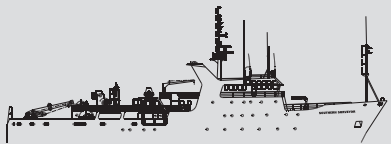


MARINE
NATIONAL FACILITY

2006 program

RV *Southern Surveyor*

CSIRO

voyage summary SS08/2006

SS08/2006

Hot Subduction – recycling of oceanic crust in a dynamic W Pacific setting. Part 2.

Itinerary

Departed Suva, Fiji 1300hrs, Saturday 19 August, 2006
Arrived Noumea, New Caledonia 0800hrs, Monday 11 September, 2006

Principal Investigator

Assoc. Prof. Leonid Danyushevsky (Chief Scientist), CODES CoE, University of Tasmania
Phone: +61 (03) 6226 2469 **Fax:** +61 (03) 6226 7662 **Email:** L.Dan@utas.edu.au.

Dr. Trevor Falloon – School of Earth Science and Centre for Marine Studies, University of Tasmania
Phone: +61 (03) 62262270 **Fax:** +61 (03) 62262547 **Email:** Trevor. Falloon@utas.edu.au

Scientific Objectives

This project aims to study the seafloor between Fiji and Vanuatu in the SW Pacific. This is a continuation of research undertaken during voyage SS10/2004.

This fundamental research in petrology and geochemistry addresses magma generation processes at active transition zones between continents and oceans. In such areas, the Earth's oceanic lithosphere is subducted back into the mantle triggering extensive volcanic activity. These processes form complex chains of volcanic islands separated from continents and from each other by extensional backarc basins. It is widely accepted that this magmatism plays an important role in the formation of the Earth's crust, atmosphere and hydrosphere.

The submarine Hunter Ridge (between Fiji and Vanuatu) contains unusual magmatic rocks not normally associated in time and space, some of which require abnormally hot temperatures during subduction. One of these magma types was discovered for the first time in a modern setting during voyage SS10/2004. Such rocks are a subject of international interest as they have implications for magma genesis on the early Earth, for which theoretical and experimental studies have proposed abnormally hot (cf. modern day) subduction zones.

To fully understand the significance of this new exciting discovery, we need to know the age and spatial distribution of magmatic rocks on the Hunter Ridge and their relationship to young magmatic rocks exposed on Kadavu Island at its northern end. This also has implications for tectonic reconstructions of the SW Pacific and understanding of SE Australia geology.

Voyage Objectives

We intend to conduct a multibeam survey, a magnetics survey and rock sampling in three areas along the Hunter Ridge. The questions which we are seeking to answer are as follows:

Kadavu and northern Hunter Ridge (area 1)

Questions:
1) What is the lateral extent of adakites on the seafloor around Kadavu Island?

2) What is the structural relationships between the northern Hunter Ridge and Kadavu Island?

To answer these questions we plan to conduct detailed swath mapping, sub-bottom profiling and dredge sampling in area 1. The use of the sub-bottom profiler will be vital in determining whether the seafloor has a volcanic, sediment-poor basement or alternatively the seafloor is formed by sediments. This information will significantly help the interpretation of the swath mapping.

Rift Zone at the southern end of the Hunter Ridge (area 2)

Questions:
1) What is the distribution of different magma types within the rift?

