University of Durham

Department of Geological Sciences

Cruise Report

RRS Charles Darwin Cruise 57

Santa Cruz de Tenerife to Ponta Delgada, Azores
15 March - 12 April, 1991

Deep-towed geophysical surveys and sampling of Kane Transform Fault
and the adjacent Mid-Atlantic Ridge

CONTENTS

ITINERARY

Departed Santa Cruz de Tenerife, Canary Islands: 1991 March 15 (day 74), 1000 GMT

Arrived Ponta Delgada, Sao Miguel, Azores: 1988 April 12 (day 102), 1900 GMT

OBJECTIVES

1. To map (using the TOBI deep-tow and WASP survey camera) the tectonic and volcanic structures of the Mid-Atlantic Ridge spreading axis immediately north of the Kane Transform, including the spreading segment adjacent to the transform and its nearest neighbour to the north.

2. To use these data to select sites for detailed sampling (by dredge and corer) of the youngest volcanic rocks present, and to carry out that sampling.

3. To map the structure of the transform fault's median ridge and the detailed fault pattern in the transform fault zone.

4. To carry out further sampling in the transform fault.

5. To seek to confirm the existence of a hydrothermal plume and vents in the median valley near 24°N.

6. To recover moorings previously laid in 1990 by *R/V Atlantis II* in the TAG area at 26°N on the Mid-Atlantic Ridge.

SUCCESS OF OBJECTIVES

Objectives 1-4 were very successfully achieved. Objective 5 had relied on having a thermistor and transmissometer on TOBI. In the event the transmissometer was not available. At the time of writing (on board at the end of the cruise) it has not been possible to replay the thermistor data, though it is intended to do so ashore, and these may add to our knowldege of plume distribution in the area. Objective 6 was attempted, and two of the three moorings were recovered. The third failed to respond to the acoustic commands.

NARRATIVE

All times are given in GMT. See Figure 1 for the overall cruise track chart, and Figure 2 for TOBI coverage and station positions in the study area.

Friday March 15th (Julian day 074)

RRS *Charles Darwin* departed Santa Cruz de Tenerife at 1000 GMT, and set course for the Kane Transform.

Saturday March 16th (day 075)

Deployed PES and magnetometer at 0820, and commenced scientific watches.

Wednesday March 20 (079)

Deployed 3.5 kHz at 1900.

Thursday March 21 (080)

We recovered the magnetometer at 0320 in preparation for our first station, a dredge at the base of the south wall of Kane Transform (see Tables 2 and 3 for station details and Figure 2 for positions). Station CD57/1D began at 0420, after a short site survey, and ended at 0955. A full suite of crustal rocks was recovered. This was followed by a second dredge (CD57/2D) close to the first, which commenced at 1110 and was completed by 1613. This recovered mainly metagabbros and peridotite.

We then proceeded to a point just south of the western ridge-transform intersection (RTI) to start the first TOBI run. TOBI deployment began at 2109, and went smoothly until the preliminary signal checks were conducted prior to connecting the depressor weight. At this point it was found that only the analogue, but not digital, signals were being received. The vehicle was therefore recovered, with no difficulties. A quick check of connectors on the vehicle failed to reveal the source of the trouble, so the run was abandoned at 2342 in favour of further dredging while the fault was investigated in more detail.

Friday March 22 (081)

The whole day was spent dredging in the vicinity of the western RTI. Station CD57/3D was conducted over the presumed neovolcanic ridge, and CD57/4D sampled a small seamount just to the west of the neovolcanic ridge. Station 5D was also over the neovolcanic ridge, slightly south of 3D.

Saturday March 23 (082)

We carried out two further dredge stations in the RTI. CD57/6D sampled the neovolcanic ridge close to the southern wall of the transform, and CD57/7D sampled what was thought to be a relict neovolcanic ridge on the western flank of the nodal deep. Stations 3D to 7D all recovered basalts with varying degrees of alteration, and 4D recovered a fragment of a rare pahoehoe flow.

By this time TOBI had been repaired, and we launched it just south of the RTI and began logging data at 1835. We then proceeded to tow it, at about 1.5 knots, across the fracture zone and up the median valley to the north.

Sunday March 23 to Friday March 29 (083-088)

The TOBI survey continued for six days (See Figure 2 for track chart and sidescan coverage). The first three days comprised a run up the median valley from the RTI to 24°43'N and back, producing a double swath (10km wide) of sidescan data covering the whole of the median valley floor. This imaged most of the neovolcanic zone in the first two major segments (a 'narrowgate' and a 'boat', or axial ridge, type) north of Kane. Because of the constraints imposed by the use of the 13 mm tow cable (due to failure of the deep-tow winch on cruise 56) we were unable to use the transmissometer on TOBI, so we obtained less information than we might have on the disposition of hydrothermal plumes in the median valley. Nevertheless, a possible temperature anomaly was recorded on the northward leg near the plume position reported by Elderfield at 22° 22.5'N. No obvious anomaly was observed farther east on the southward leg, though the temperature data will need careful examination before a definitive statement can be made.

