COPY 3

BODC

IOS

DEACON LABORATORY

RRS CHARLES DARWIN

CRUISE 33/88

5 MAY – 1 JUNE, 1988

GEOPHYSICAL AND GEOLOGICAL INVESTIGATIONS OF THE LAU BACK-ARC BASIN SW PACIFIC

CRUISE REPORT NO. 206

1989

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES
DEACON LABORATORY

INSTITUTE OF OCEANOGRAPHIC SCIENCES

DEACON LABORATORY

**Wormley, Godalming,
Surrey, GU8 5UB, U.K.**

**Telephone: 0428 79 4141
Telex: 858833 OCEANS G
Telefax: 0428 79 3066**

Director: Dr. C.P. Summerhayes

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES

DEACON LABORATORY

CRUISE REPORT No. 206

RRS CHARLES DARWIN

Cruise 33/88

5 May - 1 June, 1988

Geophysical and geological investigations of the Lau back-arc Basin, SW Pacific

Principal Scientist
L.M. Parson

1989

DOCUMENT DATA SHEET

AUTHOR	PARSON, L.M. *et al*	PUBLICATION DATE 1989
TITLE	RRS *Charles Darwin* Cruise 33/88, 5 May - 1 June, 1988. Geophysical and geological investigations of the Lau back-arc Basin, SW Pacific.	
REFERENCE	Institute of Oceanographic Sciences Deacon Laboratory, Cruise Report, No.206, 28pp.	

ABSTRACT

An integrated marine surveying and sampling programme to the central Lau (back-arc) Basin was completed to: (1) provide site survey data or Ocean Drilling Program deep drill sites due to be occupied in late 1990; (2) clarify regional plate tectonic framework, spreading ridge geometry and sub-plate evolution; (3) assess and interpret petrological variations of neovolcanic activity in the Basin; (4) continue an ongoing geochemical programme of sampling of sediments associated with hydrothermalism. An underway geophysical survey, including GLORIA long-range sidescan acquisition was coupled with rock dredging and shallow gravity coring. The back-arc ridge was mapped as a highly segmented axis, exhibiting overlapping spreading centres, axial inflections, and ridge propagation systems. All these features are described for the first time from this plate tectonic setting. Petrological analyses of the abundant fresh glass sampled from the axial valley sites, and geochemical analysis of the sediment samples are underway at UK and US universities.

ISSUING ORGANISATION	Institute of Oceanographic Sciences Deacon Laboratory Wormley, Godalming Surrey GU8 5UB. UK.	TELEPHONE 0428 79 4141 TELEX 858833 OCEANS G TELEFAX 0428 79 3066

KEYWORDS	*"CHARLES DARWIN" - CRUISE (1988) (33)* *LAU BASIN*	CONTRACT PROJECT PRICE £7.00

CONTENTS

SCIENTIFIC PERSONNEL:

Parson, Lindsay (Principal Scientist)	IOSDL Geology & Geophysics
Bloomer, Sherman	Duke Univ N. Carolina (Petrologist)
Darlington, Eric	IOSDL GLORIA
Ernewein, Michelle	Institute of Petrology, Strasbourg
Evans, Huw	RVS Mechanical Technician
Helu, Siamone	Tongan Observer
Hodkinson, Richard	Imperial College, Dept Geology
Huggett, Quentin	IOSDL Geology & Geophysics
Johnson, Lynn	Hawaiian Institute of Geophysics
Jones, Steve	RVS Instrument Technician
Miller, Suzanne	Imperial College, Dept Geology (PhD student)
Murton, Bramley	Open University, Dept of Geology
Pearce, Julian	Newcastle Univ Dept of Geology
Potter, Kay	RVS Computer Technician
Rodda, Peter	Fijian Observer
Rymer, Chris	RVS Mechanical Technician
Woodley, Colin	RVS Instrument Technician

SHIP'S PERSONNEL

Name	Rank
P. Maw	Master
K. Avery	Chief Officer
A. Louch	Second Officer
S. Beal	Third Officer
C. Brown	Radio Officer
G. Batten	Chief Engineer
G. Robertson	Second Engineer
J. Anderson	Third Engineer
P. Parker	Electrician
D. Wiseman	CPO Deck
M. Travaskis	Seaman
M. Drayton	Seaman
A. Roach	Seaman
P. Bennett	Seaman
G. Jones	Seaman
M. Williams	Motorman
K. Peters	Cook/Steward
L. Alcott	Cook
B. Stephen	2nd Steward
K. Hobbs	Steward
P. Whilding	Steward

ITINERARY

The 28 day cruise consisted of 22 days total of survey and sampling work and 6 days transit. 1.5 days passage between Fiji and the survey area was followed by eleven days each of geophysical surveying and geological sampling. The work was mainly concentrated in the Lau Basin, between the Lau Island Ridge and the Tongan Island group, ending with a single line along the axis of the southern Tongan and northern Kermadec trenches. The transit into Auckland, New Zealand took a further 4.5 days.

