous and mineralised rock, sediment, and water samples associated with igneous activity in these Troughs

Specific objectives are:
1. To perform the first detailed, high-resolution swathmap bathymetric survey of the floors and flanks of the Futuna, Erromango, and Vate Basins, using the state-of-the-art Kongsberg EM300 system recently installed on the RV Southern Surveyor;
2. Dredge igneous rock targets identified on the floors of the Basins and intervening ridges, in order to recover fresh glassy rock samples for detailed age studies and chemical analysis, particularly of volatile elements and compounds, and stable isotopic characteristics.
3. Dredge hydrothermal sulfide-rich and altered rock samples for studies of base and precious metal mineralisation;

4. To explore with the transmissometer-equipped CTD sledge for hydrothermal plume activity in these basins and intervening ridges, and to recover water samples for immediate analysis (including CH_4) on board and subsequent shore-based laboratory analysis. A specific target will be a return to the Nifonea Ridge to examine the changes (if any) to the hydrothermal system discovered during FR08/2001.

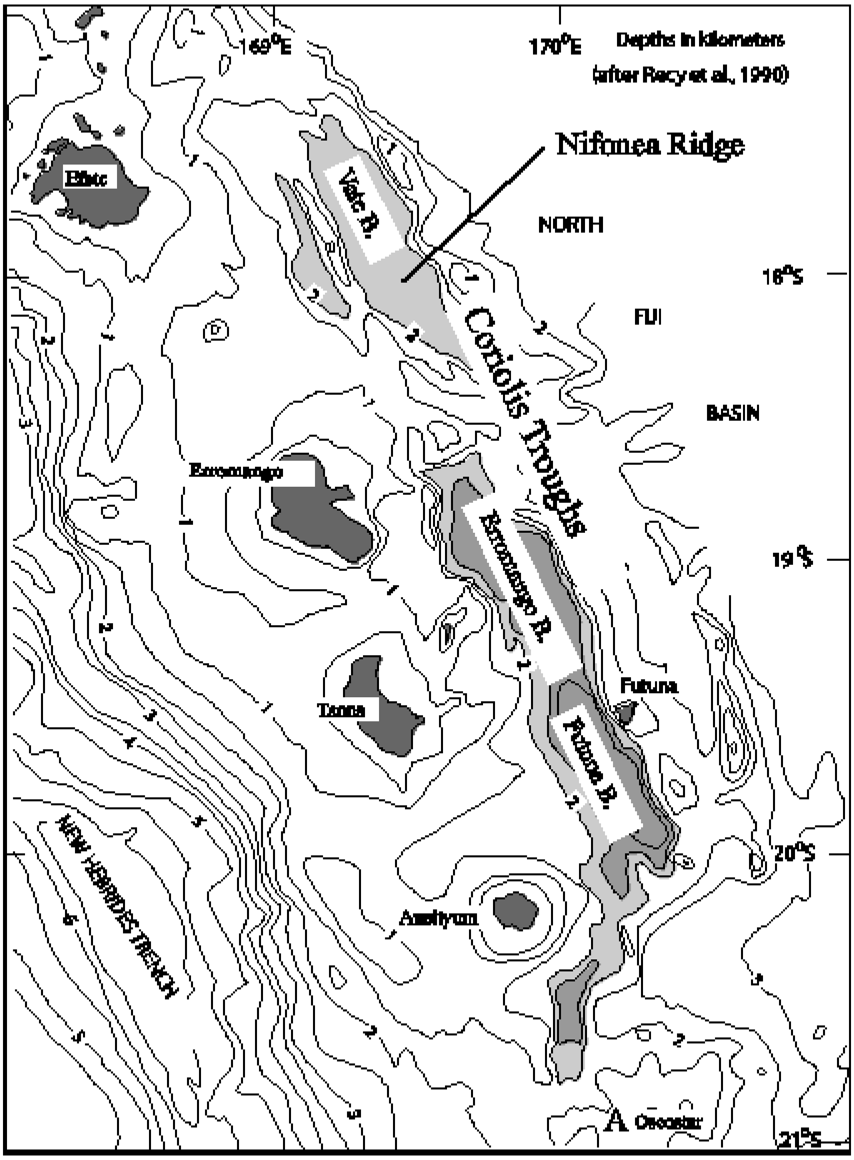

Figure 1. Location of the Coriolis Troughs comprising the Vate, Erromango, and Futuna Basins.

