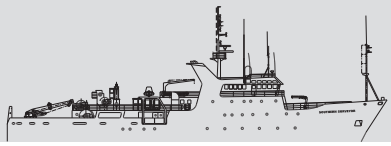

MARINE
NATIONAL FACILITY

2009 program

RV *Southern Surveyor*

CSIRO

voyage summary SS03/2009

SS03/2009

Hot Subduction – recycling of oceanic crust in a dynamic W Pacific setting. Part 3

Voyage period
03/07/2009 to 26/03/2009
Port of departure: Lautoka, Fiji
Port of return: Noumea, New Caledonia

Responsible laboratory
CODES CoE, University of Tasmania, Private Bag 79, Hobart, TAS 7001, Australia

Chief Scientist
Leonid Danyushevsky

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 voyages SS10/2004 and SS08/2006.

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.

As parts of the study area are currently volcanically active, one of our objectives is to detect the presence of any active hydrothermal systems on the seafloor, which are potential sites of formation of modern Seafloor Massive Sulphides. Much of Australia's mineral rich Phanerozoic geology developed in complex subduction-related plate

boundaries similar to the study. Thus an improved understanding of the connection between magmatism and sulphide mineralisation forming processes in the study area will have direct relevance to the interpretation of Australia's geological history and lead to a better understanding of the formation and consequent exploration for new deep earth ore deposits.

Voyage Objectives

To conduct a multibeam survey and rock sampling in three areas along the Hunter Ridge, and to measure water properties using MAPR sensors (Miniature Autonomous Plume Recorders). The questions which we are seeking to answer are as follows:

The central part of the Hunter Ridge (area 1)

Questions: 1) The highly deformed nature of the southern end of the Hunter ridge discovered during SS10/2004 raises the question of whether the deformation is the result of recent and ongoing deformation associated with the triple junction or is this style of deformation a feature of the entire Hunter Ridge? 2) How old is the magmatism along the entire Hunter Ridge? To answer these questions we plan to do detailed swath mapping, sound-bottom profiling and dredge sampling in area 1 (Fig. 1; between 178 - 174.5 °E, 20.5 – 22 °S). The use of the sound-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.

North Fiji Basin propagating spreading centre (area 2)

Questions: 1) What is the range of chemical variations in magmas erupted along the spreading centre? 2) Is there current active hydrothermal activity along the spreading centre? To answer these questions we plan to conduct in area 2 (Fig. 1; ~ 174 °E, 21.5 – 22 °S) volcanic glass sampling using a specially modified piston corer, designed for sampling glassy pillow rinds of young lavas; and water property measurements using MAPR sensors.

New Rift Zone at the southern end of the Hunter Ridge (area 3)

During SS08/2006 we were able to image the western most end of the rift (Figure 2), which revealed incipient fracturing of the Hunter Ridge extending towards Hunter Island, the southern most active volcano of the Vanuatu Island arc. This is the first time that the process of incipient arc rifting has been discovered in an active setting.

What is particularly important for our research project is the nature of volcanics associated with this rifting. The seafloor swath mapping, shows numerous young volcanic features, some of which are clearly cut by large fault scarps. We need to know the composition of the magmas erupted by these volcanoes, whether they are similar to or different to what is found in the well developed rift discovered and characterised during SS10/2004 and SS08/2006 voyages. To answer these questions we will perform ten more dredges on volcanoes associated with incipient arc rifting between 1500-2500m water depth between 173 – 172 °E, ~ 22.5 °S.

Results

The ship spent 23 days at sea. Out of these, ~19 days were spent on sites and 4 days on transit from Latouka to the study area 1, including a 2 day return trip to Latouka on the 6th of July to Medivac the 2nd cook, and from the study area 3 to Noumea (Fig. 2).

Objective 1. The central part of the Hunter Ridge (area 1)

The ship spent ~ 11 days (272 hours) doing swath mapping and dredging in area 1. During the 215 hours of swath mapping, the ship covered ~1720 nautical miles mapping an area of seafloor of ~ 9300 km2 (Figure 3).

Seafloor mapping revealed the highly deformed nature of the entire Hunter Ridge crust, identical to what was discovered at the southern end of the Hunter Ridge during SS10/2004. This puts important constraints on the tectonic history of the Ridge and questions the currently accepted view that it represents a relatively young volcanic arc. We also found and sampled a large number of small, young (post-deformation) volcanic cones along the ridge and on the adjacent seafloor of the North Fiji Backarc Basin, suggesting that both are currently undergoing an extension.

The ship spent ~ 78 hours dredging within area 1, successfully completing 24 dredging stations. Dredge details are presented in Table 1. The dredges recovered a large range of older volcanic rocks and sediments of the faulted slopes of the Hunter Ridge. We also recovered a range of intrusive rocks from the deepest scarps on the ridge. These rocks will be used to date the volcanism using a U-Pb dating techniques. We will also attempt dating the sedimentary rocks by a range of isotopic and paleontological techniques. See Table 3 for the complete list of samples.

Objective 2. North Fiji Basin propagating spreading centre (area 2)

The ship spent 50 hours sampling young volcanic glasses from the southern tip of the North Fiji Basin propagating spreading centre using a wax-coring method (Figure 4). We successfully completing 32 wax-coring stations at intervals of 1 to 2 nautical miles, recovering sufficient amounts of glass at each station to conduct full chemical analysis. (Table 2). At each wax-coring station, water property measurements aimed at identifying hydrothermal plumes were conducted using MAPR sensors The data will be used to assess the extent of chemical variability of magmas erupted along this spreading segment and constrain magma generation processes and their link to active hydrothermal systems on the seafloor. See Table 3 for the complete list of samples.

Objective 3. New Rift Zone at the southern end of the Hunter Ridge (area 3)

The ship spent ~ 5.5 days (135 hours) doing swath mapping and dredging in area 3. During the 50 hours of swath mapping, the ship covered ~400 nautical miles mapping an area of seafloor of ~ 2300 km2 (Figure 6) between the Hunter and Matthew Islands, discovering large fresh lava fields on the seafloor south of Matthew Island, indicative of active extension in this area, possibly related to southward propagation of the North Fiji Basin. Our mapping also revealed a large submerged inactive caldera between the islands of Matthew and Hunter.

The ship spent ~ 84 hours dredging within area 3, completing 31 dredging stations (table 1). Nine dredges were conducted within the mature Rift Zone at the southern end of the Hunter Ridge, completing a sampling survey initiated during SS10/2004 and SS08/2006 (Figure 5). Fourteen dredges were conducted within the New Rift Zone at the southern tip of the Hunter Ridge, which was mapped during SS08/2006 (Figure 5). Eight dredges were conducted between the islands of Matthew and Hunter. See Table 3 for the complete list of samples.

Voyage Narrative

The ship left Latouka, Fiji at 1300 hours on the 3rd of July 2009. The transit to area 1 took ~ 12 hours. Due to a short transit time, the first 2 days of the voyage were spent doing swath mapping. This is the least involved and demanding operation for both the scientific personnel and the marine crew, and thus this allowed everyone to settle down and get accustomed to their shift times. During the entire voyage, scientific personnel worked in two 12 hour shifts between 0200 and 1400 hours. Our strategy during the voyage was to alternate different operations as much as possible. Within the study areas 1 and 3 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. On the 6th of July we had to return to Latouka to Medivac the 2nd cook, and to pick-up a replacement cook. This took 47 hours in total. The ship left the study area 1 at 2230 hours GMT on the 16th of July.

Transit to area 2 took 21 hours. Within the 2nd study area, we did continuous wax coring starting at the northern end of the area and moving south. The ship left the study area at 1700 hours GMT on the 19th of July.

Transit to area 3 took 3 hours. Within this area, we did mostly dredging within the mature and young rift zones at the southern termination of the Hunter ridge and between Matthew and Hunter Islands, but also a mapping survey. before conducting the last set of dredges at the westernmost part of the area. The ship left area 3 at 1600 hours GMT on the 25th of July on its way to Noumea.

The operations record is presented in Table 4.

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.

We experienced no significant equipment failures that affected data acquisition or ship performance in general.

Summary

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

Principal investigators

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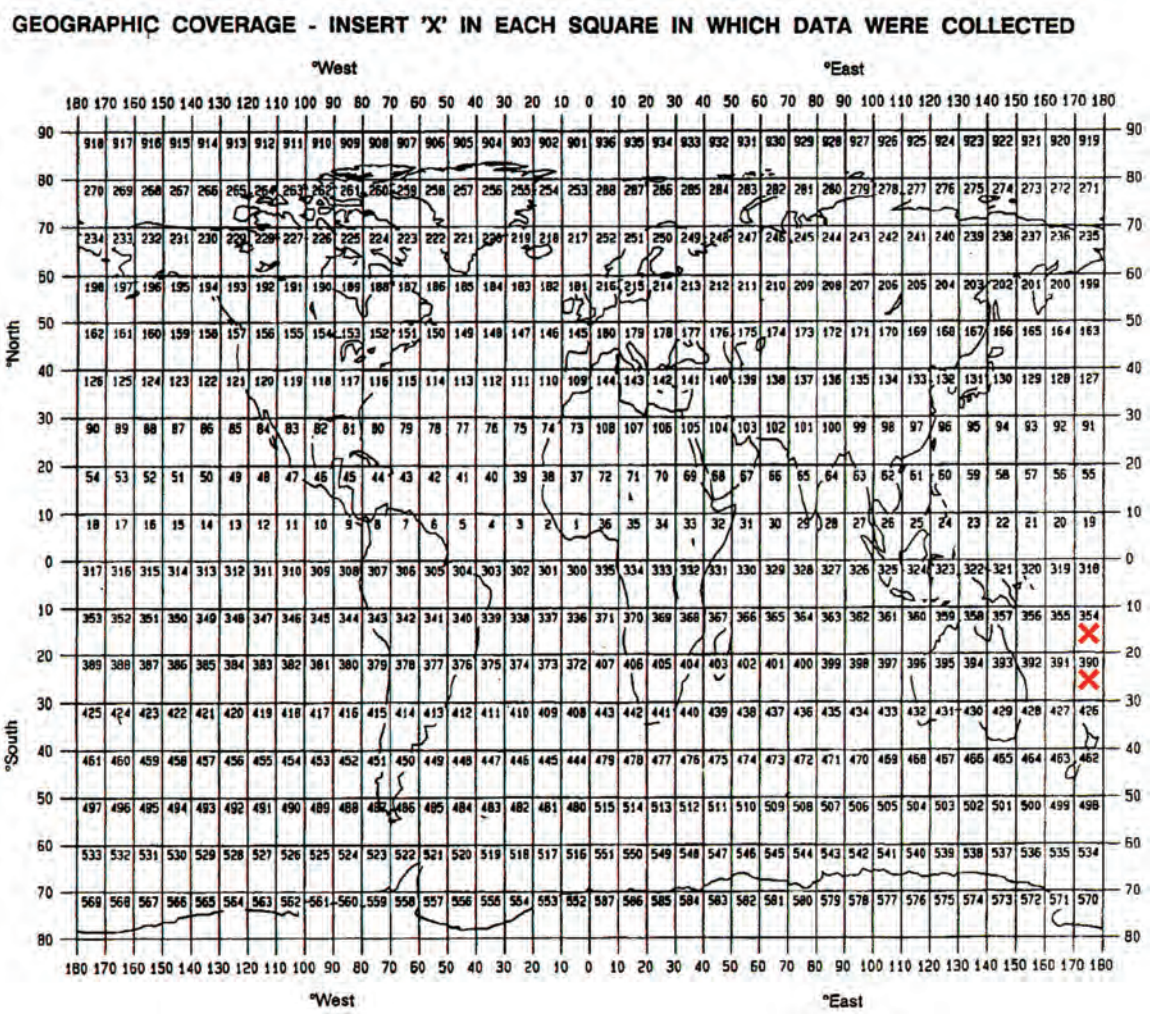

CURATION REPORT

DESCRIPTION

For each data-set or sample collected identify the arrangements made for its lodgement and or curation. The description should identify the Organisational Unit that will house and curate the data and or sample, the names of national / international repositories. Where a physical sample is to become part of a collection this should be stated and the collection named. Where physical samples are to be returned to a laboratory for further study the laboratory should be named as should the method of preservation and the proposed duration for which the sample is to be retained.

