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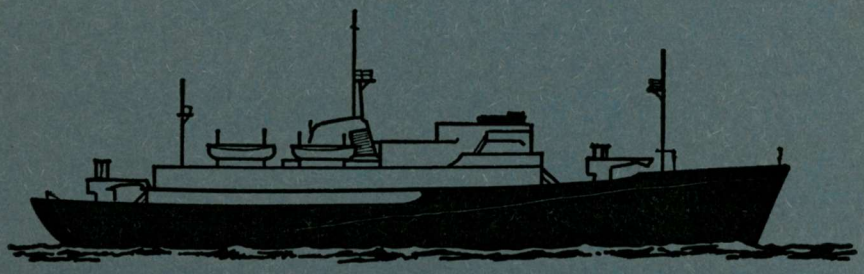

R. R. S. DISCOVERY

CRUISE 23 REPORT

JULY — AUGUST 1968

GEOPHYSICS IN AND AROUND THE BAY OF BISCAY

N. I. O. CRUISE REPORT No. 23
(Issued December 1968)

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DATES

Leave Plymouth	31st July 1968	Day 213
Return Plymouth	19th August 1968	Day 232

SCIENTIFIC PERSONNEL

Dr. A.S. Laughton (Principal Scientist)	National Institute of Oceanography
Dr. R.B. Whitmarsh	
Mr. D. Grohmann	
Mr. R.D. MacAlpine	
Mr. R. Graves	
Dr. D.H. Matthews	Dept. of Geodesy & Geophysics, Cambridge
Mr. G. Day	
Miss C.A. Williams	
Mr. M. Mason	
Mr. T. Vertue	
Mr. M. Bacon	
Mr. R. Theobald	
Mr. M.C. Tully	Institute of Geological Sciences
Mr. S. Jones	Research Vessel Unit, N.E.R.C.

SHIP'S OFFICERS

Mr. R.H.A. Davies	Master
Mr. G.L. Howe	Chief Officer
Mr. R.L. Lowe	Second Officer
Mr. H.M. Day	Third Officer
Mr. A.P. Ross-Murray	Radio Officer
Mr. N. Bothwell	Chief Engineer Officer
Mr. F. Jilla	Second Engineer Officer
Mr. M. Finnemore	Third Engineer Officer
Mr. I.H. Millineux	Fourth Engineer Officer
Mr. G.W. Davies	Junior Engineer Officer
Mr. B.L. Grant	Junior Engineer Officer
Mr. D. Bell	Electrical Officer

CRUISE INTENTIONS

The principal objective in this short cruise was the trial at sea and subsequent use of a new technique of seismic recording on the deep sea floor using pop-up methods. These experiments, using surface explosive charges, were combined with surface sonobuoy receivers using internal recorders and without radio links to the ship. The scientific aims of the seismic work were to detect reflections from the Moho using vertical and oblique incidence ray paths, and to make a series of crustal structure refraction stations across the continental margin north of the Bay of Biscay. The continental margin section was linked with gravity and seismic reflection profiles. Magnetic surveys west of the Bay of Biscay were planned to fit in the seismic development programme, to examine the transition between the magnetic trends in the Bay of Biscay and those further west which are parallel to the mid-Atlantic Ridge.

NARRATIVE

R.R.S. "Discovery" left Millbay docks at 0830 on 31st July (213) and headed WSW in calm seas towards the deep water beyond the continental shelf edge. For three days instrumental tests were made on the Pop Up Bottom Seismometer (PUBS) with tethered lowerings on the main warp, and with free floating tests on the surface for stability and radio beacon range. The first ten days of the cruise was notable for the exceptionally calm weather and absence of swell which greatly helped the trials. On 3rd August (216) a dan buoy with a radar transponder was laid in our first working area ($47\frac{1}{4}^{\circ}$N, $14\frac{3}{4}^{\circ}$W) and during the nights long magnetic survey runs in the vicinity of D/B I were made to build up a picture of the magnetic trends. Test layings of both single hydrophone sonobuoys and of the vertical array sonobuoy were made and shots fired.