The intention had been to recover TOBI after the median valley run and resume dredging. However, the instrument was working well, so to save the time needed for an extra recovery and later re-launch, we decided to continue for a further three days, surveying the western end of the Kane transform and the western RTI. This was completed by 0500 on day 088. TOBI was then recovered, coming on board at 0900. The whole TOBI survey had been carried out in excellent weather, but during the night prior to the recovery the wind freshened to force 6 , and later reached force 7. It remained at 6-7 (gusting 8) for the following 5 days.

Friday March 29 to Wednesday April 3 (088-093)

Five days of dredging then followed. These dredges (stations 8D to 25D) covered much of the neovolcanic and flanking zones of the first two spreading segments north of the transform. Dredge sites were chosen on the basis of the Sea Beam bathymetry and TOBI sidescan images. They included the crests of ridges, floors of graben, and small seamounts on or near the axis of the neovolcanic zone, and off-axis lava flows, seamounts, and in one case the foot of a major normal fault scarp in the median valley wall. A combination of bag and pipe dredge was used in each case. Stations were run by lowering the dredge vertically with the ship hove to at the start position, then steaming off at 0.5 - 1.0 kts when the dredge reached the bottom. Almost all stations were run upwind, and the dredge was generally left on the bottom for about one hour. Results were excellent: the pipe dredge always returned at least some glassy clasts, and often boulders; the bag usually contained several boulders, and only rarely returned completely empty.

We had intended to intersperse these dredge stations with camera (WASP) or more TOBI work, but the strong winds prevented this until day 093, when the wind moderated to force 4-5.

Wednesday April 3 (093)

The last of the series of dredge stations (25D) was completed by 0800 and, with wind moderated to force 4-5, the first WASP station (CD57/26W) was run. This consisted of a traverse across the entire neovolcanic ridge of the northern segment. It too was run head to wind at about 0.5 - 0.8 kts. The acoustic monitor worked very well, providing good, clear signals. Even so, as is common in running cameras over ridge-axis terrain, a few bottom contacts were made, causing some minor damage. One flash connector had broken (so that for some of the run only a single flash was operating), and the reflectors were lost from both flash units. Nevertheless, some 500 usable photographs were obtained, showing pillow lavas and talus of young but somewhat varying ages. The flash battery pack lasted for just over five hours, considerably better than the four hours predicted.

Following the WASP run, a second TOBI run was started. This was to zig-zag down the median valley, crossing between the opposing rift mountains in a zed shape, crossing both spreading segments and their junction region. The vehicle was launched at 093/2122, and after some initial minor electronic problems, logging began at about 2230.

Thursday April 4 to Friday April 5 (094-095)

The TOBI run continued until 095/1445, when logging was stopped and we began hauling in prior to recovery. The vehicle was on board by 1715. We then proceded to the south wall of the western limb of Kane Fracture Zone for dredge station 27D.

Saturday April 6 to Sunday April 7 (096-097)

The dredge was on board by 0220, and was followed by a second WASP run (station 28W), this time across the neck of the 'narrowgate' segment. The WASP had been repaired, and this time worked faultlessly, giving six hours' duration on the bottom. After recovering the WASP, we conducted a final four dredge stations (29D -- 32D), from the northern tip of segment 1 and along segment 2. The last was completed by 097/1846. The 3.5 kHz fish was recovered during the last station, and immediately afterwards we set course for the TAG area to recover moorings left there by *R/V Atlantis II* in 1990. Scientific watches stopped at midnight.

Monday April 8 (098)

We arrived at the TAG site at 0606 and hove to at the position of mooring CM3. This was released at 0732, surfaced at 0819, and grappled by the 'Searider' workboat at 0855. The Searider stayed with it while the ship headed for CM2, which was released at 0929. The ship then returned to recover CM3, which was inboard by 1108. Meanwhile the Searider had grappled CM2, and this was on board *Darwin* by 1220. The boat was recovered, and by 1240 we were hove to by CM1. Despite repeated transmissions from two opposite sides of the mooring position, nothing was heard for 1 1/2 hours. During this time the PES fish was recovered (1400). We were about to give up on CM1 when a single 'executed' (i.e. release confirmation) signal was received at the right range. We therefore waited for the expected rise time (40 minutes) and then instituted a careful surface search. Conditions were perfect: flat calm and excellent visibility. Unfortunately no sign of the mooring could be seen. In view of the fact that only a single reply was received during two hours of transmissions, it must be considered unlikely that the mooring did actually release.

At 1516 the search for CM1 was abandoned, and the ship set course for Ponta Delgada at full speed.

EQUIPMENT REPORTS

TOBI DEEP-TOW

Tobi was primarily to be used to carry out an acoustic survey using its 30 khz sidscan sonar system capable of imaging a 6 km swath. In addition, the vehicle was fitted with a 7.5 khz sub-bottom profiler, a tri-axial magnetometer and a thermistor probe. Also, for monitoring vehicle behaviour, it has a compass and pitch, roll and presure sensors. The two component electromagnetic log failed during the first run and was therefore removed. An acoustic transponder which could have been used as part of an acoustic navigation system was also incorporated but, in practice, it was there as an emergency beacon.