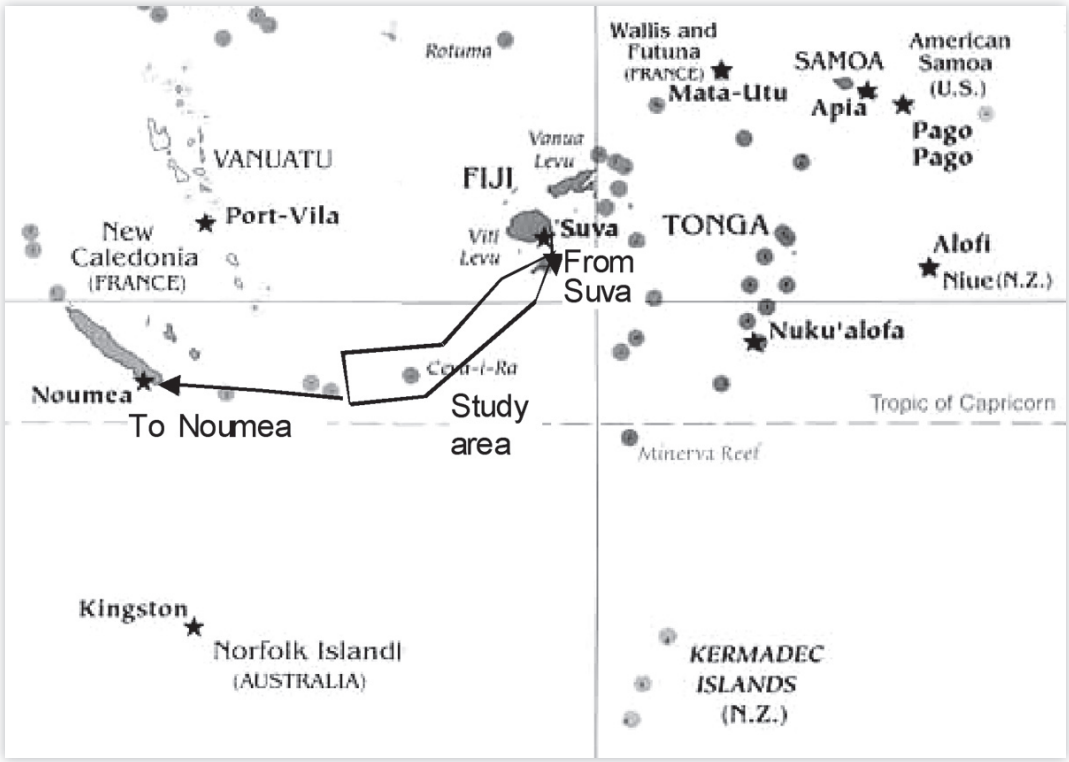
To answer this question we intend to perform 10-15 dredges within the main rift zone between 1500-2500m water depth.

North Fiji Basin propagating spreading centre (area 3)

Questions:
1) What is the age and rate of southward propagation of the spreading centre?

We plan to conduct a magnetic survey along 3 lines across the spreading ridge to obtain magnetic profiles. Due to the limited time available during voyage SS10/2204 to conduct a detailed sampling of the spreading centre, we plan to carry out further sampling using a specially modified piston corer, designed for sampling glassy pillow rinds of young lavas.

Voyage Track



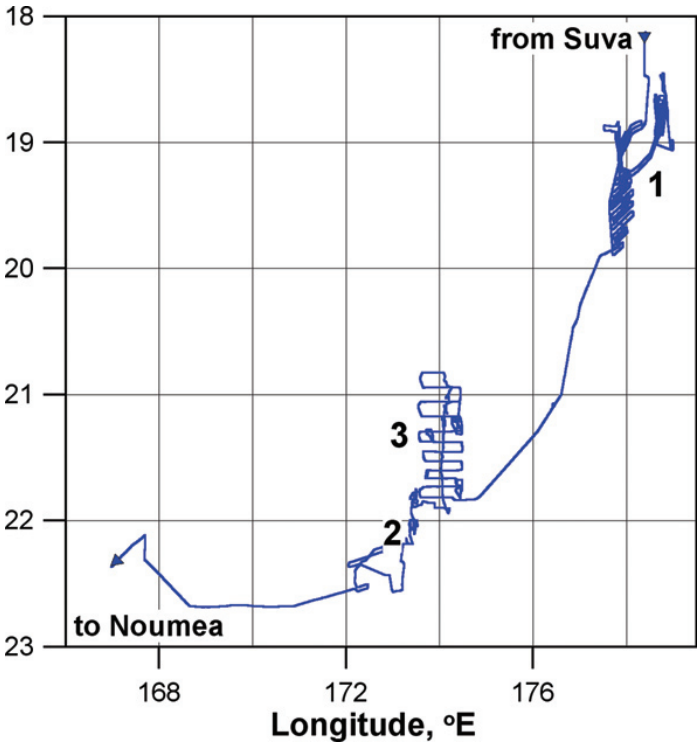


Figure 1: Voyage track. Numbers 1 to 3 indicate study areas detailed in the Voyage Objectives section.

Results

The ship spent 23 days at sea. Of these approximately 20 days were spent at sites and 3 days on transit between sites and from Suva to Noumea.

Objective 1. Kadavu and northern Hunter Ridge (area 1)

We spent approximately 8 days (197 hours) swath mapping and dredging in area 1. During the 132 hours of swath mapping, the ship covered approximately 1050 nautical miles mapping an area of seafloor of approximately 5980 km2 (Figure 2).

