UNIVERSITY of CAMBRIDGE

Department of Earth Sciences

DISCOVERY 143
CRUISE REPORT

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DAKAR - DAKAR (SENEGAL)

22 December 1983 - 19 January 1984

Bullard Laboratories,
Department of Earth Sciences,
Madingley Rise, Madingley Road,
Cambridge CB3 OEZ

R.S. White

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1. Primary Scientific Objectives

a) To investigate whether there is a heat flow anomaly across the Cape Verdes Rise, and to measure heat flow through old oceanic crust.

b) To take surface and deep water samples, and to collect atmospheric dust samples.

c) To test a prototype digital Ocean Bottom Seismometer (OBS).

2. Narrative

Four of the Cambridge team met RRS DISCOVERY on Sunday 18 December as it berthed at Dakar, and moved our equipment from the forward hold (magazine) into the labs. A lot of GLORIA electronics had been left in the laboratories and Scientific Plot and on the benches and had to be moved to provide room for our equipment. The remaining five Cambridge personnel arrived on 20 December.

DISCOVERY sailed on time at 1120 on Thursday, 22 December, although Foreign Office clearance to work within 200 n.m. of the Cape Verdes waters was not obtained until the day before we sailed. The PES and 3.5 kHz fishes, and the magnetometers were deployed 30 n.m. from Dakar and run throughout the cruise, together with the gravimeter.

The airgun profiling system was deployed after breakfast on Friday 23 December. The 600B airgun with a 40 cu. inch chamber adapted for high-speed (8 knot) towing was not stable but kited around in the ship's wake. So it could not be used and the seismic profiling throughout the remainder of the cruise used a single 160 cu. inch airgun towed conventionally, with a two-channel Geomechanique streamer. The narrow beam echo sounder was left inoperative at the end of the previous cruise.

We arrived in the water within the Cape Verdes Archipelago on Christmas Eve. Due to the exigencies of Christmas and Boxing Day on the ship and the difficulty of moving the hydrophone drum on the afterdeck to prepare for heat flow, we were unable to test the heat flow probe but instead spent the Christmas period making a very extended site survey of area ANGEL (see map). Two prime sites were chosen on the basis of long east-west lines and a grid survey about 10 x 10 n.m. in extent was made over each with a line spacing of about 2 n.m.

The airgun and hydrophone streamer were recovered at 1100 on Tuesday, 27

December. We then had to use the crane to shift the hydrophone drum weighing about 2 tonnes off the capstan at the head of the heat flow probe railway on the afterdeck. This is a hazardous procedure at sea, and one that we had to repeat many more times over the cruise, mostly in sea state 7.

The 4 m. Cambridge heat flow probe, weighing about 750 kg was deployed three times on 27 December in area ANGEL (deployments A1, A2 and A3). Only two successful heat flow stations were obtained, due to leakage in the connector block at the top of the thermistor string and in the instrument pressure case. The connector block was skimmed to remove several scratches in the face-plate and thereafter worked faultlessly.

On the morning of 28 December we proceeded to area BALTHAZAR to the Southeast of San Nicolau, and deployed the airguns at 2100. A faulty trigger lead near the gun delayed operational profiling until midnight. Surveyed two sites with 2 n.m. line spacing, finishing in the early evening of 29 December. We then deployed the heat flow probe, on station B1 which despite a faulty pinger recorded six stations in the internal digital tape. Recovered the probe at 0400 on 30 December and deployed another probe in the same area (deployment B2) shortly before breakfast. This probe worked well, and we made 16 penetrations through the day. The swell dropped somewhat and it was therefore possible to deploy the Zed boat for a surface water sample. At 1600 we moved 7 n.m. to the western part of the survey area and then continued taking stations, with in-situ conductivity measurements on alternate lowerings.