The ship had been fitted prior to cruise 56 with a "portable" traction winch carrying 10000 metres of what has become recognised as the standard deep tow cable. However, during winch tests carried out on cruise 56, it became clear that there were serious problems and that it was not going to be possible to use it. With some considerable trouble the TOBI system was reconfigured to operate on the 14mm conducting cable on one of the ship's winches. The much greater attenuation of that cable required the signals generated in the vehicle to be amplified to such a level that the problem of cross-talk between channels was greatly increased. This effect was most noticable on the sub-bottom profiler signal, but it was fortunate that, in this largely sediment-free terrain, the main use for the profiler was to detect the altitude of the vehicle above the bottom.This meant that the data after the first return, which was then corrupted by the sidescan, could be ignored. Signals normally sent down the cable to trigger the vehicle, which were at the high end of the frequency range, could not be used at all. To overcome this the vehicle was made to free run, creating synchronisation problems with the data logging system. By the start of Cruise 57 these modifications had all been implemented, tried and found to provide a useable system although care had to be taken not to exceed the maximum working load of the cable.

The vehicle was easily deployed and recovered through the after A frame, using a hydrophone winch for the umbilical storage, with good weather on all three occasions. The first launch had to be aborted before the depressor weight was deployed due to loss of digital data. The problem was eventually traced to an eight-way connector which was breaking down internally. This and associated problems were rectified and two more trouble-free launches followed.

During the two tows a total of 296 miles were covered at an average speed of 1.75 knots (an area of 2368 square km). Water depths varied (sometimes very rapidly) between about 3000 metres and 5800 metres providing the roughest terrain yet encountered by TOBI. Apart from causing operator concern, this very rough topography made it difficult for the automatic bottom detect routine to work when over the steepest gradients, sometimes requiring frequent operator intervention. Flying the vehicle was made easier by good winch control and, importantly, by the very good ship speed and direction maintained by the watch officers.

All the data was logged on recently-aquired erasable magneto-optical cartridges which have the advantage over the old WORM drives in that the data can be edited.

Although the triggering problems were only circumvented and the profiler data quality was poor, the quality of the sidescan and digital data was not noticably reduced by the use of the 14 mm cable, resulting in a generally successful survey.

WASP CAMERA SYSTEM

Two WASP runs were completed during the cruise and a total of over 1100 photographs of the seafloor were taken. Both runs covered rough terrain which made control of the vehicle and maintainance of optimum altitude difficult at times.

The first deployment on 3rd. April was ended after five hours when the flash system failed.Upon recovery it was seen that both flash head reflectors had been shaken off and lost, and one flash head cable had been severed. Damage to this cable had caused the sudden failure of the flash system, however by this time the planned run had been completed.

A spare cable was fitted and a pair of flash-head reflectors was borrowed from the RVS stereo camera system and fitted to WASP. The flash heads were repositioned slightly within the frame of the vehicle for extra protection. The data chamber batteries were replaced and solder links were made to one of the batteries as its retaining clip was damaged.

The spare rechargeable battery pack was fitted to the WASP for its second deployment on 6th April. This lasted for six hours at which time the flash system began operating intermittantly indicating low battery voltage. Although, upon recovery, there was obvious impact damage to the WASP framework, no damage was caused to the photographic or acoustic monitor components.

Films from both runs were developed by the IOSDL photographer aboard ship. Test lengths were processed to assess exposure and then the film was processed using a fifty foot capacity processing tank. This proved to be difficult to use but saved several joins in the films. Film from the first run revealed the clock battery problem in that data chamber figures were difficult to see on the film. The battery arrangement was modified for the second run and the data chamber was visible throughout. The quality of pictures throughout was very good and indicated an optimum altitude for the vehicle to be between seven and eleven metres. Above this altitude backscatter progressively obscured the images.

The system worked well during the cruise and provided useful information to complement dredge and TOBI data. It is intended to improve the WASP system's run duration and reliability. Shoulld the required funding be available further development of the system will be carried out at IOSDL by the Ocean Instrumentation Group.

SIMRAD EA500 10 KHZ ECHOSOUNDER

The printer ports failed early in the cruise, and hard copies were provided by a Waverley linescan recorder. Digital tracking of the bottom worked successfully, even on rugged mid-ocean ridge terrain, except where other acoustic signals were present, i.e. 3.5 kHz, pinger or WASP moniter. In order to track pingers an external pulse was required and the echosounder would not operate in pinger mode.

VARIAN V75 PROTON MAGNETOMETER

Ran well throughout, anomalies were reduced to IGRF 85, IGRF 90 not yet being available.

LACOSTE AND ROMBERG S84 GRAVITYMETER

A base station was established from Dique Muelle del Sur to the ship position at Dique Muelle Del Este in Santa Cruz. Anomalies were reduced to IGSN 71 and smoothed using a 10 minute averaging filter whilst on passage, or to 15 minutes after editing during dredge stations and TOBI runs. A 10 milligal colour contour plot was produced of the Kane FZ from these data.

SHIPBOARD COMPUTING SYSTEM

Data logging of magnetometer, gravity meter and navigation instruments was carried out with no equipment failures. It was noted however that the loading of the two serial ports providing output from the GPS receiver has now reached the maximum that the circuitry can provide. The consequence of this is that when the acoustic navigation system is power cycled and the GPS output is connected the receiver will reboot itself. It is becoming essential that a buffering system be provided between the receiver and the devices it is output to.