No clear structural boundary exists between the northern termination of the submarine Hunter Ridge and the western end of the Kadavu Island. The Hunter Ridge crust in this area is extensively faulted by several generations of cross-cutting faults, which are similar to its structure at the western end of the ridge (Figure 3, area 2). There are a large number of small young volcanic cones on the slopes of the Kadavu Island, on the Hunter Ridge, and on the seafloor of the North Fiji backarc basin west of Kadavu (Figure 2).

The ship spent approximately 60 hours dredging within area 1. Of 16 dredges conducted in this area, 13 are located around the western end of Kadavu and on the Hunter Ridge, and 3 are on the eastern slopes of Kadavu (Figure 2). Dredge details are presented in Table 1. Thirteen dredges at the western side of Kadavu recovered basaltic rocks with variable proportions of olivine, plagioclase and clinopyroxene phenocrysts. Sedimentary rocks were also recovered in 10 dredges. Three dredges at the eastern side of Kadavu recovered volcano-sedimentary rocks only.

Objective 2. Rift Zone at the southern end of the Hunter Ridge (area 2) and North Fiji Basin propagating spreading centre (area 3)

We spent approximately 12 days (286 hours) swath mapping, conducting a magnetics survey, wax coring and dredging in areas 2 and 3. During the 130 hours of swath mapping, the ship covered approximately 1030 nautical miles, mapping an area of seafloor of approximately 5700 km2 (Figure 3).

Mapping was focused around two areas: 1) the propagating spreading centre, where it was combined with approximately 75 hours of the magnetics survey across the spreading centre, and 2) at the western end of the study area, east of the Hunter Island, where an incipient rift has been discovered. This rift splits the western termination of the Hunter Ridge in the WSW-ENE direction.

Preliminary results indicate that the magnetics survey has intercepted the first reversal of the Earth's magnetic field, suggesting that the age of the propagating centre is approximately 1 million years in its central part.

We spent approximately 110 hours dredging within areas 2 and 3. Of 23 dredges conducted in this area, 6 are located on the spreading centre, 7 on the Hunter Ridge crust, and 10 within the rift zone (Figure 3). All dredges recovered mainly basaltic and also some andesitic lavas with variable proportions of olivine, plagioclace, clinopyroxene and orthopyroxene phenocrists. Sedimentary rocks were also recovered in 12 dredges.

We spent approximately 44 hours conducting wax coring sample of volcanic glass along the axis of the propagating spreading centre. Out of 26 wax cores, 23 recovered fresh volcanic glass.

Voyage Narrative

The ship left Suva, Fiji at 1300 hrs on the 19 August 2006. The transit to area 1 took approximately 4 hours. Due to a short transit time, the first 2.5 days of the voyage were spent doing swath mapping allowing scientific personnel and marine crew the opportunity to settle into their roles. Our strategy during the voyage was to alternate different operations as much as possible.Within the study area 1 we did 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 north-east towards south-west. The ship left the study area 1 at 0830 hrs GMT on the 27August.

Transit to areas 2-3 took 27.5 hours. Within the 2nd study area, we alternated periods of swath mapping (with or without magnetics) with dredging and wax coring. The general direction of coverage was from north-east towards south-west. The ship left the study area at 1000 hrs GMT on the 9 September on its way to Noumea.

The operations record is presented in Table 3.

During the entire duration of the voyage we ran a single beam echo sounder (EA500) and the sub-bottom profiler (EK500). The EK500 turned out to be much less useful than we expected as it can provide information on sediment cover over flat seafloor only, whereas our study areas are both characterised by complex topography.

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 to 3,500m when the seafloor is made of young volcanic rocks, and for dredging and wax coring at water depths to 4,000m.