On completion of the Balthazar survey we spent 12 hours steaming back to area Angel, surveying the fracture zone cutting through the Cape Verdes archipelago en route. Deployed the heat flow probe at station A4 in the western part of area Angel at 1700 on 31 December. Sixteen penetrations were recorded over the next 12 hours, and the probe was recovered at 0645 on New Years Day. The New Year was suitably rung in and celebrated. With the probe inboard we steamed a few miles west to station A5 and again deployed it for a further 11 penetrations. The thermister string apparently tore off its bottom mount towards the end of this run, so the probe was recovered in the afternoon.

Whilst steaming to the site in the east of area Angel (A6) the thermister string and heat flow electronics were replaced, and the new probe deployed at 1700 on 1 January. Near the end of its lowering the thermisters failed to range-scale due to a loose connection on a pressure vessel end-cap and the instrument had to be recovered. It was on deck at 2345, and the instrumentation changed to the backups and re-lowered by 0100 on 2 January. This time it worked properly, and 15 penetrations were completed by 0940. Subsequently the bottom clamp of the thermister string again sheared and the probe was recovered.

After the heat flow probe was on deck we steamed to area CASPAR recording underway geophysical data, arriving at 1030 on 3 January. Deployed the seismic profiling equipment and made a grid survey lasting 15 hours. About 1 hour was lost through airgun failure. In view of the difficulty of transferring the hydrophone winch, we kept the airgun profiling system out while we steamed a further 60 n.m. to area DONKEY. Spent 4 January making a site survey in area Donkey, and finally recovered the profiling equipment at 0130 on 5 January. We then steamed back to area CASPAR, arriving at 1100 on 5 January. The seastate was now up to Force 6 with about 8 m swell. Another surface water sample was obtained from the Zed boat, but even in the lee of the ship the swell was becoming sufficiently large that no further Zed boat launches were practicable.

The heat flow probe was deployed on station C1 at mid-day with a newly constructed clamp on the lower end of the thermister string. This prevented any further failures due to the string becoming loose at the bottom. The probe worked well all through the day, but by nightfall the wind had increased to Force 7 and the afterdeck was occassionally getting wet so we continued penetrations with the heat flow probe rather than recover it in the dark. In these conditions it was almost impossible to steer the ship at slow speeds other than directly into the wind, so rather than taking the profile exactly along a seismic reflection profile as on previous stations we had to move diagonally across the survey area taking heat flow stations at the rate of one per 40 to 60 mins en route. Finally recovered the probe, still recording data at 1100 on 6

January, after 23 hours over the side.

We next returned to area DONKEY and deployed the heat flow probe on station D1 at 1745 on 6 January. It again worked perfectly, and we took a 10 n.m. profile with 16 penetrations along the line of a reflection profile. The probe was recovered at 0700 on 7 January. The rather harder sediments here caused about 1 cm of stretch in the thermister string. In view of the large number of basement diapirs in this survey area, a second crossing (lowering D2) was made across it in order to obtain sufficient measurements to get a good regional mean for the heat flow. The instrument was recovered after 18 penetrations at 0130 on 8 January with a slightly bent nose-cone assembly at the bottom of the strength member which was straightened in the workshop. Wind was still Force 7, and the movement on the afterdeck was such that it was only just below the maximum we could safely work in. At the bottom of the main warp the heat flow instrument was oscillating vertically with an amplitude of up to 15 m due to the swell. Tensions in the wire sometimes reached 8 tonnes, varying from as little as 2 tonnes.

Through 8 January we steamed to the far north of the region (area GOLD) to make a survey over normal, old oceanic crust off the edge of the Cape Verdes Rise. The hydrophone was deployed at 0400 on 9 January and a 1.5 n.m. spacing grid survey was made over a good site with relatively flat basement relief. The survey was completed at 0015 on 10 January, the equipment recovered and the hydrophone reel moved off the capstan (taking about 2 hours for this operation). After steaming to the start of the heat flow survey line G1 the instrument was deployed at 0230 on 10 January, but almost immediately had to be recovered due to failure of the RVS 10 kHz pinger. This was quickly replaced and the first penetration was made at 0500. The seafloor here was considerably harder than in any of the previous sites and in 14 lowerings we only achieved 5 good penetrtions. In the other cases the tiltmeter telemetry to the ship showed that the probe was falling over when it hit the bottom. On recovery at 1700 on 10 January, the nose-cone assembly was found to have been bent by about 20^{o}.