Prior to the second TOBI deployment the analogue output of magnetic field was connected via a Level A instrument interface to the Data Logger and was subsequently processed.

Data processing was carried out daily for navigation and all other input.

Extensive use was made of the computing facilities on board by most cruise participants. There was initially some difficulty experienced when the user Sun workstation crashed on a number of occasions. It was decided that there was a strong likelihood that the operating system for this machine had become corrupted. The operating system was restored from the backup tapes on board and no further problems were encountered.

Whereas it is impossible to provide support for the many software packages used on board it would be an advantage if a very easy system of producing hard copy were provided for users who have brought there own small computer but no printer. The addition of a postscript printer directly connected to the computer room PC would be very useful.

CURRENT METER MOORINGS

It was proposed to recover three rigs, each with two Anderaa recording current meters, laid from ATLANTIS II in January 1990. Two of the three rigs were recovered with no difficulty. However, on interrogating the third, no consistent range information was recieved from the OCEANO release when the 'enable' code was transmitted. Repeated interrogation of the release from positions around the target position still failed to produce any consistent ranges, nor did transmission of the release code produce any 'execute' return from the transponder. A search was initiated in case of possible release and was about to be abandoned when on interrogation a single execute code and sensible range were recieved. A further search was initiated after fourty minutes (the projected release-to-surface time of the transponder), but with no effect and was eventually abandoned.

On examination of the recovered current meters, RCM8(8248) was found to be flooded, and the data from RCM8(9605) and RCM8(9351) showed that they had recorded corrupted data for half a day. RCM8(9583) had however recorded six and a half months of good data before the data had become corrupted and the meter failed to log further.

TABLE 1: UNDERWAY GEOPHYSICAL OBSERVATIONS

Instrument	Time on	Time off	Comments
Simrad 10 kHz echosounder	075/0830	098/1400	
Lacoste & Romberg gravimeter	074/0920	098/1430	Reduced to IGSN 71
Proton magnetometer	075/0830	080/0320	Reduced to IGRF 1985.0
3.5 kHz profiler	081/2400	081/1242	
	081/1554	083/1330	
	094/1050	095/1806	
TOBI	082/1835	088/0500	
	093/2230	095/1445	