The first "free fall" lay of PUBS was made on 5th August (218) which nearly proved disastrous due to a long delay in the release mechanism. It was recovered by good fortune on 7th August (220) and the release mechanism was subsequently redesigned. Meanwhile an attempt to find Moho reflections was made by firing charges in a circle around the vertical array buoy (Stations 6731 and 6732).

A second dan buoy (D/B 2) was laid on 8th August (221) after D/B I had been found adrift after interference by fishing boats in the vicinity. The radar transponder and other attachments had been stolen and grappling hooks were found still attached to the buoy. A short test seismic refraction line (Station 6733) was fired using a single

sonobuoy. A second successful free fall test of PUBS was made on 10th August (223) before we steamed sixty miles south to the southern end of what was intended to be a long refraction line. D/B III (and radar transponder) was laid and wide angle reflection experiment (Station 6735) was made using both a PUBS on the bottom and the vertical array buoy on the surface. Forty-four charges of 10 and 25 lb. were fired along a 20 mile line through the laying position. The line was subsequently profiled with the air gun (Station 6736). Set-backs in the testing programme of the cruise up to date resulted in having to curtail the first half of the programme and it was decided to leave this area and concentrate the remaining days on achieving a good reversed refraction profile at the foot of the continental slope in the Bay of Biscay. An effort was made to find and recover D/B II but this was unsuccessful due to poor weather, and so we steamed some 200 miles east into the Bay making zig-zags to improve magnetic coverage.

Dan Buoy IV (with transponder) was laid in position $46\frac{1}{2}^{\circ}$N, 10°W on 14th August (227) as an end point for the refraction line. A PUBS and two sonobuoys were laid and 82 shots ($2\frac{1}{4}$ tons) were fired from 10 miles west to 50 miles east of the laying position, this comprising one half of the reversed station (Station 6737). On recovery of the buoys, two seismic profiles of 120 miles were run across the continental rise (Station 6738), to study the structure of a ridge parallel to the shelf edge.

On 16th August (220), D/B V was laid at the eastern end of the reversed profile, followed by a PUBS, the vertical array buoy and one sonobuoy. Ninety shots ($2\frac{1}{4}$ tons) were fired from 10 miles east to 50 miles west of the laying position (Station 6739). Taken together, Stations 6737 and 6739 comprise a fully reversed refraction section with split profiles at either end to determine local structure and shots for vertical and wide angle reflections at each end. For the interpretation of seismic stations, velocimeter lowerings to 2000 m were made in the two areas worked.

On recovering all buoys a further seismic reflection profile (Station 6741) with the airgun was run across the continental rise and slope, and crossing, in particular, the Merriadzak Terrace. The ship returned to Plymouth on 19th August (232).

During the first half of the cruise, the weather was abnormally fine and calm. In the second half a steady force 5 to 6 NW-SW wind blew.

PROJECT REPORTS

Pop-Up Bottom Seismometers (PUBS)

Three PUBS were taken to sea on this cruise. They were new instruments, untried at sea, which recorded on magnetic tape and were housed in 28 inch diameter forged aluminium alloy spheres. The method of acoustic command used to initiate ballast shedding was that previously developed at N.I.O. for pop-up current meter strings.

The first week at sea was spent in doing pressure and acoustic command tests with the spheres at depths around 4500 metres, the PUBS being lowered in turn on the ship's main warp. A free fall test followed which indicated that the electrochemical method of ballast release took a very long time to operate and it had to be modified. This was done on board but even so ballast shedding could take up to four hours. A tendency for the sphere hydrophones, used to receive the acoustic command, to leak could not be rectified.

After a second successful free fall test, a variable angle profile and two 50 mile long refraction lines incorporating reflection profiles were shot using one PUBS on the sea-bed. This involved a total of 215 shots, all of which were recorded. The results obtained on this cruise will provide a good basis for assessing the usefulness of PUBS for both reflection and refraction work in the deep sea. In particular the reflection profiles were intended to show up reflections from the crust-mantle boundary.

A successful technique of launching, relocation and recovery of the PUBS has been developed. Fixes obtained from hydrophones towed astern of the ship while the PUBS rises to the surface enable the surfacing position to be located to within a cable. Five free fall drops of a PUBS were carried out on this cruise without a single loss. The instruments were dropped onto abyssal plains at depths of up to 4820 metres.

R.B.W.

