RRS JOHN MURRAY

REPORT ON CRUISE 68/1

January-February 1968

Imperial College Geochemical and Geophysical Cruise

J.S.T.
May 1968

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Hand over to Dr Matthews	(End Cruise 1)	14.2.68

SCIENTIFIC PERSONNEL

Dr. J.S. Tooms
Mr. C.P. Summerhayes
Dr. G. Borley (5.1.68-29.1.68)
Mr. M. Humphreys (5.1.68-12.2.68)
Mr. B.H. Hazelhoff Roelfzema
Mr. E. Bosshard
Mr. W.N. Li (5.1.68-29.1.68)

SHIP'S OFFICERS

Capt. M.J. Perry	Master
Mr. J.E. Higham	Mate
Mr. P.H.P. Maw	2nd Officer
Mr. M. Humphreys (up till 29.1.68)	3rd Officer
Mr. G.M. Brown (from 29.1.68)	3rd Officer
Mr. M. Jobling	Chief Engineer
Mr. C.H. Lear	2nd Engineer
Mr. D.T. Williams	3rd Engineer
Mr. M.T. Williams	Bosun

CRUISE INTENTIONS

The major purposes of this cruise can be divided into two distinct parts; (a) reconnaissance geochemical/geological investigations of the N.W. African Shelf and (b) refraction seismic and other geophysical studies in the Canaries.

During a reconnaissance survey of the N.W. African Shelf it was hoped to obtain information on both the nature and structure of the sedimentary rocks and the composition of the unconsolidated sediments. Of particular interest was the possibility of phosphatic occurrences in this area. It was hoped to obtain confirmation of the existence of marine phosphates and to outline areas where more detailed investigations would be warranted in order to obtain an understanding of the environmental factors controlling phosphate formation.

Previous geophysical studies had been undertaken in the Canaries but little information was available on the northern extent of the sedimentary basin to the west of Lanzorote. It was hoped to investigate this feature whilst sailing from the shelf into Las Palmas and also to investigate the existence and location of a major fault separating Fuertaventure from Gran Canaria.

Refraction seismic crustal studies would, it was hoped, provide in particular information on the continental or oceanic character of Gran Canaria and the western Canary Islands.

NARRATIVE

Leg I Plymouth-Bilbao

The ship sailed from Plymouth in the evening of the 5th January. Wind strengths increased and during the night the ship changec course and ran before the wind to Tor Bay. The ship remained sheltering in Tor Bay till the morning of the 7th January. Strong to gale force winds were encountered after leaving the shelter of the land. The heavy seas caused aeration beneath the hull and it was not possible to obtain satisfactory PDR records. Because of the difficulties of carrying out any scientific work combined with the sea sickness of many of the ship's officers and scientists the scientific programme was suspended during this period. On the 9th January one of the engine blowers broke down and the ship was unable to make headway into the gale force winds of the Bay of Biscay. Course was altered, therefore, and the ship entered Bilbao harbour on the 10th January for repairs.

Custom difficulties prevented completion of repairs until the 18th January. Whilst in Bilbao setting up and trials of the EG&G continuous profiling equipment which had been delivered immediately before sailing from Plymouth (i.e. 7 weeks after the promised delivery date) were completed. Difficulties

encountered with this equipment have been traced to the ship's AC power supply. Because of this it was not possible to use the equipment at full capacity.

Leg II Bilbao-Las Palmas (Geochem.)

On sailing from Bilbao echo sounder watches were kept and the magnetometer was streamed on the 19th January. Various repairs including the construction of spare parts were required to the Grifft P.D.R. which subsequently operated very satisfactorily using a relatively simple programme. Strong winds were encountered after leaving Cape St. Vincent but seas had moderated when the ship arrived on the continental shelf off Rabat on the 22nd.

The delays in Bilbao caused modification of the programme. To obtain the minimum data necessary for the geochemical reconnaissance of the N.W. African Shelf, the original sampling programme was abandoned and sampling was restricted to seven traverses at widely spaced intervals across the shelf. The three traverses north of the Canaries were sited where the phosphate formations on land might outcrop. The other four traverses, to the south of the Canaries were in a geologically different and more stable environment. Each of the traverses crossed areas of differing sedimentation conditions. In addition, available information indicated the presence of glauconite off Cap Blanc and one traverse was programmed to determine whether phosphate was being deposited

in this locality.

On each traverse a continuous seismic profile was obtained prior to sampling. Unconsolidated sediments were collected along each traverse with grabs and corers. Dredge samples (pipe and chain dredge) were obtained where the sparker record indicated rock outcrops. A selection of samples were analysed on board for phosphate and radioactivity was determined. Due to the restricted time available no water samples were collected and only a few photographic stations were completed.

Some 60 miles off Casablanca tests of the pressure casing of the UKAERE scintollometer demonstrated that it was unsuitable; the casing imploded. Radioactive measurements were made during the rest of the cruise on samples. The winch clutch slipped out of gear for the first time during these trials. During the rest of the cruise this winch trouble was encountered periodically, often when samples were at surface.

On the Casablanca traverse (Traverse 1) continuous seismic profiling was carried out on the run inshore together with some core sampling and a camera station. Dredging of outcrops was undertaken on the basis of the profiling data on a reverse traverse. In all other areas, except the last traverse VII, the profiling traverse was commenced from inshore and sampling was carried out on a reverse traverse enabling two good fixes to be obtained.

Between each traverse a magnetometer record was obtained.

The first three; northern; traverses were commenced and completed as follows:-

Leg II	Commenced	Completed
Traverse I (Casablanca)	1300/22.1.68	2300/23.1.68
Traverse II (Cap Blanc du Nord)	0730/24.1.68	1430/25.1.68
Traverse III (Cap Sim)	0400/26.1.68	1730/27.1.68

On the 27th January $7\frac{1}{2}$ hours (0130-0910) were lost due to force 8 gales necessitating moving for shelter and engine room difficulties. In practice it was later demonstrated that work could continue in force 8 winds as long as the ship was head to wind on station.

Along the three traverses the following samples were collected.