TABLE 2: STATION POSITIONS

Number	Type	Location	Start[a] Time	Latitude	Longitude	Depth	End[a] Time	Latitude	Longitude	Depth
CD57/1D	Dredge	Foot of transform S wall	080/0710	23° 38.6'N	45°16.4'W	4399	0819	23° 38.2'N	45° 15.7'W	4290
CD57/2D	Dredge	Foot of transform S wall	080/1324	23° 39.1'N	45° 20.5'W	4067	1454	23° 38.0'N	45° 20.0'W	3544
CD57/3D	Dredge	RTI NVR[b], Seg 1a	081/0555	23° 52.7'N	46° 19.6'W	4828	0716	23° 52.4'N	46° 19.0'W	4759
CD57/4D	Dredge	RTI seamount, W of NVR	081/1348	23° 53.4'N	46° 21.6W	4960	1546	23° 52.9'N	46° 20.6'W	4835
CD57/5D	Dredge	RTI NVR, seg 1a	081/2230	23° 51.9'N	46° 19.9'W	4900	0017	23° 51.6'N	46° 19.5'W	5000
CD57/6D	Dredge	RTI NVR, seg 1a	082/0435	23° 51.3'N	46° 20.6'W	4985	0810	23° 50.9'N	46° 19.4'W	4900
CD57/7D	Dredge	W flank of nodal basin	082/1350	23° 51.3'N	46° 18.0'W	5255	1439	23° 51.0'N	46° 17.4'W	5514
CD57/8D	Dredge	S. tip of NVR in RTI	088/1256	23° 50.5'N	46° 19.8'W	4920	1348	23° 51.2'N	46° 19.9'W	4914
CD57/9D	Dredge	Slightly oblique NVR, seg 1a	088/1833	23° 53.3'N	46° 19.5'W	4895	1957	23° 54.4'N	46° 19.8'W	4778
CD57/10D	Dredge	Volcano NW of nodal basin	089/0226	23° 53.6'N	46° 17.9'W	5030	0338	23° 54.4'N	46° 17.9'W	4944
CD57/11D	Dredge	Flat area,W of NVZ, seg1a	089/0935	23° 55.4'N	46° 19.3'W	4715	1040	23° 56.3'N	46° 19.3'W	4740
CD57/12D	Dredge	Large seamount,centre seg.1a	089/1623	23° 57.1'N	46° 17.9'W	4600	1735	23° 58.0'N	46° 18.1'W	4482
CD57/13D	Dredge	Axial smt.(Thatcher's Nose)	089/2225	24° 00.2'N	46° 19.4'W	4244	2345	24° 01.0'N	46° 19.4'W	4272
CD57/14D	Dredge	NVR axial graben, seg.1a	090/0439	24° 00.2'N	46° 18.2'W	4360	0601	24° 01.0'N	46° 17.7'W	4317
CD57/15D	Dredge	Seg.1a NVR	090/1113	24° 02.4'N	46° 18.2'W	4118	1323	24° 03.3'N	46° 17.9'W	4080
CD57/16D	Dredge	N. tip of segment 1a	090/1815	24° 04.6'N	46° 18.5'W	3970	1936	24° 05.4'N	46° 17.5'W	3948
CD57/17D	Dredge	S. tip of segment 1b	091/0015	24° 06.8'N	46° 17.9'W	4030	0155	24° 07.2'N	46° 17.2'W	3900
CD57/18D	Dredge	SE margin of seg.1b	091/0615	24° 08.0'N	46° 17.1'W	3900	0724	24° 08.5'N	46° 16.6'W	4000
CD57/19D	Dredge	Centre of segment 1b	091/1226	24° 11.1'N	46° 16.9'W	4100	1350	24° 11.8'N	46° 16.3'W	3855
CD57/20D	Dredge	Broad NVZ, seg.1b	091/1835	24° 14.6'N	46° 15.9'W	4179	2000	24° 15.1'N	46° 15.1'W	4177
CD57/21D	Dredge	N tip of segment 1b	092/0123	24° 18.4'N	46° 15.8'W	4390	0245	24° 18.4'N	46° 14.9'W	4447
CD57/22D	Dredge	Major scarp on W MV wall	092/0719	24° 19.7'N	46° 12.2'W	4150	0950	24° 19.5'N	46° 11.0'W	3455
CD57/23D	Dredge	S tip of seg.2, broad NVR	092/1523	24° 24.6'N	46° 13.7'W	4250	1745	24° 24.5'N	46° 12.8'W	4445
CD57/24D	Dredge	Centre of seg.2, broad NVR	092/2332	24° 33.4'N	46° 11.1'W	3787	0057	24° 33.1'N	46° 10.0'W	3731
CD57/25D	Dredge	Segment 2 axis	093/0628	24° 35.7'N	46° 09.8'W	3782	0717	24° 35.7'N	46° 09.0'W	3765
CD57/26W	WASP	Across segment 2 NVR	093/1258	24° 35.1'N[c]	46° 11.1'W	4220[c]	1818	24° 34.6'N[c]	46° 08.4'W	4180[c]
CD57/27D	Dredge	S wall of W FZ limb	095/2159	23° 50.3'N	46° 22.2'W	5160	2400	23° 50.0'N	46° 21.1'W	4600
CD57/28W	WASP	Across 'narrowgate'	096/0635	24° 07.3'N[c]	46° 18.6'W	3920[c]	1333	24° 06.3'N[c]	46° 16.4'W	3880[c]
CD57/29D	Dredge	Nested smts at N tip of seg.1b	096/1859	24° 21.5'N	46° 16.0'W	4545	2035	24° 20.8'N	46° 15.0'W	2577
CD57/30D	Dredge	Between segments 1b & 2	097/0157	24° 22.5'N	46° 13.9'W	4490	0308	24° 20.0'N	46° 14.0'W	4405
CD57/31D	Dredge	Centre of seg.2, broad NVR	097/0921	24° 30.6'N	46° 11.4'W	3688	0126	24° 29.8'N	46° 11.7'W	3640
CD57/32D	Dredge	N end of seg.2, NVR & smt.	097/1457	24° 37.8'N	46° 08.2'W	3570	1700	24° 36.4'N	46° 08.8'W	3695

[a] Ship position when instrument on/off bottom. [b] NVR = neovolcanic ridge. c Instrument position when on and off bottom