CRUISE OBJECTIVES/INTRODUCTION

Cruise 33 was designed to provide geophysical and geological information from the Lau Basin, SW Pacific, (Fig. 1 an overlay of the ship's GLORIA coverage on a generalised bathymetry annotated with major physiographic features). The data collected during this cruise would support the selection of deep drill sites identified by the Ocean Drilling Program (ODP). These sites are located in Figure 2a. The Lau Basin is a back-arc extensional basin, opening as a result of magmatism and tensional forces generated by the subducting Pacific lithospheric plate which underrides the NE Australian plate to the west. The Basin separates a palaeoarc in the west, (the Lau Ridge) from the presently active Tofua arc/Tonga Ridge system. The geophysical work included a GLORIA sidescan survey of the Central Lau Basin and Valu Fa Ridge, previously studied by French and German SEABEAM workers, and to run accurately located seismic reflection profiles, tie-lines and sidescan swaths across likely deep drill sites. A regional structural and evolutionary model for the back-arc formation was a further objective of the cruise following compilation of cruise data with existing datasets (e.g. from the National Geophysical Data Center, Boulder, Colorado). Two sections of active spreading ridge had been previously identified in the Lau Basin, one in the N and one in the SE (The Valu Fa). It was our intention to study the link between these two segments, which we refer to as the Central Lau Spreading Centre (CLSC) and the Eastern Lau Spreading Centre (ELSC) (Fig. 3). The structural link between the two, as discussed below, proved to be of a propagating ridge/dying ridge nature. The CLSC advancing south at the expense of the ELSC. This is the first time such a structure has been described from a back-arc environment, and offered the sampling programme a unique opportunity to assess petrological sedimentary characteristics using the GLORIA reconnaissance data. The geological programmes are described in more detail in later sections, and were to assess: (1) through dredging, the petrological and petrogenetic characteristics of the crustal components of the basin; and (2), by shallow coring adjacent to the ridges, to assess the quantity and geographic extent of hydrothermal activity along the ridge.

NARRATIVE

RRS Charles Darwin departed Suva 1000 hrs 5 May 1988 (2200 hrs GMT, Julian day 125. All subsequent times and days are GMT and J.D.). In calm but overcast conditions we proceeded on an easterly course at full transit speed of 11 to 12 knots towards the survey area. Weather was moderate, wind easterly with a lumpy sea and showers. Geophysical logging commenced at transit speed at 0406/126, logging the hull-mounted 10 kHz echo-sounder and gravimeter. We passed through the Lau Islands group via the Oneata Passage into the westernmost Lau Basin, the principal study area. At 1800/126 speed was reduced to deploy the 10 kHz and 3.5 kHz fish, an operation completed by 1822. Following this, the normal ships speed of 5 kts for the deployment of GLORIA was increased during the operation to 8 kts owing to the heavy swell, but was completed without problem by 1845. Speed was once again reduced to 4 kts to deploy the seismic acquisition and other geophysical equipment, (two-channel hydrophone outboard by 1905, 160 cu in airgun without wave-shape kit by 1926, magnetometer by 1934). The first west-east survey line across the northern ODP transect of drill sites was commenced at 2100/126. A constant survey speed of 8 kts was maintained throughout the geophysical work, except where crossings of potential ODP drill sites were made. Speed was then reduced to 6 kts for a 1 - 2 nm run-in and exit from site to optimise seismic reflection data quality. At the outset of geophysical logging immediate problems were recognised on the GLORIA monitor, with persistent divergence of signal trace away from the ship's track. It was realised that this was a logger fault rather than the monitor, but despite heroic efforts was not tracked down until 1700/127, when GLORIA logging was recommenced successfully. Some triggering problems with the airgun were experienced between 0630 and 0645/128, and required the recovery of the airgun harness and servicing of the solenoid. The system was redeployed by 0902/128. At 0030/129 the system was again recovered in order to test the signal on the 40 cu in airgun, and compare its penetration with the 160. Following the trials the 160 gun was once again deployed at 131/129. A series of three disposable sonobuoy stations were occupied on the survey tracks between 1613/129 and 1828/129, 1848/129 and 2142/129, and 2337/129 and 0054/130. Each station was recorded using an analogue system and the 160 cu in gun, and lasted about three hours. The sonobuoy lines were all positioned parallel to the strike of the spreading fabric associated with the active spreading ridge extending north from the Valu Fa, (here referred to as the Eastern Lau Spreading Centre). The main engine was shut down for seven minutes at 2252/130 to enable an engine transfer check to be made. At 0130/131 the same short break in engine power reduced the ships speed to only 7.5 kts. NNE-SSW survey lines were continued throughout the central Lau Basin, spaced at around 25 km, until 0231/134 when a NNW course was made to occupy crossing survey tie-lines over the northern ODP drill sites. After this grid had been completed, ship's speed was reduced at 0109/135 and all geophysical equipment except for the 10 kHz and 3.5 kHz fish was recovered by 0157/135. Course was set for the first of the sampling stations close to the active spreading section of the propagating ridge (Fig. 2; the Central Lau Spreading Centre) in the north-central section of the Basin.

All sample stations are located in Figure 2, and a record of all station times, locations and recovered materials is presented in Appendix 1. The first gravity core (CD33/1; 0432/135-0629/135) was disappointing, in that it recovered only a small amount of sediment, but retained a large chunk of basalt in the core catcher. A further seven core stations (CD33/2-8 all using a 1 tonne coring head with a single 3 metric barrel) were occupied at the active ridge, followed by seven successful dredge hauls (CD33/9-17) along the axis. A further series of dredges were completed in the northern Central Basin (CD33/16-19), in the area between the western propagator and the northern tip of the Eastern Lau Spreading Centre, in order to assess the extent of volcanic activity between two main spreading zones. For the most part, rock recovery was good, with pillows and cobble-sized pillow fragments contained in the net/chain bag, and glass chips in the pipe dredge. The last haul (CD33/19) was empty, and probably never reached the seafloor, but was the only wholly unsuccessful sample station of the 51 undertaken during the cruise.

The original plan was to continue east to the Eastern Lau Spreading Centre in order to occupy a series of core stations southwards towards the Valu Fa, followed by a final series of reciprocal dredge stations along the same axis.