Voyage Objectives
We know now that the supposedly non-magmatic and sediment-filled Coriolis Troughs (see e.g., Récy et al., 1990; Pelletier et al., 1993), some 50 km behind the active volcanic front of the southern New Hebrides Island Arc (Fig. 1), are in fact, at least partly floored by young basalt lava fields (as predicted by Price et al., 1993) of highly unusual composition (trachybasalt). On FR08/2001, we recovered trachybasalt and andesite from the northern end of the Futuna and Vate Basins respectively. In the vicinity of the Nifonea Ridge, at least 3 types of basalt were recovered based on distinctive trace element geochemical characteristics; in retrospect, it is clear that both of these basins are extensively floored by volcanic rocks, and the topographic high between the Erromango and Futuna Basins could be another spreading locus. The significance of these discoveries are as follows:

The upper mantle sources of mid-ocean ridge lavas in the Pacific and Indian Oceans are isotopically distinct (Hamelin et al., 1986). The boundary between these mantle domains lies along the length of the active arc systems in the western Pacific, from the Izu-Bonin-Mariana in the north to the Lau-Tonga system in the south (Hickey-Vargas et al., 1995). There is evidence that the Manus and North Fiji Backarc basins are both underlain by Indian-type mantle (Woodhead et al., 1998, 2001; Peate et al., 1997) with the former possibly also overlying a "mantle plume" (Macpherson et al., 2000). The New Hebrides arc is unusual in that in the vicinity of the collision zone with the D'Entrecasteaux Ridge (Fig. 2), the arc magmas seem to be tapping an Indian source in the mantle wedge overlying the subducted Australian Plate, whereas the arc volcanoes to the north and south of this collision zone are tapping Pacific-type mantle wedge sources (Crawford et al., 1995). A deepening and deflection of magma generation eastwards in the collision zone to tap sources equivalent to "ascending diapirs of asthenospheric mantle providing backarc basin-type basalts to the embryonic backarc troughs" (i.e., Coriolis or "Southern Backarc Troughs" in the South, and Jean Charcot or "Northern Backarc Troughs" in the North) of the New Hebrides Arc is invoked by Crawford et al. (1995) to account for this along-arc variability.