TABLE 3: SUMMARY OF STATION RESULTS

Number	Type	Location	Result
CD57/1D	Dredge	Foot of transform S wall	Mylonitic, deformed, massive, chlorite- and talc-rich ultramafics; deformed gabbros; dolerites; brownstones; plagiogranite.
CD57/2D	Dredge	Foot of transform S wall	Dolerites; deformed, mylonitic, and talc-rich ultramafics; massive serpentinite; ultramafic breccia.
CD57/3D	Dredge	RTI NVR,slightly tectonized, seg. 1a	Plagioclase phyric basalt, probably pillow and tube fragments.
CD57/4D	Dredge	RTI seamount, W of NVR	Sparsely plagioclase phyric basalt. Pillow and pahoehoe (sheet flow) fragments.
CD57/5D	Dredge	RTI NVR, fissure seamounts, seg. 1a	Aphyric to very sparsely plagioclase phyric basalt. Pillow fragments, one highly vesicular, with zeolite amygdales.
CD57/6D	Dredge	RTI NVR, fissure seamounts, seg 1a	Plagioclase phyric basalt with glassy rims and highly vesicular interior; older plagioclase and olivine phyric basalt.
CD57/7D	Dredge	Old ridge, W flank of nodal basin	Sparsely plagioclase phyric (olivine microphyric) pillow basalt fragments.
CD57/8D	Dredge	S. tip of NVR in RTI, segment 1a	Plagioclase phyric basalt glass fragments; older plagioclase (plus minor olivine) phyric basalt. Pillow and lava tube fragments.
CD57/9D	Dredge	Slightly oblique NVR, segment 1a	Plagioclase phyric pillow basalt fragments; plagioclase and olivine phyric pahoeoe textured sheet flow.
CD57/10D	Dredge	Volcano on NW edge of nodal basin	Palagonitised basaltic glass fragments; pelagic ooze.
CD57/11D	Dredge	Flat area W of NVZ, segment 1a	Plagioclase phyric pillow basalt fragments.
CD57/12D	Dredge	Large seamount, centre of seg.1a	Younger and older units of plagioclase phyric sheet flow, pillow basalt and glass. Oldest unit is of aphyric pillow. Ooze
CD57/13D	Dredge	Seg.1a axial smt (Thatcher's Nose')	Highly plagioclase phyric olivine-bearing basalt, (>40% phenocrysts), possibly sheet flow. Glassy rims slightly palagonitized.
CD57/14D	Dredge	NVR axial graben, segment 1a	Sparsely plagioclase phyric pillow basalt fragments.
CD57/15D	Dredge	Segment 1a NVZ, fissure seamounts	Aphyric pillow and possibly sheet flow basalt fragments; fresh glassy basalt tubules.
CD57/16D	Dredge	N. tip of segment 1a, oblique ridge	Plagioclase phyric pillow basalt and lava tubules from very recent eruption.
CD57/17D	Dredge	S. tip of seg.1b, slightly tectonized	Aphyric basalt with glassy rims (prob. sheet flow); scoriaceous aphyric basalt; plagioclase phyric pillow basalt fragments.
CD57/18D	Dredge	SE margin of seg. 1b	Plagioclase phyric pillow and possibly sheet flow basalts, some with olivine microphenocrysts; fairly glassy.
CD57/19D	Dredge	Centre of segment 1b, broad NVR	Aphyric basalt glass and very fine-grained basalt – pillow selvedges. Older, very sparsely plagioclase phyric pillow basalt fragments.
CD57/20D	Dredge	N end of segment 1b, broad NVR	Sparsely plagioclase phyric (olivine microphyric) pillow basalt. One boulder has twisted pahoehoe texture.
CD57/21D	Dredge	N tip of segment 1b, NVR	Sparsely plagioclase phyric basalt; plagioclase and olivine phyric basalt; probably pillow fragments of three different ages.
CD57/22D	Dredge	Major scarp on W MV wall, seg. 2.	Aphyric basalt (old pillows); plagioclase-olivine-clinopyroxene phyric, weathered basalt; olivine phyric basalt; variolitic pillows; basalt fragments with secondary mineralisation (zeolites, celadonite?); massive basalt (thick flow);aphyric basalt glass; rounded basalt pebbles; basaltic breccias and hyaloclastite; tectonic breccias.
CD57/23D	Dredge	S end of segment 2, broad NVR	Aphyric basalt (old pillows); highly plagioclase (sparsely olivine) phyric pillow basalt fragments with powdery black MnO_2 coating; very sparsely plagioclase phyric (possibly sheet flow) basalt; aphyric glassy to very fine-grained basalt; assorted glassy pillow rinds.
CD57/24D	Dredge	Centre of segment 2, broad NVR	Plagioclase phyric basalt, prob. sheet flow; aphyric pillow basalt with powdery black MnO_2 coating; highly weathered aphyric pillow basalts.
CD57/25D	Dredge	Segment 2 axis	Plagioclase phyric glass and basalt.
CD57/26W	WASP	Across segment 2 NVR	500 frames exposed. Mostly pillows and tubes, pillow breccias and talus. No sheet flows or sediment ponds. Few faults or fissures.
CD57/27D	Dredge	S wall of W FZ limb	Highly plagioclase phyric olivine-bearing basalt; sparsely plagioclase phyric (olivine-microphyric) basalt; greenschist facies cataclasites; hydrothermal veins.
CD57/28W	WASP	Across 'narrowgate'	800 frames. Highly variable terrain: mostly pillows , tubes, some sheets; some areas of heavy faulting/fissuring, some sed. ponds.
CD57/29D	Dredge	Nested smts at N tip of segment 1b	Sparsely plagioclase phyric old pillow basalt; highly plagioclase (olivine-bearing) phyric pillow basalt; very sparsely plagioclase-phyric old pillow basalt; pelagic ooze.
CD57/30D	Dredge	Between segments 1b and 2	Sparsely plagioclase phyric olivine-bearing basalt – bolster pillows – not fresh, with powdery black MnO_2 coating;
CD57/31D	Dredge	Centre of segment 2, broad NVR	Highly plagioclase phyric basalt – very fresh sheet flow.
CD57/32D	Dredge	NVR and smt at N end of segment 2	Very sparsely plagioclase phyric variolitic pillow basalt fragments with glassy rim; aphyric pillow, bud or sheet basalt,some with powdery black MnO_2. coating; aphyric basalt, possibly sheet flow.

