Cruise Plan: Boomerang Leg 8

Dynamics of extensional convergent margins and the origin of supra-subduction zone ophiolites: Hypothesis testing in the Tonga forearc

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1. Scientific Summary: The Tonga subduction zone, in the southwestern Pacific, is the world's most active, extension-dominated convergent margin system. We plan a geological and geophysical investigation of selected portions of the Tonga forearc to test a number of specific hypotheses about the evolution of these intraoceanic margins:

* The forearc is floored by arc-derived crust.. This crust is the earliest produced in the subduction zone and is formed at rates much higher than that of "normal" arc volcanism. Older MORB crust is non-existent or rare in the forearc basement, having been removed by a variety of sea-floor spreading and subduction erosion.

* These early forearc volcanics are unusually depleted, including boninites and depleted arc tholeiites. The chemistry of these early arc volcanics provides a unique look at the sub-arc mantle at the earliest stages of arc evolution.

* The rock assemblages in intraoceanic forearcs are a better analog for many ophiolitic complexes than active mid-ocean ridges.. The suites of volcanic, gabbroic, and ultramafic rocks sampled from intraoceanic forearcs have petrologic and geochemical features more like those of ophiolitic suites than do similar rocks sampled from mid-ocean ridges

* The hydrothermal alteration pattern in many ophiolites is more closely matched by the pattern in forearcs than by that in mid-ocean ridge crustal sections.

* Tonga is the type extensional convergent margin and is undergoing active tectonic erosion and its forearc is dominated by normal faulting and movement of material into trench and hence down subduction zone.

* Serpentine diapirs form an important part of the crust in intraoceanic forearcs and the fluids which form them, derived from the downgoing plate, constitute an important source of fluid flow in this type of convergent margins

* Intraoceanic arc volcanics show an across arc progression in composition (corresponding to an age evolution) which indicates the polarity of the system and provides a way to determine paleo-polarity in collisional belts.

* The Tonga forearc was removed from both the Samoa hotspot and Indian Ocean mantle at the time of its formation. As it has evolved and moved, both types of mantle have been introduced into different portions of the arc or back-arc.

The cruise will also provide essential site survey data for a proposed Ocean Drilling Program Leg.

2. The field program: Prior to the cruise, we will synthesize all existing geological , bathymetric and geophysical data into a single GIS database. We have designed our shipboard experiment, which will include

swath bathymetry, side-scan sonar (both derived from the Seabeam 2000 system), selected single-channel seismic lines, gravimeter and magnetometer measurements, and dredge sampling, around nine traverses of the outer Tonga forearc. Swath bathymetry will also be collected over three proses ODP sies on the eastern edge of the Tonga platform.

Transit to the first survey area will be from Suva, to the active arc at the latitudde of Vava'u (19oS), along the western edge of the active Tofua arc, across the proposed site for TF-1, and out to the first survey area over ODP Site 841.

The nine detailed survey boxes will be built around Seabeam 2000 swaths and dredge profiles from the latitude of Site 841 (to provide detailed regional context for that site) to the northern most terminus of the trench, providing complete and regular coverage of the forearc. Four parallel Seabeam 2000 swaths, with gravimeter and magnetometer measurements, will be run from the west side of the trench-slope break and back, to form survey boxes of about 30 x 30 nm, with complete bathymetric, magnetic, gravimetric, and side-scan coverage. Water depths will be 3000-4000 m on the western edges of the boxes, along the trench-slope break, and from 7000 to 10000m at the eastern end, in the axis of the trench. The location of the profiles to be run are sketched in Figure 1. At 10 kts., we estimate that it will take 6.9 days to complete the surveys.

Transit between transects will be along the trench-slope break, with Seabeam and geophysical data collection, as this is the region where any serpentine diapirs should be most apparent. There is already an old Seabeam swath covering the central axis of the Tonga Trench (Fig. 1). Transit between sites at 10 kts. will require 2.3 days; transit from Fiji and to Samoa will require 2.6 days.

After the surveys over the proposed sites of TF 2 and TF 5, we will run a transit across to the Tonga platform and back out to the trench-slope break, to collect swath bathymetry and side-scan over the proposed sites for TF 3 and TF 4 on the Tonga platform. TF 3 is just northeast of Tongatapu, and will require a transit just northeast of 'Eua.