Leg II	Sediments	Rocks	Camera Station
Traverse I	11	-	6
Traverse II	16	5	
Traverse III	12	8	

The course from Cap Sim to Las Palmas was planned to pass over the Conception Bank fishing grounds. Three unsuccessful attempts were made on the morning of the 28th January to dredge samples from this bank. The final attempt resulted in the dredge being snagged and lost.

To supplement data obtained by the Meteor, speed was decreased and the sparker streamed on approaching Lanzarote and a continuous seismic profile traverse run to Las Palmas. This was interrupted on the bank, between Gran Canaria and Fuerteventure for a dredge station. Although the depth was less than 20 fm. the station took 1½ hours due to snagging of the dredge. The pipe dredge was lost but the chain dredge was recovered full of echinoides and three small pebbles.

Leg III Las Palmas-Las Palmas (Geophysical)

Las Palmas was entered on schedule at 1020 on 29th January. However, the agent had read and misinterpretted a cable sent to Dr Dash and no berth had been arranged nor labour organised for leading explosives. Sailing was delayed therefore from the night of the 29th to 1100 hours on the 30th. This caused difficulties as it was not possible to raise the land party on Teneriffe by radio from Las Palmas due to the high ground round the harbour.

During this first geophysical leg a refraction seismic profile was run from Gran Canaria to Teneriffe and from Teneriffe to Palma. Some time was lost due to difficulties in communications and with the firing equipment. Furthermore, when the first charge of 150 lb. was fired the shock wave caused various switches to throw and the ship's compass jumped off its bearing. Following this experience charges did not exceed 100 lb. A total of 31 shots were fired during this leg.

Prior to this leg the Cambridge gravimeter had been off loaded with its batteries to avoid risks of damage during explostions; no proper slings being available on board. There is little doubt that if the gravimeter had been on board damage would have been incurred during this leg.

Leg IV Las Palmas-C. Blanco-Las Palmas (Geochem.)

On returning to Las Palmas at 1400/2.2.68 delays were again encountered and the ship did not sail until 1840 hours. Once more it was not possible to inform land parties on Pt^{a} Tenefe, Gran Canaria that the ship was delayed. On reaching Pt^{a} Tenefe the land party could not be contacted. Whilst attempting to make contact a sparker traverse was run east from Gran Canaria. No contact having been made by morning course was set for Cape Blanco at 0910/3.2.68.

On moving south the trade wind strength gradually increased and the sparker traverse in the Cap Blanco was completed in force 7 winds. Wind strengths up to force 8 were encountered during the Cap Blanco sampling traverse but after the 6.2.68 the wind strengths gradually decreased.

As the ship's course between traverse IV (Cap Blanco), traverse V (Pt^{a} Burnford) and traverse VI (C. Bojador) was close inshore, continuous scientific watches were not kept and the magnetometer was not streamed. This enabled the scientists to

obtain maximum rest between periods of intensive work and to remain reasonably fresh for the final geophysical leg when explosives were being handled.

Between traverse VI (C. Bajador) and traverse VII (C. Yubi) both magnetometer and sparker were streamed although full speed was being made.

The Cap Yubi sampling traverse was completed at 1500 hrs/ 11.2.68. Each of the four traverses had been covered by a sparker survey and the following samples collected.

Leg IV	Commenced	Completed
Traverse IV (C. Blanc)	0510/5.2.68	0610/6.2.68
Traverse V (Pt^{a} Durnford)	0430/7.2.68	0400/8.2.68
Traverse VI (C. Bajador)	0130/9.2.68	2330/9.2.68
Traverse VII (C. Yubi)	1600/10.2.68	1600/11.2.68

Leg IV	Rock Samples	Sediment Samples	Camera Station
Traverse IV (C. Blanc)	2	11	
Traverse V (Pt^{a} Durnford)	4	15	1
Traverse VI (C. Bajador)	8	13	1
Traverse VII (C. Yubi)	2	20	

The sparker was streamed on completion of traverse VII and course was set to Las Palmas. The ship's course was through the passage between Fuertenventure and Lanzorote and continued to the

west into deeper water before turning towards Las Palmas. This traverse, therefore, provided supplementary data to that obtained on the original run into Las Palmas.

Leg V Las Palmas-Las Palmas (Geophysical)

Only 3½ hours were spent in Las Palmas (0730 to 1100 hrs/ 12.2.68) before sailing for the second refraction seismic leg. During this leg a traverse was completed from Teneriffe to a point south east of Hierro. Difficulties in communications and in the firing gear were again encountered. However, 26 charges were fired. By varying the procedure it was found possible to use 150 lb charges suspended at fixed depths beneath the surface. The traverse was completed at 2310/13.2.68 and course set for Las Palmas. On arrival at Las Palmas on the 14th the ship was handed over to the Cambridge scientific party under Dr Matthews.

It should be emphasised that the success of this cruise was due in large part to the assistance and cooperation of the ship's officers and crew. In particular, they volunteered to forego their shore leaves in port. Considering the tiring motion of the ship and the high noise level, especially when winches were being used, this was a considerable sacrifice.

PROJECT REPORTS

1. Continuous Seismic Profiling

(a) EG&G Equipment: The whole sparker equipment had newly arrived at Plymouth and had to be set up and tested on board the John Murray before it was operative.

The equipment consisted of four 8000 joules EG&G sparker systems with one helix recorder and one Array Hydrophone.

Numberous troubles were encountered when setting up the system. The lack of technical advice by EG&G proved a disadvantage because the manuals provided were radically out of date. The most serious trouble we faced at this stage was the fact that John Murray's AC generator rating was not adequate. At the most an 8000 joules operation could be continuously maintained instead of a possible 32000joules. This problem could be solved by installing an additional AC generator or replacing the present one by a Diesel-driven assembly.

Once in operation the Sparker gave highly satisfactory results. The noise generated on the hydrophone could be reduced by attaching a weight onto the towing cable and records could be made at up to 10 knots speed. The normal cruising speed for profiling however had to be kept between 6 and 7 knots to improve the signal to noise ratio. Considering that much of the time

only 3500 joules were used the quality of the records is remarkable. It is estimated that a penetration of up to 2.0 seconds could have been obtained if the system had been working at full energy.