All samples and data collected during the voyage are stored at CODES, University of Tasmania. Either of the Principal Investigators can be contacted in relation to any data/ samples collected.

TRACK CHART See Figure 2 below

GENERAL OCEAN AREA(S) Southwest Pacific Ocean

SPECIFIC AREAS Between 171-180 °E; 19-23 °S

Personnel list

Scientific Participants

Name	Affiliation	Role
Leonid Danyushevsky	UTAS, CODES	Chief Scientist
Trevor Falloon	UTAS	Co-chief Scientist
Roman Leslie	UTAS	Geochemist
Sandrin Feig	UTAS	Geochemist
David Hutchinson	UTAS	Geochemist
Julie Hunt	UTAS	Geochemist
Gisela Cobenas	UTAS	PhD Student
Pavel Plechov	Moscow State University	Geochemist
Rakau Brooks	Vanuatu Geol. Survey	Observer
Ratu Bolalailai	Fiji Dept. of Mines	Observer
Lisa Woodward	CMAR	MNF Voyage Manager
Lindsay MacDonald	CMAR	MNF Electronics support
Pamela Brodie	CMAR	MNF Computing support
Tony Veness	CMAR	MNF Swath mapping support

Marine Crew

Name	Role
Ian Taylor	Master
John Barr	Chief Officer
Rob Ferries	2nd Officer
Roger Thomas	Chief Engineer
Mike Sinclair	1st Engineer
Craig Hogarth	2nd Engineer
John Howard	Chief IR
Matt Barrett	IR
Johnathon Lumb	IR
Dan Nicholson	IR
Grant Webberley	IR
David Nichols	Chief Cook
James McGarvey	2nd Cook
Stuart Siejka/Rebecca Lee	Steward

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 outstanding support of the Voyage Manager Lisa Woodward, MNF Electronics support, Lindsay MacDonald and MNF Computing support Pamela Brodie. The support of Tony Veness 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. 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

Table 1. Locations of dredging stations

Dredge#	Date	Time (GMT)	Result	Average Long	Average Lat	Average Depth
SS03/09-D39	5-Jul-09	20:30:00	Rocks	176.9672	-20.3218	1432
SS03/09-D40	6-Jul-09	2:05:00	Rocks	177.0313	-20.1196	1418
SS03/09-D41	6-Jul-09	8:17:00	Rocks	177.369	-19.9089	1588
SS03/09-D42	9-Jul-09	5:12	Rocks	177.4951	-19.8803	1412
SS03/09-D43	9-Jul-09	9:44:00	Rocks	177.5677	-19.9248	1649
SS03/09-D44	8-Jul-09	15:15:00	Rocks	176.8884	-20.3698	743
SS03/09-D44a	8-Jul-09	18:25:00	Rocks	176.8884	-20.368	775
SS03/09-D45	11-Jul-09	2:10:00	Rocks	177.3265	-20.41	2548
SS03/09-D46	11-Jul-09	8:31:00	Rocks	177.4361	-20.5326	1356
SS03/09-D47	11-Jul-09	12:11:00	Rocks	177.3723	-20.5709	2093
SS03/09-D48	11-Jul-09	15:18:00	Rocks	177.384	-20.5887	1201
SS03/09-D49	11-Jul-09	23:21	Rocks	177.2287	-20.6483	1299
SS03/09-D50	11-Jul-09	20:16:00	Rocks	177.2423	-20.6192	1557
SS03/09-D51	12-Jul-09	1:40:00	Rocks	177.2868	-20.6514	1660
SS03/09-D53	12-Jul-09	6:57:00	Rocks	177.1115	-20.7285	963
SS03/09-D54	13-Jul-09	4:59:00	Rocks	176.9148	-20.7492	3600
SS03/09-D55	13-Jul-09	23:17:00	Rocks	176.6698	-20.4762	1635
SS03/09-D56	14-Jul-09	2:25:00	Rocks	176.6549	-20.419	2417
SS03/09-D57	16-Jul-09	3:44:00	Rocks	176.3538	-21.1571	1532
SS03/09-D58	16-Jul-09	11:05:00	Rocks	175.9509	-21.3498	1660
SS03/09-D59	16-Jul-09	8:49:00	Rocks	176.0073	-21.3826	780
SS03/09-D60	16-Jul-09	13:48:00	Rocks	175.8531	-21.4126	1757
SS03/09-D61	16-Jul-09	20:30:00	Rocks	175.7997	-21.5171	1995
SS03/09-D62	16-Jul-09	17:25:00	Rocks	175.6766	-21.4641	1123
SS03/09-D63	20-Jul-09	1:16:00	Rocks	173.5334	-22.1667	815
SS03/09-D64	20-Jul-09	3:22:00	Rocks	173.4365	-22.2223	1475
SS03/09-D65	20-Jul-09	7:56:00	Rocks	173.2346	-22.0037	2068
SS03/09-D66	20-Jul-09	9:54:00	Rocks	173.2464	-21.9784	1647
SS03/09-D67	20-Jul-09	12:52:00	Rocks	173.1822	-22.1156	1309
SS03/09-D68	20-Jul-09	15:18:00	Rocks	173.1121	-22.1614	1048
SS03/09-D69	20-Jul-09	17:41:00	Rocks	173.0507	-22.1926	1551
SS03/09-D70	20-Jul-09	20:45:00	Rocks	172.8421	-22.2257	1630
SS03/09-D71	20-Jul-09	23:25:00	Rocks	172.6985	-22.279	1860
SS03/09-D72	21-Jul-09	1:53:00	Rocks	173.252	-22.3683	1630
SS03/09-D73	21-Jul-09	3:59:00	Rocks	172.6888	-22.3913	1578
SS03/09-D74	21-Jul-09	8:15:00	Rocks	172.5693	-22.3039	1003
SS03/09-D74A	21-Jul-09	10:47:00	Rocks	172.6639	-22.2915	2006
SS03/09-D75	21-Jul-09	13:13:00	Rocks	172.5805	-22.3337	1565
SS03/09-D76	21-Jul-09	16:09:00	Rocks	172.5654	-22.3525	1335
SS03/09-D77	21-Jul-09	19:33:00	Rocks	172.4726	-22.3945	1397
SS03/09-D78	21-Jul-09	21:31:00	Rocks	172.469	-22.4048	1557
SS03/09-D79	22-Jul-09	0:50:00	Rocks	172.3901	-22.3539	936
SS03/09-D80	22-Jul-09	2:49:00	Rocks	172.3131	-22.3988	1420
SS03/09-D81	22-Jul-09	4:57:00	Rocks	172.2928	-22.3939	1720
SS03/09-D81A	22-Jul-09	7:50:00	Rocks	172.2975	-22.4046	1605
SS03/09-D82	22-Jul-09	9:54:00	Rocks	172.2468	-22.4468	1071
SS03/09-D83	22-Jul-09	11:57:00	Rocks	172.2543	-22.4563	1033
SS03/09-D84	24-Jul-09	11:46:00	Rocks	172.166	-22.3867	767
SS03/09-D85	24-Jul-09	15:35:00	Rocks	171.8108	-22.5031	1331
SS03/09-D86	24-Jul-09	18:49:00	empty	171.6353	-22.362	417
SS03/09-D87	24-Jul-09	21:45:00	Rocks	171.6195	-22.3705	700
SS03/09-D88	24-Jul-09	23:18:00	Rocks	171.5571	-22.4281	1310
SS03/09-D89	25-Jul-09	2:25:00	Rocks	171.4008	-22.3318	540
SS03/09-D90	25-Jul-09	11:29:00	Rocks	171.6769	-22.436	679
SS03/09-D91	25-Jul-09	14:37:00	Rocks	171.3643	-22.5883	2101

Table 2. Locations of wax-coring stations

Station#	Date	Time (GMT)	Result	Average Long	Average Lat	Average depth
SS03/09-WC26	17-Jul-09	20:54:00	glass	174.072	-21.435	2895
SS03/09-WC27	17-Jul-09	22:33:00	glass	174.074	-21.450	2925
SS03/09-WC28	18-Jul-09	0:15:00	glass	174.083	-21.458	2855
SS03/09-WC29	18-Jul-09	0:47:00	glass	174.074	-21.471	2952
SS03/09-WC30	18-Jul-09	3:06:00	glass	174.074	-21.480	2986
SS03/09-WC31	18-Jul-09	4:42:00	glass	174.067	-21.492	2962
SS03/09-WC32	18-Jul-09	6:16:00	glass	174.074	-21.499	2973
SS03/09-WC33	18-Jul-09	7:44:00	glass	174.078	-21.510	2901
SS03/09-WC34	18-Jul-09	9:02:00	glass	174.067	-21.520	2915
SS03/09-WC35	18-Jul-09	10:16:00	glass	174.065	-21.530	2917
SS03/09-WC36	18-Jul-09	11:30:00	glass	174.064	-21.538	2897
SS03/09-WC37	18-Jul-09	12:47:00	glass	174.060	-21.552	2901
SS03/09-WC38	18-Jul-09	14:04:00	glass	174.054	-21.573	2881
SS03/09-WC39	18-Jul-09	15:16:00	glass	174.060	-21.587	2893
SS03/09-WC40	18-Jul-09	17:18:00	glass	174.039	-21.606	2782
SS03/09-WC41	18-Jul-09	18:36:00	glass	174.050	-21.621	2923
SS03/09-WC42	18-Jul-09	20:05:00	glass	174.046	-21.640	2804
SS03/09-WC43	18-Jul-09	21:36:00	glass	174.055	-21.661	2997
SS03/09-WC44	18-Jul-09	22:54:00	glass	174.057	-21.674	2982
SS03/09-WC45	19-Jul-09	0:13:00	glass	174.065	-21.698	2948
SS03/09-WC46	19-Jul-09	2:14:00	glass	174.063	-21.725	3084
SS03/09-WC47	19-Jul-09	3:49:00	glass	174.054	-21.750	3042
SS03/09-WC48	19-Jul-09	5:36:00	glass	174.037	-21.767	3111
SS03/09-WC49	19-Jul-09	7:25:00	glass	174.028	-21.788	3166
SS03/09-WC50	19-Jul-09	9:44:00	glass	174.028	-21.803	2995
SS03/09-WC51	19-Jul-09	11:10:00	glass	174.024	-21.819	3070
SS03/09-WC52	19-Jul-09	12:36:00	glass	174.020	-21.837	3082
SS03/09-WC53	19-Jul-09	13:59:00	glass	174.013	-21.855	3081
SS03/09-WC54	19-Jul-09	15:54:00	glass	174.004	-21.864	3028
SS03/09-WC55	19-Jul-09	17:36:00	glass	173.987	-21.894	3159
SS03/09-WC56	19-Jul-09	19:21:00	glass	173.994	-21.912	3067
SS03/09-WC57	19-Jul-09	20:55:00	glass	173.984	-21.929	3032