Personnel

Scientific Participants

Leonid Danyushevsky	Univ. of Tasmania	Chief Scientist
Trevor Falloon	Univ. of Tasmania	Geochemist
Michael Roach	Univ. of Tasmania	Geophysicist
Patrick Quilty	Univ. of Tasmania	Palaeontologist
Pavel Plechov	Moscow State Univ.	Geochemist
Andrew Stacey	Univ of Tasmania	PhD student/Geophysicist
Michelle Farran	Univ of Tasmania	Student
Brooks Rakau	MRD, Vanuatu	Geologist
Bob Beattie	CMAR	MNF Computing support Voyage Manager
Lindsay MacDonald	CMAR	MNF Electronics Support
Michele Spinoccia	Geoscience Australia	Swath Mapping

CMAR – CSIRO Marine and Atmospheric Research

Marine Crew

Master	Les Morrow
First Mate	Madeleine Habib
Second Mate	Andrew Laverick
C/Eng	Roger Thomas
First Eng	Rob Cave
Second Eng	Chris Heap
Bosun	Mal McDougall
IR	Tony van Rooy
IR	Graham McDougall
IR	Phil French
IR	Tony Hearne
C/Cook	Andy Goss
Second Cook	Jason Phillips
C/Steward	Charmayne Aylett

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 voyage without the support of the Voyage Manager Bob Beattie and electronics technician Lindsay MacDonald. The support of Michele Spinoccia with swath mapping was simply outstanding. We relied heavily on swath mapping, and the amount of work we have accomplished would not have been possible without his enthusiastic involvement in our work. Our 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

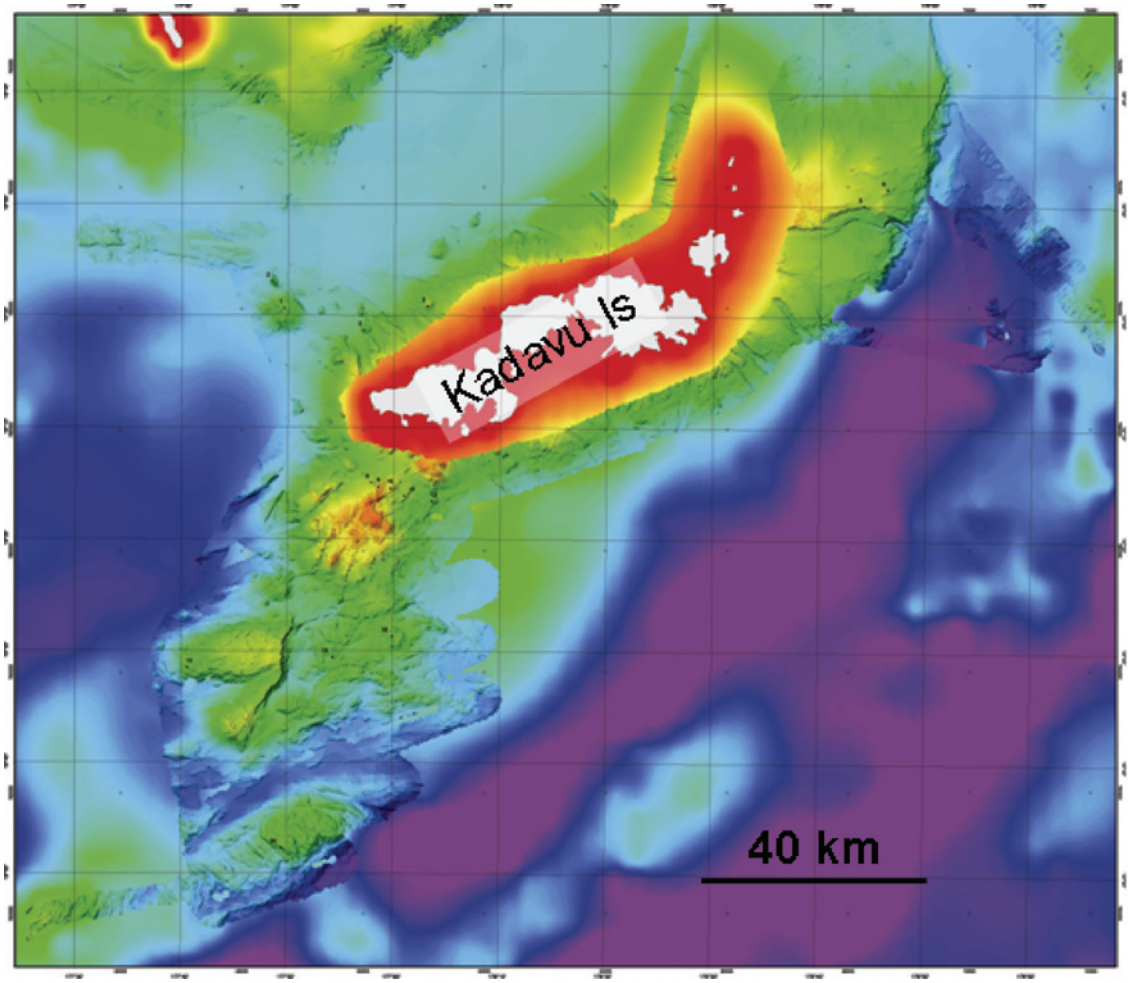


Figure 2: Topographic map of study area 1 completed during the swath mapping survey. Colour corresponds to water depth between 0 m (red) and 3,500 m (violet). Note the faulted nature of the seafloor and numerous small young volcanic cones around the western side of Kadavu Island., and the dominance of erosional features around its eastern side. Black dots indicate location of dredges.