Seismic Refraction

In this work new receiving equipment designed and built at Cambridge was used for the first time; this incorporated a four-channel FM tape-recording system and a crystal-controlled integrated circuit clock. In early trials of the system, much trouble was experienced in keeping the clocks in the buoys and on the ship in synchronisation, and Station 6733, which had been intended to test the

system on a full-scale seismic line, had to be abandoned after only a few shots as a result of trouble with the shipborne clock. Stations 6737 and 6739 form a single reversed profile; in each case shots were fired up to 10 miles from the buoys in one direction and 50 miles in the other, so that each station is itself a split profile. Unfortunately, owing to various instrumental difficulties, only short-range ground wave arrivals were seen at these stations, which do not therefore form the reversed pair intended.

M.B.

Wide Angle Seismic Reflection using the Array Buoy (A.B.)

An internally recording sonobuoy was used beneath which there was a vertical multiple hydrophone array designed to facilitate the enhancement of signals from a predetermined direction. An internal precision clock provided the timing scale. In one experiment to attempt to identify reflections from the Mohorovicic discontinuity, charges were fired in a circle of $\frac{1}{2}$ mile radius around the buoy and also in a line running past the buoy. Air gun profiles were run over the same line to provide near surface structural detail. The array buoy was also used in conjunction with other recorders in the seismic reflection/refraction lines. Analysis of records will be made in the laboratory.

Air Gun

A new modification of the air gun was tried in which the gun was fired by a H.P. solenoid valve. At the same time the low pressure line was dispensed with and the hollow centre of the piston sealed. This rig worked satisfactorily, although with a slight reduction in signal strength, but the low pressure chamber leaked and the L.P. line had to be restored. It was then operated with the L.P. line for a few hours until the solenoid shook loose from the valve. The gun was then re-rigged for free firing.

In order to improve the signal to noise ratio in the array, it was partially tapered, and towed from a long length of elastic cord made fast to the starboard echo sounding boom. It is difficult to assess the improvement this brought about but it was possible to see sub-bottom steaming at nine knots (full speed with two engines) into a rough sea.

Three lines were profiled across the gravity anomaly at 47°N, 9°W totalling some 135 miles. One line was run over the PUBS station and another parallel to the continental margin. A long line was profiled, starting in deep water, running up the Meriadzek Terrace onto the shelf,

providing a very good section. In all, approximately 260 miles were profiled.

G.A.D.

Gravity measurements

The gravimeter was operated on all passage and survey lines. Some instrumental problems were met when setting up the equipment, including a component failure in the platform and earth loops in the gravimeter which had to be removed before we could set up the cross-coupling computer. The motor alternator for the platform was found to produce an intolerable amount of electrical noise which made it impossible to see the PUBS pinger on the P.D.R. One pair of brushes was found to be improperly seated, but correcting this did not reduce the noise sufficiently and the platform was switched off when searching for the PUBS. While shooting the seismic lines the gyro was removed and the platform and gravimeter were lashed up to the deckhead.

The cross-coupling computer was continuously operated on the gravity lines, but the weather was so favourable that the error was never more than 3 mgals except for one period, (day 225-226) when 10 mgals was commonly indicated.

G.A.D.

Magnetic measurements

The magnetometer was towed along all passage tracks as a matter of routine. The tracks were chosen however to fill gaps in existing data.

Night ship steaming time was used in doing a magnetic survey centred around 47°N, 15°W. The object was to see whether the Biscay lineations, radiating from the corner of the Bay of Biscay, continued as far west as 15°W or whether, as suspected from current compiled data, oceanic lineations parallel to the M.A.R. were to be found at this longitude.

The location of the survey area was chosen partly to fit into the seismic programme of the cruise and partly to substantiate previous data.

Magnetic measurements were collected along 800 miles of track in the vicinity of D/B I and II. When plotted the results revealed a distinct lineation pattern trending NNW/SSE.

C.W.

Deck acceleration measurements during explosive firing

Three component accelerometers were used to monitor the movement of the deck in the electronics laboratory during the firing of explosive charges up to 300 lb., in order to assess any problems that might arise after the installation of the shipborne computer. The accelerometers were attached to a wooden block secured to the deck and the outputs recorded on the U/V recorder used to obtain shot instant information from the ship's geophone. Preliminary analysis of the records showed that accelerations were worst in the vertical but even for a 300 lb. charge at a depth of 200 ft. and 1,000 ft. astern, this did not exceed $\frac{1}{2}g$.

