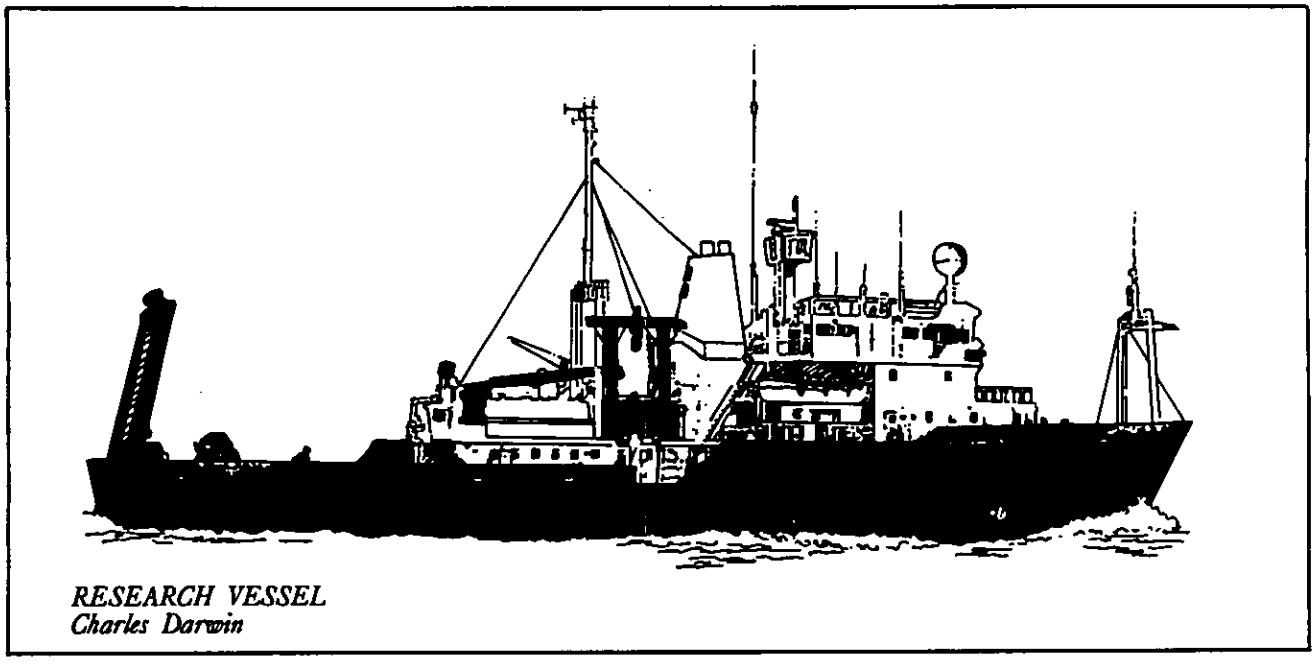
UNIVERSITY OF CAMBRIDGE

CRUISE REPORT

BULLARD LABORATORIES
DEPARTMENT OF EARTH SCIENCES



RESEARCH VESSEL
Charles Darwin

RRS CHARLES DARWIN 70

SEISMIC SURVEYS ON REYKJANES RIDGE SPREADING AXIS AND EDORAS BANK CONTINENTAL MARGIN

R.S.White

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CRUISE REPORT

RRS CHARLES DARWIN 70

Seismic Surveys of Reykjanes Ridge Spreading Axis and Edoras Bank Continental Margin

11th July - 2nd August 1992
Greenock - Barry

R.S. White
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Crew List

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M.C. Sinha	"
T.A. Minshull	"
T.A. Henstock	"
J. Bown	"
A.J. Barton	"
J.R. Leonard	"
P.W. Carter	"
R.A. Scrutton	Edinburgh
A.R. Cumming	RVS
D.G. Booth	"
J. Wyner	"
G.H. Evans	"
M.A. Davies	"
D. Dunster	"
D.A. Jones	"
G.R. White	"
R.A. Bourne	Master
C. Leather	Chief Officer
R.C. Plumley	Supernumerary Chief Officer
S. Sykes	Second Officer
R.A. Warner	Third Officer
J.G. Baker	Radio Officer
I.R. Bennett	Chief Engineer
S.A. Moss	Second Engineer
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W.D. Lutey	Electrical Engineer
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G. Crabb	"
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R. Johnson	"
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P.W. Robinson	"
R.M. Stephen	Second Steward
V.G. Hall	M/Man

SUMMARY

This cruise was intended as a site survey across the East Greenland continental margin in preparation for ODP drilling on Leg 152 scheduled for October 1993. It replaced a funded 2-ship seismic experiment originally programmed for summer 1992 by NERC using an unsuitable second ship for this project. The two-ship experiment was therefore postponed for programming in the subsequent 1993-94 ship season when the more suitable RRS James Clark Ross was expected to be in the region. Unfortunately the NERC decided not to programme the two-ship experiment when it considered the next year's programme one year later.

Equally unfortunately, none of the East Greenland objectives could be attempted on this cruise because the Master decided on the basis of available ice maps that he would not allow the seismic equipment to be operated within 220 km of the reported edge of the pack ice. Since this prevented us working in our planned area we had to develop alternative projects whilst at sea. Two projects were completed successfully.

The first was a multichannel seismic (mcs) and ocean bottom seismometer (OBS) survey of the Reykjanes Ridge active spreading centre at 61-62°N, to investigate the effect of the Iceland plume on active rifting processes. The second was another mcs and OBS survey of the Edoras Bank continental margin, in an area already drilled by the DSDP. Each survey consisted of a grid of underway profiles using magnetics, gravity, 3-5 kHz and 10 kHz echo sounding, with 5 OBS deployments, disposable sonobuoys and mcs profiles. The mcs profiles used a 4446 cu. in. 12-gun array as a source with a 48-channel, 2-4 km long hydrophone streamer.

The two surveys will provide crustal constraints on rifting within the sphere of influence of the Iceland plume: the Reykjanes Ridge at the present day, and the Edoras Bank at the time of continental breakup.

ACKNOWLEDGMENTS

This was the third in a series of Cambridge cruises in the early summer, and many people had assisted in either two or all three of the cruises. We are grateful for their considerable work which kept almost all the equipment working well. The RVS technical staff provided their usual excellent service at sea: in particular the 4-beam, 12-gun array was a real improvement over earlier airgun sources, and the mcs streamer and Sercel recording system worked faultlessly throughout the cruise.

NARRATIVE

Friday, 10th July 1992

Equipment driven up in van to Greenock to rejoin ship. Rather little had to be shipped, since it was already onboard from previous cruise northwest of Scotland (PSO Dr. Penny Barton). Equipment was re-ordered in the labs, with additional gear moved from RRS Challenger (which was moored adjacent to Charles Darwin). Wet Lab. used for mechanics of OBS, Constant Temperature Lab. for electronic innards of OBS, Main Lab. for mcs birds and retrievers (starboard bench), Sercel and SAQ electronics (starboard side), underway recording, Reftek, disposable sonobuoys, echo-sounder magnetometer, chart table (port side). Plot used for Sercel tape storage and gravimeter control electronics.