Table 3. Sample descriptions

Dredge#	Sample No	Description	Weight, kg
SS03/09-D39	D39/1a	Orangy brown to dark grey, fine grained, slightly-moderately weathered vesicular basalt porphyry. Phenocrysts of CPx (<5 mm) and Plagioclase (<1-5 mm). Vesiculars are small (<5 mm) and rarely filled. Porosity est. 8-10% Manganese crust relatively thick ~5 mm.	7
SS03/09-D39	D39/1b	Glass from 1a	0.1
SS03/09-D39	D39/2	Moderately weathered, sparsely phyric, moderately vesicular basalt	0.25
SS03/09-D39	D39/3	Highly altered, aphyric basalt. Now clay with small magnetites	0.2
SS03/09-D39	D39/4	Areas of highly weathered and relatively unaltered, sparsely phyric slightly vesicular basalt. Phenocrysts Olivine+Plagioclase	2
SS03/09-D39	D39/8	Fresh, sparsely phyric, slightly vesicular pillow lava. Small Ol, Cpx	10
SS03/09-D40	D40/1	Fresh, moderately phyric, massive basalt	2.5
SS03/09-D40	D40/2	moderately altered pumice with magnetite crystalls	0.2
SS03/09-D40	D40/3	Fresh, sparsely phyric massive basalt. Phenocrysts of Olivine, CPx	1
SS03/09-D41	D41/1	Moderately vesicular, moderately phyric lava (Ol-CPx rich). High-Mg. Dark grey, fine grained, slight altered. Phenocrysts of CPx ~4 mm, Ol - 7 mm, Pl <1 mm. Thin Mn crust (<1mm), porosity ~20%	15
SS03/09-D41	D41/2	Highly vesicular, CPx-Ol rich lava with less amount of Pl. Moderately phyric, dark grey, fine grained. Most of vesicles are rounded. Phenocrysts of CPx <3 mm, Ol < 4 mm. Porosity ~ 25%	4
SS03/09-D41	D41/3	Moderately vesicular, moderately phyric lava (Pl-CPx-Ol). Fresh, slightly altered, vesicles ~20%. CPx ~ 2 mm, Ol < 1.5 mm, Pl ~ 1mm. Thin Mn-crust < 0.5 mm. Apparent layering	3
SS03/09-D41	D41/4	Fresh, sparsely phyric lava with small (<1mm) phenocrysts. Ol > CPx. Mn crust < 0.5 mm	2.5
SS03/09-D41	D41/5a	Poorly vesicular, nearly aphyric Plag basalts. Gray, fine grained, slightly altered. Mn crust almost absent.	2
SS03/09-D41	D41/5b	The same as D41/5a but with layering defined by darker grey with vesicles. Porisity ~10%. Buble size <1 mm	"-"
SS03/09-D41	D41/6	Moderately vesicular basalt with CPx phenocrysts(sparse). Dark grey, fine grained, fresh and slightly weathered, vesicular basalt porphyry. CPx phenocrysts < 3 mm (rare) with plag. CPx bright green. Vesicles 2-3 mm, Porosity ~15-20 %. Few amygdales. Thin patchy manganese crust.	1.5
SS03/09-D41	D41/7	Fresh, CPx-Ol-Plag porphyritic basalt. Massive. Greenish grey, fine grained, sligthly altered. Phenocrysts of CPx (significant) <3 mm, Olivine (significant) < 4 mm, Plag < 1.5 mm. Thin patchy Mn crust.	0.9
SS03/09-D41	D41/8	Fresh, Grey, aphyric banded, vesicular basalt. Olivine phrnocrysts. Darker layers with very small vesicles and layers with no vesicles. Thin patchy Mn crust.	0.5
SS03/09-D41	D41/9	Conglomerate with fist sized rounded basalt clasts. Light orange and grey, conglomerate composed of < 10 cm sized patchy rounded clasts of basaltic material similar to ather from the dredge. Matrix a fine-grained orange silty sand. Matrix well cemented.	3
SS03/09-D41	D41/10	Fresh sparsely phyric, moderately vesicular lava. Small phenocrysts: Ol, CPx, rare Pl	6
SS03/09-D41	D41/11	Moderately fresh, moderately vesicular phyric basalt (Ol-CPx+Plag	8
SS03/09-D42	D42/1	Fresh, aphyric with occasional microphenocrysts. Massive. Small Olivine, Plagioclase	0.75
SS03/09-D42	D42/2	Massive, sparsely phyric fresh lava. Large Ol phenocrysts and rare small plagioclase	0.75
SS03/09-D42	D42/3	Massive with some vesicles, fresh lava. Sparsely phyric with Cpx and Olivine	1
SS03/09-D42	D42/4	Massive with some vesicles phyric fresh lava with large Olivine and rarely Cpx	1
SS03/09-D42	D42/5	Moderately vesicular, slightly weathered aphyric with very rare olivine phenocrysts	1.5
SS03/09-D42	D42/6	Moderately weathered hyaloclastite with slightly weathered (<7cm) clasts of vesicular-massive lava	3
SS03/09-D42	D42/7	Moderately weathered massive phyric lava with large euhedral olivine	0.5
SS03/09-D43	D43/1	Slightly altered, aphyric with occassional microphenocrysts, massive with fresh glass. Small Olivine and Cpx, thick Mn crust	1.5

SS03/09-D43	D43/2	Slightly altered, aphyric with occassional microphenocrysts, massive. Small Olivine,Cpx and Plag, thick Mn crust	0.75
SS03/09-D43	D43/5	Fresh grey pumice with quartz+glass	2
SS03/09-D44		No hard rocks, only sediments and coral limestones	
SS03/09-D44a	D44a/1	Hyaloclastite/conglomerate with rounded/sub-rounded vesicular lava coddles (~7 cm). Moderately altered sparsely phyric lavas. Phenocrysts of CPx, amphibole(?), olivine(?)	3
SS03/09-D44a	D44a/2	Hyaloclastite/conglomerate with rounded/sub-rounded 5 cm clasts of moderate-highly altered vesicular basalt	1.5
SS03/09-D45	D45/5	Hyaloclastite/Gritstone with glass	1
SS03/09-D45	D45/6	Slightly weathered aphyric vesicular lava. Rare altered Olivine phenocrysts	2
SS03/09-D45	D45/7	Slightly altered, slightly vesicular lava with CPx-Plag-Ol phenocrysts sparsely phyric with glass	2
SS03/09-D45	D45/8	Highly weathered coarse sandstone(?) with glass clasts	1
SS03/09-D45	D45/9	Slightly weathered sparsely phyric, sligthly vesicular lava with Plag, Ol+CPx	3.5
SS03/09-D45	D45/10	Fresh, sparsely phyric, slightly vesicular lava with glass rind. Phenocrysts of Ol+Cpx	2.5
SS03/09-D45	D45/11	Hyaloclastite with large clasts including glass	1.5
SS03/09-D45	D45/12	Slightly weathered massive with small vesicles aphyric lava with hyaloclastite rind containing glass. Rare phenocrysts of olivine.	1.5
SS03/09-D45	D45/13	Slightly weathered, massive lava with small vesicles. Aphyric.	1
SS03/09-D45	D45/14	Slightly weathered vesicle aphyric lava	1
SS03/09-D45	D45/15	Slightly weathered sparsely phyric vesicular lava with Ol+CPx+Plag	1
SS03/09-D45	D45/16	slightly altered, fine-grained aphyric massive dyke material	1
SS03/09-D45	D45/17	slightly altered aphyric lava with ol-cpx and glassy rind	1
SS03/09-D45	D45/18	Slightly altered moderately vesicular aphyric lava with patchy glass rind (altered)	1.5
SS03/09-D45	D45/19	Slightly altered moderately vesicular aphyric lava	"-"
SS03/09-D46	D46/7	Coarse grained tonalite. Isotropic, non porphyritic. Quartz, Plag+Amphibole and Biotite(?)	2.5
SS03/09-D46	D46/8	Medium grained moderately altered Diorite > mafies +qtz	0.5
SS03/09-D46	D46/9	Medium grained highly altered microgabbro	0.5
SS03/09-D46	46/10	Fine grained slightly altered phyric microdiorite/andesite	0.5
SS03/09-D46	D46/11	Medium-grained slightly altered microgabbro	4
SS03/09-D46	D46/12	fine-grained moderately altered andesite. Epidote?, Magnetite	4
SS03/09-D46	D46/13	massive slightly altered aphyric basalt with ocassional plag, CPx	4
SS03/09-D46	D46/14a	Fresh aphyric massive lava with occassional vesicles and rare plagioclase with glass	
SS03/09-D46	D46/14b	Fresh aphyric massive lava with occassional vesicles and rare plagioclase. Glass preserved	0.25
SS03/09-D46	D46/15	Massive, slightly altered, aphyric with occassional phenocrysts of CPx, Ol and Plag	1
SS03/09-D46	D46/16	Massive slightly -moderately altered aphyric lava with occassional phenocrysts of Plag	"-"
SS03/09-D46	D46/17	Massive with some small vesicles, sligthly altered, aphyric lava	"-"
SS03/09-D46	D46/18	Massive, slightly altered aphyric pillow lava with occassional phenocrysts of Ol and chilled margin	"-"
SS03/09-D46	D46/19	Massive sligthly altered aphyric with occassional microphenocrysts of Ol, CPx	0.5
SS03/09-D47	D47/1	Coarse grained Gritstone with basalt clasts <1 cm (altered)	1.5
SS03/09-D47	D47/3	Metabasic coarse grained amphibolite. Fresh	1
SS03/09-D47	D47/7	Slightly altered amphibolitized Diorite/Granodiorite	"-"
SS03/09-D47	D47/8	Medium grained amphibolite with a relict basalt xenolith	0.02
SS03/09-D48	D48/1	3 pieces of aphyric vesicular lava	1
SS03/09-D48	D48/2	2 pieces of gabbroic rock - microgabbro	0.5
SS03/09-D48	D48/3	2 pieces of dolerite	0.5
SS03/09-D48	D48/4	6 pieces of metagabbro	0.5
SS03/09-D48	D48/5	2 pieces of aphyric nm-vesicular volcanics	0.8
SS03/09-D48	D48/6	1 piece of metadolerite	0.3
SS03/09-D48	D48/7	1 large piece of metagabbro - cut into 3 pieces	2