TABLE 4: SCIENTIFIC PERSONNEL

Dr. Simon Allerton	University of Oxford	Geophysicist
Dr. Paul Browning	University of Bristol	Geologist
Mike Conquer	IOSDL	Photographer
Mike Davis	RVS	Mechanical support
Colin Day	RVS	Mechanical support
Dr. Pamela Kempton	NERC Isotope Laboratory	Geochemist
Bob Kirk	IOSDL	WASP/TOBI
Gareth Knight	RVS	Computer support
Kate Lawson	University of Durham	PhD student
Dr. Catherine Mevel	University of Paris	Geologist
Nick Millard	IOSDL	TOBI
Dr. Bram Murton	IOSDL	Geologist
Chris Poulson	RVS	Instrument support
Robin Owens	University of Durham	MSc student
Dr. Julian Pearce	University of Durham	Geochemist
Dr. Hans Schouten	Woods Hole Oceanogr. Inst.	Geophysicist
Prof. Roger Searle	University of Durham	Chief scientist
Bernie Woodley	RVS	Instrument support

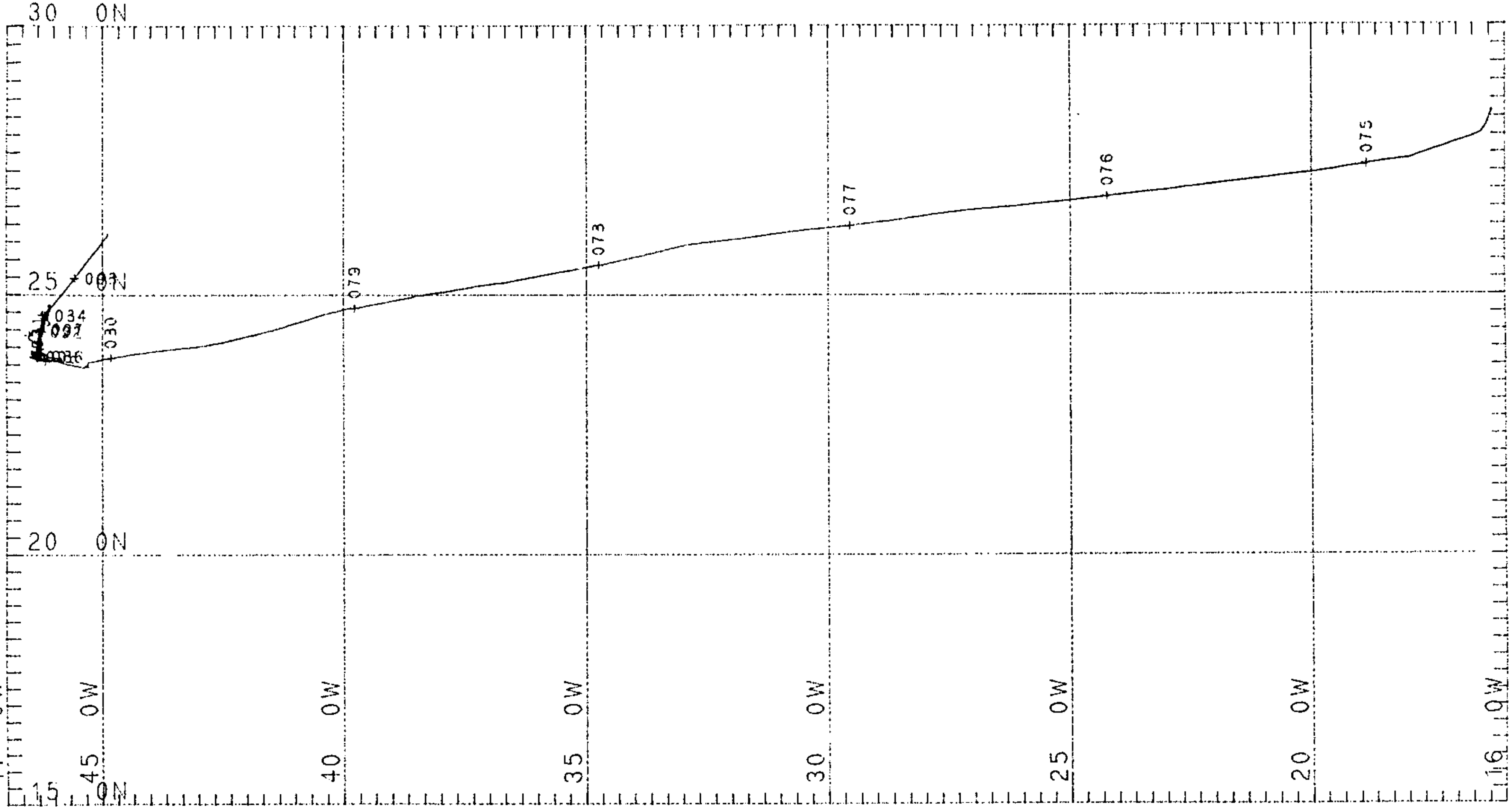
TABLE 5: SHIP'S CREW

P. J. MacDermott	Master
R. A. Bourne	Chief Officer
S. Sykes	2nd Officer
P. A. Burridge	3rd Officer
B. Donaldson	Radio Officer
I. G. McGill	Chief Engineer
G. Gimber	2nd Engineer
B. J. McDonald	3rd Engineer
P. E. Edgell	Electrical Engineer
M. Trevaskis	CPO (Deck)
J. Carew	Seaman
P. H. Dean	Seaman
A. E. Olds	Seaman
A. G. Scriven	Seaman
P. R. Bennett	Seaman
C. K. Perry	CPO (Catering)
P. J. Bishop	Cook
R. M. Stephen	2nd Steward
D. E. Jenkins	Steward
C. J. Elliot	Steward
M. J. Brennenstuhl	Motorman

Figures

Figure 1. Overall track chart for cruise CD57.

