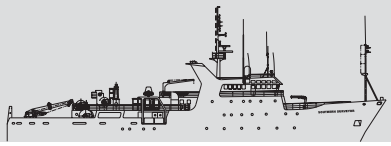

MARINE
NATIONAL FACILITY

2004 program

RV *Southern Surveyor*

CSIRO

voyage summary SS010/2004

SS10/2004

Hot Subduction – recycling of oceanic crust in a dynamic W Pacific setting.

Itinerary

Depart Brisbane 1000 hrs, Saturday 2 October, 2004
Arrive Nuku'alofa, Tonga 1000 hrs, Tuesday 26 October, 2004

Principal Investigator

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Scientific Objectives

Production of continental crust mainly occurs in the 'subduction factory' of the W Pacific region, via recycling (subduction) of old oceanic crust back into the mantle. In most instances, this old, altered, wet oceanic crust being returned to the mantle dehydrates at <100km depth. Water released in this process ascends into the mantle 'wedge' above the subducted 'slab' of oceanic crust, triggering partial melting, and the generation of magmas that rise to form the well-known island arc volcanoes of the Pacific 'ring of fire'.

We aimed to discover the nature of subduction-related magmas associated with an abnormally young and hot over-riding mantle above the subducting slab. Such settings are rare globally, but one well developed example occurs where the main N-S orientated spreading centre of the actively opening North Fiji Basin (between Fiji and Vanuatu) is propagating into the submarine Hunter Ridge, an extinct island arc formed ~7 and 3 million years ago. We wanted to know how this young, very hot mantle wedge affected dehydration/melting of the down-going slab of oceanic crust, what type of magmas were generated, and whether any chemical signal is being transmitted from the slab along the active spreading centre. The study has implications for magma genesis on the early Earth, for which theoretical and experimental studies have proposed abnormally hot (cf. modern day) subduction zones.

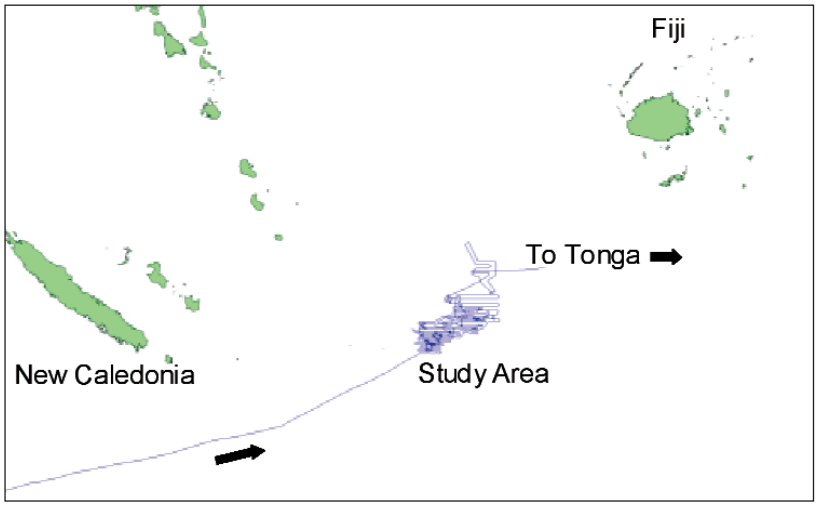
Voyage Objectives

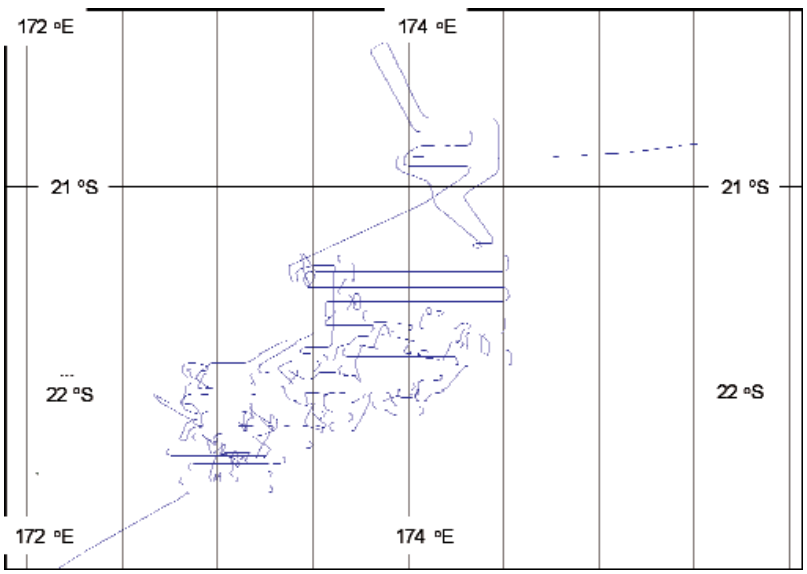
Key problems addressed during this cruise include:

1) the exact location of the propagating tip of the North Fiji spreading centre, where it interacts with the Hunter ridge, was unknown due to the lack of seafloor mapping between 173-174oE, ~ 22oS. We conducted seafloor mapping in this area

2) the nature of magmas associated with subduction into very hot, young over-riding oceanic lithosphere. Does the downgoing slab partially melt, rather than dehydrate, thus imprinting quite distinctive geochemical features on the magmas generated? We conducted systematic dredging in the area to reveal the compositional range of erupted magmas

Voyage Track





Results

The ship spent 25 days at sea. Out of these, ~ 16.5 days have been spent on site and 8.5 days for transit from Brisbane to the study area and from the study area to Tonga.

Objective 1. Seafloor mapping between 173-174oE, ~ 22oS.

The ship spent ~ 10 days (239.5 hours) doing swath mapping within the study area. During this time, the ship has covered ~2050 nautical miles with an average speed of ~8.5 kn. We also completed two CTD scans within the study area. This part of the voyage was a complete success and we did not encounter any problems.

We have performed a detailed mapping survey at the southern termination of the Hunter Ridge where it joins the Vanuatu Island Arc (Fig. 1). In this area, the Hunter Ridge is being split by the south propagating spreading centre of the North Fiji Backarc Basin (Fig. 1). Our survey has discovered a young, volcanically active rift zone that has split the southern end of the Hunter Ridge in the SW-NE direction (Fig. 1; compare with the topographic map of this area that existed prior to our voyage, Fig. 2).

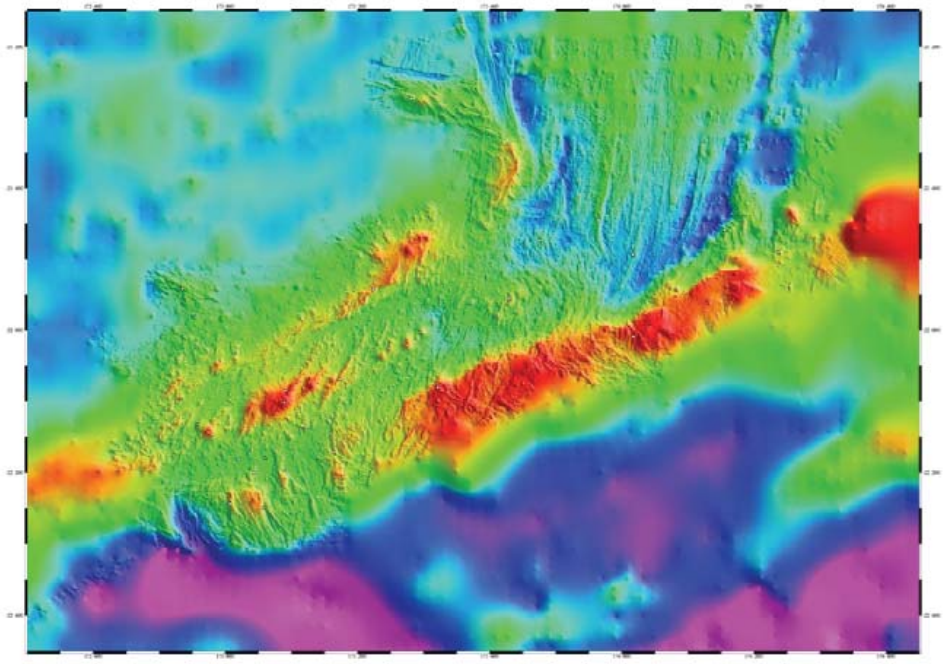


Figure 1. Topographic map of the study area completed during the swath mapping survey. Colour corresponds to water depths between 600 m (red) to 4,500 m (violet). 1 – Hunter Ridge; 2 – rift zone; 3 – propagating spreading centre; 4 – older crust of the North Fiji Basin; 5 – South Fiji Basin.