SS03/09-D48	D48/8	4 pieces of highly altered volcanics	1
SS03/09-D48	D48/9	3 pieces of highly altered plutonic - gabbro?	2
SS03/09-D49	D49/1	Conglomerate with cobbies of basalt and some glass fragments	8
SS03/09-D49	D49/2	Conglomerate with cobbies of basalt and Mn crust	0.5
SS03/09-D49	D49/3	Siltstone with small fragments of glass and coarse sand sized clasts of basalt	0.1
SS03/09-D49	D49/4	slightly altered, moderately vesicular lava (clast from conglomerate?)	0.1
SS03/09-D49	D49/5	Slightly altered medium grained amphibolized microgabbro/dolerite with rare relict altered olivines(?)	0.5
SS03/09-D49	D49/6	Slightly altered aphyric lava with chilled margin and glassy rind. With occassional Pl, CPx	1.5
SS03/09-D49	D49/7	Slightly-moderately altered, sparsely phyric basaltic andesite? With Px, Pl	0.5
SS03/09-D49	D49/8	Moderately altered sparsely vesicular aphyric lava. Possible rare altered olivine phenocrysts	3.5
SS03/09-D50	D50/1	Fresh gabbro with thick Mn rind	2
SS03/09-D50	D50/2	altered gabbro with finely layered sediment cover	2
SS03/09-D50	D50/3	Fresh gabbro interior to Mn-encrusted piece	1
SS03/09-D50	D50/4	1 very large piece of Mn-encrusted gabbro.	8
SS03/09-D50	D50/5	5 pieces of metadolerite or volcanics	3
SS03/09-D50	D50/6	2 pieces of hih altered volcanics	2
SS03/09-D50	D50/7	1 large piece of highly altered volcanic	2
SS03/09-D51	D51/2	Assorted gravel sized pieces of pumice and lava	0.5
SS03/09-D53		Only sediments in the dredge	"-"
SS03/09-D54	D54/2	Slightly altered, moderately vesicular aphyric lava with occasional Plag+CPx phenocrysts	0.75
SS03/09-D54	D54/3	Fresh-slightly altered, moderately vesicular, sparsely phyric lava with Plag+CPx+Olivine phenocrysts	1.5
SS03/09-D54	D54/4	Fresh-slightly altered, vesicular, aphyric lava with some glass	1.25
SS03/09-D54	D54/5	Fresh-slightly altered massive banded sparsely phyric lava with glassy margin. Vesicles in layers. Phenocrysts of Plag, CPx	1.5
SS03/09-D54	D54/6	Fresh-slightly altered massive banded aphyric lava with glassy margin	2.5
SS03/09-D54	D54/7	Fresh moderately vesicular phyric lava with small phenocrysts of Plag+CPx	1.5
SS03/09-D54	D54/8	Fresh-slightly altered, moderately vesicular, phyric lava. Phenocrysts of Plag, CPx, Ol (?)	2.5
SS03/09-D55	D55/3	Conglomerate composed of variably altered basalt clasts. Fine-medium grained s.s. matrix	2.5
SS03/09-D55	D55/4	Slightly altered moderately vesicular phyric lava with Pl, Ol, CPx phenocrysts. Xenoliths of mafic/ultramafic rock (troctolite or gabbro?) + peridotite (lherzolite?) Chilled margin with altered glass.	1
SS03/09-D55	D55/5	Slightly altered moderately vesicular phyric lava with CPx, Ol, Pl phenocrysts. Chilled margin	"-"
SS03/09-D55	D55/6	Conglomerate compound of variably altered basalt clasts. Mn crust	"-"
SS03/09-D56	D56/3	Fresh-slightly altered massive sparsely phyric lava with Ol and CPx phenocrysts	0.75
SS03/09-D56	D56/4	Fresh-slightly altered submassive lava with small vesicles, aphyric with small rare Ol+CPx phenocrysts	2
SS03/09-D56	D56/5	Fresh-slightly altered moderately vesicular phyric lava with small Olivine, CPx phenocrysts	"-"
SS03/09-D56	D56/6	Fresh-slightly altered submassive lava with significant portion of mineralized vesicles (amygdales), phyric with small Olivine and some(rare) CPx	"-"
SS03/09-D57	D57/1	Moderately-slightly altered massive moderately phyric lava. Small partially altered Olivines, Plag + (rare) CPx	1.75
SS03/09-D57	D57/2	Slightly altered massive phyric lava. Significant small olivines with plagioclase and sparse CPx. Small fine grained xenoliths	2.25
SS03/09-D57	D57/3	Slightly altered massive phyric lava. Significant small olivines + some CPx. Some glass under Mn crust	1.75
SS03/09-D58	D58/3	Hyaloclastite with some pieces of vesicular lava and glass	"-"
SS03/09-D58	D58/4	Fresh, moderately vesicular phyric lava with pseudolayering (vesicles % and size). Px, Glass, Olivine and some Mn crust	5
SS03/09-D58	D58/5	Slightly altered massive lava with some vesicles. Phenocrysts of CPx, Ol	"-"
SS03/09-D58	D58/6	Slightly altered massive phyric lava. CPx phenocrysts and some glass	"-"
SS03/09-D58	D58/7	Hyaloclastite with large blocks of vesicular lava	"-"

SS03/09-D59	D59/5	Moderately altered massive (with small vesicles) aphyric medium-fine grained lava with occassional small black phenocrysts (pyroxene/magnetite?)	3
SS03/09-D59	D59/6	Moderately altered, moderately vesicular, sparsely phyric lava with CPx and possibly small rare Olivine	3
SS03/09-D59	D59/7	Moderately altered massive aphyric lava with occasional phenocrysts of plagioclase and CPx(?). Significant amount of very small yellow grains olivine or alteration mineral.	3.5
SS03/09-D59	D59/8	moderately altered moderately vesicular aphyric lava with occasional Pl crystalls	2
SS03/09-D59	D59/9	Moderately altered massive aphyric lava but with occasional phenocrysts of plagioclase and a dark mineral (CPx?)	0.75
SS03/09-D59	D59/10	Slightly altered moderately vesicular phyric lava with CPx. Vesicles filled by brown mineral. Some glass and a chilled margin	1.5
SS03/09-D60	D60/1	Vesicular aphyric lava	5
SS03/09-D60	D60/2	vesicular swiss cheese, sparsely olivine-phyric lava	5
SS03/09-D60	D60/3	vesicular swiss cheese, sparsely olivine-phyric lava	10
SS03/09-D61	D61/1	Plag-Ol+Px(?) phyric aphyric ligthly vesiculated pillow lava	5
SS03/09-D61	D61/2	Sparsely phyric Ol+Pl vesicular lava with vesicle trails	10
SS03/09-D61	D61/3	Sparsely phyric Ol+Pl vesicular lava with vesicle trails	4
SS03/09-D61	D61/4	Sparsely phyric Ol+Pl vesicular lava with vesicle trails	4
SS03/09-D61	D61/5	Small piece of altered pillow fragment with glass rind (glass taken)	0.1
SS03/09-D61	D61/6	Sparsely Olv-phyric aphyric vesicular lava. Occasional large vesicles and Ol-Pl-CPx clots	3
SS03/09-D61	D61/7	Aphyric vesicular lava with vesicular trails. Finely vesicular. Very rare Ol+Pl. Piece enclosed in thick mud deposit	1
SS03/09-D61	D61/8	Aphyric vesicular (distinct round vesicles) lava	1.5
SS03/09-D61	D61/9	Aphyric vesicular lava	0.5
SS03/09-D61	D61/10	Large piece of hyaloclastite with fresh glass (glass piece taken)	5
SS03/09-D62	D62/1	Pillow lava fragment with glass rind (glass taken)	0.2
SS03/09-D62	D62/2	Ol+Plg+Pyx? phyric vesicular lava	0.8
SS03/09-D62	D62/3	Ol-phyric vesicular lava, minor Plag	10
SS03/09-D62	D62/4	large piece of vesicular Olivine-phyric minor plagioclase lava	15
SS03/09-D62	D62/5	large piece of vesicular Olivine-phyric minor plagioclase lava	10
SS03/09-D62	D62/6	large piece of vesicular Olivine-phyric minor plagioclase lava	2
SS03/09-D62	D62/7	Pillow lava fragment with glass rind (glass taken)	0.2
SS03/09-D62	D62/8	Ol-phyric vesicular lava, minor Plag	0.5
SS03/09-D62	D62/9	Hyaloclastite breccia with fresh glass pieces (glass taken)	5
SS03/09-D63	D63/2	Altered hyaloclastite with dunite xenoliths	"-"
SS03/09-D63	D63/3	Slightly-moderately altered,vesicular lava. Aphyric with xenoliths and xenocrysts of olivine	2
SS03/09-D63	D63/4	Slightly altered, moderately vesicular phyric lava. Phenocrysts of Olivine, CPx + Plag	2
SS03/09-D63	D63/5	Slightly altered, massive with occasional vesicles, phyric with Plag, CPx(?) and xenocrysts of Olivine. Lots of small Dunite xenolits.	3.5
SS03/09-D63	D63/6	Slightly altered, submassive, phyric lava with small dunite xenoliths and olivine xenocrysts	1.25
SS03/09-D63	D63/7	As D63/6 but with larger xenoliths	0.75
SS03/09-D63	D63/8	As D63/6 but with larger xenoliths	1.5
SS03/09-D63	D63/9	Slightly-moderately altered, submassive, amigdalidal lava with phenocrysts of CPx+Olivine and xenoliths of dunite	3
SS03/09-D63	D63/10	slightly altered, sparsely vesicular phyric lava with phenocrysts of CPx+Olv and xenoliths of dunite	4.5
SS03/09-D63	D63/11	slightly altered-fresh highly microvesicle lava with Cpx+Ol phenocrysts. Glass - chilled margin	2.5
SS03/09-D64	D64/3	Slightly altered-fresh moderately vesicular phyric lava with a glassy chilled margin with Pl-CPx phenocrysts	2
SS03/09-D64	D64/4	Slightly altered, slightly vesicular, phyric lava with portions of a glassy chilled margin and flow texture in bands of deformed vesicles. Plagioclase+CPx+Olivine?	1.25