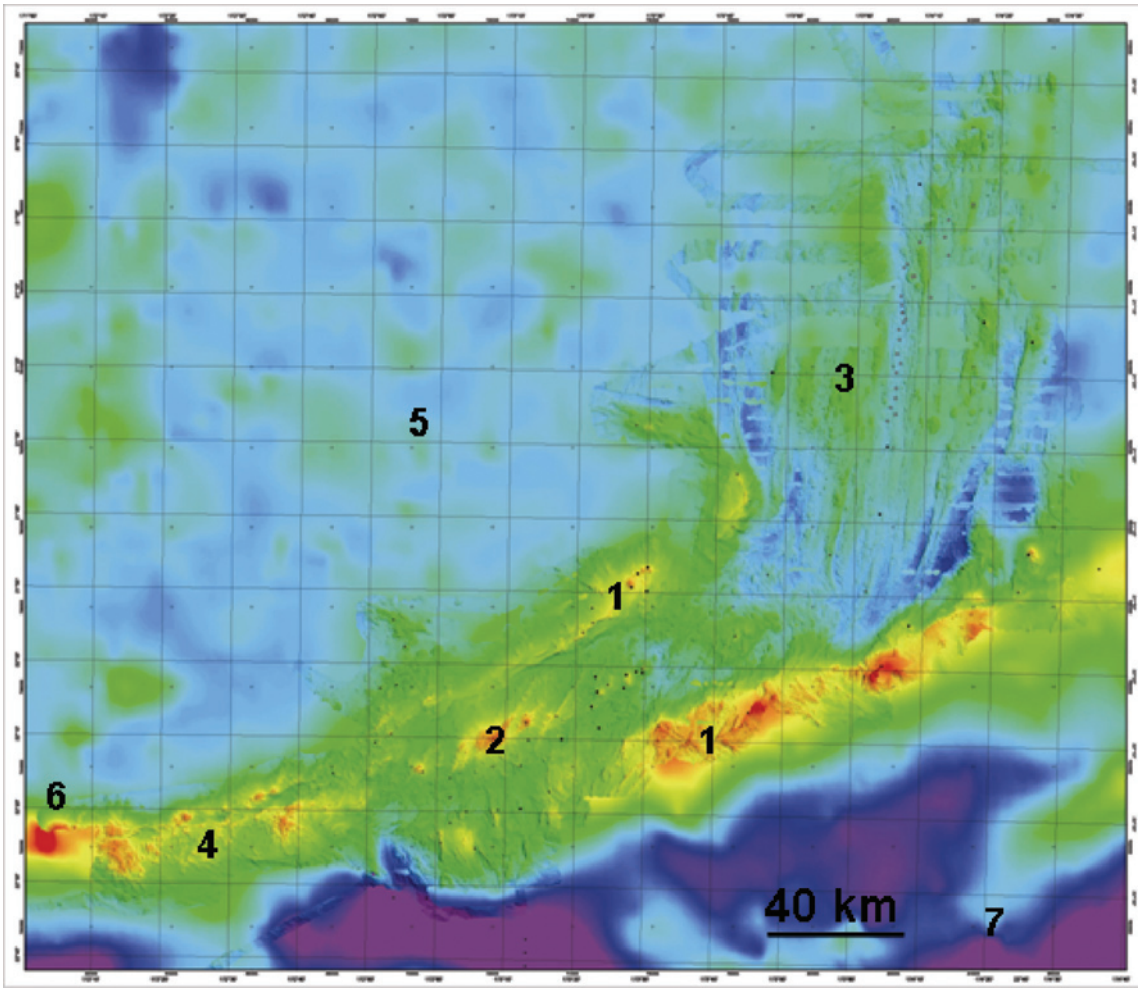


Figure 3: Topographic map of study areas 2 and 3 completed during the swath mapping surveys SS08/2006 and SS10/2004. Colour corresponds to water depth between 500 m (red) and 4,500 m (violet). 1 - Hunter Ridge; 2 - rift zone; 3 - propagating spreading centre; 4 – incipient rift zone; 5 - older crust of the North Fiji Basin; 6- Hunter Island; 7 - South Fiji Basin. Black dots indicate location of dredges, open circles indicate locations of wax cores along the axis of the propagating spreading centre.