The weather had been deteriorating steadily over the final dredge recovery, however, and with a steady 25 kt wind blowing from 150° the master requested us to continue with dredge stations, enabling the ship to maintain a head-to-wind attitude, rather than core from the mid-ships winch with the attendant risk of running the warp under the ship. Dredge stations CD33/20-25 were thus completed in a continuous programme along the Eastern Lau Spreading Centre. By 1941/141 the weather had improved sufficiently to allow coring to recommence. Sites were located around the northern section of the Eastern Lau Spreading Centre, and coring continued (Stations CD33/26-40) until the last station at 2227/143. A final dredge station (CD33/41) was completed in the intermediate spreading basin at 176°10.3'W, 19°16.5'S. Course was then set to pick up geophysical tie lines in the Central Lau Basin to support additional potential deep drill sites. The geophysical survey equipment was streamed between 2230/144 and 0030/145 and the survey commenced at 0100/145. A reconnaissance line to the west-central Basin was followed by a short drill-site box survey, and all the Lau Basin geophysical work was completed by 1500/145. The final series of core stations were completed between 1707/145 and 2313/146 (CD33/42-51) along the southern end of the Eastern Lau Spreading Centre. Geophysical gear was then redeployed by 0200/147 for the final time to complete site survey lines across ODP deep drill sites on the arc and forearc components of the plate boundary. An easterly line was taken across the arc through a shallow water passage, and into the deep western Pacific Ocean. Short dog-legs were made in the track to ensure adequate coverage of ODP sites, before making our transit line to Auckland. Seismic acquisition continued until 2100/148, and this equipment was recovered and serviced. Speed was then increased to allow us to continue GLORIA, magnetometer and gravity surveying at 10 kts along the axis of the Kermadec Trench and forearc. This work continued in gradually increasing seas until 000/151 when all gear was finally recovered in readiness for approach to Auckland. Passage to Auckland continued without further event and the RRS Charles Darwin docked by 2200/153 (1000 local time, 1 June).

OBJECTIVES AND RESULTS OF CORE SAMPLING PROGRAMME

The aim of the sediment sampling programme was to recover cores adjacent to the active spreading ridge so as to study the variation in the hydrothermal component of sediments along the ridge. The accurate location of the active spreading ridge had been possible through the preceding GLORIA survey. A total of 33 coring stations were occupied during a 5.5 day period. At 32 of these stations, an RVS Driscoll corer with a 3 m barrel was used, whilst at the remaining site an IOSDL wide-barrel Calvert corer with a 4 m barrel was operated. Of the 33 stations, cores were recovered from 24, ranging in length from 0.3 m to 2.65 m, but the remaining 9 stations recovered only small amounts of sediment trapped in the core catcher. The sandy nature of these latter samples suggests little penetration and/or wash-out on retrieval of the core. The core stations were concentrated in 2 areas, one between 19°00'S, 176°30'W and 19°17'S, 176°30'W, where eight stations were located, the other between 20°36'S, 176°05'W and 21°44'S, 176°22'W where 25 stations were located. In both areas, stations were positioned on the flanks of the active ridge where seismic records suggested sediment to be present.

Cores in the west of the area ranged in length from 0.71 to 2.72 m and consisted predominantly of brown ferromanganese oxide rich foraminiferal oozes. Some more ash-rich layers, particularly towards the bottom of the cores were recognised. Cores recovered from the east of the region were generally shorter, ranging from 0.28 m to 1.74 m in length. These again contained brown 'ferromanganese oxide-rich' foraminiferal oozes, particularly at the surface, but contained much greater amount of volcaniclastic material than those from the west, and were characterised by ash, sand and gravel bands. The physical characteristics of this material presumably accounted for the shorter penetration or the corer and the resulting poor, or washed-out cores. Volcanic ash bands were generally grey-green in colour whilst sand and gravel layers were dominated by grey basalt and pumice fragments. No cores were cut onboard ship, but were sealed for shipment to Imperial College. The cores will be opened and subsampled for bulk chemical, selective chemical, lithological and mineralogical analyses to assess the variation in hydrothermal signature along the ridge.

In addition to core samples, sediments were also recovered from the pipe dredge during several hard rock sampling stations. These samples represent a homogenised sample of probably the top 20 cm of surface sediment and will be analysed in a similar manner to core subsamples. At one rock dredge station along the axial valley of the Eastern Lau Spreading Centre (CD33/20 20°35.3'S, 176°176°14'W), basalt was recovered with strong ferromanganese oxide staining and yellow precipitates on fractures surfaces, possibly hydrothermal in origin.

DREDGING REPORT

Scientific Objectives: The preliminary results of the GLORIA survey completed before the start of dredging are summarised in the model presented in Fig. 2. The ridge configuration thus recognised guided the dredge programme accordingly. The principal objective of the dredging programme was to collect representative samples of the recent volcanic rocks from the active ridge areas, which (together with the samples from active Tofua arc) would provide good sample coverage of a 200 km-long zone of active volcanism above an intra-oceanic subduction zone. The petrology and geochemistry of these rocks will then provide the basis for studying: (a) the relationship between subduction geometry and geochemical signature from the subduction zone; and (b) the magma chamber processes associated with rift propagation in a marginal basin setting. A full analytical and petrographic post-cruise programme is planned to achieve these objectives.

Dredging logistics. A total of 5.5 days was allotted to the dredging programme, during which time 19 dredge stations were attempted, of which 18 were successful. Dredging was carried out using a chain dredge with attached pipe dredge. Most of the dredge sites lay between 2500 and 3000 m water depth. All sites were surveyed by 3.5 kHz sub-bottom profiler prior to site selection.

Sample Localities. Of the successful dredge stations, six were located on the Central Lau Spreading Centre, six on the Eastern Lau Spreading Centre and six in the zone between these centres. Sampling in the Central Lau Spreading

Centre started close to the propagating tip in the south of the area and finished where the ridge widens in the north (c.18°53'S) which is also close to the southern limit of sampling by the German SONNE (SO-35-2) cruise. Of these, four were located in the axial graben, one on the eastern inner wall of the graben and one the eastern flank of the rift. Dredge stations on the Eastern Lau Spreading Centre represent an along-ridge transect from the dying tip in the north to the near-arc ridge segment (at 20°35.0'S) in the south, about 1-2 degrees north of the Valu Fa Ridge site sampled during the SONNE cruise. Five of these dredge stations were located, at least in part, in or on the flanks of the axial graben, the remaining station being off-axis to the east. Of the dredge stations between the two main spreading centres, three were located on seamounts just south of the Central Lau Spreading Centre and three on the small ridge segment further east. An additional sample was recovered during coring (station CD33-1) in a trough west of the Central Lau Basin Spreading Centre.