The four transducers had been screwed together to facilitate the handling. This arrangement caused some problems in very shallow water as the impulses from the different arrays lengthened the overall pulse. This difficulty was overcome by firing only one unit until the depth of the sea allowed the simultaneous use of the four.

The hydrophone being of the Array type provided optionally a summed output or individual outputs. Its full length of source, 150 ft, with 9 active elements could only be used in deep sea. The length of the towing cable had to be reduced and only one active element used in shallow water in order to record near vertical angle reflections. The arrangement of having the array batteries attached to the hydrophone seemed to be very impractical. These dry cells lasted only about three days and the current was drained continuously once they were installed. The small screws which attached the battery housing to the towing cable were too fragile to stand up to frequent unscrewing and tightening. To avoid any damage the battery housing was then omitted and the DC-voltage supplied by the shipboard electronics was used quite successfully to operate the preamplifiers without noticeable change in the noise level.

The detectable penetration was mainly dependent on the ship's speed. The higher the speed, the noisier the record and this limited the feasible top speed to 8 knots. At speeds above 8 knots the record became very noisy and its quality poor.

In very shallow water the detectable penetration was limited to the multiples of the bottom reflection resulting in undesirable reverberations covering most of the useful part of the record.

It was a major disadvantage that the recorder had no centre trigger. At the present stage the scale had to be changed as soon as the detectable penetration got near the lower boundary of the recording paper. The profile was then split up into parts being recorded on different scales which could not be stuck together to provide a continuous picture. It would be very easy to modify the present instrument by adding a second light source 180 degrees shifted from the present one. A change-over switch would provide the required "edge" or "centre" operation of the triggering circuit. We strongly recommend that this modification be done as soon as possible.

(b) Continental shelf programme: All traverses of geochemical interest across the continental shelf were profiled with the Sparker equipment prior to the geochemical/geological investigation. The following is a summary of these traverses:

depth of water	detectable penetration	speed	energy	sea state
Traverse 1 23/1/68 off C. de Fedala				
0-200 m	50-260 mi/sec	6 kts	3500	moderate
200-750 m	≤500 "		joules	
Traverse 2 24/1/68 Cap Blanc du Nord				
0-200 m	100-260 mi/sec	6½-7	3500	calm
200-750 m	≤700 "	kts	joules	
750-1200 m	700-250 "			
Traverse 3 26/1/68 Cap Sim				
0-200 m	80-260 mi/sec	6½-7	3500	moderate
200-750 m	≤600 "	kts	joules	to
750-1200 m	700-250 "			rough
Traverse 4 5/2/68 Cap Blanc du Sud				
0-200 m	100-250 mi/sec	6 kts	1200 joules	heavy sea, heavy
200-750 m	≤450 "		3500	rolling and
750-1600 m	600-350 "		joules	pitching
Traverse 5 7/2/68 Pt[a] Durnford (Villa Cisneros)				
0-200 m	50-400 mi/sec	7-7½ kts	1200 joules	moderate
200-750 m	≤665 "		3500	
750-900 m	580-500 "		joules	
Traverse 6 9/2/68 Cap Bojador				
0-200 m	260 mi/sec	7½-8 kts	1200 joules	moderate
200-750 m	≤595 "		3500	
750-1450 m	480-200 "		joules	
Connecting profile Cap Bojador to Cap Yubi - Traverse				
0-200 m	65-600 mi/sec	10½ kts	1200 joules	moderate to
200-750 m	725-575 "		3500 joules	calm
700-1100 m	480-760 "		8000	
1100-1800 m	≤400 "		joules	

depth of water	detectable penetration	speed	energy	sea state
Traverse 7 10/2/68 Cap Yubi				
0-200 m	75-150 mi/sec	7½-8 kts	1200 joules	moderate
200-750	≤550 "		3500-8000	to
750-1250 m	510-550 "		joules	calm

(c) Canaries Region: As many Sparker profiles were recorded as the time and the refraction work allowed. The following is the summary of these profiles.

Lanzarote-Las Palmas 28/1/68-29/1/68

Along Lanzarote no penetration. West of Fuerteventure a penetration of 200 mi/sec. Between Pta Colorada (Fuerteventure) and Las Palmas no penetration.

Tenerife-Gomera 1/2/68 Station 183

No penetration.

Pta Montana Roja (Tenerife) - La Isleta (Gran Canaria) 2/2/68 Station 215

No penetration.

West of Pta Tenefe (Gran Canaria) 3/2/68 Station 216

Penetration at a water depth of 1800 m 400 mi/sec.

Cap Yubi Traverse - Las Palmas 11/2/-12/2/68 Station

West of Lanarote-Fuerteventure:

0-200 m	no penetration	8-10 kts	1200-8000	moderate
200-750 m	750 mi/sec		joules	sea
750-1300 m	630 mi/sec			

East of Lanzarote-Fuerteventure:

0-200 m	no penetration	8-10 kts	1200-8000 joules	moderate
200-750 m	no penetration			
750-2200 m	no penetration			
2200-3300 m	430 mi/sec			

2. Geology and Geochemistry

Structurally there is a marked difference between the shelf north of the Canaries and that to the south. In the north there has obviously been considerable recent tectonic activity. The sedimentary rocks have been extensively faulted and there is commonly minor folding of the rocks. To the south of the Canaries the area is structurally much less interesting; the beds being little folded or faulted.

Immediately off the shelf on the C. Yubi traverse a minor seamount was crossed. This seamount extended above the level of the adjacent shelf. No obvious structures were detected on the seismic profiling record and no samples were obtained by dredging.

Sampling: The following types of sampling stations were completed.

	No. of stations							
Traverse	I	II	III	IV	V	VI	VII	Total
Dredge	4	5	8	4	5	10	7	43
Grab	7	11	7	8	7	3	9	51
Gravity Corer	-	1	1	1	3	2	4	12
Boomerang Corer	4	4						8

All but two of the dredge stations were combined pipe and chain dredge stations. Grab stations were operated at the same time as gravity corer (and camera) stations by using the grab as a trigger. The grab operated extremely well in shallow water but at depth greater than 100 fms. samples tended to wash out.