Figure 2. CD57 detailed study area at western ridge-transform intersection of Kane fracture zone. Contours are depth in metres at 1000 m interval. Non-shaded areas show TOBI coverage. Dots indicate dredge locations (with station number), and heavy lines show WASP (camera) tracks.



MERCATOR PROJECTION

GRID NO. 1

--- Track plotted from bestnav

SCALE 1 TO 12000000 (NATURAL SCALE AT LAT. 24)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

RRS Charles Darwin cruise 57 trackplot

Figure 1

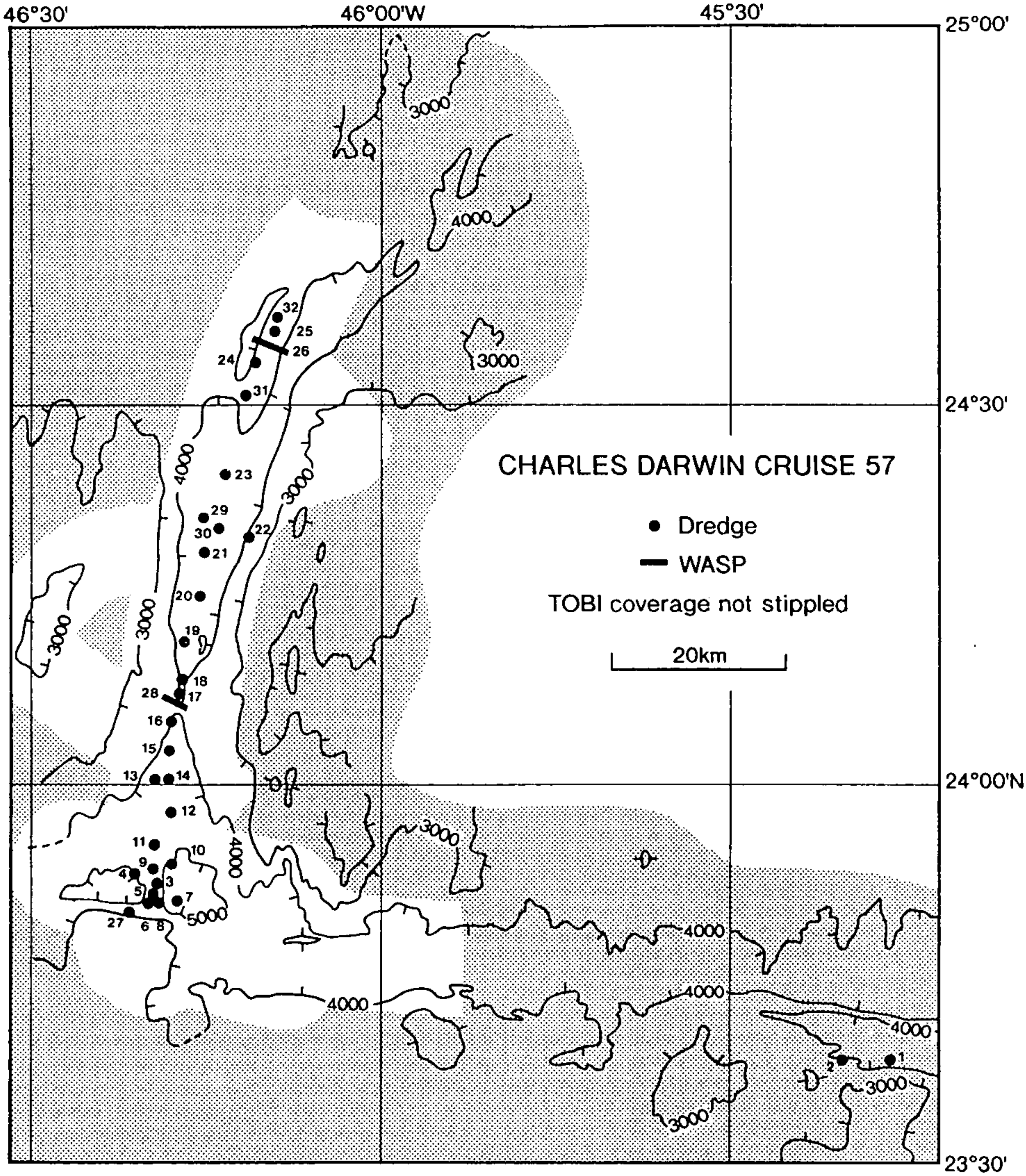

46°30'
46°00'W
45°30'
25°00'
24°30'
24°00'N
23°30'
CHARLES DARWIN CRUISE 57
Dredge
WASP
TOBI coverage not stippled
20km
3000
4000
5000

Figure 2