Of the rocks recovered, large quantities of fresh basalt glass were the main materials sampled from the axial graben of the Central Lau Spreading Centre: some clearly spalled off pillows, some off sheet flows. In off-axis dredge hauls, variably altered, slightly manganese-stained pillow lavas were most common, many still with glassy rinds. Samples were all basaltic, varying from aphyric through olivine-phyric to olivine-plagioclase phyric; alteration assemblages were predominantly of brown, oxidative type. Sheet flows and pillows with fresh glassy margins were also the main rock types recovered from the central graben of the Eastern Lau Spreading Centre, with more altered and manganese-stained equivalents recovered off-axis. Although aphyric and olivine- and plagioclase-phyric basalts have been sampled, some of the rocks (both sheet flows and pillows) have andesitic, possibly dacitic, affinities. Lavas from the zone between the two main spreading centres vary from olivine-plagioclase phyric pillow basalts in the more central seamounts to glassy, possibly andesitic pillow lavas and sheet flows in the more easterly small spreading centre. In addition to the in situ volcanic rocks cited above, pumice and gravels containing rock and microfossil fragments and unconsolidated sediments were recovered from a number of localities.

RVS SERVICES

The operation of all RVS equipment and related support for the cruise was effective and relatively problem-free. A number of minor incidents with the seismic acquisition system required short intervals in recording during servicing requirements. Analogue tape recording of the seismic data was routine, although it was regretted that digital acquisition of the data was not available. Computer support was continuous and efficient, providing all the routine services relevant to geophysical surveying. Additional use was made of the shipboard computing facilities by a number of the scientific party, in particular the digitiser. Digitised records were returned to IOSDL for further processing. Navigation was troublesome on occasions due to non-uniform coverage by transit satellites, and the non-availability of an atomic standard with which to optimise the Global Positioning System cover. GPS gave us in the order of eight hours total cover each day, and a clock would have increased this cover to nearly eleven. In terms of accurately positioning sampling stations in the future this would have to be considered as an essential requirement. Credit must go to the RVS personnel for their assistance and co-operation at all times of the cruise.

GLORIA IMAGE PROCESSING

Shipboard processing of GLORIA data was limited by problems encountered in getting the Digidata drive to communicate with the GLORIA IBM. A faulty card was suspected but no spare was available. Consequently anamorphic ratios (laser scans per data line,) and depth ratios had to be calculated by the level C and hand-cranked into the IBM. This inevitably proved unsatisfactory, as ratios were rounded to the nearest hour only. Since the cartridge-recorded data could not be transferred to 9-track tape onboard ship, they were retained to be dumped onto the archive tape at a later date prior to full processing at IOSDL.

Some attempt was made to enhance the data using a series of shading programmes developed by Roger Searle. Using these programmes it is possible to estimate the shape of the athwartships signal response away from the GLORIA vehicle. Where this response falls away dramatically at the far range, it is possible to enhance the signal level using a function derived from both the average and maximum signal response. It is also possible to increase the low signal level immediately adjacent to the ships track nadir. Shaded results, however, were not a significant improvement over the original data. A number of amendments were possible to the original programme which were designed to allow a more selective shading function in a single pass. Groups of rows, for instance, could be shaded by different functions depending on their different signal response either along-track, or across-track port and starboard.

SUMMARY OF CONCLUSIONS

Geophysical data recorded during Cruise 33 indicates that a re-interpretation of back-arc structure and active ridge geometry is required in the Lau Basin. The spreading ridge configuration was mapped as a series of separate, actively spreading centres, named from east to west as the Eastern Lau Spreading Centre (the northern extension of the Valu Fa Ridge), the Intermediate Lau Spreading Centre, and the Central Lau Spreading Centre (Fig. 3). The Central Lau Spreading Centre is interpreted as a southward-propagating oceanic ridge, and the Eastern Lau Spreading Centre is interpreted as a southward-dying domed ridge. The Intermediate Lau Spreading Centre appears as a diffuse zone of volcanic activity centred on a short ridge segment, possibly a subordinate southward propagator. The Eastern LSC is characterised by a structural segmentation of ridge inflections and incipient overlapping axial zones at a frequency of between 40 and 100 km. A compilation of cruise data and existing geophysical data suggest a jump of active back-arc axis towards the active arc from an additional, extinct ridge axis here referred to as the Western Lau Spreading Centre. The timing of this jump may coincide with that for the initiation of the pair of southward propagator (CLSC) which presently advances into the basin at the expense of the newly positioned axis (ELSC). Preliminary results of the geological sampling programme are included along in the relevant summary sections, and more detailed results will be forthcoming following further laboratory analyses.