The boomerang corers did not operate very satisfactorily on the shelf, no doubt due to too little reaction weight. Better results were obtained; except in areas of shell sand; with the gravity corer and the additional time required was small. Accordingly, most coring was with the gravity corer.

Rock Samples: Most of the rock outcrops sampled on the shelf north of the Canaries consisted of limestone or conglomeratic phosphatic rock. Outcrops at the edge of the shelf on the slope were argillaceous; normally consisting of multicoloured clay.

To the south most outcrops consisted of shell beds.

Sediment Samples: On traverses I to III the inshore sediments consisted of sand which in some cases contained glauconite. Further offshore the sediments consisted of mud. By contrast in the south (traverses IV-VI) the shelf is more or less continuously covered with shell sand. In the deeper water globigerina muds are encountered.

P_2O_5 Analyses: Because of the difficulty of weighing on board, aliquots of samples were 'weighed' volumetrically and the phosphate content determined colorimetrically. This procedure gave only very

approximate results but demonstrated that this method could be employed to guide the sampling programme.

67 samples were analysed of which 4 sediments and 7 rocks contained more than 1% P_2O_5. There appeared to be a close relationship between the outcrop of the phosphate rich rocks and the phosphate rich sediments.

Radiometric Analyses: Radiometric analyses on board were highly encouraging regarding the use of this procedure to control bottom sampling. The phosphate rich samples gave counts up to 15 times greater than the norm.

3. Refraction Programme

Two long lines across the western part of the Canary Archipelago were shot using John Murray as the shooting vessel. The method used to detonate the explosives was the conventional electrical shotfiring method with exploder on board and a firing line to the detonator in the charge.

The charges were prepared at the stern of the special table and thrown over board. The delay till firing depended on charge size and ship's speed, which was normally 5 knots, and amounted to between 60 and 120 seconds. The charge size varied between 25 lb and 150 lb. The first 150 lb charge blew off the steering motor, all engine room breakers fell and the gyrocompass was made inoperative. In consequence the charge size was limited

to 75-100 lb. Even with such limited charges the bottom reflection of these shots sometimes blew off the steering gear and the gyro-motor of the compass. Later a further attempt was made to fire bigger charges by suspending them some 100 metres below the surface. Using this method charges up to 150 lb were shot without any detriment to the ship's instruments. However, the procedure proved to be too time consuming and was in consequence abandoned.

The locations of the shotpoints were determined with the DECCA-Radar and Plotter which proved to be an excellent instrument.

In total 4450 lb of "Geoplex" were used in four shooting days. No incident whatsoever was encountered during the shooting and this shows that the method used was very safe. The only major disadvantage for electrical shotfiring from John Murray was the lack of a fast winch. The capstan as it was used to reel the cable in and out did not permit a shot to be fired more than once every 12 minutes and limited the ship's speed to 4 knots if a narrow spacing of shots was desired. For this type of work near the recording station, where a fast sequence of shots is needed, it is imperative to have a winch and cable which would permit between shots to be not more than 5-6 minutes. The cruising speed of the shooting vessel then could be increased to 8-9 knots.

The following is a summary of the refraction shooting:

Line E stations 164-176

Location: $270^{\circ}57\frac{1}{2}'N/16^{\circ}02\frac{1}{2}'W$ - $28^{\circ}04'N/16^{\circ}21\frac{1}{2}'W$

Explosives: 700 lb used

Line F stations 177-204

Location: $28^{\circ}13'N/16^{\circ}57'W$ - $28^{\circ}28'N/17^{\circ}48\frac{1}{2}'W$

Explosives: 1125 lb used

Line G stations 205-213

Location: $28^{\circ}29\frac{1}{2}'N/17^{\circ}54'W$ - $28^{\circ}01'N/18^{\circ}02'W$

Explosives: 225 lb used

Line H stations 288-315

Location: $28^{\circ}08\frac{1}{2}'N/16^{\circ}54'W$ - $27^{\circ}37'N/18^{\circ}11\frac{1}{2}'W$

Explosives: 2400 lb used

4. Gravimeter and Magnetics

The Cambridge University had kindly lent us their sea gravimeter. It was understood that it would be installed and made operative on board the John Murray prior to our sailing. Unfortunately, this was not the case. The gravimeter was brought on board and installed onto the platform only two hours before sailing. It was therefore not possible to run up the gyro and obtain a reasonable gravimeter record prior to the departure. It was considered that a gravimeter record with only one base station at the end of the profile (and hence no information about drift and the behaviour of the instrument) would be of little value. In consequence the gravimeter was not used. In Las Palmas the gravimeter was landed and the gyro dismounted from the platform to avoid any possible damage by the shockwaves of the refraction shooting.

The magnetometer was in operation along the Spanish and Portuguese coast until we reached Casablanca and on some lines in the Canaries region. The instrument worked satisfactorily. Few troubles were encountered with the ink flow to the pen of the analog recorder. The phase lode did not work in every cycle but nevertheless the records were of good quality.

It was interesting to study the behaviour of the magnetometer when in simultaneous operation with the sparker. As long as the energy at the transducer was small the magnetic record was of average quality with periodic disturbances. When we increased the power output of the sparker the record became useless due to erratic readings of up to $\pm 500\,\gamma$. In consequence, it was necessary to choose the most suitable geophysical method to be used on a given profile.