Saturday, 11th July 1992

Sailed on schedule at 0900 (BST) through North Channel in choppy seas. 10 kHz and 3.5 kHz echo-sounder fishes deployed in afternoon, and scientific watches commenced at midnight.

Sunday, 12th July 1992

Nasty ship motion. Ice reports obtained from Bracknell and South Greenland show edge of concentrations of pack ice lying approximately 30 nm (55 km) off the coast of East Greenland. Although the instructions issued by RVS Marine Office to the Master allowed him to sail up to the edge of the pack ice at his discretion but otherwise to remain 50 nm away, the Master set the limit of seismic operations at 120 nm (220 km) seaward of the edge of the pack ice. We were not permitted to use the hydrophone streamer or the airguns to landward of this line. Since this prevented us doing any of the ODP site survey work, all of which lay in the area where the Master was not prepared to let us work, we immediately started preparing alternative plans for work on the Reykjanes Ridge spreading axis.

Meanwhile, we steamed along a line across Hatton Trough parallel to our earlier work in 1985 to provide a survey for a planned BIRPS profile. Once we had crossed the site of the Hatton Bank seismic study, we steamed along a flow-line profile from there to the spreading axis of the Reykjanes Ridge, across the oceanic crust of the Iceland Basin.

Clocks moved back to GMT at night, and remained so until the end of scientific work.

Monday, 13th July 1992

Sea still choppy. On transit across Iceland Basin. Firing system for Sercel had to be modified, as the system implemented by RVS gave a variable shot instant while the Sercel tapes wound up to full speed. See Appendix for details of the timing system finally implemented.

Site chosen for Reykjanes Ridge axis seismic survey is approximately mid-way between Iceland RRISP profiles and existing Bunch and Kennett sonobuoy profiles. Since the Master was unhappy with measuring the 200 nm limit from the tip of Reykjanes peninsula, and preferred to measure from a semi-submerged offshore rock some 35 nm south west of the peninsula,

we decided to remove all ambiguity by requesting permission from Iceland for our seismic work. This was obtained, via RVS, by 1900 on Tuesday, 14th July.

Tuesday, 14th July 1992

Sea dropped to approx. Force 3 and ship now making $11^{1}/2$ knots. Arrived at the Reykjanes Ridge axis about 2000, then proceeded to the first OBS lay position for the seismic survey.

Wednesday, 15th July 1992

Sea still Force 3-4. Arrived OBS 11 site approximately 0330, pulled in magnetometer and made a brief site survey so as to deploy the OBS away from steep scarps. OBS 11 deployed at 0505. We then proceeded to deploy the remaining four OBS, in each case making a small site survey first (see Appendix for details of deployment times and positions). Final OBS deployed at 1733 by which time the wind had increased to 20 knots from a deep depression to the south of us.

Commenced deploying mcs streamer at 2100, completing it by 0020. No further balancing was necessary: two 25 m sections were open circuit, so we continued without them.

Thursday, 16th July 1992

Continued testing streamer through the night. Magnetometer out from approx. 0030 to 0600, while we moved southwestwards towards the start of the shooting profile.

Airgun deployment commenced at 0700, steaming into the wind. Starboard inner beam out by 0915, starboard outer by 1020. By 1430 all four beams were out and all guns firing except for the backup 120 cu. in. All compressors working (both Darwin-installed compressors plus two containerised compressors. They can cope well with firing 4446 cu. in. at 40 sec. interval.

The afternoon was spent trying to remove jitter from the RVS firing system. Eventually we lashed together a system using

1. Sercel wind-up and trigger from ship's clock.
2. Reftek fire pulse from relay closure on Cambridge Cream clock approx. 1 sec. after ship's clock.
3. Guns fired 50 msec after Cream clock relay closure.
4. Sercel start of recording time is from Reftek time break (ie Cream clock plus 50 msec).

Test line (CAM 70) recorded whilst on transit to start of main firing line. Start of main line reached at 2000, one hour after OBS recording started. CAM 71 shot along ridge axis.

Friday, 17th July 1992

Recording of CAM 71 continued without incident, though about 9 shots were lost from the Sercel around midnight due to a bug in the RVS Sercel control software. Guns continued to fire correctly. Ended CAM 71 at 0730, then began turning onto next profile at 2 degrees per minute. Many dropouts on GPS navigation.

Began CAM 72 shortly after lunch. Wind ~20 knots, Force 5, with rolling swell. Wind E to NE. Unmodified SSQ906 sonobuoys gave good records. Finished CAM 72 just before midnight. Lost 8 mins of Sercel recording due to software bug around midnight, but guns kept firing (off Cambridge cream clock) on schedule.

Saturday, 18th July 1992

Started CAM 73 before breakfast. Wind remained 20-25 knots, shifting more northerly (approx. 020°) by evening. Several more disposable sono-buoys launched successfully (see Appendix). Recording at 40 sec. shot interval continued uneventfully through CAM 73 and CAM 74, and the programme remained in synchronisation with the pre-programmed OBS recording windows.

Sunday, 19th July 1992

Finished final 40 sec. line (CAM 74) at 0900. Then turned northwards and fired one final profile across the axis at 20 sec. firing interval using array of 2300 cu. in. (200 + 300 + 120 + 160 + 400 + 300 + 120 + 700). Compressors could provide 1800-1850 psi for this airgun array. At approximately 1500 one of the containerised compressors broke down and pressure dropped to approx. 1500 psi. We therefore ended the reflection profile and commenced pulling in guns at 1600. All guns recovered 4 hours later by 2000. Sea now dropped to Force 3-4.

MCS hydrophone recovery commended at 2040 and completed by 2240. Also recovered 3.5 kHz fish to get it out of the way of OBS recoveries through starboard "A" frame.

OBS 11 released immediately; on surface at 0004 Monday and onboard by 0024. Recovery of this and all subsequent OBS was very straight-forward, using GPS to navigate to the sites. Evenings were very light and buoys easily visible.

Monday, 20th July 1992

OBS recovery proceeded smoothly, with magnetometer runs between OBS to increase coverage, until at 1345 on passage to the final OBS 12 position, one of the crew, Stuart Cook, caught his hand under a wire while leading it onto a drum. This was during crew maintenance operations unconnected with the scientific programme. We immediately broke off our work, and steamed towards Iceland. A helicopter sent from Iceland winched Stuart Cook off at 2112 and we then steamed back toward the OBS position. It transpired that he had crushed two fingers, but not broken any bones. The entire operation to winch him off by helicopter used about 12 hours, so we cut out two survey lines across the ridge axis to get back on schedule.

Tuesday, 21st July 1992

Final OBS recovered successfully and then we set course for Edoras Bank, since we still could not do any work on the East Greenland margin. The 3.5 kHz echo sounder was not deployed, as it required repair work on the cable feathering. Weather good, and passage speed fast.

Wednesday, 22nd July 1992

Flat seas, though got rougher later in the day. Arrived in survey area in early morning, then ran a survey line across the continental margin. 3.5 kHz echo sounder re-deployed and first OBS deployed at 1400. Finished laying OBS along a 80 km long transect by 1930. Launches now taking approximately 3 mins from arrival on station.

Commenced deploying mcs streamer at 2122. Finished at 0020 on Thursday.