Table 1. Dredge list

Dredge#	Average Long	Average Lat	Average Depth	Result
SS08/06-D1	177.8268	-18.9892	1340	Rocks
SS08/06-D2	177.8073	-18.9498	1840	Rocks
SS08/06-D3	178.0509	-18.9858	1040	Rocks
SS08/06-D4	177.9513	-19.0220	1455	Rocks
SS08/06-D5	178.7337	-18.8332	1158	Rocks
SS08/06-D6	178.7701	-18.8080	1100	Rocks
SS08/06-D7	178.7913	-18.4991	1565	Mud with rock fragments
SS08/06-D8	177.9643	-19.2496	893	Rocks
SS08/06-D9	177.9748	-19.2552	665	Rocks
SS08/06-D10	177.9946	-19.2573	685	Rocks
SS08/06-D11	178.0164	-19.2693	1060	Rocks
SS08/06-D12	178.0601	-19.2772	1340	Rocks
SS08/06-D13	177.6763	-19.5261	1430	Rocks
SS08/06-D14	177.9053	-19.5102	1580	Rocks
SS08/06-D15	177.9986	-19.4786	1335	Rocks
SS08/06-D16	177.8248	-19.7957	1462	Rocks
SS08/06-D17	174.4226	-21.7298	1310	Rocks
SS08/06-D18	173.7973	-21.3316	2525	Rocks
SS08/06-D19	174.4203	-21.2533	2098	Rocks
SS08/06-D20	174.3036	-21.2106	1890	Rocks
SS08/06-D21	174.1441	-20.9008	3020	Rocks
SS08/06-D22	174.0764	-21.4946	2950	Rocks
SS08/06-D23	174.0620	-21.6480	3020	Rocks
SS08/06-D24	174.1363	-21.9007	1540	Rocks
SS08/06-D25	173.4248	-21.8658	1400	Rocks
SS08/06-D26	173.4985	-21.8288	1530	Rocks
SS08/06-D27	173.4621	-21.8175	1068	Rocks
SS08/06-D28	173.4796	-21.7918	1230	Rocks
SS08/06-D29	173.5051	-21.7794	1220	Rocks
SS08/06-D30	173.4960	-22.0105	1873	Rocks
SS08/06-D31	173.4800	-22.0148	1983	Rocks
SS08/06-D32	173.4571	-22.0254	1535	Rocks
SS08/06-D33	173.4563	-22.0468	1702	Rocks
SS08/06-D34	173.3831	-22.0281	1955	Rocks
SS08/06-D35	173.3888	-22.0604	1630	Rocks
SS08/06-D36	173.3738	-22.0943	1805	Rocks
SS08/06-D37	173.3933	-22.1417	2040	Rocks
SS08/06-D37A	173.3023	-22.1689	2060	Rocks
SS08/06-D38	173.2063	-22.3252	2493	Mud with rock fragments

Table 2. Wax core list

Wax core#	Average Long	Average Lat	Average Depth	Result
SS08/06-W1	174.2675	-20.9428	2484	Empty
SS08/06-W2	174.2100	-20.9793	2777	glass
SS08/06-W3	174.1418	-21.0306	2613	glass
SS08/06-W4	174.2019	-21.0185	2758	Empty
SS08/06-W5	174.2113	-21.5596	2793	Empty
SS08/06-W6	174.1303	-21.0805	2427	glass
SS08/06-W7	174.1708	-21.1552	2738	micro glass
SS08/06-W8	174.1056	-21.0893	3030	glass
SS08/06-W9	174.1265	-21.1082	2684	micro glass
SS08/06-W10	174.1312	-21.1075	2611	lots of glass
SS08/06-W11	174.0998	-21.1533	3062	lots of glass
SS08/06-W12	174.1018	-21.1739	3072	glass
SS08/06-W13	174.1042	-21.1894	2948	micro glass
SS08/06-W13a	174.1034	-21.1913	2962	lots of glass
SS08/06-W14	174.1064	-21.2119	2963	lots of glass
SS08/06-W15	174.1120	-21.2053	2999	lots of glass
SS08/06-W16	174.0957	-21.2291	2973	micro glass
SS08/06-W17	174.0973	-21.2517	3011	lots of glass
SS08/06-W18	174.0934	-21.2835	2921	lots of glass
SS08/06-W19	174.1012	-21.3053	3015	lots of glass
SS08/06-W20	174.0922	-21.3255	2932	lots of glass
SS08/06-W21	174.0918	-21.3609	2970	glass
SS08/06-W22	174.0909	-21.3833	2988	lots of glass
SS08/06-W23	174.0804	-21.4052	2959	lots of glass
SS08/06-W24	174.0920	-21.4200	2912	lots of glass
SS08/06-W25	174.0721	-21.4357	2899	lots of glass