Station No.	Type	Date	Time GMT from	To	Lat N & to Lat N	Long W & Long W	Depth Range UCF	CF	Comment
107	PM	19.1.68 21.1.68	1550	 1300	43°49', 37°11.5'	08°23.5' 09°34'	34 1130	35 1160	
TRAVERSE I (Cap de Fedala)									
108	CSP/RAC	22.1.68	1326	1615	34°25' 34°21'	07°42' 07°40'	990- 495	1018- 509	Empty counter pressure casing imploded. One hydrophone failed.
109	UC	22.1.68	1620	1650	34°21'	07°40'	490	504	Camera trials.
110	BC/ (CSP)	22.1.68	2140	2305 (2225)	34°18' 34°15'	07°34' 07°33'	360 260	371 268	One out of 4 corers lost. Good seismic profiling record.
111	UC/G	23.1.68	0001	0100	34°08.0'	07°35.5'	194	200	Mud.
112	RD/PD	"	0130	0220	34°05.0' 34°04.5'	07°33.0' 07°33.6'	96 78	99 81	Large mud sample.
113	UC/G	23.1.68	0300	0328	34°00.7'	07°32'	70	72	Mud.
114	UC/G	23.1.68	0400	0433	33°57'	07°30.5'	63	65	Mud.
115	UC/G	"	0505	0530	33°52.3'	07°29.8'	60	62	Mud.
116	UC/G	"	0550	0620	33°50.2'	07°28'	48	50	Mud.
117	UC/G	"	0650	0718	33°46.2'	07°25.7'	34	35	Silty mud.
118	G	"	0750	0805	33°43.4'	07°23'	18	19	Fine sand and coral.
118a	CSP	"	0825	1535	33°44.5' 34°29'	07°24.3' 07°44'	19-858 643	20-882 660	

Station No.	Type	Date	Time GMT from	to	Lat N & Long W	to Lat N / Long W	Depth Range UCF	CF	Comment
119	RD/PD	23.1.68	1618	1748	34°27'	07°43'	733	753	Mud in PD
					34°26.8'	07°42.9'	680	698	
120	RD/PD	"	1827	2026	34°16.5'	07°42.5'	745	765	Mud (sticky) in PD
					34°16.2'	07°42.4'	668	686	Cal. Mudst. in RD
121	RD/PD	"	2148	2300	34°13'	07°31.5'	290	298	Mud in PD
					34°12.5'	07°31.3'	230	237	Coral in RD
122	PM	"	2310		34°13'	07°31'	228	235	
		24.1.68		0730	33°11'	08°36.5'	14	14	
TRAVERSE II (C. Blanc du Nord)									
123	CSP	24.1.68	0744	1525	33°10'	08°38.3'	15	15	
					33°27'	09°39.5'	1870	1923	
124	UC/G	"	1630	1940	33°26'	09°39.5'	1760	1811	Grab did not trigger. Strong currents.
125	RD/PD	"	2000	2132	33°20'	09°32'			
					33°20'	09°31.5'	730	750	Mud in both RD and PD
							664	682	
126	RD/PD	"	2319		33°21.2'	09°26.4'			
		25.1.68		0050	33°21.0'	09°25.8'	485	499	Mud in RD.
							402	414	Coral in PD.
127	RD/PD	"	0148	0252	33°17.5'	09°17.2'	382	393	Sticky mud.
					33°17.4'	09°16.8'	380	391	
128	BC	25.1.68	0329	0437	33°16.5'	09°09'	187	193	2 out of 4 corers recovered
					33°15.9'	09°07'	152	157	

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N	Long W & to Long W	Depth Range UCF	CF	Comments
129	G	25.1.68	0445	0535	33°16.5'	09°09.5'	201	207	Brown fine sand.
130	G	"	0549	0602	33°17.5'	09°08'	169	174	Misfired.
131	G	"	0617	0626	33°15.5'	09°06'	127	131	Misfired.
132	G	"	0645	0652	33°15.7'	09°03'	93	96	Misfired.
133	GC/G	"	0700	0848	33°15'	09°01.5'	88	91	Fine sand and shell in grab. ½ ft. core.
134	G	"	0943	0955	33°15'	08°59.9'	73	76	Sand
135	G	"	1031	1040	33°13.5'	08°53'	60	62	Cobble and shells.
136	RD/PD	"	1105	1130	33°12.8 33°12.5'	08°52'. 08°51.3'	61 60	63 62	Phosphorite and shell limestone in RD. PD empty.
137	G	"	1200	1205	33°12.4'	08°49.5'	61	63	Muddy sand.
138	G	"	1220	1230	33°11.1'	08°46.3'	58	60	Mud and fine sand.
139	RD/PD	"	1240	1317	33°10.5' 33°10'	08°44' 08°43.5'	40 41	41 42	Shells and phosphate pebbles.
140	G	"	1400	1407	33°08.8'	08°39.3'	26	27	Muddy fine sand.
141	G	"	1435	1440	33°08.3'	08°36.5'	10	10	Fine sand.
TRAVERSE III (C. Sim)									
142	CSP	26.1.68	0400	1135	31°24' 31°18.5'	09°54.3' 10°49.5'	15 540	15 555	
143	GC/G	"	1205	1323	31°18'	10°48.6'	510	525	7' core. Grab empty.
144	RD/PD	"	1435	1537	31°18.3' 31°18.3'	10°40.7' 10°40'	385 373	397 395	Mud in pipe. Rock dredge empty.

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N	Long W & to Long W	Depth Range UCF	CF	Comments
145	G	26.1.68	1603	1623	31°17.8'	10°36.2'	330	340	Sand
146	G	"	1648	1706	31°17.5'	10°32.5'	304	313	Black sand.
147	G	"	1730	1741	31°17.6'	10°29.2'	285	294	Black sand
148	RD/PD	"	1808	2033	31°17.3' 31°17.8'	10°25.3' 10°24.8'	256 258	263 266	Conglomeratic phosphorite. Pipe bottom out.
149	G	27.1.68	0800	0910	31°22.8'	09°48.8'	7	7	Coral and sand.
150	G	"	1000	1006	31°22.5'	09°57.5'	45	46	Mud
151	RD/PD	"	1050	1120	31°22.7' 31°22.9'	10°02.3' 10°01.8'	66 68	67 70	Limestone and black sand.
152	RD/PD	"	1133	1202	31°21.7' 31°21.8'	10°05.2' 10°04.7'	70 72	72 74	Conglomeratic phosphorite.
153	G	"	1225	1245	31°21.3'	10°08.5'	70	72	Sand, mud and shells.
154	RD/PD	"	1335	1415	31°20.8' 31°20.8'	10°17' 10°16.5'	218 180	225 186	Conglomeratic phosphorite and glauconitic sandy mud.
155	RD/PD	"	1435	1528	31°19.5' 31°19.8'	10°19.7' 10°18.9'	254 230	261 237	Glauconitic mud and limestone.
156	RD/PD	"	1555	1640	31°19.8' 31°19.9'	10°23.8' 10°23.2'	308 222	317 229	Phosphatic limestone.
157	RD/PD	"	1650	1712	31°19.8' 31°19.9'	10°25' 10°24.3'	175 157	180 182	Phosphatic limestone.