SS03/09-D64	D64/5	Slightly altered, slightly vesicular phyric lava with patches of a glassy chilled margin. Phenocrysts of Ol and CPx	2
SS03/09-D64	D64/6	Slightly altered, slightly vesicular phyric lava. Phenocrysts of CPx and rare Plagioclase	2.5
SS03/09-D65	D65/1	Ol+2Px+Pl phyric andesite	3
SS03/09-D66	D66/3a	Slightly altered massive, phyric lava with phenocrysts of plagioclase and Cpx	2.5
SS03/09-D66	D66/3b	Moderately altered massive, phyric lava with phenocrysts of plagioclase and Cpx	2
SS03/09-D66	D66/4	Moderately altered slightly vesicular, phyric very dark lava. Phenocrysts of Plag+some CPx	1.5
SS03/09-D66	D66/5	Slightly altered, massive phyric lava. Phenocrysts of Plag and CPx	2.5
SS03/09-D66	D66/6	Slightly altered, massive phyric lava. Phenocrysts of Plag, CPx and some Olivine	2
SS03/09-D66	D66/7	Slightly altered, massive phyric lava. Phenocrysts of Plag, CPx and some Olivine	2
SS03/09-D66	D66/8	Moderately-highly altered, massive, phyric lava. Phenocrysts of plagioclase + rare Cpx	2
SS03/09-D66	D66/9	highly altered massive Pl-phyric lava	"-"
SS03/09-D66	D66/10	slightly altered, massive phyric lava with Pl and CPx phenocrysts	"-"
SS03/09-D66	D66/11	slightly-moderately altered, massive lava with Pl and rare CPx	"-"
SS03/09-D67	D67/2	Slightly altered, moderately vesicular lava with Ol+CPx phenocrysts. Thin glassy chilled margin	3
SS03/09-D67	D67/3	Slightly-moderately altered slightly vesicular lava with Ol+CPx. Glassy margin	1.75
SS03/09-D67	D67/4	Slightly altered. Slightly vesicular lava. Phyric with Ol+CPx. Chilled margin with altered glass	1.75
SS03/09-D67	D67/5	Slightly-moderately altered, slightly vesicular sparsely phyric with Olivine and CPx. Chilled margin with thin glassy rind.	1.5
SS03/09-D67	D67/5b	Small fragments of same lithology as D67/5 with glass	"-"
SS03/09-D67	D67/6	Slightly altered, moderately vesicular with phenocrysts of Olivine and CPx. Chilled margin with glass	2.75
SS03/09-D68	D68/2	Fresh-slightly altered, massive phyric lava with Pl+CPx(rare). Fine grained with xenoliths. Layered. Dacite?	1.75
SS03/09-D68	D68/3	Fresh-slightly altered, massive phyric lava with Pl+CPx(rare). Fine grained with xenoliths. Layered. Dacite? Some layers slightly coarser grained with more plag phenocrysts	2.5
SS03/09-D68	D68/4	fresh-slightly altered massive phyric lava with Pl and rare CPx. Very fine grained	3
SS03/09-D68	D68/5	Fresh-slightly altered massive greyish black-grey phyric Dacite(?) with phenocrysts of plagioclase and other dark silicate (amphibole?)	2.75
SS03/09-D68	D68/6	slightly altered massive black phyric andesite (?) with phenocrysts of Plagioclase and less CPx and Ol. Some glass.	2.5
SS03/09-D68	D68/7	As D68/6 but with significantly more CPx. Slightly altered, massive, black, phyric with phenocrysts of Plagioclase and CPx. Matrix very fine grained with glass	3
SS03/09-D68	D68/8	Light grey, massive, slightly altered, aphyric Rhyolite with patches of pumice-texture. Flow banding	1.75
SS03/09-D68	D68/9	As D68/6 but volcanic breccia with areas of highly vesicular lava	1.5
SS03/09-D68	D68/10	Dark grey, very fine grained, massive, phyric lava. Phenocrysts of Plagioclase and some CPx. Sub trachitic texture	2
SS03/09-D68	D68/11	Light grey, very fine grained, massive with small vesicles, sparsely phyric with plagioclase	1.5
SS03/09-D69	D69/2	Fresh-slightly altered, extremely fine grained, black glassy, massive, with some compressed vesicles, sparsely phyric with Plag. Foliation is parallel to vesicles. CPx. Dacite?	2.75
SS03/09-D69	D69/3	Fresh-slightly altered, extremely fine grained, greyish black, massive, phyric dacite (?) with phenocrysts of Plagioclase. Almost glass matrix	3
SS03/09-D69	D69/4	Grey, fresh-slightly altered, extremely fine grained, glassy, massive, phyric, foliated Dacite (?). Phenocrysts of plagioclase ± augite.	2.5
SS03/09-D69	D69/5	fresh - slightly altered, fine grained, glassy, massive, phyric with Plag+CPx	0.75
SS03/09-D69	D69/6	Grey, fine grained, massive, phyric Andesite. Phenocrysts of Plagioclase and Amphibole ± Augite	1.5
SS03/09-D69	D69/7	Fresh - slightly altered, highly vesicular Dacite with sharp glassy brittle texture. Significant glass content. Almost pumice in patches.	1.5
SS03/09-D69	D69/8	Fresh - slightly altered, very fine grained, dark grey, massive, phyric with Pl+CPx (Diopside) or Olivine glassy rock	"-"

SS03/09-D69	D69/9	Banded grey and black, extremely fine grained/glassy, massive aphyric with rare plagioclase phenocrysts	"-"
SS03/09-D69	D69/10	Dark grey & light grey, extremely fine grained massive, phyric with plagioclase and rare Olivine phenocrysts. Possibly Olivines are xenocrysts. Some small Olivine has reaction rims.	"-"
SS03/09-D70	D70/1	Massive, vesicular Ol+Plg+CPx phyric lava	3
SS03/09-D70	D70/2	Massive, vesicular Ol+CPx phyric lava with minor Plag	5
SS03/09-D70	D70/3	Massive, vesicular Ol+Plg+CPx phyric lava	3
SS03/09-D70	D70/5	Pillow fragment - Ol-Cpx-Plg glassy rind (glass taken)	0.3
SS03/09-D70	D70/6	Pillow fragment - Ol-Cpx-Plg glassy rind (glass taken)	0.2
SS03/09-D71	D71/1	Vesicular, Oliv+CPx phyric pillow lava. Ol+CPx in glomeroporphyrish clumps, glass rind	3
SS03/09-D71	D71/2	vesicular, Oliv+CPx phyric pillow lava. glass rind (glass taken)	2
SS03/09-D71	D71/3	vesicular, Oliv+CPx phyric pillow lava. glass rind (glass taken)	1
SS03/09-D71	D71/4	more massive, Ol-Px-phyric lava with occasional large vesicles	0.5
SS03/09-D71	D71/5	Vesicular Ol+CPx-phyric pillow lava with glass rind (glass taken)	2
SS03/09-D71	D71/6	Vesicular Ol+CPx-phyric pillow lava with glass rind (glass taken)	1
SS03/09-D71	D71/7	Vesicular Ol+CPx-phyric pillow lava with glass rind (glass taken)	2
SS03/09-D71	D71/8	more massive, relatively non-vesicular Ol-CPx phyric lava	2
SS03/09-D71	D71/9	large block of pillow lava, massive to vesicular highly Ol-CPx-phyric with glass rind (glass taken)	5
SS03/09-D71	D71/11	Vesicular Ol-CPx-phyric pillow lava with glass rind (glass taken)	2
SS03/09-D72	D72/2	Vesicular Ol-Plg-phyric pillow lava with glass rind (glass taken)	2
SS03/09-D72	D72/3	Massive, vesicular, Ol-phyric lava	2
SS03/09-D72	D72/4	Massive vesicular, Ol-Plag phyric lava with dunite xenoliths	3
SS03/09-D72	D72/5	vesicular pillow lava fragment with glass rind (glass taken)	0.3
SS03/09-D72	D72/6	3 pieces of glassy evolved lava Plg-Pyx phyric	1
SS03/09-D72	D72/7	pillow lava, glass rind (glass taken)	1
SS03/09-D72	D72/8	massive, vesicular lava, Plg-Px-phyric	1
SS03/09-D73	D73/1	Ol-phyric vesicular pilow lava, glass rinds	4
SS03/09-D73	D73/2	Ol-phyric vesicular pilow lava, glass rinds	4
SS03/09-D73	D73/3	Aphiric vesicular pillow lava with glass rind (glass taken)	3
SS03/09-D74	D74/3	Slightly altered-fresh, massive phyric lava with Pl+Cpx phenocrysts and clots, rare Ol	0.25
SS03/09-D74	D74/4	As D74/3 with geochemistry	"-"
SS03/09-D74	D74/5	Slightly altered, massive (with occasional vesicles) phyric lava with plagioclase, CPx as phenocrysts and as clots. Ol?	"-"
SS03/09-D74	D74/6	Slightly altered, massive (with occasional vesicles) phyric lava with plagioclase, CPx (2 kinds) phenocrysts	"-"
SS03/09-D74	D74/7	As D74/6 without geochemistry	"-"
SS03/09-D74A	D74A/2	Fresh-slightly altered moderately vesicular phyric lava with Olivine, CPx, Plagioclase phenocrysts. Chilled margin. Also CPx-Pl clots.	25
SS03/09-D74A	D74A/3	Slightly altered, massive light grey lava sparsely phyric with plag-Ol phenocrysts. Very fine-grained.	0.5
SS03/09-D74A	D74A/4	Fresh-slightly altered moderately vesicular phyric lava with Olivine, CPx, Plagioclase phenocrysts and few CPx-Pl clots.	1.7
SS03/09-D74A	D74A/5	Fresh-slightly altered sparsely vesicular phyric lava with Olivine, CPx, Plagioclase phenocrysts and also CPx-Pl clots.	1.5
SS03/09-D74A	D74A/6	Fresh-slightly altered sparcely vesicular phyric lava with Olivine, CPx, Plagioclase phenocrysts and also CPx-Pl clots. (two kinds of CPx?)	"-"
SS03/09-D75	D75/4	Hyaloclastic breccia with some fresh glass and xenolithes of dunite?	"-"
SS03/09-D75	D75/5	Slightly altered - fresh, moderately vesicular phyric lava with Cpx, Ol, Pl?	"-"
SS03/09-D75	D75/6	Slightly altered - fresh, sparsely vesicular phyric lava with Cpx, Ol, Pl?	"-"

