VOYAGE PLAN SS02/2003

Title
TELVE-2003 (Tonga-Eastern Lau Vents Expedition)
Submarine hydrothermal plume activity and petrology of the Eastern Lau Spreading Centre and neighbouring Tofua Arc, Tonga.

Itinerary
Depart Auckland 1000 hrs, Friday 14 March, 2003
Arrive Nuku'alofa 1000 hrs, Thursday 3 April, 2003

Principal Investigator
Professor Richard J Arculus (Chief Scientist)
Australian National University
Department of Geology
Australian National University
Canberra, ACT 0200
Tel: 02 6125 3778
Fax: 02 6125 5544
Email: Richard.Arculus@anu.edu.au

Scientific Objectives
At the southern end of the Lau backarc basin, the Valu Fa Ridge of the Eastern Lau Spreading Centre (ELSC - Fig. 1) hosts one of the most active hydrothermal systems on the planet. The ELSC is propogating southwards into pre-existing Lau backarc Basin crust, and the spreading axis gradually approaches (to about 40 km) the axis of the Tofua arc. The Tofua arc itself is highly active with numerous submarine eruptions reported in the last 50 years. Thus within a relatively confined region geographically, highly active, submarine arc and backarc systems are in close proximity. Systematic petrologic and geochemical linkages between arc and backarc axes provides a superb opportunity to understand the fundamental underlying processes of melt transfer from mantle to crust with accompanying volatiles in a suprasubduction zone setting.

The major scientific objectives are a study of the hydrothermal plume activity with systematic vertical hydrocasts (including CTD-optical profiling) and "tow-yos" to map plume sizes, their distributions, and to characterize their chemical signatures. We will couple this effort with sample grabs and dredges. In addition, we will build upon established success with hydrocasts and tow-yo's in the southern Kermadec arc (NZAPLUME voyage) in pursuit, detection and sampling of hydrothermal (and ^{3}He) plumes from intra-and cross-arc edifices.

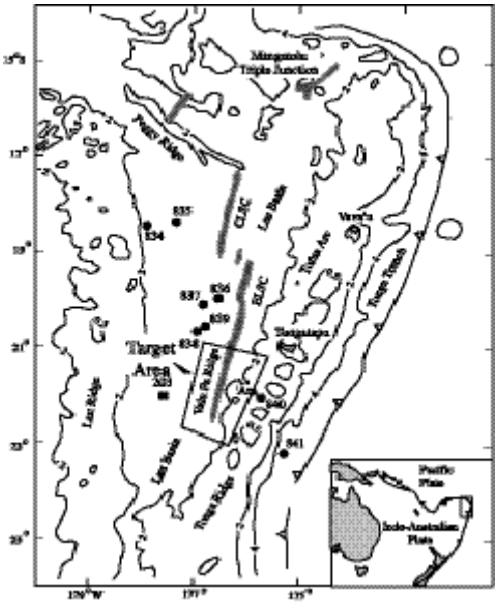

Figure 1. Lau Basin and Tonga Trench-Arc system showing the target area of the voyage. Also shown are the locations of ODP Leg 135 Sites 834-841, and DSDP Site 203. Bathymetry in km.

Specific objectives are:

1. To perform the first systematic survey of hydrothermal activity along an incipient back arc spreading ridge (3 segments of Valu Fa Ridge extending 150 km) and compare the intensity and chemistry of that activity to magmatic-hydrothermal emissions along an adjacent volcanic arc section (southern Tonga arc).
2. We will extend the same plume-location/charaterization approach to the adjacent active Tofua arc where one active subaerial volcano (Ata) is known but a number of active submarine centres have been inferred. Of particular interest is the possibility of submerged rhyolitic calderas which are now known to alternate with subaerial (mafic-dominated) centres in the Izu-Bonin arc, and to be highly mineralised. Similarly, the major objective in the arc domain is to characterise chemical compositions and fluxes of the plumes for eventual quantitative calculations of mass (volatiles and metals) fluxes.
3. In both backarc and arc environments, we will execute video camera tows to image hydrothermal activity, and recover fresh glassy rock samples for detailed chemical analysis, particularly of volatile elements and compounds, and stable isotopic characteristics.

Voyage Objectives

We will sample along the axis of the Valu Fa Ridge, the Tofua Arc between about 21°30' and 24°10'S, and one transverse hydrothermal cast from the backarc to arc region at ~ 22°30'S. More specifically, objectives of the voyage are:

1. Perform a continuous along-axis survey for hydrothermal activity along the three segments of the Valu Fa back arc spreading ridge. At sites of intense plume activity, provide cross-axis surveys in order to provide a three-dimensional image of plume distribution and for thermal and chemical inventory purposes. Conduct vertical CTD-sampling profiles along the survey section (on return transit).
2. To the extent possible, conduct a systematic survey for hydrothermal activity along the S. Tonga arc adjacent to the Valu Fa ridge. Perform vertical casts over all identified arc volconoes within a continuous survey section and cross-volcano tow-yos at selected sites. Define the adjacent ocean water with respect to survey parameters in order to construct arc section distributions of hydrothermal properties.
3. Compare (for the first time) the incidence and chemistry of hydrothermal emissions along the adjacent back arc ridge and volcanic arc sections.