Station No.	Type	Date	Time GMT from	to	Lat N & Long W	to	Depth Range UCF	CF	Comments
					Lat N	Long W			
Conception Bank									
158	RD	28.1.68	0912	0942	29°57'	12°43'	17	100	Dredge empty.
					29°58.5'	12°42'	104	107	
159	RD	"	1015	1050	29°59'	12°41.3'	94	97	Dredge empty.
					30°00'	12°42.1'	95	98	
160	RD	"	1133	1217	29°55'	12°46.5'	150	155	Dredge lost.
					29°54.5'	12°46'	165	170	
Ianzorote-Las Palmas									
161	CSP	"	1740		29°28.5'	13°27'	300	309	Magnetometer also streamed throughout.
		29.1.68		0310	28°16.5'	14°38.5'	448	461	
163	CSP	"	0520	1000	28°13.5'	14°42.5'	23	41	
					28°08'	15°19'	1110	1139	
162	RD	"	0345	0504	28°14'	14°11.5'	40	41	3 volcanic pebbles.
					28°14.5'	14°10.8'	18	19	
Leg III (Las Palmas-Las Palmas: Geophysics)									
164	RS	31.1.68	0909		27°57.5'	16°02.75'	1034	1062	
165	RS	"	0931		27°57.5'	16°04.5'	1056	1084	
166	RS	"	0959		27°57.5'	16°08.0'	1332	1366	
167	RS	"	1048		28°00.5'	16°10.5'	1465	1506	
168	RS	"	1115		28°00'	16°13.25'	1276	1310	
169	RS	"	1136		28°00.5'	16°14.5'	1288	1322	

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N &	Long W to Long W	Depth Range UCF	CF	Comments
170	RS	31.1.68	1154		28°00.75'	16°16.25'	1220	1254	
171	RS	"	1212		28°01.25'	16°17.25'	1170	1202	
172	RS	"	1228		28°02.00'	16°18.25'	1158	1189	
173	RS	"	1243		28°02.5'	16°19.0'	1135	1166	
174	RS	"	1258		28°03.0'	16°19.75'	1061	1088	
175	RS	"	1310		28°03.5'	16°20.75'	982	1009	
176	RS	"	1323		28°04.0'	16°21.5'	946	971	
177	RS	"	1735		28°13'	16°56.75'	540	555	
178	RS	"	1807		28°13.25'	16°59.25'	377	388	
179	RS	"	1820		28°13.5'	17°00'	342	352	
180	RS	"	1834		28°13.75'	17°00.75'	302	311	
181	RS	"	1850		28°14.25'	17°01.75'	250	258	
182	RS	"	1905		28°14.5'	17°02.75'	278	286	
184	RS	1.2.68	0912		28°14.5'	17°04.5'	142	146	
185	RS	"	0929		28°15.25'	17°05.75'	148	152	
186	RS	"	0944		28°15.75'	17°07.00'	260	268	
187	RS	"	1001		28°16.0'	17°08.5'	245	252	
188	RS	"	1015		28°17.25'	17°10.5'	272	280	
189	RS	"	1032		28°18.75'	17°12.5'	222	229	
190	RS	"	1308		28°23'	17°20.25'	1188	1221	
191	RS	"	1337		28°24'	17°22.75'	1324	1359	

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N &	Long W to Long W	Depth Range UCF	CF	Comments
192	RS	1.2.68	1558		28°23.75'	17°35.0'	1388	1428	
193	RS	"	1611		28°24'	17°36.25'	1366	1403	
194	RS	"	1623		28°24.25'	17°37.0'	1354	1391	
195	RS	"	1635		28°24.5'	17°38.25'	1330	1365	
196	RS	"	1652		28°25.25'	17°39.25'	1286	1320	
197	RS	"	1705		28°25.75'	17°40.5'	1250	1284	
198	RS	"	1716		28°26'	17°41.25'	1232	1265	
199	RS	"	1728		28°26.25	17°42.25'	1188	1221	
200	RS	"	1739		28°26.75'	17°43.5'	1150	1181	
201	RS	"	1750		28°27.25'	17°44.5'	1060	1089	
202	RS	"	1800		28°27.5'	17°45.75'	915	940	
203	RS	"	1811		28°27.75'	17°46.75'	796	818	
204	RS	"	1826		28°28'	17°48.75'	470	483	
205	RS	"	1913		28°29.5'	17°53.25'	608	625	
206	RS	"	1924		28°30.0'	17°55.5'	782	804	
207	RS	"	1935		28°30.25'	17°56.25'	841	864	
208	RS	"	1946		28°30.25'	17°57.25'	843	866	
209	RS	"	1956		28°30.5'	17°58'	828	871	
210	RS	"	2005		28°30.5'	17°59'	830	853	

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N	Long W & to Long W	Depth Range UCF	CF	Comments
211	RS	1.2.68	2011		28°30.75'	18°00.25'	950	977	
212	RS	"	2028		28°30.75'	18°01'	1006	1034	
213	RS	"	2038		28°31'	18°02'	1083	1112	
215	CSP	2.2.68	0724	1310	28°03' 28°11.5'	16°22.7' 15°19.6'	36 1368	37 1405	
Leg IV (Las Palmas-C. Blanc-Las Palmas)									
216	CSP	3.2.68	0001	0410	27°51' 27°44.5'	15°19.7' 14°57.4'	52 995	54 1023	
TRAVERSE IV (Cap Blanc)									
217	CSP	5.2.68	0445	1345	20°47.9' 20°51.1'	17°09.5' 18°10'	16 866	16 890	
218	G	"	1412	1520	20°51.6'	18°09.9'	906	931	No sample.
219	G	"	1550	1635	20°51.7'	18°06'	880	874	No sample.
220	G	"	1705	1738	20°52'	18°01.2'	810	833	No sample.
221	RD/PD	"	1814	2030	20°52.2' 20°53.5'	17°55' 17°54.4'	680 757	698 799	No sample. Glob. Sand in pipe.
222	GC	"	2130	2217	20°53.6'	17°44'	470	483	5 ft. Green globigerina sand.
223	RD/PD	"	2250	2253	20°53.5' 20°53.5'	17°41.8' 17°40.8'	310 303	322 312	Muddy sand.