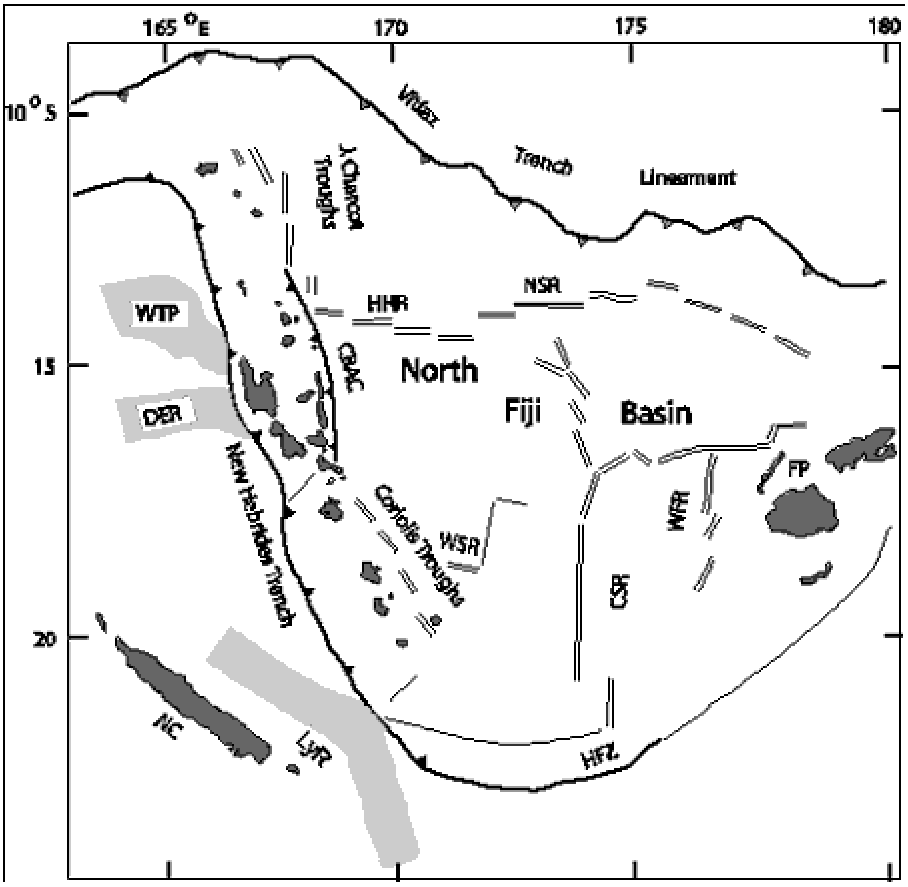

Figure 2. Regional distribution of significant tectonic elements in the vicinity of the Vanuatu Arc. Abbreviations: WTP = West Torres Plateau; DER = D'Entrecasteaux Ridge; NBAT= Northern Backarc (or Jean Charcot) Troughs; CBAC = Central Backarc Compression zone; SBAT = Southern Backarc (or Coriolis) Troughs; NC = New Caledonia; LyR Loyalty Ridge; VTL = Vitiaz Tectonic Lineament; HHR = Hazel Holme Ridge; NSR = Northern Spreading Ridge; WSR = Western SR; CSR = Central SR; WFR = West Fiji Ridge; FP = Fiji Plateau; HFZ = Hunter Fracture Zone.

With materials recovered from the Coriolis Troughs during the SS06/2004 voyage, we will be able to examine in the Vanuatu segment of the New Hebrides system the deep processes accompanying arc-backarc formation in terms of mantle contributions. Globally, it appears the most refractory (i.e., prior melt-depleted) arcs are those with accompanying and active backarc basins — the hypothesis

is that advection occurs of a potential mantle source from a melting event beneath a backarc ridge towards the arc and a zone of fluid ingress from the subducting lithosphere, triggers another melting stage (e.g., Woodhead et al., 1993). In the New Hebrides case, we now observe the most actively spreading region on Earth (Lagabrielle et al., 1997) forming the North Fiji Basin presumably establishing a highly depleted mantle residue. But the Coriolis Troughs are not only tapping relatively fertile mantle but also other mantle sources that are upwelling beneath the North Fiji Basin.
In terms of the initial geographic objective, after leaving Noumea we will commence single-pass mapping in the vicinity of the New Hebrides arc front near the Gemini and Oscostar Seamounts (the latter was volcanically active in 1996) at 20^o 60'S 170^o 14'E, and then proceeding northwards to the southern end of the Futuna Basin at 20^{o}S, pursuing the voyage track outlined below. Our operation mode will generally be:

1. Swath mapping of portions of the individual basins within the watch constraints of the available expertise;
2. Explore for hydrothermal plume activity, both as a complement to the CTD work completed on FR 08/2001 and as a new exploratory effort;
3. Dredge targets identified by the swathmapping and CTD work;

REFERENCES
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Hickey-Vargas, R., Hergt, J.M., & Spadea, P. (1995) The Indian Ocean type isotopic signature in western Pacific marginal basins: origin and significance. In (B. Taylor & J. Natland, eds.) Active Margins and Marginal Basins of the Western Pacific. Geophysical Monograph, American Geophysical Union, **88**, 175-197.

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Macpherson, C.G., Hilton, D.R., Mattey, D.P., & Sinton, J.M. (2000) Evidence for an ^{18}O-depleted mantle plume from contrasting ^{18}O/^{16}O ratios of back-arc lavas from the Manus Basin and Mariana Trough. Earth & Planetary Science Letters, **176**, 171-183.

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Voyage Track

From Noumea, we will sail for about 20 hours to the first waypoint (A) at Oscostar (21^{o}S 170^{o} 14'E - Fig. 1) which will be the location for the first vertical hydrocast and dredge at the volcanic arc front.

From Waypoint A, we will proceed NNE to the SW edge of the southern portion of the Futuna Basin (Zone A) and commence swath mapping of the floors of this NNW-SSE-striking basin. Depending on the results of this mapping, we will deploy the CTD and dredge on targets of interest.