4. Coordinate results of back arc ridge survey with RIDGE 2000 investigators slated to perform similar surveys further north on Lau backarc spreading ridges.

Voyage Track

From Auckland, we will sail (~3.5 days) to waypoint A (24° 10.8'S 177° 00.0'W - Fig. 2) which will be the location for the first vertical hydrocast at the southernmost point of our intended arc transect, and is located close to Volcano # 16 (RV Sonne notation). Note that two vertical hydrocasts will be planned at each known vent site or volcano accompanied by grabs, video tows, dredging and coring operations as the sample returns indicate the most promising sites.

From Waypoint A, we will proceed along the Tofua arc to "Volcano no. 8" (Pelorus - which the Sonne has reported having a large submarine caldera). We will then cross to the backarc ridge and tow the 4 axial segments in three south-to-north traverses; the two small southern segments will be completed in one tow and the noting the northern segment will take 34 hours. This will be followed by a hydrocast (and bottom sample) back along the ridge, possibly stopping to cross tow at Vai Lili. We then plan to transit to the arc station north of Volcano # 8, and hydrocast/sample northwards to Volcano # 5. At this point, an assessment of whether to complete a cross tow from the arc to backarc in the vicinity of Vai Lili, or continue along the arc northwards towards Volcano # 1 will be made. In any case, a final transit of about 2.5 hours from the northernmost "arc cast" on Figure 2 will be made to Nuku'alofa.

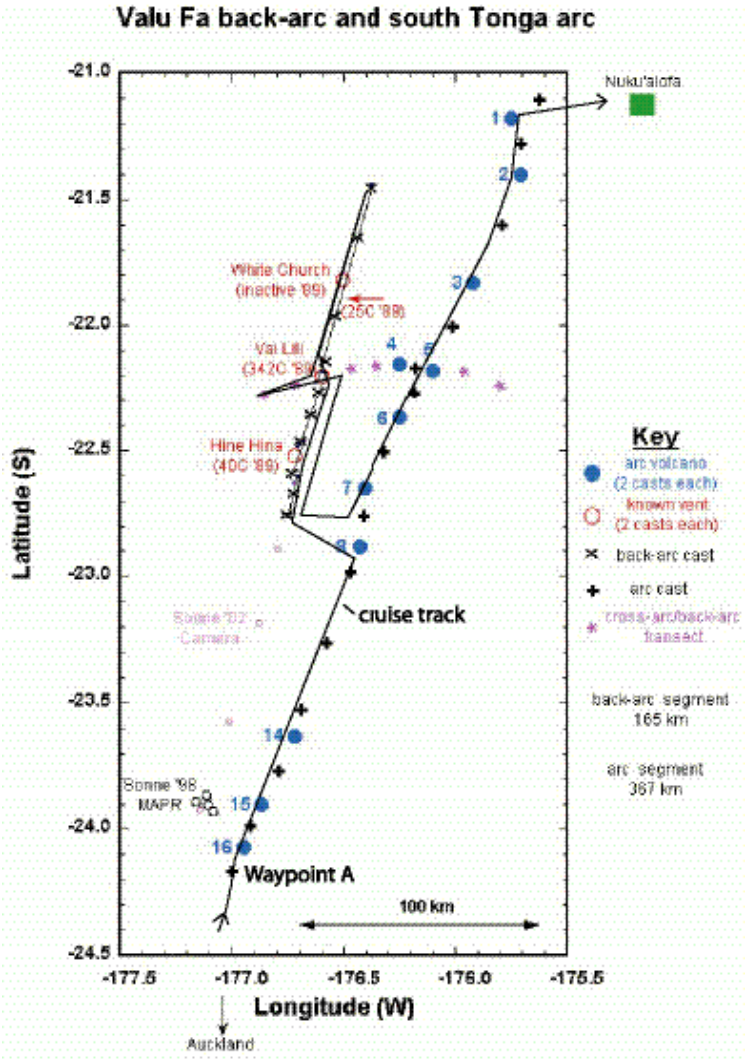

Figure 2. Details of targets in the Tofua arc and Valu Fa Ridge and voyage track for SS02/200

Time Estimates

Action	Time (days)
Transits	
(from Auckland to Waypoint A & Volcano #1 to Nuju'alofa)	119 hours 3.5
Casts (52 at 11 samples each = 572 samples)	104 hours 4.3
Tow-yo's (10 @ ~ 142 samples)	120 hours 5.0
Rock sampling & camera tows	161 hours 6.7
Total	(504 hours) 21.0