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N &	Long W to Long W	Depth Range UCF	CF	Comments
224	RD/PD	6.2.68	0020	0114	20°53.1'	17°37.6'	120	124	Shell sand in pipe. Shells
					20°53.5'	17°37.3'	70	72	and rocks in dredge.
225	G	"	0203	0213	20°53'	17°31'	44	45	Medium sand.
226	G	"	0257	0308	20°52.2'	17°24.6'	31	32	Sand and shell fragments.
227	RD/PD	"	0357	0424	20°51.5'	17°19.4'	28	29	Sand and shells in pipe.
					20°51.4'	17°18.8'	22	23	Calcareous sandstones in RD.
228	G	"	0500	0507	20°50.6'	17°13.2'	21	22	Sand and shells.
229	G	"	0545	0552	20°50.4'	17°08.1'	12	12	Shell fragments.
230	G	"	0601	0609	20°51.1'	17°08.5'	16	16	Fine sand.
TRAVERSE V (Pt[a] Durnford)									
231	CSP	7.2.68	0430	1325	23°34.8'	17°18.1'	11	11	
					23°38.5'	16°04'	488	502	
232	GC	"	1336	1420	23°34.8'	17°13.1'	508	522	No core.
233	GC	"	1507	1529	23°34.2'	17°11.2'	392	404	5 ft. green mud.
234	RD/PD	"	1635	1728	23°33.6'	17°00.7'	264	272	Limestone
					23°33.3'	17°00.3'	222	229	
235	RD/PD	"	1752	1830	23°33'	16°57.5'	120	124	Shells in pipe. Shelly
					23°32.7'	16°57'	72	74	limestones in RD.
236	UC	"	1845	1934	23°32.8'	17°00.7'	235	243	
					23°32.3'	17°00.3'	226	234	

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N &	Long W to Long W	Depth Range UCF	CF	Comments
237	G	7.2.68	2005	2017	23°32.1'	16°57.4'	58	60	Shells
238	RD/PD	"	2035	2057	23°32' 23°31.7'	16°54.8' 16°54.2'	55 55	57 57	Shells
239	RD/PD	"	2129	2205	23°31.4' 23°31.7'	16°50' 16°49.5'	45 42	46 43	Shells and shelly limestone
240	G	"	2230	2239	23°31.1'	16°45.9'	32	33	Shelly sand
241	RD/PD	"	2257	2312	23°30.7' 23°30.4'	16°43.2' 16°42.6'	32 32	33 33	Shelly sand in pipe.
242	G	"	2356	2405	23°30.3'	16°36'	19	20	Shells
243	GC	8.2.68	0053	0107	23°30'	16°28.9'	17	18	3" shell fragments.
244	G	"	0155	0200	23°29.5'	16°22'	16	17	Shell fragments.
245	G	"	0247	0253	23°29'	16°15.5'	12	13	Shell fragments.
246	G	"	0335	0340	23°28.2'	16°08.8'	13	14	Shell fragments.
247	G	"	0353	0355	23°28.2'	16°06.5'	10	11	Shell fragments.
TRAVERSE VI (C. Bojador)									
248	CSP	9.2.68	0130	0625	26°09' 26°30.5'	14°32' 15°03'	16 755	17 776	
249	RD/PD	"	0741	0845	26°29.5' 26°29'	15°01.5' 15°01'	776 696	798 715	Glob. mud.
250	RD/PD	"	0910	1035	26°27.5' 26°26.8'	14°59' 14°58'	558 528	574 543	Glob. mud and some coral.

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N &	Long W to Long W	Depth Range UCF	CF	Comments
251	GC	9.2.68	1100	1140	26°24.4'	14°54.7'	532	547	4½ ft. mud.
252	RD/PD	"	1237	1404	26°21.5' 26°21'	14°51.3' 14°50.3'	362 312	373 321	Coral and sand.
253	UC	"	1429	1520	26°21.2' 26°21.3'	14°50.5' 14°50.7'	308 312	317 321	
254	GC	"	1600	1634	26°17.1'	14°45'	115	119	No core.
255	G	"	1644	1648	26°17.1'	14°45'	113	116	Shell sand.
256	G	"	1707	1717	26°14.6'	14°43'	75	77	Shell sand.
257	G	"	1732	1740	26°13.2'	14°41'	57	59	Shell sand.
258	RD/PD	"	1758	1819	26°11.5' 26°11.3'	14°38' 14°39'	46 44	47 45	Shell sand.
259	RD/PD	"	1832	1847	26°11.1' 26°11.2'	14°39' 14°38.5'	45 45	46 46	Shelly limestone.
260	RD/PD	"	1920	1940	26°11.1' 26°10.7'	14°37.7' 14°38'	41 39	42 40	Shell fragments.
261	RD/PD	"	1955	2035	26°10.6' 26°10.5'	14°36.5' 14°37'	32 32	33 33	Shell limestone.
262	RD/PD	"	2112	2140	26°09.8' 26°09.5'	14°36.7' 14°36.5'	32 25	33 26	Coral and shell sand
263	RD/PD	"	2200	2219	26°09.1' 26°09.1'	14°34.9' 14°34.[illegible]'	19 17	20 18	Shell limestone and shell sand.
264	RD/PD	"	2248	2309	26°08.6' 26°08.8'	14°32.9' 14°33'	15 15	16 16	Limestone and shell sand.