This mapping and sampling strategy will be repeated in the Erromango and Vate Basins (Zones B to D), but we will also ensure that the intervening ridges are mapped and sampled in the event that submarine igneous and hydrothermal activity is occurring in these locations.

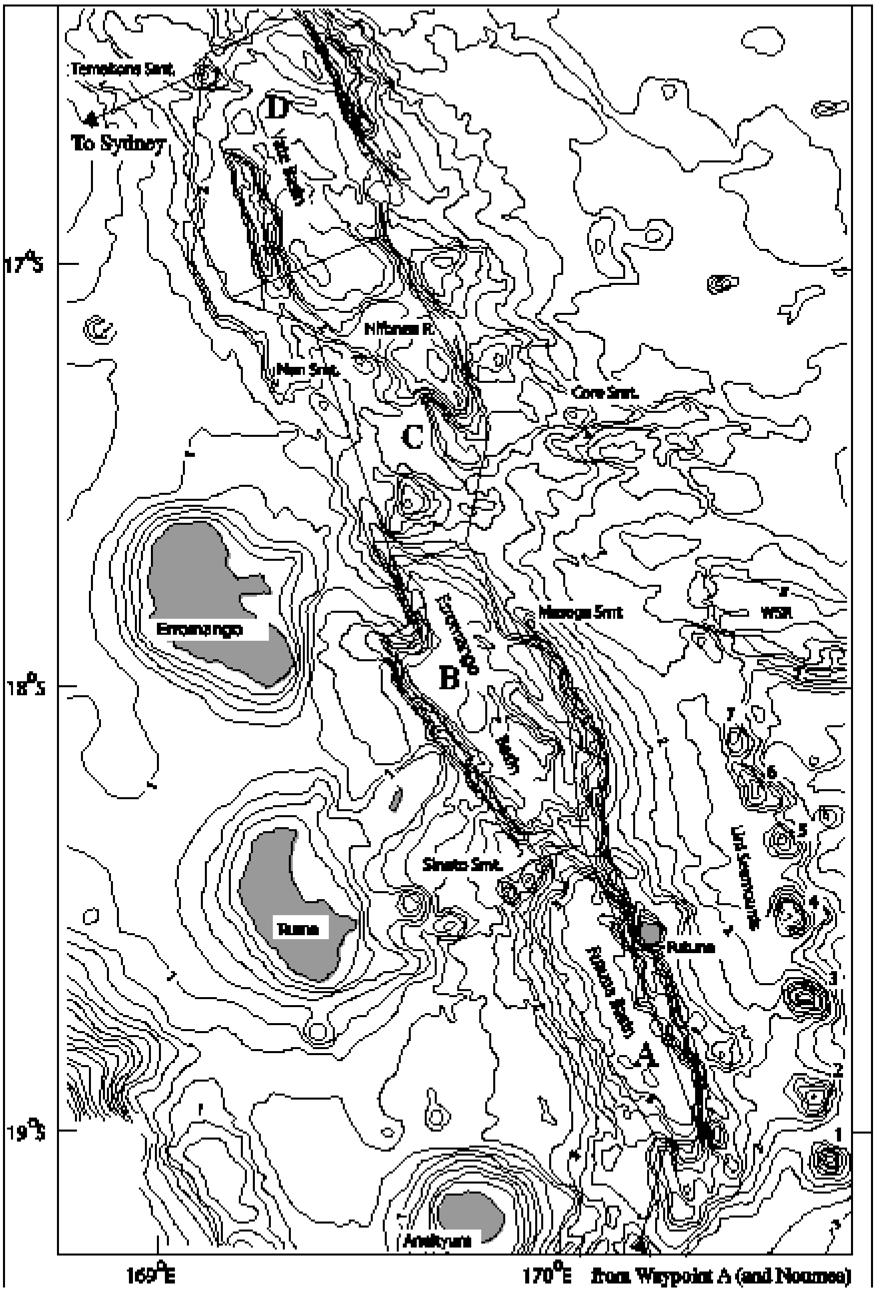

Figure 3. Intended voyage track for SS06/2004; note that details of the specific swathmapping tracks within Zones A to D will be finalised depending on information to be received concerning optimal coverage/speed/resolution of the Kongsberg EM300 system.