SS03/09-D75	D75/7	Slightly altered - fresh, moderately vesicular phyric lava with Cpx, Ol, Pl phenocrysts and clots of Pl-CPx	"-"
SS03/09-D75	D75/8	Slightly altered - fresh, massive with small vesicles phyric lava with Ol, CPx and rare plagioclase	"-"
SS03/09-D75	D75/9	As D75/8 but slightly more vesicular	1.5
SS03/09-D75	D75/10	As D75/8 but with larger phenocrysts of Olivine	1.5
SS03/09-D75	D75/11	Fresh massive phyric lava with CPx, Ol phenocrysts	"-"
SS03/09-D75	D75/12	Microgabbro (possible Opx) and xenoliths of vesicular lava	"-"
SS03/09-D76	D76/1	Vesicular massive Ol+Opx+Cr-spinel phyric lava (boninite)	15
SS03/09-D76	D76/2	vesicular massive, Ol+Plg phyric lava	1
SS03/09-D76	D76/3	vesicular massive, Ol+Plg phyric rare CPx lava	1
SS03/09-D76	D76/4	vesicular, massive, Ol+Pl-phyric lava	1
SS03/09-D76	D76/5	vesicular, massive, Ol+Pl-phyric lava	1
SS03/09-D76	D76/6	vesicular, massive, Ol+Pl-phyric lava	0.5
SS03/09-D76	D76/7	vesicular, massive, Ol+Pl+CPx-phyric lava	0.8
SS03/09-D76	D76/8	vesicular, massive, Ol+Pl+CPx-phyric lava	1
SS03/09-D76	D76/9	pillow lava fragment with fresh glass (glass taken)	0.3
SS03/09-D76	D76/10	Plagioclase rich pillow lava with glassy margin (glass taken)	2
SS03/09-D77	D77/1	Massive, vesicular Ol-Plag-CPx phyric lava with dunite xenoliths	1
SS03/09-D77	D77/2	Massive, vesicular Ol-Plag-CPx phyric lava	1
SS03/09-D77	D77/3	Massive, vesicular Ol-Plag-CPx phyric lava	1
SS03/09-D77	D77/4	Pillow lava fragment	1
SS03/09-D78	D78/1	vesicular, massive, Ol+Pl-phyric lava	1
SS03/09-D78	D78/2	vesicular, massive, Ol+Pl-phyric lava	1
SS03/09-D79	D79/1	Ol+Plg+CPx-phyric, vesicular massive lava	2
SS03/09-D79	D79/2	Ol+Plg+CPx-phyric, vesicular massive lava with gabbroic clots	1
SS03/09-D79	D79/3	Ol+Plg+CPx-phyric, vesicular massive lava	1
SS03/09-D80	D80/1	Black, fine-grained microvesicular lava with thin quench glassy margin. Porphyritic qith light green macrocrysts of CPx, near colourless CPx and Olivine. Layered defined by vesicles. Fresh.	1.5
SS03/09-D80	D80/1a	As D80/1 but with less layering. For geochemistry	"-"
SS03/09-D80	D80/2	As D80/1 with larger vesicles and no layering and no glass margin	2
SS03/09-D80	D80/3	Black, fine-grained, fresh, slightly altered sparsely phyric-aphyric with rare brown-green Olivine phenocrysts. Glassy margin. Vesicular.	"-"
SS03/09-D80	D80/4	Dark brownish black, slightly altered, microvesicular lava - sparsely phyric with small microphenocrysts of CPx, Olivine and Plagioclase. Glassy margin	2.75
SS03/09-D80	D80/5	Fresh-slightly altered moderately vesicular lava. Phyric with CPx,Ol and less Plagioclase phenocrysts. Glassy margin	2.75
SS03/09-D81	D81/2	Slightly altered vesicular lava, phyric with CPx+Ol phenocrysts and less plagioclase? <= 1 cm xenoliths of Olivine±CPx±oxides	2.75
SS03/09-D81	D81/3	As D81/2 but with smaller xenolith/xenocrysts	1.5
SS03/09-D81	D81/4	Fresh-slightly altered, vesicular phyric lava. Phenocrysts of Augite+Diopside(?) +Olivine+some Plagioclase and oxides. Occasional small xenoliths of Ol±CPx	1.25
SS03/09-D81	D81/5	As 81/4	1.5
SS03/09-D81	D81/6	Fresh-slightly altered vesicular, phyric lava. Phenocrysts - pale green CPx, Olivine ± oxides	1
SS03/09-D81A	D81A/5	Fresh-slightly altered, vesicular phyric lava. Ancaramite (?), significant green CPx and Olivine	"-"
SS03/09-D81A	D81A/6	Slightly altered vesicular lava, phyric with CPx+Ol phenocrysts	"-"
SS03/09-D81A	D81A/7	Fresh-slightly altered, vesicular, phyric lava. Phenocrysts of CPX, Ol. Glassy margin	2
SS03/09-D81A	D81A/8	Fresh-slightly altered, vesicular, phyric lava with glassy margin. CPx<<Ol	4
SS03/09-D81A	D81A/9	As D81A/8. Fresh-slightly altered, vesicular, phyric lava with glassy margin. CPx<<Ol	3

SS03/09-D81A	D81A/10	Fresh-slightly altered, vesicular, phyric lava. Phenocrysts of Ol+Diopside(CPx)	5
SS03/09-D81A	D81A/11	Fresh-microvesicular, phyric lava. Microcrysts of Ol+CPx (large Olivine). Glassy margin	1.25
SS03/09-D81A	D81A/12	Slightly altered, massive with some small vesicles. Plagioclase+Diopside phyric lava. Surface flow texture.	1.5
SS03/09-D81A	D81A/12a		1
SS03/09-D81A	D81A/13	pillow lava - glass rinds	0.5
SS03/09-D82	D82/1	Highly altered, resedimented rhyolite - fresh Plg, Pyx, Qtz - groundmass altered. Well developed flow banding	10
SS03/09-D83	D83/2	Massive, slightly vesicular, 2 Pyx, Plg, Mag phyric andesite.	2
SS03/09-D83	D83/3	Altered, massive, slightly vesicular 2Px-Pl-Mgt-phyric andesite	1
SS03/09-D83	D83/4	Slightly altered, massive, slightly vesicular - 2 Pyx-Plg-Qtz-TiMt-phyric dacite	0.5
SS03/09-D83	D83/5	Slightly altered, massive, slightly vesicular - 2 Pyx-Plg-Qtz-TiMt-phyric dacite	1
SS03/09-D83	D83/6	Dark, massive, vesicular Plag+CPx+(Ol?)-phyric lava	2
SS03/09-D83	D83/7	Light, massive, altered, 2Pyx-Plg-TiMt-phyric lava	1
SS03/09-D83	D83/8	Massive, altered, 2Pyx-Plg-TiMt-phyric lava	1
SS03/09-D83	D83/9	Massive, altered, 2Pyx-Plg-TiMt-phyric lava	1
SS03/09-D83	D83/10	Magmatically layered rhyolitic flow - lava/pyroclastic?	1
SS03/09-D84	D84/2	Lava block with phenocrysts of amphibole. Highly vesicular.	1
SS03/09-D84	D84/3	Slightly altered, sub-massive phyric lava with significant plagioclas, with some CPx and Opx	1.5
SS03/09-D84	D84/4	As D84/3. Slightly altered, sub-massive phyric lava with significant plagioclas, with some CPx and Opx	"-"
SS03/09-D85	D85/3	Slightly altered, sub massive with a proportion of open vesicles aphyric lava. Phenocrysts of (rare) Plagioclase, CPx and some Opx. CPx looks very dark in places - possibly Hornblende	4.5
SS03/09-D85	D85/4	As D85/3. Slightly altered, sub massive with a proportion of open vesicles aphyric lava. Phenocrysts of (rare) Plagioclase, CPx and some Opx. CPx looks very dark in places - possibly Hornblende	5
SS03/09-D85	D85/6	3 cut cobbles as D85/3	3
SS03/09-D85	D85/7	As D85/3. Slightly altered, sub massive with a proportion of open vesicles aphyric lava. Phenocrysts of (rare) Plagioclase, CPx and some Opx. CPx looks very dark in places - possibly Hornblende	1.5
SS03/09-D86		Lower part of dredge was broken. All content was lost	"-"
SS03/09-D87	D87/1	Vesicular, Ol+Plg+CPx-phyric lava	1
SS03/09-D87	D87/2	Vesicular, Ol+Plg+CPx-phyric lava	1
SS03/09-D87	D87/3	Vesicular, Ol+Plg+CPx-phyric lava	1
SS03/09-D87	D87/4	Altered piece of hyaloclastite breccia	0.5
SS03/09-D88	D88/1	Massive, vesicular, Ol+CPx+Plg-phyric lava	2
SS03/09-D88	D88/2	Vesicular pillow lava with altered glassy rind (no fresh). Ol+CPx+Plg-phyric	1
SS03/09-D88	D88/3	Massive, vesicular, Ol+CPx+Plg-phyric lava	2
SS03/09-D88	D88/4	Massive, vesicular, Ol+CPx+Plg-phyric lava	1
SS03/09-D89	D89/1	Massive, vesicular, Ol+Plg+2Pyx-phyric lava. Plag occurs in large glomerocrysts	0.25
SS03/09-D89	D89/2	Small fragments of same lava type as D89/1	0.2
SS03/09-D89	D89/3	Small piece of a pumaceous pillow fragment with fresh interior. Sparsely phyric (Plg+2Pyx)	0.1
SS03/09-D89	D89/4	5 small pieces of pumaceous pillow fragments	0.3
SS03/09-D90		Only sediments in the dredge	"-"
SS03/09-D91	D91/1	Small fragments of glass from pillow lava	0.2
SS03/09-D91	D91/2	Fresh, massive with occasional vesicles phyric lava with Pl and CPx, also some Pl-CPx clots.	"-"
SS03/09-D91	D91/3	As D91/2	"-"
SS03/09-D91	D91/4	As D91/2	"-"