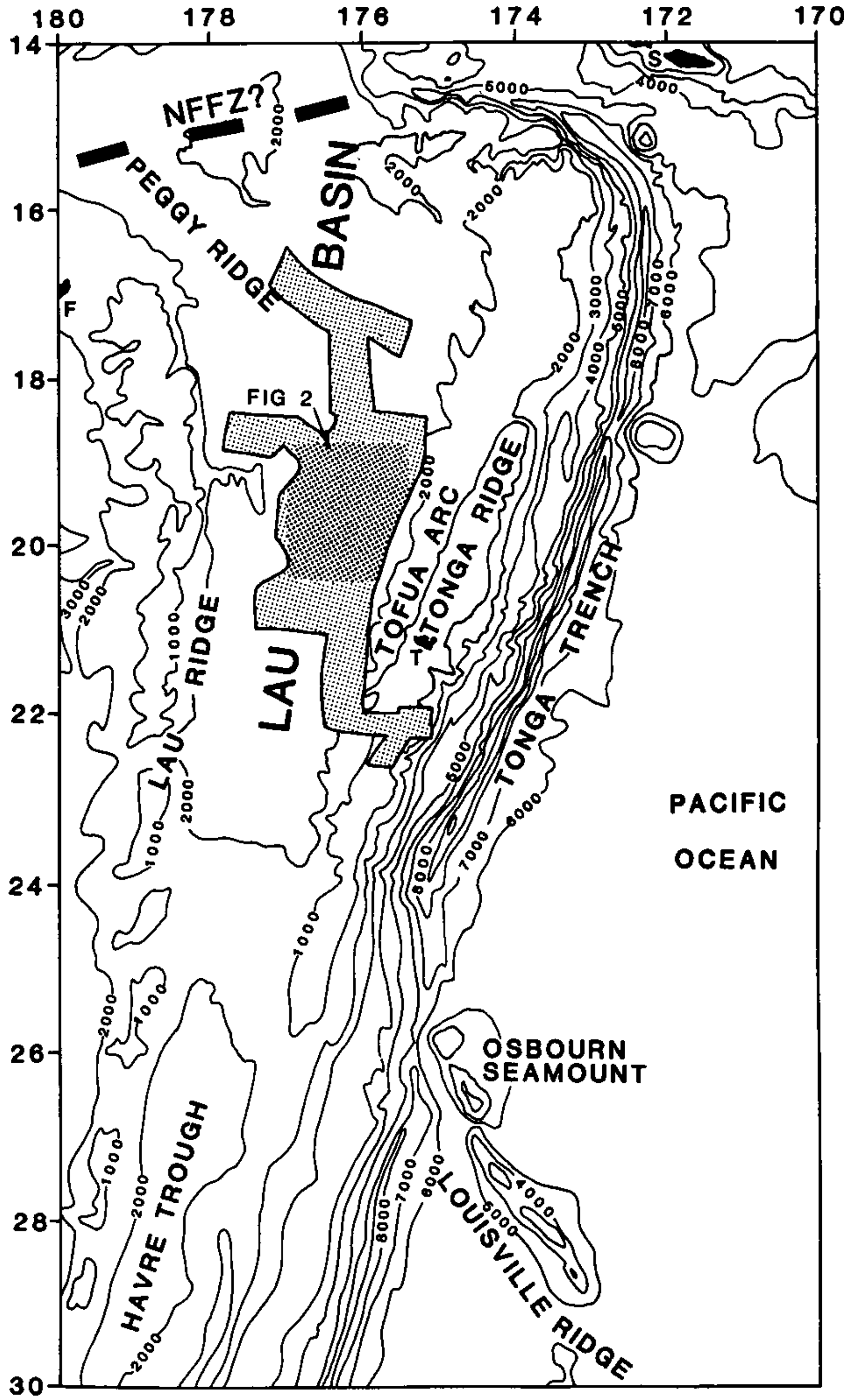

Figure 1: Generalised bathymetry of the survey area, including an outline of the GLORIA coverage in the Central Lau Basin. Transit track out of area to New Zealand in hold. T = Tonga; F = Fiji; S = Samoa. NFFZ? Locates probable position of the Nina Fo'on Fracture Zone.