Table 3 Operations record

Operation	Date Start	Time Start GMT	Date Finish	Time Finish GMT	Hours
Mapping Survey 1	19/08/2006	5:00:00	21/08/2006	21:15:00	64.25
Winch repair	21/08/2006	20:15:00	22/08/2006	1:30:00	5.25
Dredges 1, 2	22/08/2006	1:30:00	22/08/2006	11:00:00	9.50
Mapping Survey 2	22/08/2006	11:00:00	22/08/2006	19:15:00	8.25
Dredges 3,4	22/08/2006	19:15:00	23/08/2006	3:00:00	7.75
Mapping Survey 3	23/08/2006	3:00:00	24/08/2006	1:00:00	22.00
Dredges 5,6	24/08/2006	1:00:00	24/08/2006	10:00:00	9.00
Mapping Survey 4	24/08/2006	10:00:00	24/08/2006	20:00:00	10.00
Dredges 7	24/08/2006	20:00:00	25/08/2006	0:30:00	4.50
Mapping Survey 5	25/08/2006	0:30:00	25/08/2006	13:00:00	12.50
Dredges 8,9,10,11,12	25/08/2006	13:00:00	26/08/2006	3:15:00	14.25
Mapping Survey 6	26/08/2006	3:15:00	26/08/2006	7:30:00	4.25
Dredges 13	26/08/2006	7:30:00	26/08/2006	10:45:00	3.25
Mapping Survey 7	26/08/2006	10:45:00	26/08/2006	15:00:00	4.25
Dredges 14	26/08/2006	15:00:00	26/08/2006	19:00:00	4.00
Mapping Survey 8	26/08/2006	19:00:00	26/08/2006	19:30:00	0.50
Dredges 15	26/08/2006	19:30:00	26/08/2006	22:45:00	3.25
Mapping Survey 9	26/08/2006	22:45:00	27/08/2006	4:30:00	5.75
Dredges 16	27/08/2006	4:30:00	27/08/2006	8:30:00	4.00
Transit to Area 2	27/08/2006	8:30:00	27/08/2006	20:30:00	12.00
Engine repair	27/08/2006	20:30:00	27/08/2006	23:30:00	3.00
Transit to Area 2	27/08/2006	23:30:00	28/08/2006	12:00:00	12.50
Mapping Survey 10	28/08/2006	12:00:00	28/08/2006	16:00:00	4.00
Dredge 17	28/08/2006	16:00:00	28/08/2006	19:30:00	3.50
Mapping Survey 11	28/08/2006	19:30:00	28/08/2006	20:30:00	1.00
Magnetic Survey 1	28/08/2006	20:30:00	30/08/2006	14:30:00	42.00
Dredge 18	30/08/2006	14:30:00	30/08/2006	20:30:00	6.00
Mapping Survey 12	30/08/2006	20:30:00	30/08/2006	22:30:00	2.00
Magnetic Survey 2	30/08/2006	22:30:00	31/08/2006	7:00:00	8.50
Dredges 19, 20	31/08/2006	7:00:00	31/08/2006	15:30:00	8.50
Magnetics Survey 3	31/08/2006	15:30:00	1/09/2006	15:30:00	24.00
Dredge 21	1/09/2006	15:30:00	1/09/2006	20:30:00	5.00
WC1	1/09/2006	20:30:00	2/09/2006	0:00:00	3.50
WC2	2/09/2006	0:00:00	2/09/2006	2:19:00	2.32
WC3	2/09/2006	2:19:00	2/09/2006	4:15:00	1.93
WC4	2/09/2006	4:15:00	2/09/2006	5:59:00	1.73
WC5	2/09/2006	5:59:00	2/09/2006	7:39:00	1.67
WC6	2/09/2006	7:39:00	2/09/2006	9:33:00	1.90
WC7	2/09/2006	9:33:00	2/09/2006	11:40:00	2.12
WC8	2/09/2006	11:40:00	2/09/2006	13:30:00	1.83
WC9	2/09/2006	13:30:00	2/09/2006	14:40:00	1.17
WC10	2/09/2006	14:40:00	2/09/2006	15:34:00	0.90
WC11	2/09/2006	15:34:00	2/09/2006	17:13:00	1.65
WC12	2/09/2006	17:13:00	2/09/2006	18:30:00	1.28
WC13	2/09/2006	18:30:00	2/09/2006	19:39:00	1.15
Swath mapping	2/09/2006	19:39:00	2/09/2006	21:45:00	2.10