Radar Transponders

Two Decca-Alpine radar transponders were used on dan buoys I, III, IV and V, powered by 24 V80 Varley accumulators. One of these was stolen from D/B I. Only D/B I was used for the full battery life and this lasted for four days. However there was some doubt about the state of the accumulators before laying. This transponder gave a maximum range of 15 miles in very calm conditions.

D/B III, IV and V were laid for short periods only, and with well charged batteries, ranges of 24 to 28 miles were obtained in force 6 - 7 winds.

In conjunction with the newly fitted Decca RM 729 Interscan Radar, position fixing from the dan buoys within the working ranges was extremely satisfactory and the off tuning of the transponders allowed for good discrimination against clutter.

A.S.L.

DAN BUOY POSITIONS

	Laid	Recovered	Position	Remarks
D/B I (+ R.T.)	0930/216	1100/221	47°15.8'N 14°47.5'W	Fixed by 4 star fixes and 6 sun P/L's. Adrift when recovered, after interference by fishing boats. R.T. stolen.
D/B II	1320/221	lost	47°15.0'N 14°48.5'W	Fixed by 4 star fixes, 2 sun P/L's, relative position to moored pellets of D/B I and by topography.
D/B III (+ R.T.)	0800/224	1745/225	46°28'N 14°07'W	Fixed by 2 sun P/L's.
D/B IV (+ R.T.)	0600/227	0355/228	46°23'N 9°50'W	Fixed by 1 star fix.
D/B V (+ R.T.)	0700/229	1010/230	46°13.9'N 8°34.1'W	Fixed by 1 (v. good) star fix.

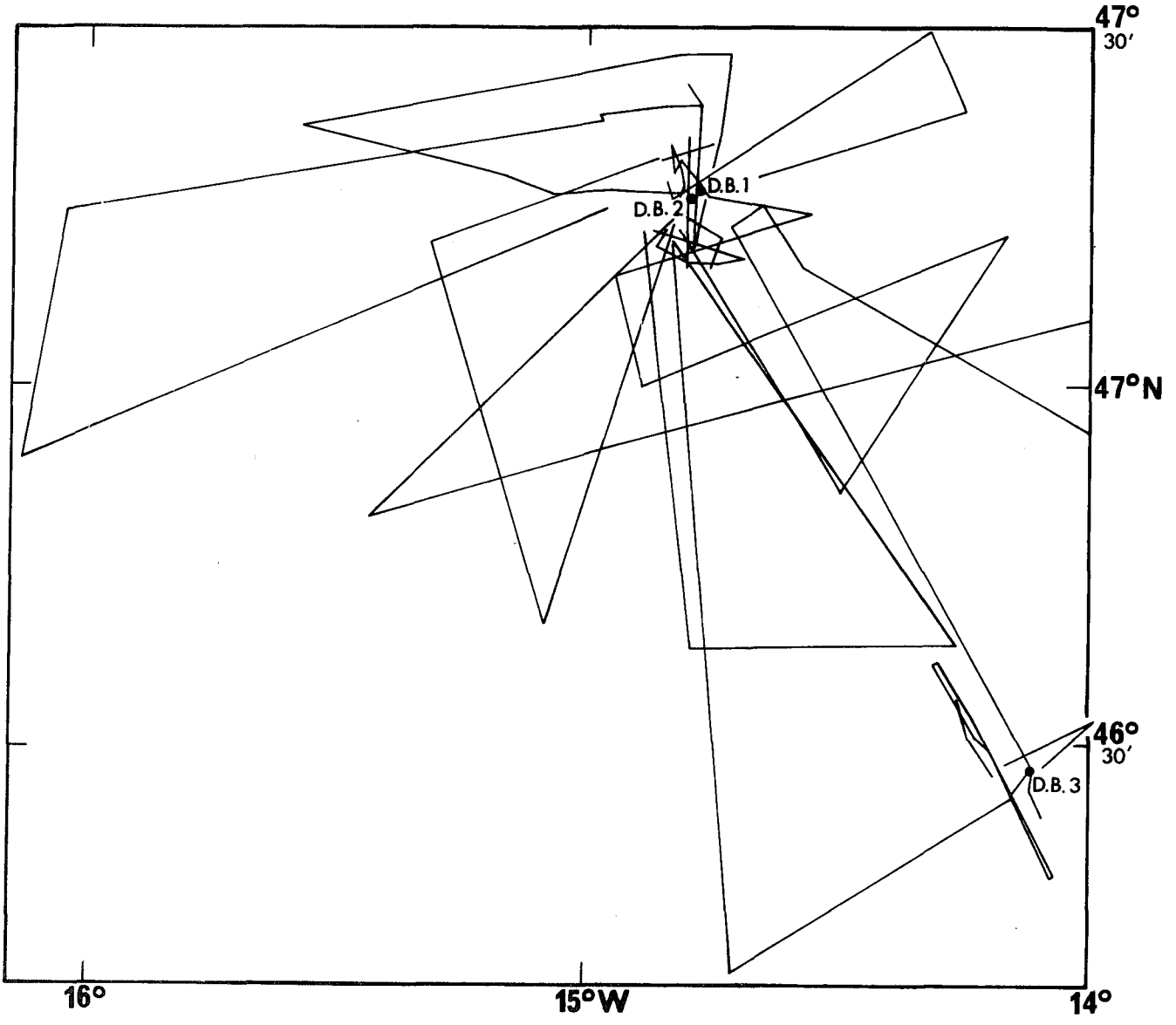
(R.T. = Radar Transponder)