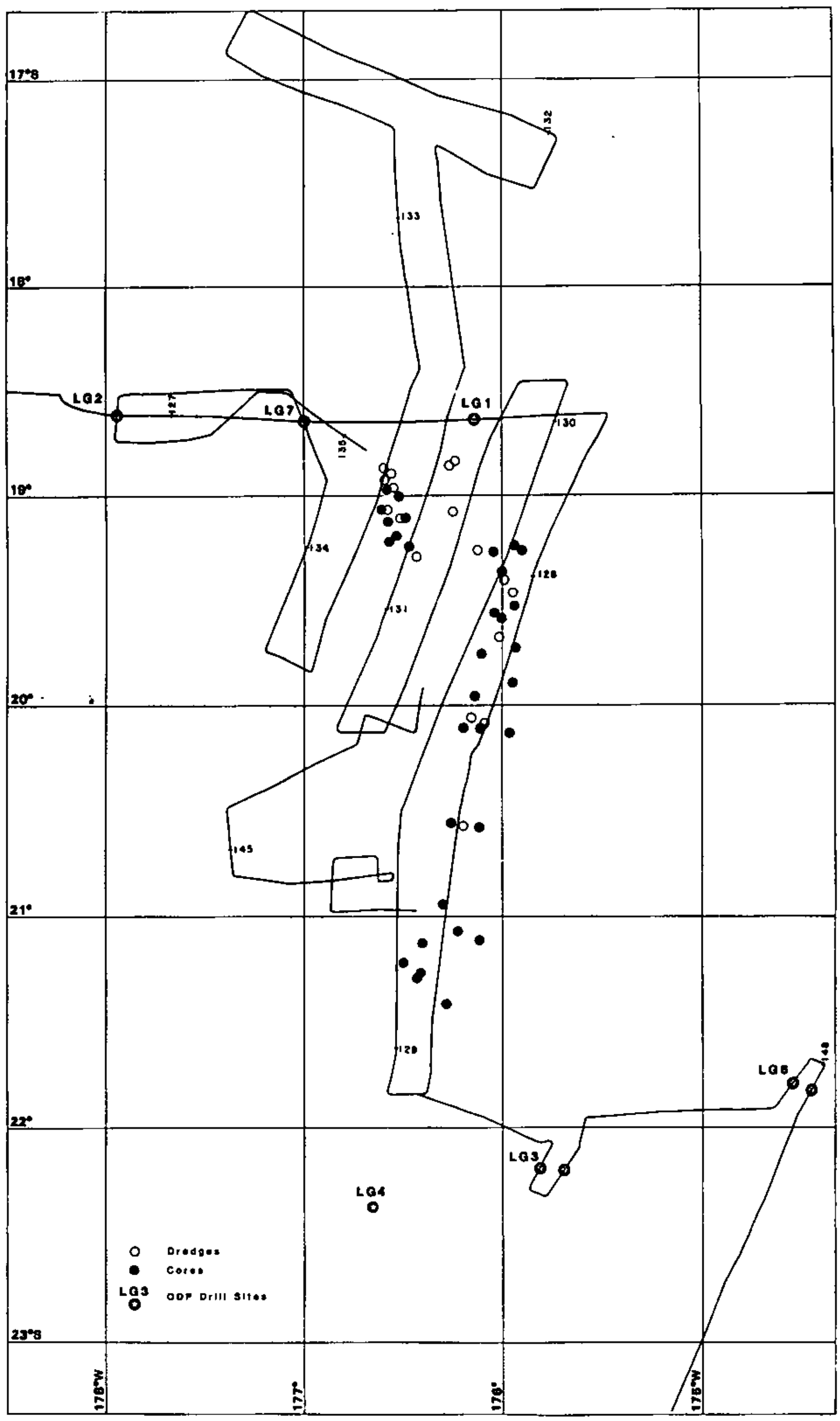

Figure 2a Ships track in northern area. Filled circles are core stations, open circles are dredge stations. Starred circles are original ODP proposed sites (pre-CD33/88).

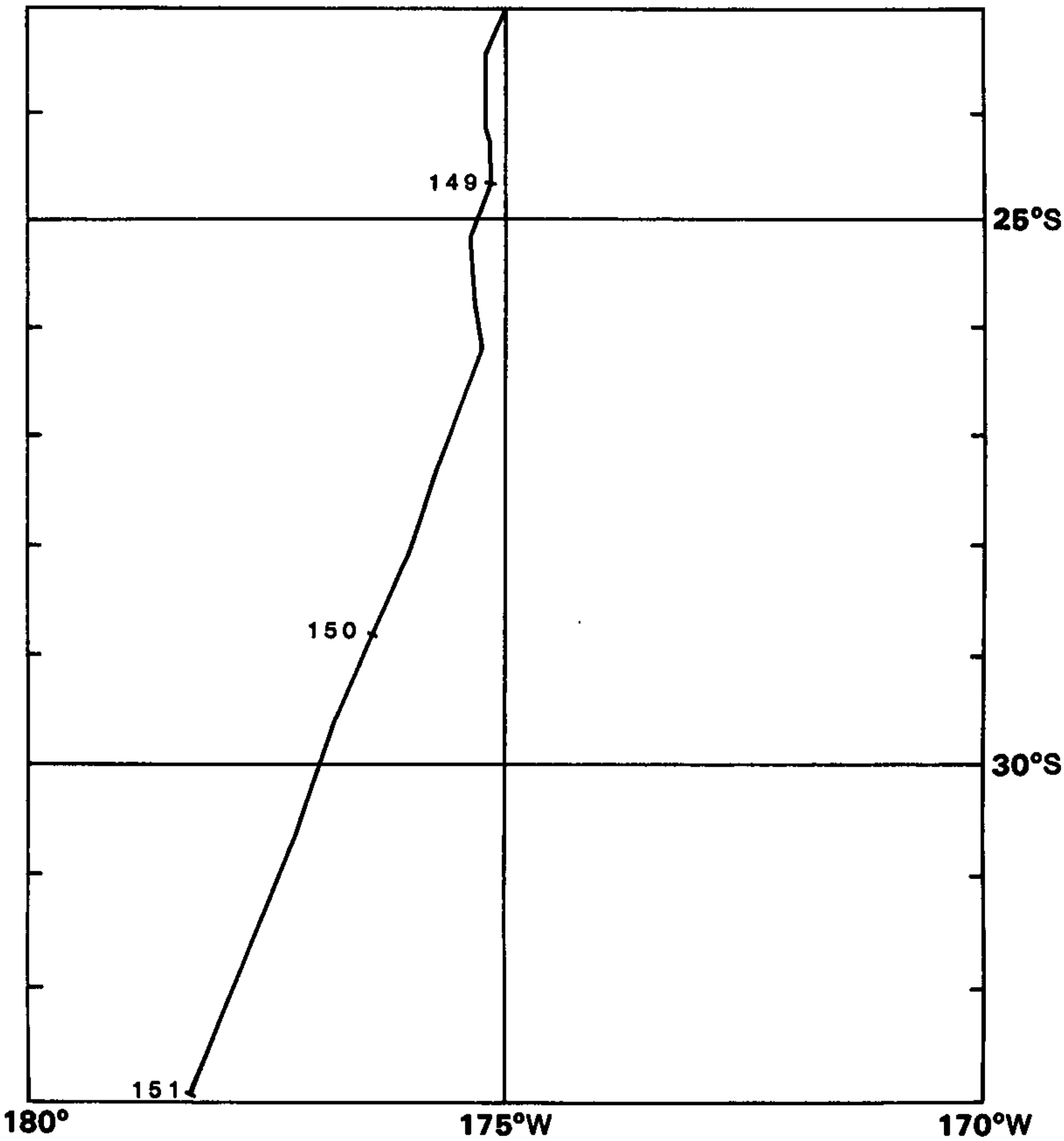

Figure 2 b   Ship's survey track in southern area.