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N	Long W & to Long W	Depth Range UCF	CF	Comments
TRAVERSE VII (C. Yubi)									
265	CSP	10.2.68	0001	2200	26°12.7' 27°59'	14°31.5' 12°57'	24 975	25 1002	
266	G	"	2228	2232	27°57.7'	12°56.5'	10	11	Fine sand.
267	G	"	2248	2250	27°58.5'	12°57'	20	21	Sand and coral.
268	G	"	2308	2311	27°59.5'	12°57.5'	22	23	Sand and coral.
269	G	"	2324	2327	28°00.2'	12°57.7'	23	24	Sand and shell fragments.
270	G	"	2342	2346	28°01.2'	12°58.3'	25	26	Sand and shell fragments.
271	G	"	2358	2404	28°02'	12°59'	21	22	Sand and shell fragments.
272	RD/PD	11.2.68	0028	0115	28°05' 28°05.5'	13°00' 13°00.5'	27 31	28 32	Sand in pipe.
273	RD/PD	"	0140	0217	28°08.7' 28°09'	13°02.5' 13°03'	42 42	43 43	Sand in pipe. Shelly limestone.
274	G	"	0241	0246	28°11.5'	13°04.7'	48	49	Fine shell sand.
275	G	"	0305	0313	28°14'	13°06.5'	54	56	Shell sand.
276	G	"	0332	0339	28°16.5'	13°08'	56	58	Shell sand.
277	RD/PD	"	0349	0450	28°17.5' 28°17.1'	13°08.7' 13°09.2'	180 150	185 155	Glob. sand, shells and limestone.
278	GC	"	0525	0548	28°21.5'	13°11.5'	357	367	4½ ft. gritty clay.
279	GC	"	0617	0635	28°24.5'	13°14'	456	469	4½ ft. clay.

Station No.	Type	Date	Time GMT from	to	Lat N & to Lat N &	Long W to Long W	Depth Range UCF	CF	Comments
280	RD/PD	11.2.68	0707	0850	28°27' 28°26.5'	13°15.7' 13°14.8'	535 486	550 500	Soft mud.
281	GC	"	0935	0947	28°29'	13°17.2'	563	579	4½ ft. core mud.
282	GC	"	1040	1054	28°30.5'	13°17.5'	578	594	5 ft. mud.
283	RD/PD	"	1103	1225	28°31.5' 28°31.1'	13°18' 13°17.2'	583 570	600 586	Sand in pipe.
284	RD/PD	"	1258	1428	28°34.5' 28°35.2'	13°20.5' 13°21.2'	656 518	674 533	Mud in pipe.
285	RD/PD	"	1450	1505	28°38' 28°37'	13°23.7' 13°24.2'	692 560	711 576	Mud in pipe.
(Lanzorote-Las Palmas)									
286	CSP	11.2.68 12.2.68	1655	0715	28°37' 28°08'	13°26' 15°21'	1795 292	1847 301	
Leg V (Las Palmas-Las Palmas: Geophysics)									
287	RS	12.2.68	2151						Misfire
288	RS	"	2328		28°05'	17°01'	324	334	50 lb.
289	RS	13.2.68	0725		28°07'	16°55.75'	720	740	75lb.
290	RS	"	0755		28°06.5'	16°58.25'	600	617	100 lb.
291	RS	"	0822						Misfire
292	RS	"	0931						Misfire
293	RS	"	1028		28°06.25'	16°58.25	596	613	75 lb.

Station No.	Type	Date	Time GMT from	to	Lat N & Long W	to Lat N & Long W	Depth Range UCF	CF	Comments
294	RS	13.2.68	1058		28°05.75'	17°00.5'	244	251	75 lb.
295	RS	"	1124		28°05.25'	17°02.5'	210	216	75 lb.
296	RS	"	1142		28°04.5'	17°03.5'	160	165	75 lb.
297	RS	"	1328		27°59.25'	17°17.75'	500	514	75 lb.
298	RS	"	1348		27°59'	17°18.75'	700	719	75 lb.
299	RS	"	1419		27°56.5'	17°21.25'	1040	1068	75 lb.
300	RS	"	1450		27°56.25'	17°22.5'	1250	1284	75 lb.
301	RS	"	1530		27°55.25'	17°26'	1535	1578	75 lb.
302	RS	"	1605		27°54'	17°29.5'	1590	1634	100 lb.
303	RS	"	1644		27°52.5'	17°33.5'	1725	1774	125 lb.
304	RS	"	1731		27°48.25'	17°38.25'	1710	1758	150 lb.
305	RS	"	1819		27°48'	17°44.25'	1570	1613	150 lb.
306	RS	"	1856		27°47'	17°49'	1220	1253	150 lb.
307	RS	"	1924		27°45.75'	17°50.75'	1018	1046	75 lb.
308	RS	"	1942		27°44.5'	17°52.5'	896	920	75 lb.
309	RS	"	2002		27°43'	17°53.75'	500	514	50 lb.
310	RS	"	2018		27°43'	17°55'	585	601	50 lb.
311	RS	"	2204		27°39.5'	18°05.5'	838	862	25 lb.

Station No.	Type	Date	Time GMT from	to	Lat N & Long W	to Lat N & Long W	Depth Range UCF	CF	Comments
312	RS	13.2.68	2218		27°38.75'	18°07'	1012	1040	25 lb.
313	RS	"	2233		27°38.25'	18°08.25'	1112	1141	50 lb.
314	RS	"	2250		27°37.75'	18°10'	1120	1149	50 lb.
315	RS	"	2306		27°37'	18°11.5'	1360	1398	50 lb.

Abbreviations

PM	Magnetometer	G	Grab
CSP	Continuous Seismic Profile	RD	Rock Dredge
RAC	Radioactive Counting	PD	Pipe Dredge
UC	Underwater Camera	RS	Refraction Seismic
BC	Boomerang Corer	GC	Gravity Corer