Table 4. Operations record

Operation	Date Start	Time Start GMT	Date Finish	Time Finish GMT	Hours
Transit from Latouka	3/07/2009	4:00:00	3/07/2009	16:15:00	12.25
Mapping Survey 1	3/07/2009	16:15:00	5/07/2009	19:45:00	51.50
Dredge 39	5/07/2009	19:45:00	5/07/2009	22:53:00	3.13
Mapping Survey 1	5/07/2009	22:53:00	6/07/2009	2:00:00	3.12
Dredge 40	6/07/2009	2:00:00	6/07/2009	5:15:00	3.25
Mapping Survey 1	6/07/2009	4:38:00	6/07/2009	7:30:00	2.87
Dredge 41	6/07/2009	7:30:00	6/07/2009	10:36:00	3.10
Mapping Survey 1	6/07/2009	10:36:00	6/07/2009	12:10:00	1.57
Transit to Lautoka	6/07/2009	12:10:00	8/07/2009	11:00:00	46.83
Mapping survey 2	8/07/2009	11:00:00	8/07/2009	14:30:00	3.50
Dredge 44; 44a	8/07/2009	14:30:00	8/07/2009	20:00:00	5.50
Mapping survey 2	8/07/2009	20:00:00	9/07/2009	4:30:00	8.50
Dredge 42, 43	9/07/2009	4:30:00	9/07/2009	11:45:00	7.25
Mapping survey 2	9/07/2009	11:45:00	11/07/2009	1:45:00	38.00
Dredge 45	11/07/2009	1:45:00	11/07/2009	5:45:00	4.00
Mapping survey 2	11/07/2009	5:45:00	11/07/2009	8:10:00	2.42
Dredge 46, 47, 48	11/07/2009	8:10:00	11/07/2009	17:00:00	8.83
Mapping survey 2	11/07/2009	17:00:00	11/07/2009	20:00:00	3.00
Dredge 50, 49, 51	11/07/2009	20:00:00	12/07/2009	4:00:00	8.00
Mapping survey 2	12/07/2009	4:00:00	12/07/2009	6:30:00	2.50
Dredge 53	12/07/2009	6:30:00	12/07/2009	9:00:00	2.50
Mapping survey 3	12/07/2009	9:00:00	13/07/2009	4:00:00	19.00
Dredge 54	13/07/2009	4:00:00	13/07/2009	8:30:00	4.50
Mapping Survey 3	13/07/2009	8:30:00	13/07/2009	22:30:00	14.00
Dredge 55, 56	13/07/2009	22:30:00	14/07/2009	5:30:00	7.00
Mapping Survey 3	14/07/2009	5:30:00	16/07/2009	1:30:00	44.00
Dredge 57	16/07/2009	1:30:00	16/07/2009	22:30:00	21.00
Mapping Survey 4	16/07/2009	22:30:00	17/07/2009	20:00:00	21.50
Wax coring 26,27,28,29	17/07/2009	20:00:00	18/07/2009	2:50:00	6.83
Wax coring 30 -37	18/07/2009	2:50:00	18/07/2009	14:00:00	11.17
Wax coring 38 -40	18/07/2009	14:00:00	18/07/2009	18:15:00	4.25
Wax coring 41-45	18/07/2009	18:15:00	19/07/2009	2:15:00	8.00
Wax coring 46-54	19/07/2009	2:15:00	19/07/2009	17:10:00	14.92
Wax coring 55-57	19/07/2009	17:10:00	19/07/2009	22:30:00	5.33
Transit to dredge sites	19/07/2009	22:30:00	20/07/2009	1:15:00	2.75
Dredge 63-71	20/07/2009	1:15:00	21/07/2009	1:30:00	24.25
Dredge 72-76	21/07/2009	1:30:00	21/07/2009	20:00:00	18.50
Dredge 77-79	21/07/2009	20:00:00	22/07/2009	2:30:00	6.50
Dredge 80-83	22/07/2009	2:30:00	22/07/2009	13:30:00	11.00
Mapping Survey 5	22/07/2009	13:30:00	24/07/2009	16:00:00	50.50
Dredges 84-91	24/07/2009	16:00:00	25/07/2009	16:00:00	24.00
Transit to Noumea	25/07/2009	16:00:00	26/07/2009	18:00:00	26.00

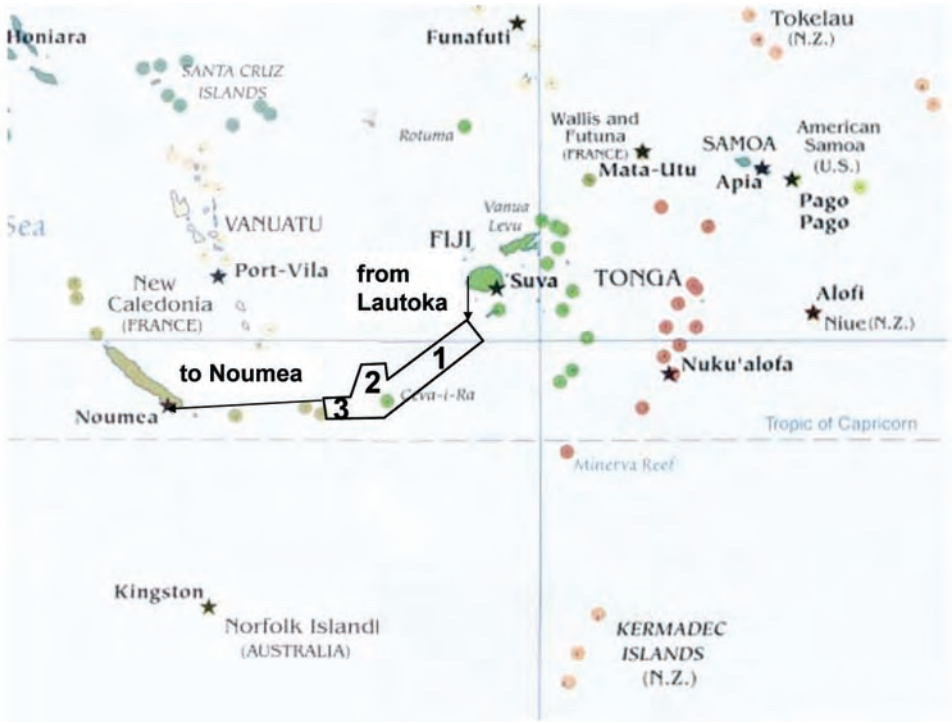

Figure 1. General area of operations with specific research areas marked by numbers 1, 2 and 3

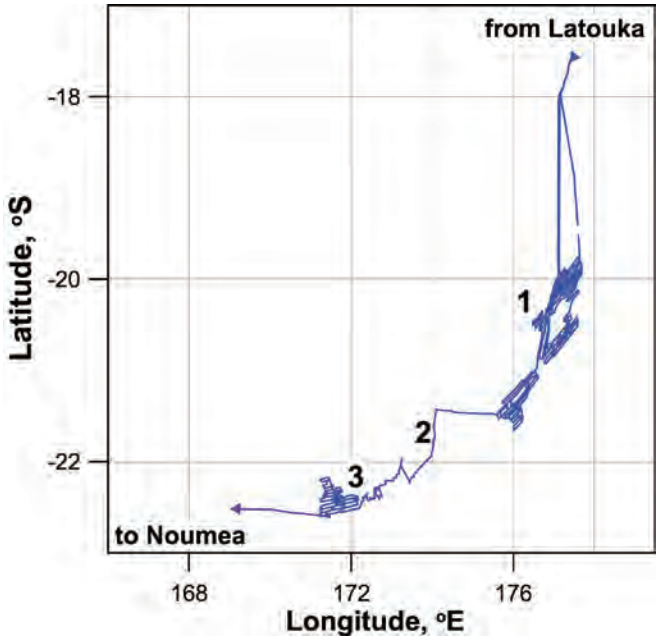

Figure 2. Voyage track. Numbers 1 to 3 indicate study areas detailed in the Voyage Objectives section

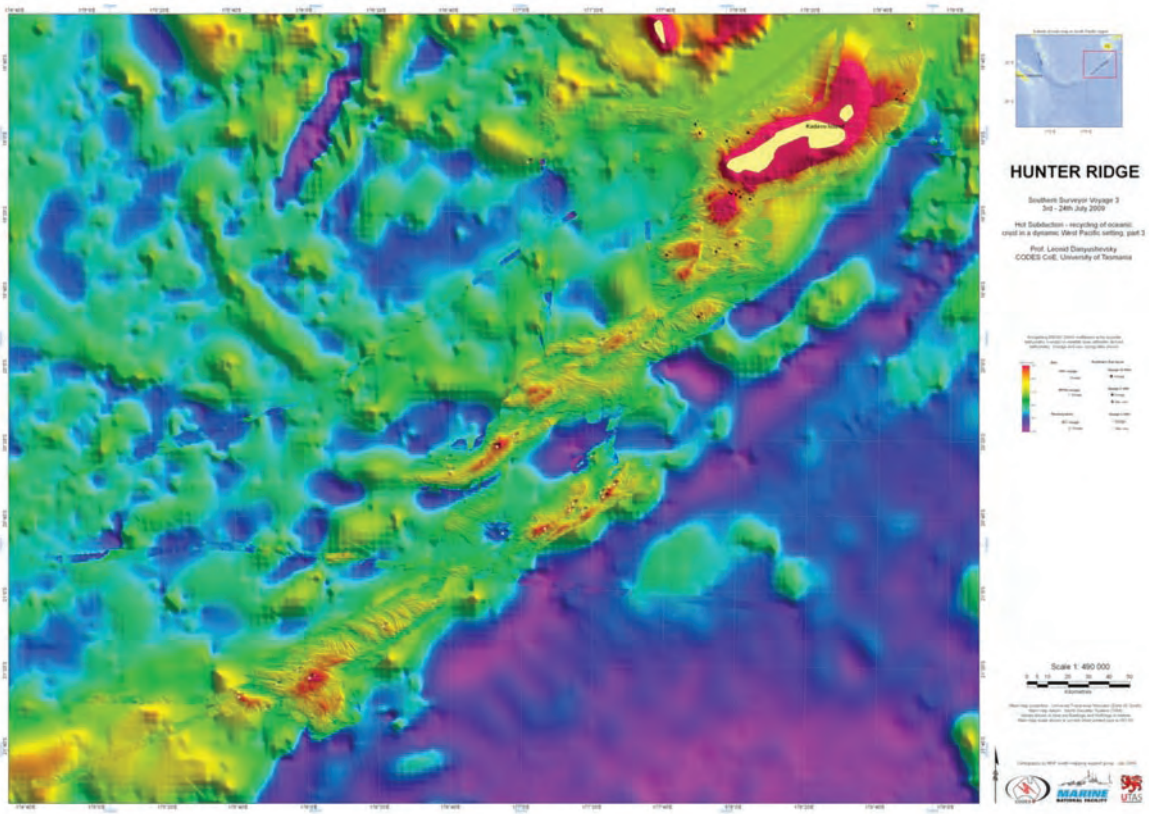

Figure 3. Seafloor bathymetry of the central part of the Hunter Ridge (area 1)

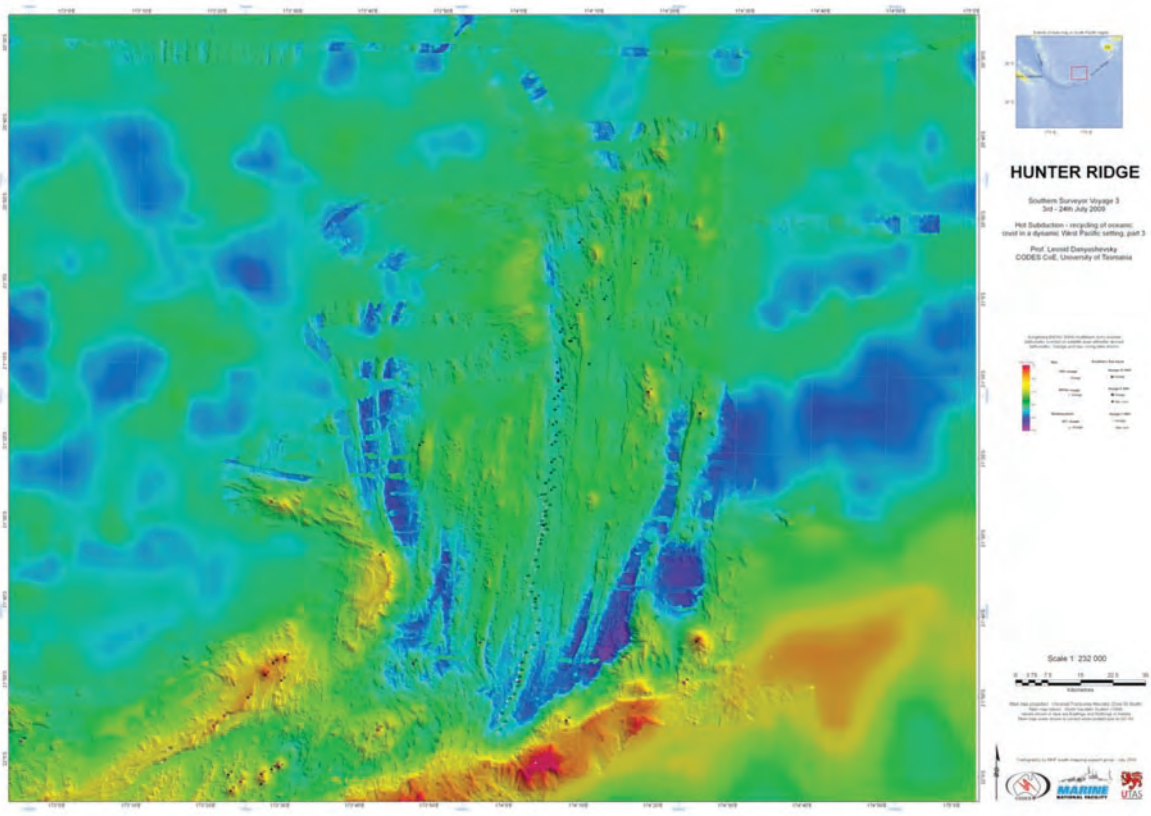

Figure 4. Seafloor bathimetry at the southern termination of the North Fiji Backarc Basin (area 2)