Thursday, 23rd July 1992

We had planned to deploy the airguns steaming downwind, but the rougher seas meant that we thought it better to continue into the wind. Commenced airgun deployment at 0030. Finished by 0730 with all guns firing. Seas dropped through the day. Cam 76 was shot at 40 sec. intervals out across oceanic crust. At 1230 we turned and commenced the run in across the oceanic crust, ocean-continent boundary, to the top of Edoras Bank, and crossing all the OBS. This dip line was excellent, with calm seas (Force 3) and all equipment working well. Good sonobuoy (no. 8) deployed over oceanic crust, with arrivals out to at least 30 km over flat basement. OBS 14 commenced recording at 1800, at which time we were 55 nm from the OBS and profiling towards it.

During the evening the wind and seas began to rise somewhat, but the main dip line was shot in seas mostly less than Force 4. Dipping reflectors imaged well offshore onto oceanic crust.

Friday, 24th July 1992

The software bug affecting the Sercel recording had been fixed, and no shots were lost around midnight. But around midnight one of the two buoys holding the tail of the starboard inner gun boom was apparently lost and the depth dropped about 2 m.

Following completion of the dip line, we shot strike lines through the OBS positions in progressively deteriorating weather. But since the main objective of these lines was to record wide-angle arrivals at the OBS, we continued firing.

Profile CAM 78 along strike on Edoras Bank was completed at 2200, with a following sea.

Saturday, 25th July 1992

Weather deteriorated to Force 6 during the night. Confused sea with approx. 5 m swell. On CAM 80 we had difficulty maintaining 4.9 knots over the ground profiling speed: as the ship increased speed to maintain ground speed so the front of the array rose to 30-35 ft. and became much noisier. Winds 20-25 knots by the evening.

Sunday, 26th July 1992

Mostly Force 6-7 through the day. Streamer mostly quite noisy. Final strike profile (CAM 82) through OBS 14 was quiet, with the sea on the beam. By this profile it was clear that the remaining buoy on the starboard inner beam had broken off and this airgun beam was towing deep. But guns continued firing, so we carried on.

Monday, 27th July 1992

Wind dropped a little to 15 knots, and sea moderated a little by the morning. At 0500, as we were about to turn to the NW to continue a flow-line profile to the ridge axis, the Master ordered the profile to be aborted and the seismic gear recovered. Streamer and guns recovered by 1405. One hydrophone channel (no. 47) damaged during recovery.

During the evening the weather worsened to Force 8 with heavy swell. Commenced magnetics, gravity and bathymetry grid survey across the margin, and stretching across the Maury Channel.

Tuesday, 28th July 1992

Continued grid survey in 25 knot winds, with heavy swell. All underway equipment operating well except for gravimeter which had mis-calibrated analogue correction circuitry and so was producing useless output. We logged the individual beam outputs separately on a P.C., from which some data may be recovered after the cruise.

Wednesday, 29th July 1992

Weather improving but still a big swell. Tim Minshull, Martin Sinha and John Leonard started recovering OBS at approx. 1400. All OBS were inboard by 0030 on Thursday.

Thursday, 30th July 1992

Completed XBT deployment, then deployed magnetometer after OBS were inboard and finished off the site survey before setting course for Barry in the forenoon. Sea had dropped a lot, and we made good progress homeward.

Friday, 31st July 1992, Saturday, 1st August 1992

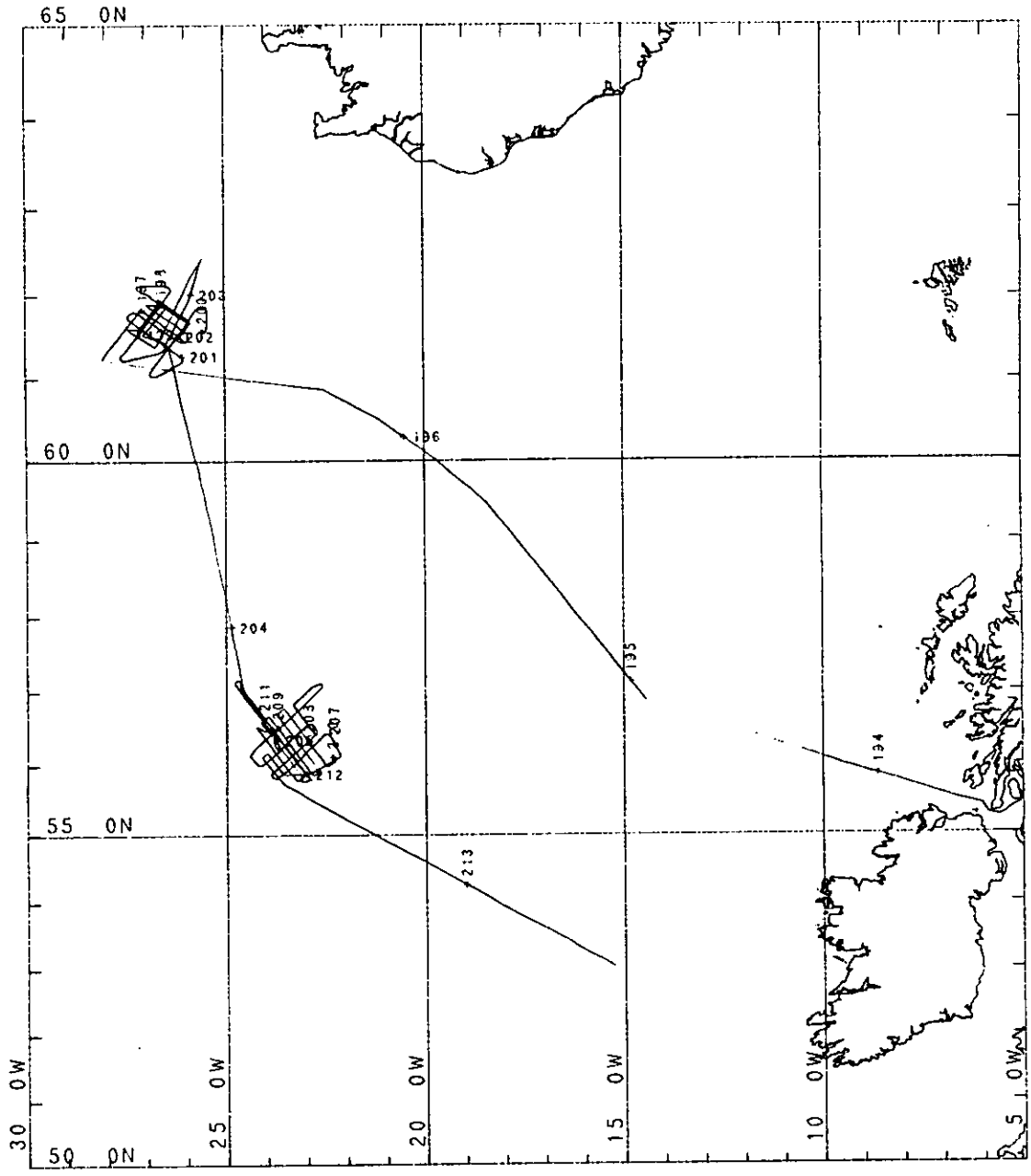
Continued packing equipment from 3 Cambridge cruises. Clocks advanced one hour to BST in the evening of Friday 31st. Sea improving and weather warming up all the time.