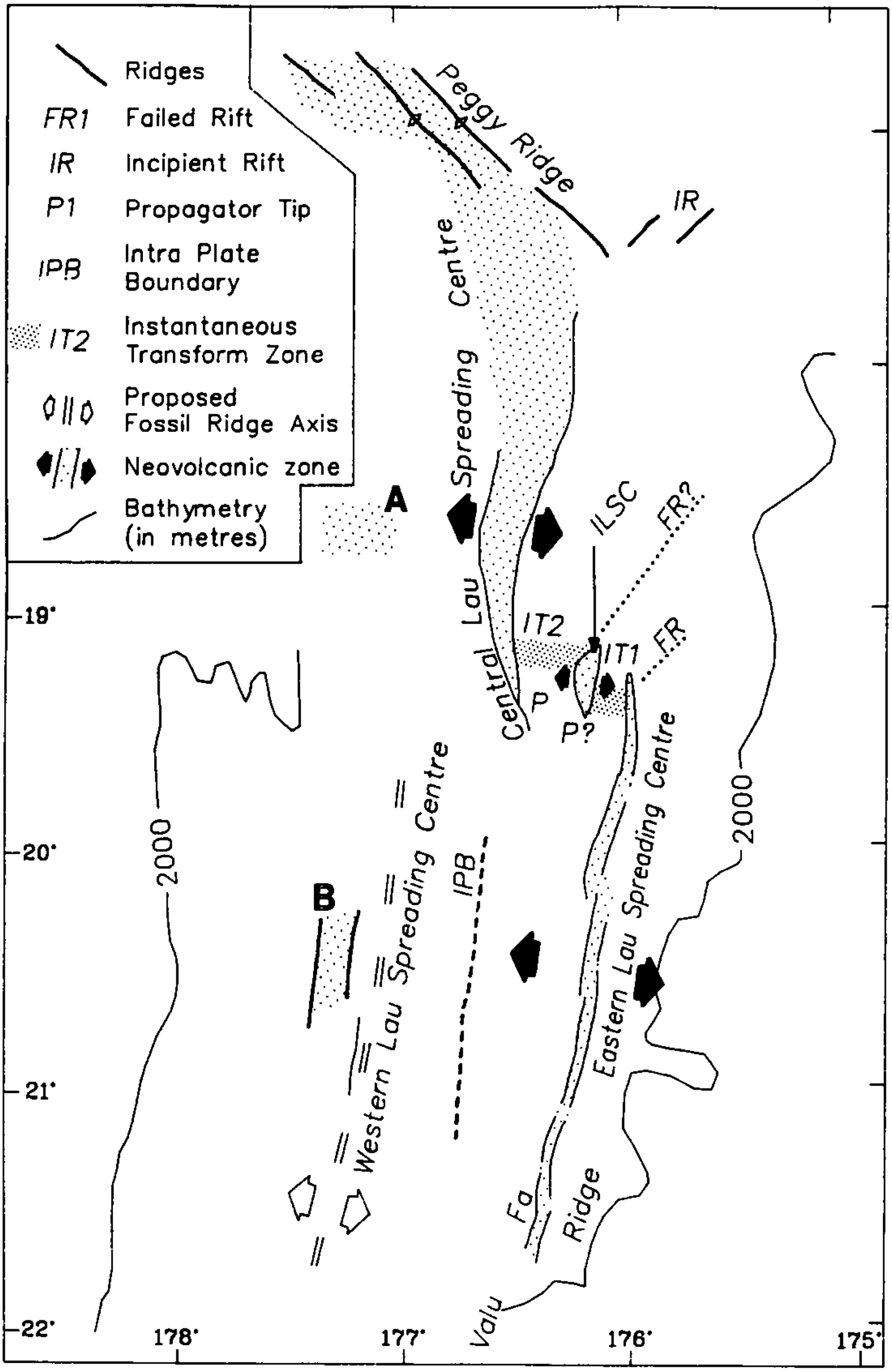

Figure 3: Preliminary interpretation the spreading ridge configuration derived from the geophysical survey data from CD33.

APPENDIX

Dredge and core sampling stations - Prefix C- and D- for station numbers diffentiates shallow core from dredge. All sites are located in Fig. 2.

Station Number	Start-Finish Times	Latitude	Longitude	Water Depth (m)	Location	Recovery
CD33-D12	0904/137 1014/137	18°55.7'S 18°56.0'S	176°32.8'W 176°33.6'W	2375	Western slope of CLSC ridge tip	Large haul, largely pillow fragments, many with glassy margins; sediment and pumice.
CD33-D13	1357/137 1447/137	18°57.4'S 18°58.7'S	176°34.1'W 176°33.9'W	2260	Axial graben, CLSC ridge tip	Moderate haul, mainly glassy basalt sheet flows
CD33-D14	1719/137 1822/137	18°58.2'S 18°58.0'S	176°32.0'W 176°31.4'W	2200	Scarp, east flank of CLSC rift	Moderate haul, mainly of altered vesicular basalt with some fresh scoriaceous basalt; gravel, pumice and sediment.
CD33-D15	2242/137 2300/137	18°54.2'S 18°52.7'S	176°33.7'W 176°33.7'W	2285	Axial rift, CLSC ridge tip	Moderate haul of fresh basalt glass, largely in sheet morphology; sediment
CD33-D16	0621/138 0650/138	18°53.4'S 18°53.7'S	176°15.6'W 176°15.5'W	2135	Seamount of CLSC	Small haul of mud and gravel including few basaltic glass chips
CD33-D17	1311/138 1321/138	18°51.4'S 18°51.4'S	176°18.6'W 176°18.5'W	2300	Seamount of CLSC	Small haul comprising one large basalt pillow
CD33-D18	0030/139 0220/139	19°04.2'S 10°04.9'S	176°13.0'W 176°11.7'W	2650	Central ridge of ILSC	Moderate haul of aphyric altered basalt with some glass chips: gravel, pumice and sediment
CD33-D19	0747/139	19°17.08'S	176°07.8'W	2630	Scarp, SE of ILSC	Nil
CD33-D20	0217/139 0235/139	19°28.5'S 19°29.4'S	175°59.9'W 175°57.7'W	2640	Central axis of ELSC tip	Moderate haul of glassy sheet flows, tubes, fingers and pillows.