When the heat flow was on deck a water dip with velocimeter attached was made using the electric winch and 6 mm. conducting cable. Despite initial problems with non-triggering, 30 litre water bottle samples were collected from 100, 300, 500, 1000 and 3000 m, and a continuous velocity profile recorded. On recovery at 2300 the bottom-most bottle was found to have become entangled in a bight of the wire and had probably been onto the seafloor.

A second heat flow survey was started in area GOLD at site G2 at 2400 on 10 January, having replaced the nose-cone assembly and added 400 kg to the weight-stand to assist penetration. A Seacon connector with wrong manufacturer connetions caused some delay but this was corrected and the probe was operational by 0330 on 11 January. In the course of 9 lowerings, 4 good penetrations were achieved. When the probe was recovered at 1520 on 11 January, the main strength member was found to be bent and again there was a 10^{0} bend in the nose-cone assembly.

While the strength member was replaced by a new spare and the nose-cone assemblies were straightened and welded we moved back southwards to area FRANKINCENSE, arriving at 0530 on 12 January. However, the seas were too rough to permit us to safely deploy the hydrophone streamer and airgun since the wind was now a steady Force 7, gusting to Force 8. We ran a magnetic survey until 0830, when the profiling equipment was deployed. The grid survey was completed by 0100 on 13 January: although many basement diapirs were present a reasonably flat area was found for the heat flow measurement. From 0230 to 0700 on 13 January another deep water dip was made, following which the prototype digital OBS was tested by lowering it beneath a Dahn buoy and steaming 8' away firing the airgun: a disposable sonobuoy profile was recorded simultaneously for comparison of the data. The OBS was recovered at 1300 on 13 January.