Sunday, 2nd August 1992

Arrived off Barry by breakfast. Went into dock mid-morning and moored astern of the newly converted Discovery.

Monday, 3rd August 1992

All Cambridge equipment offloaded in the morning, packed into a container on a lorry and returned to Cambridge. Unloaded in Cambridge on Tuesday, 4th August.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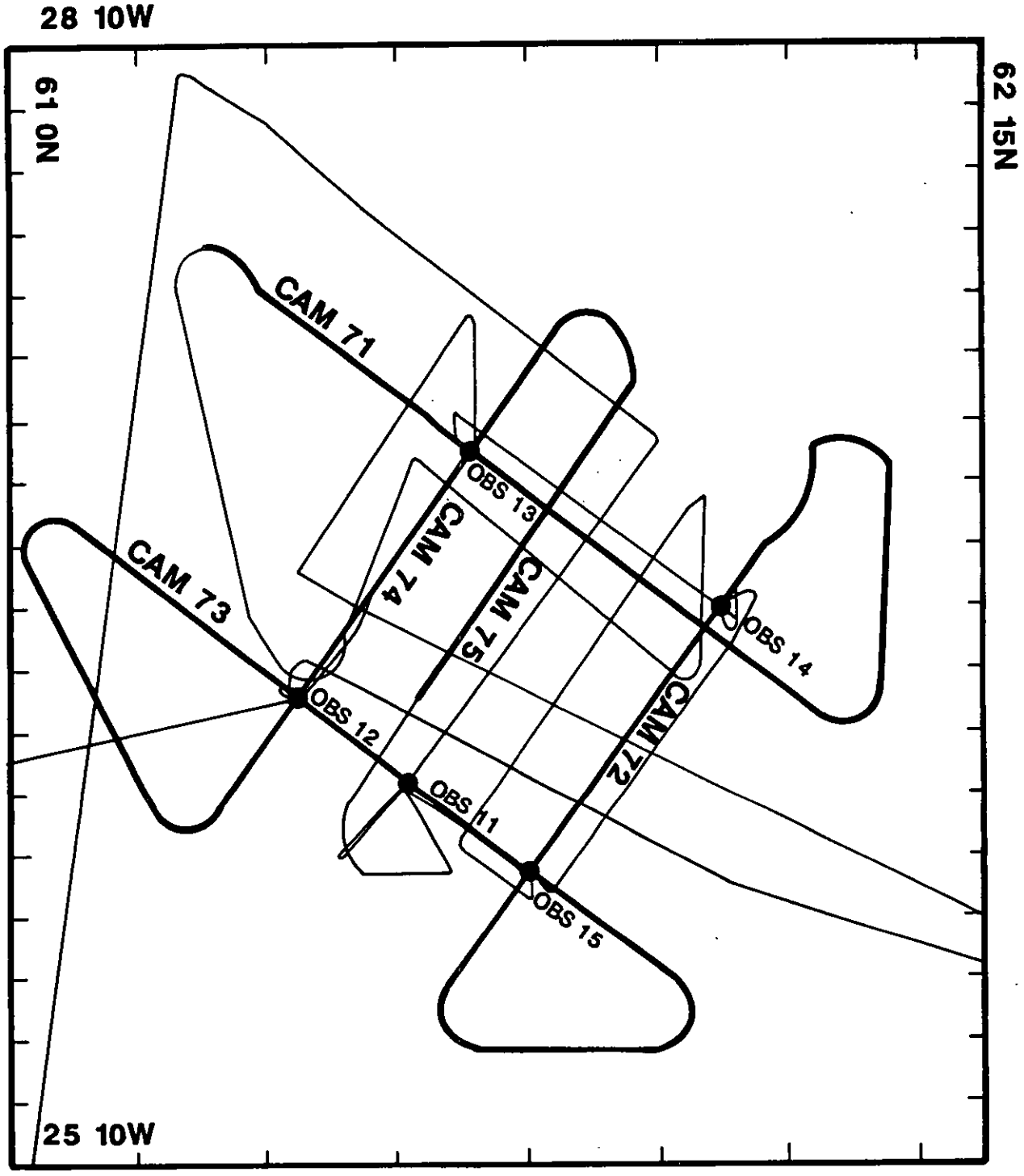
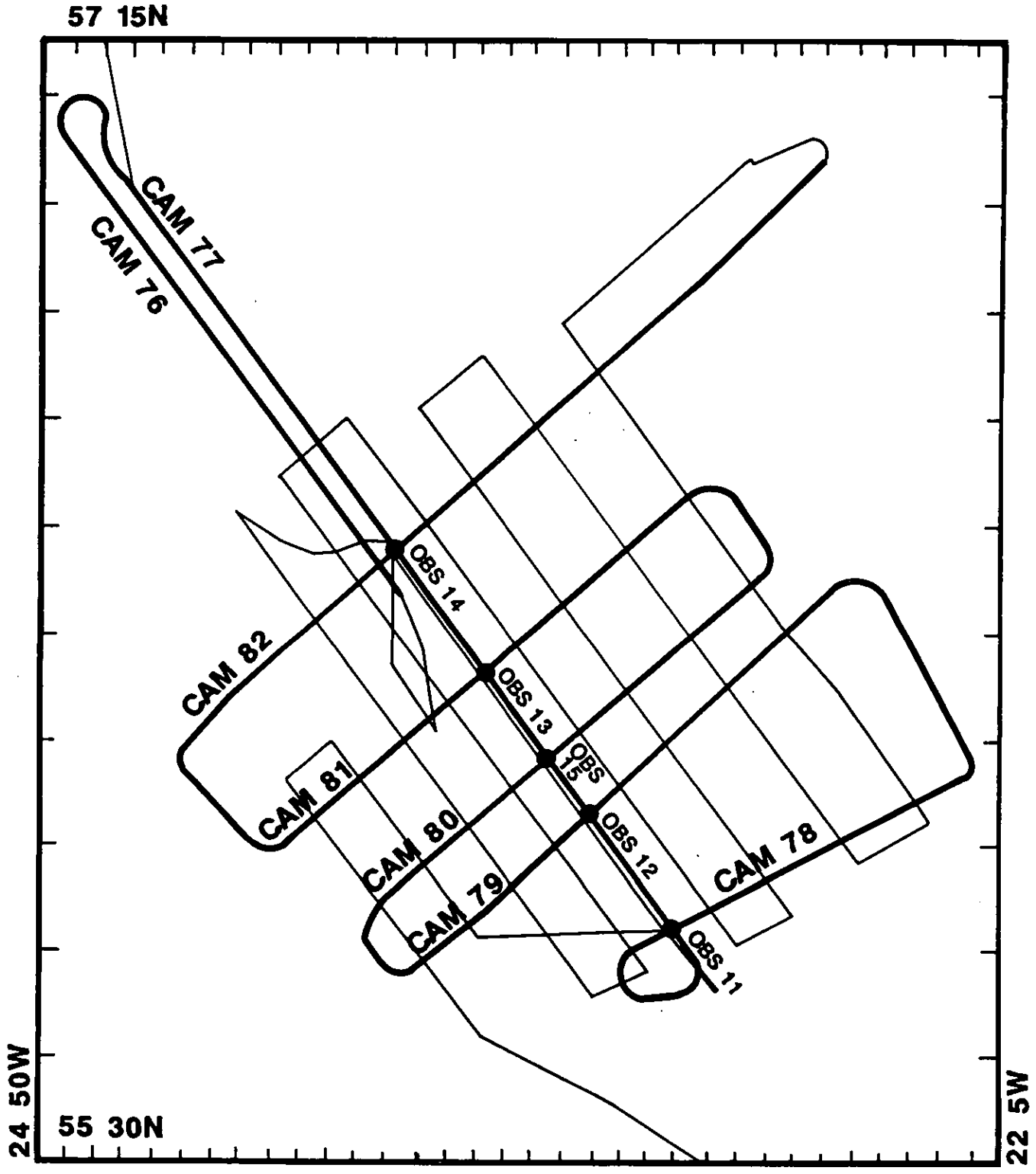
REYKJANES RIDGE SURVEY