Time Estimates

Action Time (days)

Transits

- from Noumea to Waypoint A at Oscostar 20 hours 0.8
- swath mapping @ 7 knots, 1820 nm 260 hours 10.8
- CTD Casts (30 at 10 samples each = 300 samples) 60 hours 2.5
- Rock sampling 200 hours 8.3
- from Zone D to Sydney 108 hours 4.5
- contingency 24 hours 1.0
- Total (672 hours) 28.0

Based on experience, the following times (hours) are estimated for operations other than swath mapping, including positioning and set-up:
Operation 1000m 2000m 3000m

- CTD single dip 2.0 3.0 3.5
- Dredge 3.0 3.5 4.0

Southern Surveyor Equipment
In addition to the swathmapper, we are assuming that the type of equipment in place for our last RV Southern Surveyor voyage can be made available for the SS06/2004 voyage, comprising:

- all winches, deck crane, deck machinery
- all laboratories
- differential GPS, scientific sounder (narrow and broad beam receivers)
- CTD-transmissometer, 11 * 10 litre Niskins
- 12 kHz pingers (2), Smith-McIntyre grab(s)
- computers, trackplot software
- fridges and freezers, clean air cabinet
- underway ADCP
- Benthos altimeter
- National Facility dredges (2) as spares

User Equipment
From CSIRO Exploration and Mining (North Ryde); equipment for water sampling and on-board analysis:

- Filtration racks, 3 ea. with two positions (0.65 cu. m)
- Clean air flow hood (0.54 cu. m)
- Sample boxes for trace metals,18 ea. (1.50 cu. m)
- Sample equipment for methane
- Computer/monitor/printer/VCR for CTD (0.25 cu. m)
- Tool chests, 4 ea. (0.66 cu. m)
- Ice chests, 3 ea. (0.60 cu. m)
- Shipping trunks for onboard flow injection analysis (H_2S and Mn)
- pH determinations. (0.60 cu. m)
- Sulfide sampling storage totes and support equipmentt. (0.30 cu. m)
- Dry nitrogen cylinders, G-size, 3 ea. (0.30 cu. m)

Total volume: approximately 12.5 cubic meters, to be delivered to RV Southern Surveyor at Sydney prior to departure of SS05/2004, and off-loaded at Sydney on return of SS06/2004 (ship's crane required).

Special Requests
1. The dredges (and necessary weak links) from GA will be on board (loaded at Sydney) from the previous Southern Surveyor (SS05/2004) voyage (Dr. Neville Exon, Chief Scientist; Steve Dutton, GA Marine Operations Manager). Plastic buckets and bags for rock/sulfide samples will also be loaded together with similar sampling materials for SS05/2004.
2. Prior checking and calibration of wire-out and tension measurement
3. Second colour printer always recording exactly what is displayed on the SIMRAD monitor. Echoview display on separate monitor.
4. Real-time output of nav and winch data as spreadsheet, for recall after each operation (e.g., for planning the next operation)
5. Rapid creation of digital CTD data (down and upcast) in spreadsheet form, for detailed comparisons between casts for planning purposes.

6. Synchronisation between SIMRAD and ship time.

Provisional Personnel List

- Professor Richard J. Arculus ANU Petrology/tectonics
- Dr. Timothy F. McConachy CSIRO Exploration & Mining Hydrothermal plumes/sulfides
- Associate Professor David A. Gust QUT Petrology
- Dr. Kurt Knesel UQ Petrology/tectonics
- Mr. Roman Leslie CODES Petrology
- Mr. Hadley Craig University of Waikato Petrology
- Mr. Matthew Stevens ANU Petrology
- Mr Don McKenzie CSIRO Marine and Atmospheric Research Voyage Manager/CTD
- Mr Lindsay Pender CSIRO Marine and Atmospheric Research Computing
- Mr Lindsay MacDonald CSIRO Marine and Atmospheric Research Electronics
- Mr Cameron Buchanan GA (Canberra) Swath mapping
- Mr Brooks Rakau Geology, Mines and Rural Water Supply Vanuatu Observer

This voyage plan is in accordance with the directions of the National Facility Steering Committee for the Research Vessel Southern Surveyor.

Chief Scientist
Professor Richard Arculus