Based on experience, the following times (hours) are estimated for some of these various operations, including positioning and set-up:

Operation	**1000m**	**2000m**	**3000m**
CTD single dip	2.0	3.0	3.5
Core	2.0	3.0	3.5
Grab	2.0	3.0	3.5
Dredge	3.0	3.5	4.0
Video	3.0	4.0	n/a

Southern Surveyor Equipment

We are assuming that the type of equipment in place for our last RV Franklin voyage (FR03/02) can be made available for this RV Southern Surveyor 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 (or equivalent) software
- fridges and freezers, clean air cabinet
- underway pH and ADCP
- Benthos altimeter
- National Facility dredges (2) as spares
- small National Facility gravity corer with various barrels up to 1.5 m long (users to supply PVC liners and core catchers – see User Equipment)

User Equipment

From Geoscience Australia (already on board from SS01/2003), IGNS (Wellington) and CSIRO (North Ryde).

From IGNS (including NOAA needs) the CTD-MINTS system:

- CTDO stand with Sea Bird CTD, 19 water bottles, Benthos altimeter, load cell, landing pallet (2.9 cu. m), spare bottles (10), pressure filtration apparatus, miscellaneous support equipment in 2 boxes (1.84 cu. m)
- Filtration racks, 3 ea. with two positions (0.65 cu. m)
- Clean air flow hood (0.54 cu. m)
- "Terminator" He crimper (0.30 cu. m)
- He sample boxes, 3 ea. (0.39 cu. m)
- He tubing in coiled rolls (0.50 cu. m)
- Sample boxes for trace metals,18 ea. (1.50 cu. m)
- Sample boxes for methane, 10 ea. (0.50 cu. m)

- 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) and deck
- pH determinations, 3 ea. (0.60 cu. m)
- Sulfide sampling storage totes and support eqpt. (0.30 cu. m)
- Dry nitrogen cylinders, G-size, 3 ea. (0.30 cu. m)

otal volume: approximately 12.5 cubic meters, to be delivered to Southern Surveyor at Auckland, and off-loaded at Nufu'alofa (ship's crane required).
Note: chemicals to support sampling and onboard chemistry will be loaded at Auckland with MSDS documentation (Gary Massoth will supply a complete listing to the ship, via Ron Plaschke, well in advance of chemicals arrival in Auckland)

From CSIRO North Ryde (Tim McConachy):
Bottom photography: Deep tow video system and related equipment including sled, and two nitrogen bottles (one bottle for clean air cabinet). Sealite batteries. Recording CTD-transmissometer. This gear to be loaded in Hobart prior to SS01/2003 (19 Feb).
From ANU (Richard Arculus):
Microscopes, PCs, buckets for rock samples, depressor weights for dredges, 75mm UPVC downpipe for core liners (comes in 6m lengths), core catchers (CSIRO can supply sample). This gear to be loaded in Hobart.

Special Requests

1. The dredges (and necessary weak links) and camera cage (from CSIRO N. Ryde) will be on board (loaded at Hobart) from the previous Southern Surveyor (SS01/2003) voyage (Professor Tony Crawford, Chief Scientist; Steve Sutton, GA Operations Manager). We plan to have available from IGNS (Wellington), at relatively short notice, 2 dredges to be accessible in the event SS01/2003 loses a critical number of dredges. Our plan is to ship gear (camera and cage, gravity corer) and consumables (all boxed in wire cages) to arrive by 10th March 2003, three days before scheduled departure from Auckland. Plastic buckets and bags for rock/sulfide samples will already be on board from SS01/2003. Additional water sampling apparatus and storage containers will be loaded at Auckland.
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. Cornel E. J. de Ronde, IGNS (NZ), marine chem/hydrothermal plumes
Mr. Gary. J. Massoth, IGNS (NZ), marine chem/hydrothermal plumes
Dr. Edward T. Baker, NOAA (USA), marine chem/hydrothermal plumes
Dr. John E. Lupton, NOAA (USA), marine chem/hydrothermal plumes
Dr. Chris Yeats, CSIRO (N. Ryde), economic geology/computing
Dr. David M. Christie, Oregon State Uni (USA) petrology
Professor Charles H. Langmuir, Harvard Uni (USA), petrology

Dr. Tim Worthington, Christian-Albrechts Uni, Kiel petrology
Don McKenzie, CSIRO (Hobart), Voyage Manager/CTD
Lindsay Pender, CSIRO (Hobart), Computing
Lindsay MacDonald, CSIRO (Hobart), Electronics
TBA, Tongan Representative to be determined

Special permission has been granted on this overseas voyage for the Tongan Representative to participate in the capacity of an observer and therefore occupy a spare cabin.

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