EDORAS BANK SURVEY



CRUISE REPORT OF PROCEEDINGS

SHIP: RRS CHARLES DARWIN
CRUISE NO: CD70

CRUISE DATES: GREENOCK 11th July 1992
to BARRY 2nd August 1992

(a) Main Objectives

To make multichannel seismic (mcs) reflection, Ocean Bottom Seismometer (OBS) refraction, gravity, magnetics, 3.5 kHz and 10 kHz echo sounder surveys on planned Ocean Drilling Project (ODP) sites for drilling in September 1993 on ODP Leg 152. None of these objectives could be achieved due to decisions made entirely by the NERC and its officers. This is a severe indictment of the way the NERC have operated in this instance. It is also a major embarrassment that we have been unable to provide the site survey data for a high-profile international project in which Britain has a particular interest (see attached letter).

The weather in the East Greenland survey area was good throughout most of the cruise, with a settled high-pressure region on the East Greenland margin, and the ice conditions were not abnormal for the time of year with a 30 nm wide zone of pack ice around the coast. If we had been able to work to within sight of the edge of the pack ice we could have achieved our objectives. If we could have worked up to the outer marked limit of any known iceberg we could have done site surveys over all but one of the southern sites, we could have relocated the seismic lines, and achieved the bulk of the objectives. But because we were not allowed to deploy the seismic gear within 50 nm of the marked outer limit of any bits of floating ice, even when the symbol for clear water was shown landward of that line, we could not enter the work area at all.

The sequence of events was as follows:

(i) My initial request for ship-time was for the period August to mid-October, with the explanation that ice would limit operations outside that window (see attached). In January of this year I was allocated ship-time on Charles Darwin during July 1992.

(ii) My cruise plans were sent to RVS in February 1992, with maps showing the work areas (attached). Whilst I was at sea on Charles Darwin in April 1992, the RVS Operations Office sent the cruise plans to the Master, Captain McDermott, with a request for his comments. Captain McDermott had been off East Greenland in August 1991, on Charles Darwin, in some extremely rough weather. His opinion was that, apart from the pack ice around the coast which would obviously be a barrier to us, he saw no problems in our plans.

(iii) Shortly before sailing, the RVS Marine Superintendent sent a memo to the Master of Charles Darwin outlining operation restrictions in the vicinity of ice. Unfortunately, this was not discussed with me, or even copied to me, although it clearly had profound implications on the likelihood of our being able to work off East Greenland.

(iv) After we had sailed, I was shown the RVS instructions concerning ice. The Master of Charles Darwin told me that he would not allow us to deploy the mcs streamer and airguns within 50 nm of the estimated outer limit of all known icebergs, as marked on the Bracknell maps. This prevented us doing any work in the planned area (see attached map). My initial plan had been to steam in slowly towards the edge of the pack ice in daylight, to assess the situation, and then to deploy the seismic gear if there was little ice about. But the Master's instructions meant that this would have been futile.

There has been gross failure of the NERC in this matter. First, the cruise was scheduled outside the time period I had specified. Second, the instructions issued by the RVS and implemented by the Master prevented any work being done off East Greenland. The ice conditions were not abnormal for the time of year: it would be equally impossible to do this work under these instructions in any other year during July.

Whether or not the conditions specified by RVS and the Master were appropriate could be debated, though of course, once at sea, I was bound by the operational directions of the Master. The Charles Darwin is not ice-strengthened and it would not be sensible to risk collisions with ice. Nevertheless, there is no question whatsoever that the matter should have been discussed with me prior to sailing. It is quite clear that decisions made by NERC personnel rendered it impossible to even attempt to do this work.

Once it became apparent that we would be unable to work on the East Greenland margin, we substituted two new projects. The remainder of this report addresses those projects.

Scientific Objectives

(v) To study the variations in the present-day mantle thermal anomaly surrounding the Iceland plume by a detailed seismic reflection and refraction survey on the Reykjanes Ridge spreading centre at 61.5° located mid-way between earlier seismic surveys on the ridge axis to north and south.

(vi) To study variations in the mantle thermal anomaly associated with initiation of the Iceland plume by a detailed seismic reflection and refraction survey across the Edoras Bank continental margin, south-west Rockall Plateau, to complement an earlier seismic survey to the north over the Hatton Bank continental margin.

(b) Geographical Area: Northern North Atlantic, 55-62°, 22-28°W

(c) Sea and Weather Conditions: Mostly around Force 5, with excursions to Force 8 during Edoras Bank Survey, and short calmer periods.

(d) The substitute objectives were met in full, with no major problems other than deteriorating weather and sea conditions during the Edoras Bank survey which compelled us to break off the mcs survey two days earlier than planned. A further 12 hours were lost due to the necessity of evacuating by helicopter to Iceland one of the crew who had damaged his hand during operations unconnected with the scientific work.

(e) Equipment Performance: All the scientific equipment except the S40 Gravimeter worked well. However, much of the geophysical equipment is now very ancient and is operating well below current standards, which limits our ability to continue doing front-line research. All 10 OBS deployments using Oceano releases were successful, the mcs streamer was well balanced and worked almost faultlessly, and the Sercel recording system gave less trouble than I have ever experienced on previous cruises. The new airgun deployment system worked very reliably with 11 guns firing throughout. The only weakness remains the tail buoys on the beams (two were lost completely), and the tendency of the beams to pull in towards the streamer and to damage it.

I was pleased that many of the shortcomings noted from my previous cruise on CD67 had been put right, including mending the Chernikeef log and the Reftek monitors, and developing a system for deploying the magnetometer whilst seismic profiling.

(f) Ship Performance: The ship did all that we required of it, and did it well. The officers showed considerable skill in maintaining our stringent course and speed requirements and in recovering OBS, even in adverse weather conditions. The crew provided willing support on deck, and I heard many favourable comments about the standard of catering.

(g) Recommendations:

(i) The new style airgun umbilical worked well. The 12-gun array again proved to be a powerful and well focused seismic source. RVS should purchase a fourth umbilical winch.

(ii) As recommended in my previous report on CD67, the Hippo tail buoys on the airgun beams, which are really designed for moorings, should be replaced by torpedo-shaped buoys.

(iii) Some way needs to be found to hold the airgun beams outboard away from the streamer. In my previous report I mentioned paravanes. If these are impractical, another solution may be to lengthen significantly the pivoting arms from which the beams are deployed.