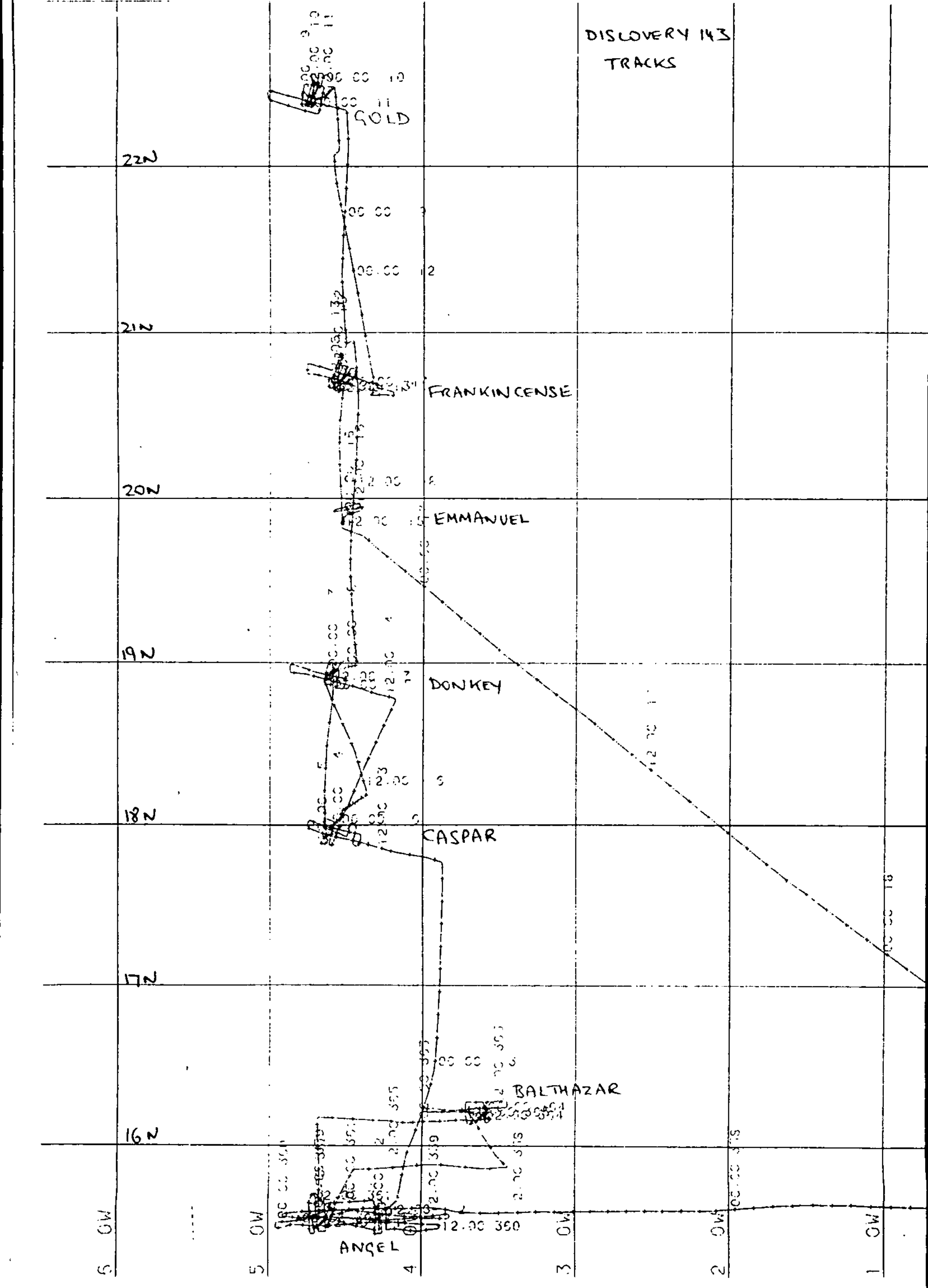
Having moved the hydrophone off the capstan, which was not a pleasant job in the heavy seas, we launched the heat flow probe (station F1) at 1515 on 13 January. A total of 17 successful penetrations were completed and the probe recovered at 0945 on 14 January. The thermister string was stretched and had to be replaced, but the strength-member and nose-cone were undamaged. A second heat flow traverse across the survey area (F2) was started at 1100 and completed after a further 17 penetrations at 0200 on 15 January.

From FRANKINCENSE we moved south 50 n.m. to area EMMANUEL, but due to the weather conditions (still Force 7), we were unable to move the hydrophone onto the capstan and so commenced a heat flow lowering (E1) straightaway on the basis only of the 3.5 kHz and magnetic records. The probe was recovered at 1930 after 10 penetrations, the thermister string tightened and a new instrument deployed at 2015 on 15 January (E2). This station was continued through the night, recovering the instrument on the morning of 16 January after 16 penetrations. The RVS 10 kHz pinger clamps came loose and the pinger was lost on this last deployment (see report in Appendix 8 for details).

A planned piston corer deployment with our heat flow instrumentation attached had to be abandoned because the hydraulics on the after davit developed a bad leak. Instead the digital OBS was deployed under a dahn buoy for a second test, again firing an airgun into it and simultaneously recording a sonobuoy profile. The OBS was recovered at 1300 on 16 January in pouring rain and Force 7 winds after a successful run.

Our final work in area EMMANUEL was to take a seismic reflection profile along the line of the heat flow traverse. Unfortunately the weather again precluded moving the Geomechanique array onto the capstan so we used the 20 + 10 m Geomechanique hand-deployed streamer. Despite heroic efforts adding weights to the streamer and pulling it in and out several times in torrential rain, it was only possible to record a very poor quality profile with the 160 cu. inch airgun.