STATION LIST

Station No.	Type	Equip.	Date	Time (GMT)/Day No. From	To	Lat. Long.	to	Lat. Long.	Depth range UCF to UCF		CF to CF		CM to CM		Comments
6731	S. Refl.	AB	7 Aug.	1123/220	1430/220	47°11.5'N 14°47'W		47°20'N 14°47'W	2540	2559	2620	2641	4791	4830	
6732	SRP	AG	7	1430/220	1700/220	47°11.5'N 14°47.5'W		47°22.5'N 14°47'W	2538	2560	2618	2641	4788	4830	11 miles of profile
6733	S. Refr.	SB	8	1400/221	1656/221	47°11.5'N 14°48.5'W		47°21.5'N 14°48.5'W	2534	2564	2613	2645	4779	4837	
6734	V	V	8	2130/221	2250/221	47°11'N 14°51.5'W			2550	-	-	-	4663	-	to 2000 m. depth
6735	S. Refl.	AB PUBS	11/12	1625/224	0830/225	46°37'N 14°19'W		46°19'N 14°04'W	2556	-	2637	-	4674	-	44 charges
	SRP	AG													
6736	SRP	AG	12	0900/225	1630/225	46°34'N 14°16.5'W		46°19.5'N 14°04'W	2556	-	2637	-	4674	-	17 miles of profile
6737	S. Refr.	SB PUBS	14/15	0718/227	0311/228	46°27'N 10°06'W		46°23'N 8°39'W	2492	2548	2573	2632	4705	4813	82 charges
6738	SRP	AG	15/16	0400/228	0540/229	46°35'N 9°40'W (via dog leg to N)		46°16'N 8°40'W	1914	2550	1968	2634	3599	4817	103 miles of profile
6739	S. Refr.	SB AB PUBS	16/17	0726/229	0938/230	46°15'N 8°17'W		46°22'N 9°44'W	2508	2546	2589	2630	4735	4810	90 charges
6740	V	V	17	1010/230	1142/230	46°14'N 8°35'W			2544	-	2628	-	4806	-	to 2000 m. depth
6741	SRP	AG	17	1342/230	1436/231	46°28'N 8°21'W (via two dog legs)		48°03'N 7°41'W	2504	108	2585	112	4727	205	150 miles of profile

S. Refl. Seismic Reflection
S. Refr. Seismic Refraction
SRP Seismic Reflection Profile
V Velocity measurement

AB Array Buoy
SB Sono Buoy
PUBS Pop Up Bottom Seismograph
V Velocimeter
AG Air Gun



Tracks in the vicinity of dan buoys 1,2 and 3

Fig. 2