(iv) The Hamworthy compressors off Challenger should be containerised forthwith. The air supply is still well below current requirements, but containerising the Hamworthys would at least be an economical step in the right direction.

(v) The LaCoste S40 gravimeter is useless and will remain so until it is properly serviced and calibrated by the manufacturers. Long gravity traverses for comparison with satellite measurements were one of the aims of this cruise, but could not be achieved due to the poor condition of the gravimeter. As a minimum, the S40 should be upgraded to digital operations. It would be better to purchase a more modern gravimeter, as this one is incapable of the resolution we often require, even when it is working properly.

(vi) As I have written many times before, it is appalling that the Sercel has not been upgraded to record in demultiplexed form, despite a categorical assurance by the Superintendent of RVS at a Users' Meeting that this would be done. There are two reasons why this is so bad. The first is that we shall now have to waste another £10,000 of NERC money in demultiplexing the Sercel tapes. The second is that we cannot do any kind of data quality monitoring on the recorded multiplexed tapes. I know of no other similar seismic operation where such expensive data has to be recorded blind with no opportunity of off-line quality monitoring.

(vii) We have no way of knowing the feather angle of the streamer most of the time. Possibilities for improvement include fitting compass sections, and/or a better radar reflector on the tail buoy.

(viii) Could RVS design a disposable sonobuoy launcher to throw sonobuoys sideways out of harm's way by the gear towed behind the ship?

(ix) The DeckMaster 53 graphical navigation system used on the Bridge as a temporary installation was excellent for navigating our survey lines and for recovering the OBS. I recommend that it be installed permanently, with a slave monitor screen in the Main Lab.

(x) It is extremely regrettable that the Superintendent of RVS should commandeer one of the scientific berths for training a deck officer after staffing had been agreed between the RVS Operations Office and ourselves. As a consequence we had to drop a scientist the week before we sailed. We have always been very willing to accommodate non-scientific staff for training, but on this particular cruise we were already over-subscribed and RVS were well aware of that. If RVS are now going to reserve the right to usurp one of the scientific berths at very short notice, we need to know this so that we can plan our staffing accordingly.

(h) Other Comments:

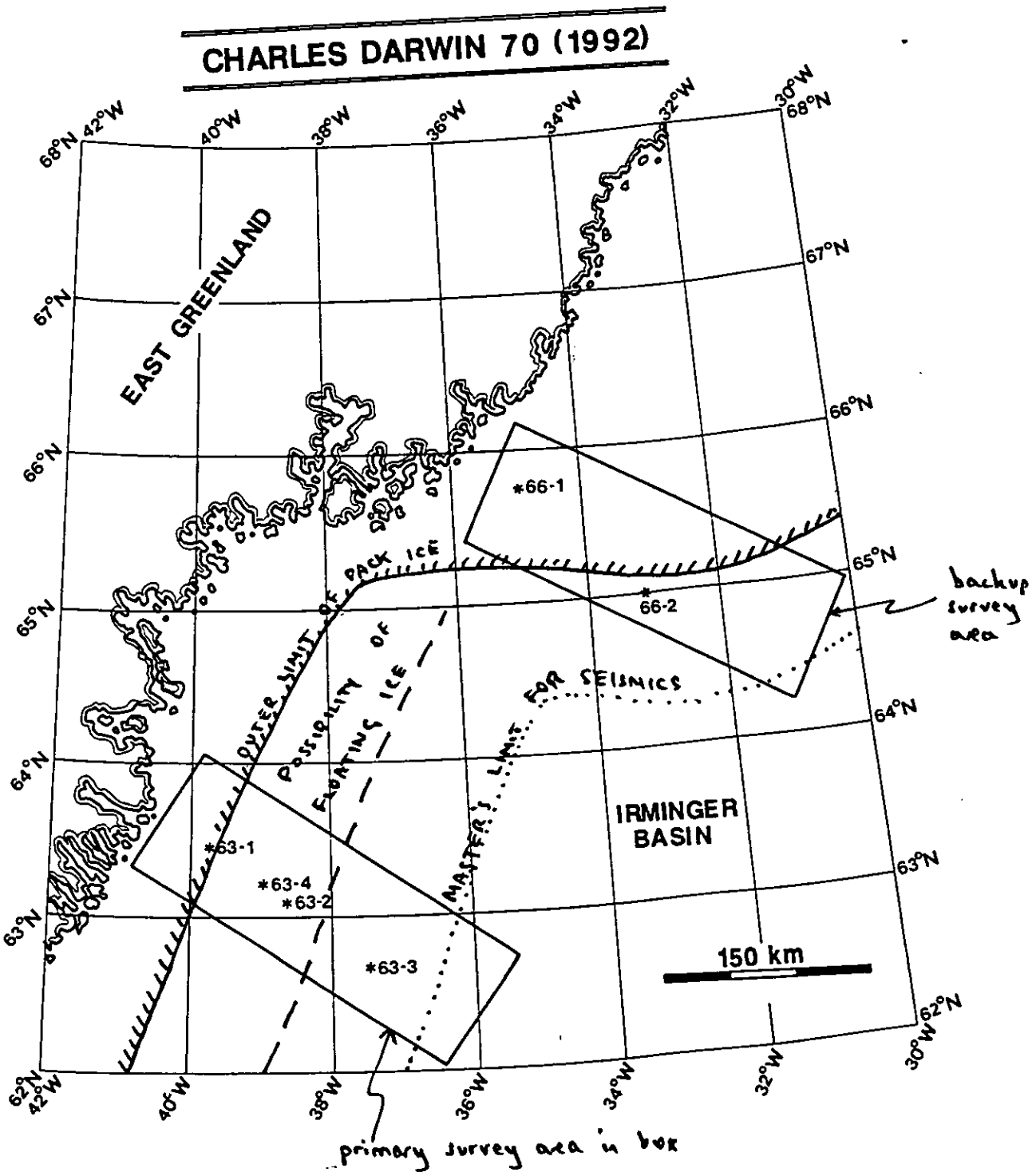
I am grateful to RVS staff and the FCO, who arranged clearance to relocate an experiment in Icelandic waters at 24 hours notice.

I have again been enormously impressed by, and very grateful for, the dedication, good humour and willingness of the RVS technicians who bear the brunt of getting and keeping the equipment operational. It is a privilege and a pleasure to sail with them. My heart sinks at the sense of gloom and despondency with which most of them view the impending move of RVS to Southampton, and with the probability that RVS will lose the services of many of them. Nor can I understand the economics of the move to Southampton: if just a few percent of the budget had been spent on upgrading the scientific equipment on the ships, we would have one of the best equipped research vessels in the world, instead of which we are having to use largely obsolete equipment which in some cases is 20 years old.