We left area EMMANUEL at 1930 on 16 January after completing the reflection line and proceeded towards Dakar with normal underway geophysical equipment running. Scientific work had to be abandoned at 1130 on 18 January as we came into Senegalese waters since the Foreign office had not cleared our work there. We berthed for bunkering at Dakar at 0330 on 19 January, and moved our equipment in 120 boxes down to the forward magazine locker whilst alongside during the morning and early afternoon. The scientific party departed on the evenings of 19 and 20 January.



DISCOVERY 143
TRACKS
GOLD
22N
21N
FRANKINCENSE
20N
EMMANUEL
19N
DONKEY
18N
CASPAR
17N
BALTHAZAR
16N
ANGEL
6 0W
5 0W
4
3 0W
2 0W
1 0W

APPENDIX 1

Summary of heat flow stations

Area	Location	Water Depth (corr. m)	No. of Lowerings		Successful Stations
ANGEL (west)	15°30'N 24°36'W	4000	A1	2	2
			A2	1	0
			A3	0	0
			A4	16	16
			A5	11	9
					27
ANGEL (east)	15°33'N 24°18'W	3870	A6	27	15
					15
BALTHAZAR	16°15'N 23°35'W	3630	B1	6	6
			B2	21	18
					24
CASPAR	17°57'N 24°38'W	3710	C1	26	26
					26
DONKEY	18°54'N 24°36'W	4030	D1	16	16
			D2	18	18
					34
EMMANUEL	19°53'N 24°31'W	4400	E1	10	10
			E2	16	16
					26
FRANKINCENSE	20°43'N 24°30'W	4740	F1	17	17
			F2	17	17
					34
GOLD	22°25'N 24°43'W	5160	G1	14	5
			G2	9	4
					9
TOTALS				227	195

APPENDIX 2

Air particle sample					
From		To		Area	Run No.
date	time	date	time		
22.12.83 (356)	1900	357	0930	-	1
357	1500	358	1600	-	2
360	1615	361	1050	-	3
361	1530	362	2030	A	4
363	2300	364	1600	B	5
364	2030	365	1730	B	6
365	1745	1	0600	B	7
1	1500	1	1700	-	8
2	1000	2	1750	-	8
2	1930	3	0900	-	9
5	1430	5	1900	C	10
7	1750	8	0100	D?	11
10	0700	10	2240	G	12
11	1110	11	1515	G	12
13	1620	14	0840	F	13
14	1400	15	0030	-	14
15	1350	15	2015	E	15

APPENDIX 3

Scientific Personnel

R.S. White	P.S.O.	(Cambridge)
C.A. Williams		(Cambridge)
P.J. Barton		(Cambridge)
S.R. Fowler		(Cambridge)
C. Craig		(Cambridge)
S. Bury		(Cambridge)
R.C. Courtney		(Cambridge)
T.R.E. Owen		(Cambridge)
P. Carter		(Cambridge)
K. Robertson		(R.V.S.)
E. Lawson		(R.V.S.)
J. Taylor		(R.V.S.)
A. Grave		(I.O.S.)
G. Lodge		(I.O.S.)
B. Woodley		(I.O.S.)
R. Phipps		(I.O.S.)
G. Alexander		(I.O.S.)

APPENDIX 4 : TABLE OF DAY NUMBERS

356/1983	22 December 1983
357	23 "
358	24 "
359	25 "
360	26 "
361	27 "
362	28 "
363	29 "
364	30 "
365	31 "
001/1984	1 January 1984
002	2 "
003	3 "
004	4 "
005	5 "
006	6 "
007	7 "
008	8 "
009	9 "
010	10 "
011	11 "
012	12 "
013	13 "
014	14 "
015	15 "
016	16 "
017	17 "
018	18 "
019	19 "

APPENDIX 5

Gravity Base stations

The La coste-Romberg gravity meter (No. 540*) was switched on just prior to cruise 142. It was linked to the British Hydrographic office base station No. MS6 on Mole 1 on 19.12.83

g	base station	978 468.2
g	aboard ship	978 468.34

The drift during cruise 142 was -0.021 mgal/day, which was considered by us to be minimal and hence no repeat base station connection was made prior to sailing on cruise 143.