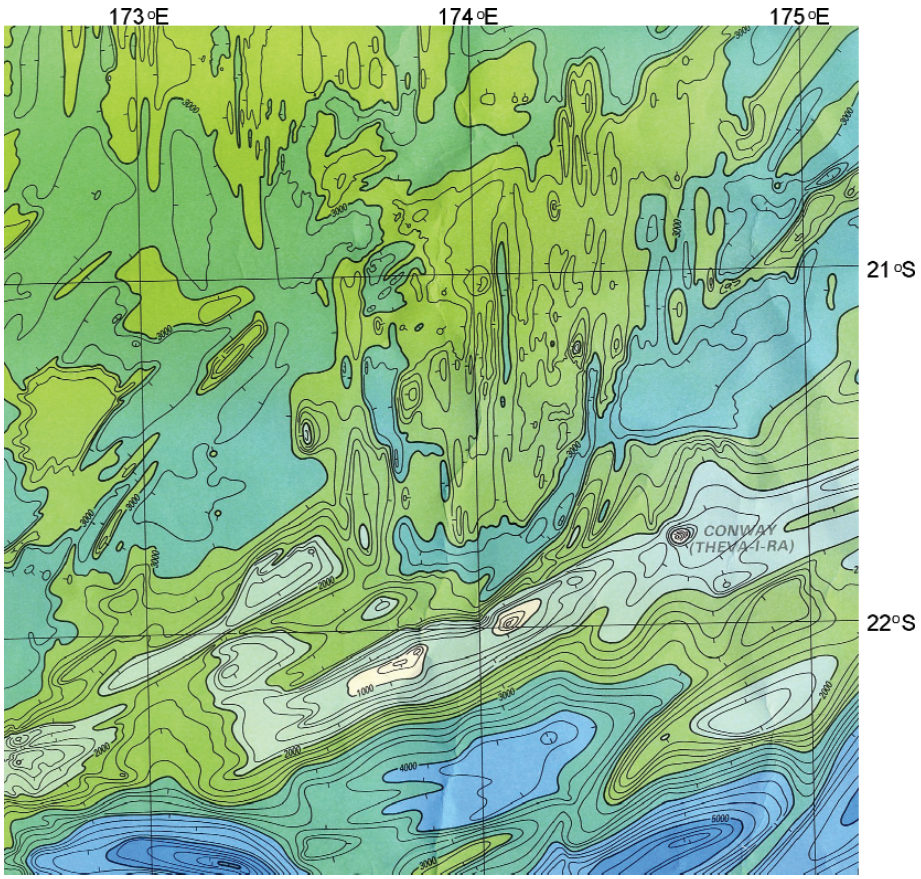


Figure 2. The topographic map of the study area that existed prior to our voyage.

To the west from the intersection with the spreading centre, the Hunter Ridge crust is cut by multiple generations of cross-cutting faults. Some of the faults indicate anticlockwise rotation of the southern tip of the Hunter Ridge and the rift zone (Fig. 1).

Objective 2. Dredging of magmatic rocks from the study area.

The ship spent ~ 5.8 days (138.5 hours) dredging the seafloor within the study area. During this time, we have completed 33 dredges in water depths between 700 m and 3,100 m, spending 4 hours per dredge on average. Twenty nine dredges recovered different types of volcanic rocks. Fourteen of the successful dredges sampled the Hunter Ridge crust; 10 dredges were conducted within the volcanic rift zone; 2 dredges sampled the propagating spreading centre; and 3 dredges sampled the older crust of North Fiji Backarc Basin. This part of the voyage was a complete success as we planned to perform 25 dredges only.

We have collected a total of 204 samples of different volcanic rock types. Samples vary in size between 0.3 - 15 kg. Dredge details are presented in Table 1.