(i) Signed: Robert S. White

Professor Robert S. White
Bullard Laboratories
Cambridge University

1st August 1992



ICE CONDITIONS DURING JULY 1992

from Bracknell and Ice Centre, Narssarssuaq, Greenland
(Work areas in rectangular boxes, ODP sites shown as stars)

GRAVITY DATA

All the gravity data recorded by the data logging system is useless, due to the analogue correction circuits being badly out of adjustment. We recorded digital outputs from the beams and it is possible that some of the gravity values can be re-calculated from this. However, the recording mechanism for the digital data was not intended for continuous monitoring and is far from complete. Individual discs lasting about 6 hours each were recorded on a P.C. There were many P.C. crashes at times of disc change-overs, and consequently many data gaps. Furthermore, caution should be exercised over the time-stamping of the P.C. data: times were taken from the P.C.'s internal clock, which drifted badly and was reset manually from time to time. Gravity base station values were taken in Greenock and Barry.

6th July 1992, Greenock, Sugar Quay, James Watt Dock MOD/MS6
Station 008.32

g from base station at meter on ship	= 981592.55 mgals
G at meter on ship	= 09954.2 division
S40 Meter calibration	= 0.9917

2nd August 1992 Barry

g from base station at meter	= 981 190.36
G at meter	= 09549.9

Drift Rate is + 0.057 mgal/day over 22 days

REYKJANES RIDGE SEISMIC SURVEY

OBS Number	Latitude	Longtitude	Water Depth (uncorr m.)	Deployment Time	Recovery Time	Sink Rate	Rise Rate
11	61°30.91'N	26°11.92'W	1338	0505/197	1223/202	76	74
12	61°22.53'N	26°22.50'W	1409	0736/197	0502/203	83	~70
13	61°35.95'N	27°05.08'W	790	1020/197	1016/202	79	~70
14	61°54.92'N	26°40.36'W	850	1419/197	0610/202	76	75-80
15	61°40.59'N	15°57.72'N	1407	1733/197	0202/202	75	80

All OBS used Oceano Releases, 80 kg bottom weights, hydrophone (no geophone), 8 m.sec recording, Buoyancy of 4 x 17" glass spheres plus 1 x 14" sphere on stray line.

EDORAS BANK SEISMIC SURVEY

OBS Number	Latitude	Longtitude	Water Depth (uncorr m.)	Deployment Time	Recovery Time	Sink Rate	Rise Rate
11	55°52.07'N	23°01.15'W	1683	1400/204	0017/212	74	77
12	56°02.71'N	23°15.64'W	2335	1540/204	2210/211	95	65
13	56°16.27'N	23°33.82'W	2632	1754/204	1816/211	80	67
14	56°27.65'N	23°49.54'W	3122	1933/204	1543/211	77	70
15	56°08.04'N	23°22.80'W	2354	1639/204	2013/211	75	65

MULTICHANNEL SEISMIC LINES

Line Number	First Shot	Last Shot	SERCEL Start Tape	SERCEL End Tape	Comments
REYKJANES RIDGE					
CAM70	1725/198	2019:20/198	1A	5A	Test Line
CAM71	2020:00/198	1342:40/199	6B	31A	
CAM72	1343:20/199	0113:20/200	32B	47A	
CAM73	0114:00/200	0000:00/201	48B	79A	
CAM74	0008:00/201	1046:00/201	80B	95A	
CAM75	1046:40/201	1525:00/201	96B	109	Probably no useful data on 109A
EDORAS BANK					
CAM76	0752:00/205	1358:00/205	110A	119B	
CAM77	1358:40/205	1409:20/206	120A	159B	
CAM78	1410:00/206	0146:00/207	160A	178A	
CAM79	0146:40/207	1450:40/207	179B	200A	
CAM80	1600:00/207	0344:40/208	201B	220A	
CAM81	0345:20/208	1559:20/208	221B	240A	
CAM82	1600:00/208	0522:00/209	241B	263B	

Notes

1. All lines were shot at 4.9 knots, 40 sec interval (100m shot spacing) with the exception of CAM75, which was shot at 20 sec interval.

2. Line starting and ending points are variable, and lie somewhere on the turns between lines. Data was recorded continuously, including turns, so it will only be useful to process the straight-line portions of the tracks after the streamer had straightened out.

3. Reykjanes Ridge, 9 sec records, 64 shots per tape.

4. Edoras Bank, 11 sec records, 55 shots per tape.

5. Filter setting on Sercel was out throughout (= 3Hz low-cut).

6. The rearmost depth sensor on the mcs streamer had an intermittent fault which gives some spurious readings on it.

7. Sercel auxiliary channels:
   - Aux 1. Water break
   - Aux 2. RVS ship's clock (1 Hz)
   - Aux 3. Cambridge cream clock
   - Aux 4. Unused

TELEDYNE STREAMER

Front End

Ship - stern of ship
Tow Cable typically 107 m, but variable (see below)
3 x Spring 165 m

Depth 1
Water Break

Active 1-6

Depth 2

Active 7-12

Depth 3

Active 13-20

Depth 4

Active 21-28

Depth 5

Active 29-34

Depth 6

Active 35-42

Depth 7

Active 43-46

Depth 8

Active 47-48

1 x Spring (with 3 x floats)
Tow rope
Tail buoy

Spring section approx. 55 m.
Active sections 50 m (comprising 2 x 25 m in parallel)
Depth sections 1 m
Streamer drum circumference = 3.85 m

Dimensions

Distance of GPS aerial from stern		45 m
Estimated distance astern of airguns	Outer beams:	65 m
	Inner beams:	70 m

(from estimated umbilical lengths of 80-85 m)

Tow cable lengths (from stern):

Time	Line	RN	Turns on drum	Length/m
1644/198-2052/198	CAM 70-71	1-367	8	99
2052/198-2055/198	CAM 71	368-371	7	103
2055/198-1525/201	CAM 71-75	372-6734	6	107
0752/205-0231/206	CAM 76-77	1-1679	7	103
0231/206-0926/207	CAM 77-79	1680-4461	$9^{1}/2$	93
0926/207-0522/209	CAM 79-82	4462-8316	$6^{1}/2$	105

AIRGUN DEPTH SENSOR CALIBRATIONS

1. Reykjanes Ridge Deployment

Depths recorded by REFTEK are incorrect and should be converted using the following calibration point determined after recovery. Depths are measured on the beam and 1m should be added to obtain gun depth.

TRUE DEPTH (m)	10	11	12	13	14	15
RECORDED DEPTHS						
a) Array 1, Depth 7 (Port Outer rear)	11.02	11.82	12.46	13.56	14.46	15.18
b) Array 1, Depth 5 (Port Inner Middle)	5.65	6.47	7.31	8.27	9.15	9.93
c) Array 2, Depth 1 (Starboard Outer Front)	5.50	6.22	7.20	8.06	8.96	9.94
d) Array 1, Depth 2 (Starboard Outer Rear)	5.56	6.56	7.16	8.30	9.04	10.08

2. Edoras Bank Deployment

Tail buoy ropes for the two port beams were increased from 14m to 17m lengths. Starboard beam buoys were left at 14 m. Mid-way through the deployment, first one and then the second tail buoys were lost from the starboard inner beam, leaving the beam to sink deeper. Unfortunately, the depth sensor on this beam failed, but the bubble pulse periods of the guns were logged routinely after this (and are recorded in the Sercel log book), so it will be possible to estimate the gun depths from those. The depth sensors were re-calibrated before the Edoras Bank deployment, and all gave a similar calibration curve for which the average is as shown here:

TRUE DEPTH (m)	10	11	12	13	14	15
MEASURED DEPTH ON REFTEK (m)	8.43	9.36	10.16	11.08	11.99	12.85

ECHO-SOUNDERS

The 10 kHz echo-sounder used the SIMRAD inoard system, with an 8-element fish deployed on the port side. Depths on the Simrad readout assume a sound velocity in water of 1500 m/sec. All the depths in the data logger were tracked automatically by the Simrad and may need editing over very steep areas.