At the end of cruise 143 a link was made to WHOI station No. 826 (chosen since this is recognized as being linked to the IGSN '71 network).

19.1.84	g	base station	978 467.33
	g	besides ship	978 467.38
	g	aboard ship	978 467.53

g 19.12.83 and 19.1.84 = - 0.81 mgal
drift = - .029 mgal/day

But Station MS6 lies geographically between WHOI station 843 and 826

g	826	978	467.33
g	MS6	978	468.2
g	843	978	467.38

It was noticed that station MS6 should perhaps have a value closer to 978 467.3 and may not therefore be a very accurate station.
This would have introduced an error of 0.9 mgal which would have the effect of reducing the drift to .007 mgal/day.

Other factors possibly affecting on board g accuracy

On 6.1.84 between 0454 - 0510 there was a power failure to the gravimeter. This was not recognised until ~ 0900 g values between 0900 and ~ 1200 are probably unreliable also a tare could possibly have been introduced here.

On 9.1.84 at ~ 1600 the main gyro was down for half an hour and subsequently a number of fairly rapid change-overs were made between the main and standby gyros, each with appropriate direction resets. This may have introduced errors into the eotvos calculations.

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* Said to be the best gravimeter produced by L-R, having a typically low drift rate.

The values used by the data logger are:-

g base 978 468.34 and zero draft rate
correspoding meter reading 6715.0

Recommended values for final correction are:-

g base 978 468.34
drift - .029 mgal/day

RVS Meter number S40
Meter calibration constant 0.9917

APPENDIX 6

Configuration of 2 section hydrophone - geomechanique/AMG

Tow cable	-	200 metres O.A.		
Spring	-	50 metres		
Weight	-	25 metre? 50 kg		
Spring	-	50 metres		
Depth	-	2 metres		
Active	-	50 metres	-	(1)
Neutral	-	50 metres		
Active	-	50 metres	-	(2)
Neutral	-	50 metres		
Tail Rope	-	100 metres		

Distribution

Dr B. Rule, NERC, Swindon
Dr L.M. Skinner, RVS, Barry
Dr S. White, NERC, Swindon
Dr J. Mather, NERC, Swindon
Dr E. Nickless, NERC, Swindon
Dr A.S. Laughton, I.O.S., Wormley
Dr I. Hill, Leicester
Cruise participants (19)
Cruise File
Dr R.S. White (6)

APPENDIX 7

Merge-Merge Geophysical Data Tape (24RSW1)

1600 bpi.