Within each of the nine survey boxes a three-dredge profile will be the basic sampling pattern. The profiles will include one deep, one intermediate, and one shallow dredge moving up the landward slope of the trench. Each of the dredges will be planned to have a fairly long on-bottom track. Previous experience has shown the trench slope assemblages to be diverse, talus samples; given the likely degree of normal faulting and downslope movement, long dredge tracks which give a representative sampling are of more use than short tracks used in a futile effort to determine a stratigraphy on the landward slope. Eight additional dredges are allocated for shallow targets along the trench slope break that are suspected to be serpentinite diapirs. An additional nine dredges are planned for features of particular interest--mid- or lower-slope seamounts, to fill in particularly complex slope sampling, and to fill in for empty dredges. A total of forty-four dredge lowerings is planned. The proposed dredging will take 15 days of work. The dredging will be interspersed with the surveying, as we move northwards up the forearc. We may need to attempt one or two gravity cores, to obtain surface sedmient data for proposed ODP rentry cones.

Gravity and magnetic data will be collected along all of the Seabeam swaths to aid in identification of serpentinite masses and to provide some constraints on crustal structure, to be compared with the detailed crustal structure study across the forearc at the latitude of Capricron Guyot (Dorman and Hildebrand, pers. comm., 1995). Single-channel seismic surveys will be run at the western end of seven of these profiles (1, 2, 3, 5, 6, 7, 9) to define the pattern of faulting in the distal end of the forearc basin, to examine the geometry of the basement, to look for discontinuities in the patterns of faulting with depth, and to determine the general geometry of fault patterns along the forearc. A grid of lines about 5 nm apart will be used. We have allocated 5.8 days for the SCS surveys, as we are assuming we will need to run them at 8 kts. or less and that we may need to do them with the Seabeam system off.

Our total estimate for the cruise as outlined is approximately 33 days

All dredged samples will be sorted by type at sea, weighed and split for gross description. This data will provide histograms of sample distribution each haul and will provide the data to select representative samples for preliminary shipboard sampling. Slabs of representative samples will be returned to the shore-based labs with the scientific party. Shipboard data will be compiled into preliminary mosaics at sea. At sea Wright will use techniques to filter the raw GPS navigation and to perform nearest-neighbor weighting of SB2000 beampoint data. Each day's multibeam data may be accessed easily by the entire shipboard scientific party with the help of Bill Ryan's L-DEO MapMaker software package. Procedures to grid the SB2000 sidescan data have been developed by Catherine Johnson and Dave Sandwell at SIO, along with Dan Scheirer at UCSB. Wright will have access to this software during the cruise.

A summary of the cruise plan and work days:

Location	Type of Work	Approximate Lat/Long	Work included
near Vava'u	turning point from Fiji	19oS, 175oW	Seabeam, gravity, magnetic survey from F
TF 1	turning point	22o36'S, 176o13'W	Seabeam, gravity, magn survey
Site 841	detailed geophysical and sampling survey	23o30'S,175o30'W	Seabeam 2000, gravity, magnetics, dredge samp
TF2	detailed geophysical and sampling survey	21o44'S,174o40'W	Seabeam 2000, gravity, magnetics, dredge samp
TF3	swath bathymetry for ODP site survey	20o54'S, 174o59'W	Seabeam 2000, gravity, magnetics
Survey 3	detailed geophysical and sampling survey	21oS, 174oW	Seabeam 2000, gravity, magnetics, dredge samp
Survey 4	detailed geophysical and sampling survey	20oS,173o30'W	Seabeam 2000, gravity, magnetics, dredge samp
Survey 5	detailed geophysical and sampling survey	19oS, 173oW	Seabeam 2000, gravity, magnetics, dredge samp
TF 5	detailed geophysical and sampling survey	17o36'S, 172o44'W	Seabeam 2000, gravity, magnetics, dredge samp
TF 4	swath bathymetry for ODP site survey	17o38'S, 174oW	Seabeam, gravity, magn
Survey 7	detailed geophysical	16o30'S, 172o30'W	Seabeam 2000, gravity,

	and sampling survey		magnetics, dredge samp
Survey 8	detailed geophysical and sampling survey	15o30'S, 172o30'W	Seabeam 2000, gravity, magnetics, dredge samp
TF 6 and TF 7	detailed geophysical and sampling survey	15oS, 173o25'W	Seabeam 2000, gravity, magnetics, dredge samp
Samoa	end port		Seabeam 2000, gravity, magnetics in transit

Total:	Days Seabeam 2000:	33
	Days digital SCS:	6
	Number of dredges:	44
	Days magnetics:	33
	Days gravity:	20
	Number ofGravity cores:	1-2?

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