WC14	2/09/2006	21:45:00	2/09/2006	22:57:00	1.20
WC13A	2/09/2006	22:57:00	3/09/2006	0:45:00	1.80
WC15	3/09/2006	0:45:00	3/09/2006	2:10:00	1.42
WC16	3/09/2006	2:10:00	3/09/2006	3:45:00	1.58
WC17	3/09/2006	3:45:00	3/09/2006	5:26:00	1.68
WC18	3/09/2006	5:26:00	3/09/2006	6:55:00	1.48
WC19	3/09/2006	6:55:00	3/09/2006	8:25:00	1.50
WC20	3/09/2006	8:25:00	3/09/2006	10:16:00	1.85
WC21	3/09/2006	10:16:00	3/09/2006	12:00:00	1.73
WC22	3/09/2006	12:00:00	3/09/2006	13:26:00	1.43
W23	3/09/2006	13:26:00	3/09/2006	14:46:00	1.33
W24	3/09/2006	14:46:00	3/09/2006	15:56:00	1.17
W25	3/09/2006	15:56:00	3/09/2006	17:15:00	1.32
W26	3/09/2006	17:15:00	3/09/2006	18:25:00	1.17
Dredge 22,23	3/09/2006	18:25:00	4/09/2006	8:30:00	14.08
Dredge 24	4/09/2006	8:30:00	4/09/2006	13:44:00	5.23
Transit to D25	4/09/2006	13:44:00	4/09/2006	20:00:00	6.27
Dredge 25	4/09/2006	20:00:00	4/09/2006	23:00:00	3.00
Dredge 26, 27	4/09/2006	23:00:00	5/09/2006	6:15:00	7.25
Dredge 28	5/09/2006	6:15:00	5/09/2006	8:45:00	2.50
Dredge 29	5/09/2006	8:45:00	5/09/2006	13:30:00	4.75
Transit to D30	5/09/2006	13:30:00	5/09/2006	17:00:00	3.50
Dredge 30	5/09/2006	17:00:00	5/09/2006	20:20:00	3.33
Wire repair	5/09/2006	20:20:00	6/09/2006	1:00:00	4.67
Dredge 31	6/09/2006	1:00:00	6/09/2006	5:30:00	4.50
Dredge 30 repeat	6/09/2006	5:30:00	6/09/2006	10:00:00	4.50
Dredge 32	6/09/2006	10:00:00	6/09/2006	14:30:00	4.50
Dredge 33	6/09/2006	14:30:00	6/09/2006	19:00:00	4.50
Dredge 34	6/09/2006	19:00:00	6/09/2006	23:00:00	4.00
Dredge 35	6/09/2006	23:00:00	7/09/2006	2:30:00	3.50
Dredge 36	7/09/2006	2:30:00	7/09/2006	5:41:00	3.18
Dredge 37	7/09/2006	5:41:00	7/09/2006	9:45:00	4.07
Dredge 37A	7/09/2006	9:45:00	7/09/2006	13:55:00	4.17
Transit to D38	7/09/2006	13:55:00	7/09/2006	15:30:00	1.58
Dredge 38	7/09/2006	15:30:00	7/09/2006	19:30:00	4.00
Wire spooling	7/09/2006	19:30:00	7/09/2006	23:30:00	4.00
Mapping survey 13	7/09/2006	23:30:00	9/09/2006	10:00:00	34.50