Cruise	Time Zone	Date	Time	Lat.	Long.	Depth Uncorr.	Depth Corr.	Carter's area	Mag. field	Mag. Anomaly	FAA
DISC/143/1	O	831223	022	15.1727	- 18.9220				32799	150	- 1
DISC/143/1	O	831223	024	15.1745	- 18.9268	3250	3252	21	32798	150	- 4
DISC/143/1	O	831223	026	15.1763	- 18.9916				32798	149	- 2
DISC/143/1	O	831223	028	15.1781	- 18.9364				32799	149	- 3
DISC/143/1	O	831223	030	15.1799	- 18.9413	3264	3266	21	32799	149	- 2
DISC/143/1	O	831223	032	15.1817	- 18.9461				32800	149	1
DISC/143/1	O	831223	034	15.1835	- 18.9509				32801	149	O
DISC/143/1	O	831223	036	15.1854	- 18.9557	3270	3272	21	32802	150	4
DISC/143/1	O	831223	038	15.1871	- 18.9605				32803	151	- 2
DISC/143/1	O	831223	040	15.1889	- 18.9653				32806	152	1
DISC/143/1	O	831223	042	15.1907	- 18.9701	3290	3292	21	32807	153	4
DISC/143/1	O	831223	044	15.1925	- 18.9747				32808	154	3
DISC/143/1	O	831223	046	15.1944	- 18.9797				32809	154	1
DISC/143/1	O	831223	048	15.1962	- 18.9845	3300	3303	21	32810	154	2
DISC/143/1	O	831223	050	15.1980	- 18.9892				32810	153	1
DISC/143/1	O	831223	052	15.1998	- 18.9940				32810	153	2
DISC/143/1	O	831223	054	15.2016	- 18.9988	3307	3310	21	32810	152	- 1
DISC/143/1	O	831223	056	15.2034	- 19.0035				32810	154	- 1
DISC/143/1	O	831223	058	15.2051	- 19.0083				32811	154	- 2
DISC/143/1	O	831223	100	15.2070	- 19.0131	3314	3317	21	32812	154	- 4
DISC/143/1	O	831223	102	15.2088	- 19.0179				32813	154	- 3
DISC/143/1	O	831223	104	15.2106	- 19.0227				32814	155	1
DISC/143/1	O	831223	106	15.2123	- 19.0275	3319	3322	21	32814	154	1
DISC/143/1	O	831223	108	15.2141	- 19.0323				32815	155	- 2
DISC/143/1	O	831223	110	15.2159	- 19.0371				32816	155	4
DISC/143/1	O	831223	112	15.2177	- 19.0419	3325	3328	21	32817	155	1
DISC/143/1	O	831223	114	15.2195	- 19.0467				32818	155	- 1
DISC/143/1	O	831223	116	15.2213	- 19.0514				32818	155	- 1
DISC/143/1	O	831223	118	15.2231	- 19.0563	3331	3334	21	32819	155	1

GRAVITY: uses base of 978 468.34 = 6715.0 on meter
zero drift rate

MAGNETICS: Corrected to IGRF 1980

BATHYMETRY: Digitised by hand at 6 min intervals and corrected to appropriate Carter areas

APPENDIX 8

Loss of Pinger on DISCOVERY 143

One RVS free-running 10 kHz pinger was lost on DISCOVERY 143 whilst heat-flow probing using the Cambridge probe on the main coring warp of DISCOVERY. The circumstances of the loss are as follows:

The pinger was attached 100 m above the heat flow probe. It was 80 m above the end of the main warp which was attached via a swivel to a 20 m pennant terminated by a second swivel attached at the bottom to the weight-stand of the heat flow probe. The loss occurred on the seventeenth, and final, deployment of the probe, an identical configuration having been successfully operated on the previous sixteen deployments.

The probe was lowered in 4200 m of water at 2033 Z on 16 January 1984. The pinger operated normally until the third penetration of the heat flow probe at 0010z/016. On pullout at 0021z/016 we noticed the pinger trace jump about 60 msecs late. At the time I assumed that this was due to a jump in the time-base within the pinger since we had seen its timing go unstable for a short period on previous occasions. The pinger continued to operate normally after the jump. In retrospect this jump was almost certainly due to the pinger sliding 80 m down the main warp until it stopped against the swivel. The clamps must have loosened as the wire tautened and then slackened on pullout.

The pinger continued to work normally until the eleventh penetration at 0546z/017, when the trace disappeared at the moment of penetration of the heat flow probe into the sediment. Since the pinger at this point was still 20 m above the seabed it either sprang loose as the weight of the probe (~1000 kg) was released and the warp rebounded elastically or it became entangled in a bight of wire and was pulled off on withdrawal of the heat flow probe.

A possible modification to reduce the possibility of this recurring would be to add a very short wire strop with a locking karabiner type clip on the end which loops around the warp. Then if the clamps loosen the pinger would slide down the warp but could only be pulled off the warp by breaking the strop or the karabiner clip.

Robert S. White
P.S.O. DISCOVERY 143
17 January 1984