Station Number	Start-Finish Times	Latitude	Longitude	Water Depth (m)	Location	Recovery
CD33-D21	0824/140 0856/140	19°27.3'S 19°26.5'S	175°55.6'W 175°55.5'W	3000	ELSC ridge tip	Moderate haul mainly of crystalline-to-glassy basalt and glassy sheet flows; gravel and pumice
CD33-D22	1549/140 1656/140	19°40.5'S 19°41.4'S	176°00.8'W 175°59.5'W	2732	Central section ELSC	Moderate haul of glassy to crystalline pillows, tubes buds and sheet flows some andesitic; pumice
CD35-D23	0041/141 0130/141	20°03.5'S 20°03.4'S	176°09.5'W 176°09.8'W	2585	Graben near S tip of ELSC rift	Moderate haul, mostly vesicular crystalline-to-glassy sheet flow end pillow fragments; gravel.
CD33-D24	0541/141 0630/141	20°04.3'S 20°05.8'S	176°05.9'W 176°05.0'W	2700	Graben further east of D23	V.small haul of pumice and gravel containing few fragments glass and lava
CD33-D25	1408/141 1512/141	20°35.0'S 20°35.0'S	176°08.6'W 176°07.1'W	2620	Central graben ELSC	V.large haul of altered to rare fresh pillow lavas and fresh sheet flows; gravel
CD33-C26	1911/141	20°35.6'S	176°05.4'W	2481	E side ELSC axis	Small amount gritty sediment in c/c
CD33-C27	0036/142	20°21.1'S	176°12.1'W	2396	W flank of S ELSC rift	1.3 m sediment with distinct ash layer at base
CD33-C28	0356/142	20°08.0'S	176°11.5'W	2478	Small pond W of overlapping spreading segment	1.55 m core, brown ooze at top, white sandy layer at base

Station Number	Start-Finish Times	Latitude	Longitude	Water Depth (m)	Location	Recovery
CD33-C29	0715/142	20°08.0'S	176°05.9'W	2700	Immediately E of rift axis	Small amount of sediment in c/c
CD33-C30	1059/142	20°07.7'S	175°57.9'W	2340	9 nm E of ELSC axis	1.36 m dark brown ooze with forams and volcanic silt
CD33-C31	1332/142	19°58.65'S	175°08.85'W	2679	3.5 nm W of ELSC axis	0.40 m dark brown ooze
CD33-C32	1653/142	19°53.8'S	175.57.3'W	2612	6 nm E of ELSC axis	1.25 m ooze, gravel at base
CD33-C33	2118/142	19°45.3'S	176°06.4'W	2118	5 nm W of ELSC axis	0.85 m stiff ooze, ashy at base
CD33-C34	0044/143	19°42.5'S	175°56.4'W	2630	2.5 nm E of ELSC axis	1.8 m brown ooze with ash 25 cm from base
CD33-C35	0311/143	19°34.85'S	176°02.7'W	2717	3-4 nm W of ELSC axis	2 Fe-Ma stained pumice fragments and little sediment in c/c
CD33-C36	0650/143	19°31.09'S	175°53.3'W	-	Flat-topped high 3-4 nm from ELSC axis	Dark brown sediment with coarse layers
Cd33-C37	1055/143	19°22.6'S	176°00.4'W	2825	Immediately W of ELSC ridge tip	0.32 m dark brown compacted sediment
CD33-C38	1355/143	19°17.0'S	175°52.0'W	2807	E of southern ELSC ELSC tip	Short core of sandy well-compacted brown sediment, sand at base, ooze at top
CD33-C39	1645/143	19°14.8'S	175°54.2'W	3138	Small graben N tip of ELSC	0.5 m dark brown ooze stiff at base

Station Number	Start-Finish Times	Latitute	Longitude	Water Depth (m)	Location	Recovery
CD33-C40	2227/143	19°35.0'S	176°00.7'W	2785	Trough east of ELSC axis	0.9 m stiff ash and brown ooze.
CD33-D41	0542/144 0607/144	19°16.5'S 19°16.7'S	176°10.3'W 176°10.4'W	3125	S tip of ILSC, axial graben	Small haul containing altered pillow basalt, fresh pillow and sheet flow fragments.
CD33-C42	1707/145	20°58.7'S	176°18.6'W	2359	3-4 nm W of ELSC	0.4 m brown ooze with black ash layers. c/c contained sandy rocky sediment
CD33-C43	2006/145	21°05.1'S	176°12.0'W	2469	4 nm E of ELSC axis	0.84 m brown ooze with green and grey ash
CD33-C44	2339/144	21°09.7'S	176°23.5'W	2452	W of ELSC ridge	Pumice fragment and black sand in c/c
CD33-C45	0242/146	21°18.2'S	176°16.0'W	2487	E of ELSC ridge	Small c/c sample
CD33-C46	0550/146	21°16.29'S	176°24.65'W	2469	3 nm W of axis, flat basin	c/c sample only
CD33-C47	0847/146	21°15.2'S	176°30.1'W	2380	7 nm W of axis	Dark sand, forams, pumice in catcher
CD33-C48	1138/146	21°19.3'W	176°30.1'W	2535	8 nm W of axis basin	1.28 m dark brown ooze
CD33-C49	1505/146	21°25.9'S	176°17.8'W	2476	4 nm W of ridge in flat sediment	0.61 nm brown ooze at top, volcanic ash base

Station Number	Start-Finish Times	Latitude	Longitude	Water Depth (m)	Location	Recovery
CD33-C50	1824/146	21°32.92'S	176°34.4'W	2784	7 nm W of base of Valu Fa ridge	Small amount sediment and Fe- stained pumice in c/c
CD33-C51	2315/146	21°44.37'S	176°22.0'W	2479	5 nm E of ELSC flat sediment floor	0.5 m core, brown ooze at surface, grey ash at base