Table 1. Dredge list

Dredge#	Average Longitude	Average Latitude	Average Depth	Result
SS10/04-D1	172.966	-22.245	1475	Rocks
SS10/04-D2	172.990	-22.293	2255	Empty
SS10/04-D3	173.011	-22.405	1757	Rocks
SS10/04-D4	173.096	-22.416	1807	Rocks
SS10/04-D5	173.073	-22.333	2060	Rocks
SS10/04-D6	173.149	-22.328	2215	Rocks
SS10/04-D7	173.101	-22.300	2370	Empty
SS10/04-D8	173.033	-22.303	2385	Rocks
SS10/04-D9	172.930	-22.220	1880	Empty
SS10/04-D10	173.273	-22.286	1753	Rocks
SS10/04-D11	173.203	-22.229	1935	Rocks
SS10/04-D12	173.148	-22.169	695	Rocks
SS10/04-D13	173.152	-22.141	760	Rocks
SS10/04-D14	172.889	-22.160	1640	Rocks
SS10/04-D15	187.500	-22.130	870	Rocks
SS10/04-D16	173.287	-22.115	1455	Rocks
SS10/04-D17	173.535	-22.134	1010	Rocks
SS10/04-D18	172.861	-22.057	2493	Rocks
SS10/04-D19	172.891	-21.902	2275	Rocks
SS10/04-D20	172.919	-21.963	2485	Rocks
SS10/04-D21	173.411	-22.042	1725	Rocks
SS10/04-D22	173.493	-22.005	1745	Rocks
SS10/04-D23	174.029	-22.016	945	Rocks
SS10/04-D24	174.397	-21.817	1675	Rocks
SS10/04-D25	173.470	-21.455	2045	Rocks
SS10/04-D26	173.714	-21.562	1743	Rocks
SS10/04-D27	173.349	-21.925	1395	Rocks
SS10/04-D27A	173.372	-21.904	1685	Rocks
SS10/04-D28	173.716	-21.928	1870	Rocks
SS10/04-D29	173.791	-21.788	2830	Rocks
SS10/04-D30	173.941	-21.741	2640	Rocks
SS10/04-D31	174.028	-21.822	3020	Empty
SS10/04-D31repeat	174.028	-21.822	3020	Rocks
SS10/04-D32	174.260	-21.765	2525	Rocks

Voyage Narrative

The ship left Brisbane at 1000 hrs on the 2nd of October 2004. During the 5.5 days of transit to the study area we prepared our shift teams for work (scientific personnel worked in two 12 hour shifts between 0200 and 1400 hours); tested the swath mapper; and assembled dredges. We arrived at the southwest corner of the study area (172o50'E; 22o30'S) at 1815 hrs GMT on the 6th of October and performed a CTD scan to the water depth of 2,000 m.

Within the study area our strategy consisted of alternating periods of swath mapping and dredging. We would first map a part of the study area large enough to identify important tectono-magmatic features, and then dredge rocks from these features. The general direction of coverage was from the south-western corner towards the north-eastern corner. The ship left the study area at 0400 hrs GMT on the 23rd of October.

The operations record is presented in Table 2.

During the entire duration of the voyage we ran a single beam echo sounder (EA500).