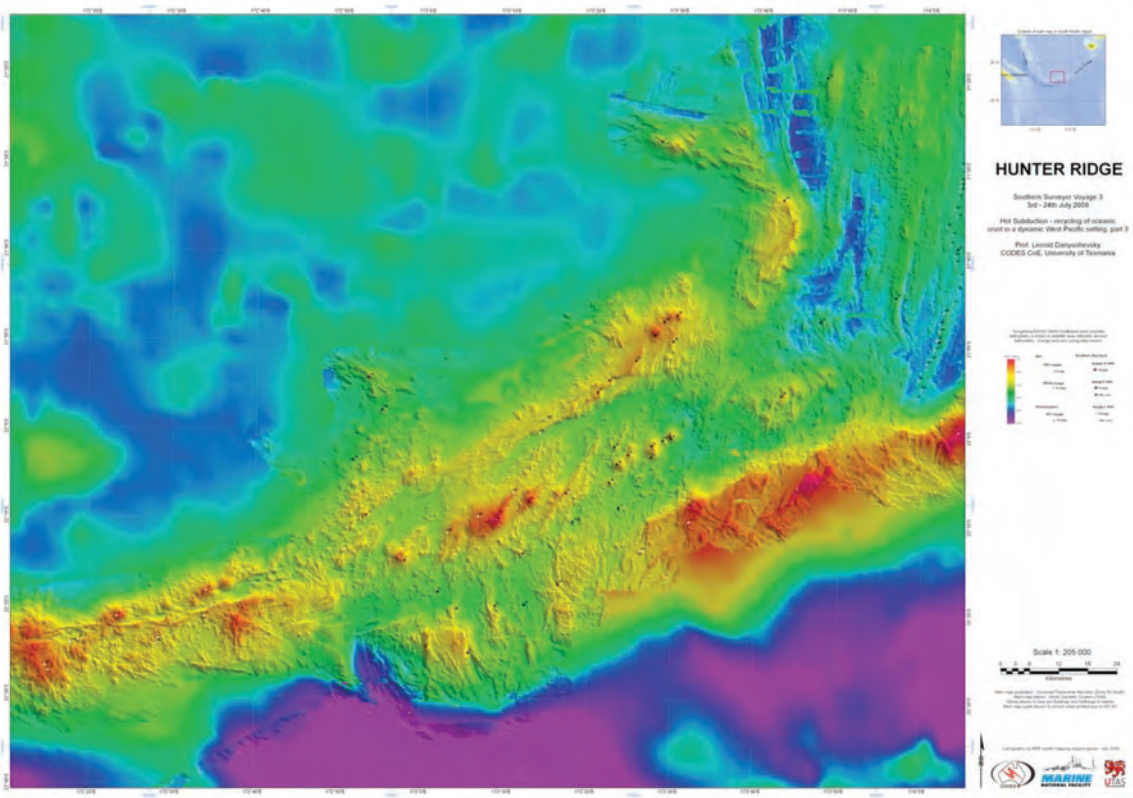

Figure 5. Western termination of the Hunter Ridge (area 3). 1 – the new rift zone.

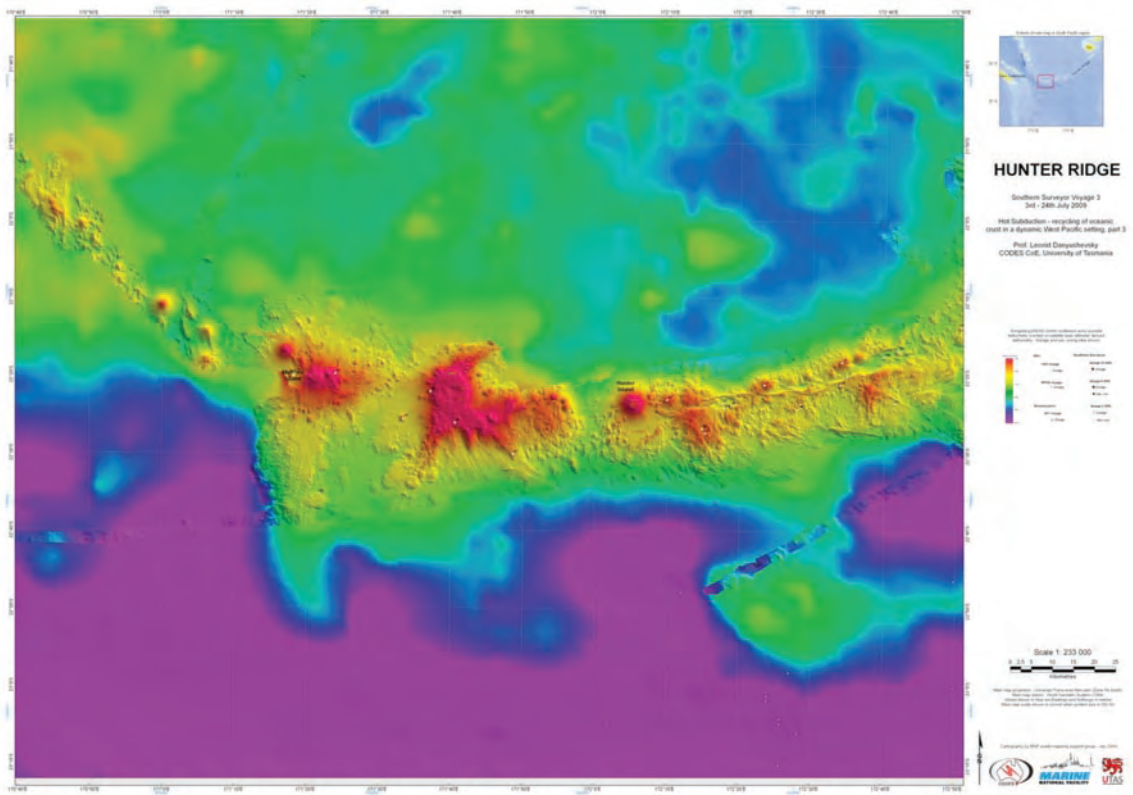

Figure 6. Junction between the Vanuatu Island Arc and Hunter Ridge (area 3). 1 – the new rift zone at the western termination of the Hunter Ridge; 2 – the southern termination of the Vanuatu Arc; 3 – Islands of Mathew and Hunter at the junction. Note large submarine lava fields to the south of the Mathew Island indicative of fissure eruptions.

CSR/ROSCOP PARAMETER CODES

METEOROLOGY

M01 Upper air observations
M02 Incident radiation
M05 Occasional standard measurements
M06 Routine standard measurements
M71 Atmospheric chemistry
M90 Other meteorological measurements

PHYSICAL OCEANOGRAPHY

H71 Surface measurements underway (T,S)
H13 Bathythermograph
H09 Water bottle stations
H10 CTD stations
H11 Subsurface measurements underway (T,S)
H72 Thermistor chain
H16 Transparency (eg transmissometer)
H17 Optics (eg underwater light levels)
H73 Geochemical tracers (eg freons)
D01 Current meters
D71 Current profiler (eg ADCP)
D03 Currents measured from ship drift
D04 GEK
D05 Surface drifters/drifting buoys
D06 Neutrally buoyant floats
D09 Sea level (incl. Bottom pressure & inverted echosounder)
D72 Instrumented wave measurements
D90 Other physical oceanographic measurements

CHEMICAL OCEANOGRAPHY

H21 Oxygen
H74 Carbon dioxide
H33 Other dissolved gases
H22 Phosphate
H23 Total - P
H24 Nitrate
H25 Nitrite
H75 Total - N
H76 Ammonia
H26 Silicate
H27 Alkalinity
H28 PH
H30 Trace elements
H31 Radioactivity
H32 Isotopes
H90 Other chemical oceanographic measurements

MARINE CONTAMINANTS/POLLUTION

P01 Suspended matter
P02 Trace metals
P03 Petroleum residues
P04 Chlorinated hydrocarbons
P05 Other dissolved substances
P12 Bottom deposits
P13 Contaminants in organisms
P90 Other contaminant measurements

MARINE BIOLOGY/FISHERIES

B01 Primary productivity
B02 Phytoplankton pigments (eg chlorophyll, fluorescence)
B71 Particulate organic matter (inc POC, PON)
B06 Dissolved organic matter (inc DOC)
B72 Biochemical measurements (eg lipids, amino acids)
B73 Sediment traps
B08 Phytoplankton
B09 Zooplankton
B03 Seston
B10 Neuston
B11 Nekton
B13 Eggs & larvae
B07 Pelagic bacteria/micro-organisms
B16 Benthic bacteria/micro-organisms
B17 Phytobenthos
B18 Zoobenthos
B25 Birds
B26 Mammals & reptiles
B14 Pelagic fish
B19 Demersal fish
B20 Molluscs
B21 Crustaceans
B28 Acoustic reflection on marine organisms
B37 Taggings
B64 Gear research
B65 Exploratory fishing
B90 Other biological/fisheries measurements

MARINE GEOLOGY/GEOPHYSICS

G01 Dredge
G02 Grab
G03 Core - rock
G04 Core - soft bottom
G08 Bottom photography
G71 In-situ seafloor measurement/sampling
G72 Geophysical measurements made at depth
G73 Single-beam echosounding
G74 Multi-beam echosounding
G24 Long/short range side scan sonar
G75 Single channel seismic reflection
G76 Multichannel seismic reflection
G26 Seismic refraction
G27 Gravity measurements
G28 Magnetic measurements
G90 Other geological/geophysical measurements