Table 2. Operations record

Operation	Date Start	Time Start GMT	Date Finish	Time Finish GMT	Hours
CTD scan	10/06/04	18:15	10/06/04	20:15	2
Mapping Survey 1	10/06/04	20:15	10/08/04	3:50	32
Dredges 1, 2, 3, 4, 5, 6, 7, 8, 9	10/08/04	3:50	10/09/04	15:30	36
Mapping Survey 2	10/09/04	15:30	10/09/04	21:30	6
Dredges 10, 11	10/09/04	21:30	10/10/04	7:30	10
Mapping Survey 3	10/10/04	7:30	10/10/04	19:00	9.5
Dredges 12, 13	10/10/04	19:00	10/11/04	2:30	7.5
Mapping Survey 4	10/11/04	2:30	10/11/04	4:30	2
Dredges 14	10/11/04	4:30	10/11/04	9:00	4.5
Mapping Survey 5	10/11/04	9:00	10/11/04	14:00	5
Dredges 15, 16	10/11/04	14:00	10/11/04	20:00	6
Mapping Survey 6	10/11/04	20:00	10/12/04	0:00	4
Dredges 17	10/12/04	0:00	10/12/04	3:00	3
Mapping Survey 7	10/12/04	3:00	10/12/04	11:00	8
Dredges 18	10/12/04	11:00	10/12/04	15:00	4
Mapping Survey 8	10/12/04	15:00	10/14/04	4:30	37.5
Dredges 19	10/14/04	4:30	10/14/04	8:45	4.25
Mapping Survey 8a	10/14/04	8:45	10/14/04	10:15	1.5
Dredges 20	10/14/04	10:15	10/14/04	14:00	3.75
Mapping Survey 9	10/14/04	14:00	10/14/04	20:30	6.5
Dredges 21, 22	10/14/04	20:30	10/15/04	4:30	8
Mapping Survey 10a	10/15/04	4:30	10/15/04	15:30	11
Dredge 23	10/15/04	15:30	10/15/04	18:30	3
Mapping Survey 10b	10/15/04	18:30	10/16/04	2:30	8
Dredge 24	10/16/04	2:30	10/16/04	5:30	3
Mapping Survey 10c	10/16/04	5:30	10/17/04	5:00	23.5
Dredge 25	10/17/04	5:00	10/17/04	11:00	6
Mapping Survey 10d	10/17/04	11:00	10/18/04	3:00	16
Dredge 26	10/18/04	3:00	10/18/04	5:30	2.5
Transit 26-27	10/18/04	5:30	10/18/04	19:00	11.5
Dredge 27	10/18/04	19:00	10/18/04	22:30	3.5
Transit 27-27a	10/18/04	22:30	10/18/04	22:30	0
Dredge 27a	10/18/04	22:30	10/19/04	3:00	4.5
Transit 27a-28	10/19/04	3:00	10/19/04	5:30	2.5
Dredge 28	10/19/04	5:30	10/19/04	9:30	4
Transit 28-29	10/19/04	9:30	10/19/04	11:00	1.5
Dredge 29	10/19/04	11:00	10/19/04	15:30	4.5
Transit 29-30	10/19/04	15:30	10/19/04	17:30	2
Dredge 30	10/19/04	17:30	10/19/04	22:00	4.5
Transit 30-31	10/19/04	22:00	10/19/04	22:00	0
Dredge 31	10/19/04	22:00	10/20/04	3:00	5
CTD scan	10/20/04	3:00	10/20/04	5:30	2.5
Dredge 31repeat	10/20/04	5:30	10/20/04	10:30	5
Wire repair	10/20/04	10:30	10/20/04	13:30	3
Transit 31-32	10/20/04	13:30	10/20/04	14:30	1
Dredge 32	10/20/04	14:30	10/20/04	18:30	4
Transit 32-33	10/20/04	18:30	10/20/04	22:00	2.5
Dredge 33	10/20/04	22:00	10/21/04	0:00	2
Winch repair	10/21/04	0:00	10/21/04	4:00	4
Mapping Survey 11	10/21/04	4:00	10/23/04	4:00	48

Summary

In my opinion, the voyage was a complete success. All scientific objectives have been met. The ship is superbly equipped to perform swath mapping at water depth less than 3,500m when the seafloor is made of young volcanic rocks, and for dredging at water depths down to 4,000m.

Personnel

Leonid Danyushevsky – Univ. of Tasmania, Chief Scientist
Trevor Falloon – Consultant, Geochemist
Chris Small – Columbia University, Geophysicist
Andrew Stacey – Univ of Tasmania, Geophysicist; PhD student
Sofia Tetroeva – Univ of Tasmania, Geochemist; PhD student
Patricia Sie – Monash University, Geochemist; PhD student
Ilai Waga – MRD, Fiji University, Geologist
Pamela Brodie – CSIRO Marine Research, Computing/Voyage Manager
Drew Mills – CSIRO Marine Research, Electronics Support
Hiski Kippo – CSIRO Marine Research, Computing Support (Trainee)
Andrea Cortese – Geoscience Australia, Swath Mapping
Michele Spinoccia – Geoscience Australia, Swath Mapping

Master – Les Morrow
First Mate – Sammy Durnian
Second Mate – Drew Meincke
C/Eng – John Morton
First Eng – Dave Jonker
Second Eng – Seamus Elder
Bosun – Mal McDougall
IR – Russel Williams
IR – Keith Mitchell
IR – Fiona Perry
IR – Tony Hearne
C/Cook – Gerald Hogg
Second Cook – Bob Cumming
C/Steward – James McGarvey

Acknowledgements

We would like to thank the crew of Southern Surveyor for the support and understanding during the voyage. We would not have achieved as much as we did during the cruise without the support of the Voyage Manager Pamela Brodie and electronics engineer Drew Mills. The support from the swath mapping personnel Andrea Cortese and Michele Spinoccia was simply outstanding. We relied heavily on swath mapping, and the amount of work we have accomplished would not have been possible without their enthusiastic support. Out thanks also go to Prof. A. J. Crawford from the University of Tasmania for continuous support during planning and preparation of the voyage.

Leonid Danyushevsky
Chief Scientist