The 3.5 kHz echo sounder used the fish deployed from a davit on the starboard side.

Time marks on the Simrad echo-sounder are taken from the main ship's clock, but those on the 3.5 kHz are taken from an internal clock and so may not be keyed exactly the same.

MAGNETOMETER

The sensor head is approximately 650 H (100 m) behind the stern of the ship.

SHOT TIMING

1. The initial power-on pulse for the Sercel was taken from the ship's master clock. For the 40 sec records, the pulses were initiated at 00 seconds on an even minute. So the cycle was repeated as:

   0000:00
   0000:40
   0000:20 etc.

2. The trigger to the REFTEK guns firing system was taken from the Cambridge Cream Clock, synchronised to the second marks, and output approximately 1 sec after the Sercel power-on.

   i.e. 0000:01
   0000:41
   0000:21 etc.

   The delay is not precisely 1 sec, because the Cream Clock was reset manually. The precise delay should be taken from the clock calibration curves which were recorded throughout the cruise.

3. The guns were fired 50 msec after receiving the trigger from the Cream Clock. The time break sent from the REFTEK when the guns fired was used to initiate the digital output on the Sercel.

4. This complicated system of using two separate clocks to initiate the Sercal and the Reftek gun firing was necessary because the pulses output from the RVS computer control system produced jitter of several tens of milliseconds. This would not have mattered for the mcs reflection profiles, which did not start their zero time until the gun pulse was received, but it would have been fatal for our OBS records which are recorded against independent clocks.

5. The triggers to the SAQ system, the jet pen monitor of disposable sonobuoys, the STORE 4DS and the Waverley Recorder were all taken from the Cambridge Cream Clock (i.e. they were 50 msec before the gun firing instant).

DISPOSABLE SONOBUOY RECORDING

Ths disposable sonobuoys were recorded on the STORE 4DS (analogue) and on the RVS SAQ system (digital). Two separate receivers were tuned in to each sonobuoy, and recorded on two separate channels of the STORE 4DS and the SAQ, with different (fixed) gain settings.

STORE4DS:	Channel 1:	Sonobuoy with Gain 20
	Channel 2:	Sonobuoy with Gain 50
	Channel 3:	Cream clock with trigger superimposed (trigger is 50 msec before gun detonation
	Channel 4:	150 Hz flutter correction signal
SAQ System	Channel 1:	Disposable sonobuoy
	Channel 2:	Disposable sonobuoy
	Channel 3:	Sercel Channel 4 monitor
	Channel 4:	Cream Clock

Normally a 20 sec record length was used on the SAQ system when disposable sonobuoys were deployed, but 9 sec or 11 sec at other times.

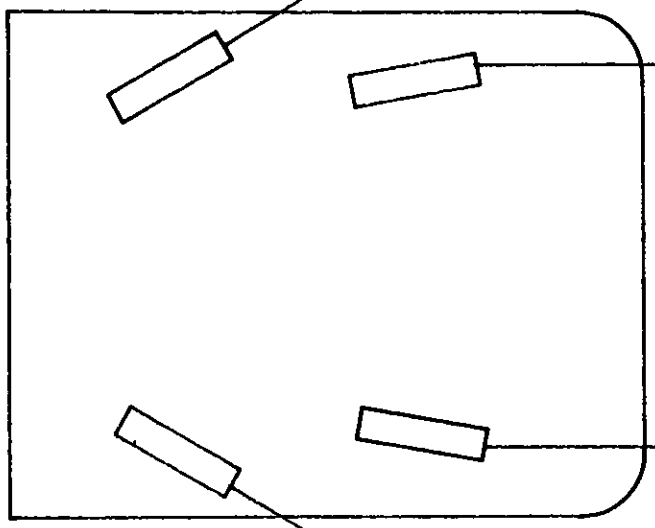
DISPOSABLE SONOBUOYS

Sonobuoy No.	Deployment Time	Latitude	Longitude	Type	Hydrophone Depth	Comments
1	1517/99	61°57.77'N	26°49.10'W	Dowty SSQ906	30 m	Good
2	1745/199	61°50.97'N	26°28.27'W	Dowty SSQ906	140 m	Good
3	0908/200	61°35.53'N	26°04.22'W	Dowty SSQ906	140 m	Hydrophone cut by streamer at 0926/200
4	0935/200	61°34.01'N	26°06.84'W	Dowty SSQ906	140 m	Hydrophone cut by streamer at 0955/200
5	1345/200	61°18.28'N	26°32.18'W	Dowty SSQ904A	137 m	Good
6	0009/201	61°16.75'N	26°07.52'W	Dowty SSQ906	140 m	Good
7	0523/201	61°31.20'N	26°52.20'W	Dowty SSQ906	140 m	Good
8	1554/205	57°00.03'N	24°33.61'W	Ultra SB6E4	137 m	Excellent

TABLE OF JULIAN DAY NUMBERS

Sat	11th	July 1992	193
Sun	12th		194
Mon	13th		195
Tues	14th		196
Wed	15th		197
Thur	16th		198
Fri	17th		199
Sat	18th		200
Sun	19th		201
Mon	20th		202
Tues	21st		203
Wed	22nd		204
Thur	23rd		205
Fri	24th		206
Sat	25th		207
Sun	26th		208
Mon	27th		209
Tues	28th		210
Wed	29th		211
Thur	30th		212
Fri	31st		213
Sat	1st	August 1992	214
Sun	2nd		215

SHIP CD
CRUISE 70



Depth 1 — Depth 2

BEAM COLOUR - RED 1100

GUN No	1	2	3
SIZE	300	200	600
REFTEK GROUP	1	1	1
REFTEK TRACE	1	2	3
CONNECTOR No	1	2	3

Depth 3

BEAM COLOUR - YELLOW 746

GUN No	5	6	7
SIZE	160	120	466
REFTEK GROUP	1	1	1
REFTEK TRACE	5	6	7
CONNECTOR No	5	6	7

Depth 5

BEAM COLOUR - BLUE 900

GUN No	9	10	11
SIZE	300	200	400
REFTEK GROUP	2	2	2
REFTEK TRACE	1	2	3
CONNECTOR No	9	10	11

Depth 6 — Depth 7

BEAM COLOUR - WHITE 1820

GUN No	13	14	15
SIZE	700	120	1000
REFTEK GROUP	2	2	2
REFTEK TRACE	5	6	7
CONNECTOR No	13	14	15

Sercel Header

Byte	Data			Type
1 - 10	Record Number (5 times)			BCD (MSB:LSB)
11	Sample Rate (H) & Type of record (L)			
12	Fixed Gain (L)			
13,14	Trace Count			
15,16	Shot Point Number			
17,18	Null Bytes			
19 - 22	Identification			
23,24	Reel Number (Fixed at start of line & NOT changed)			
25,26	Day (" " " " " & " ")			
27,28	Month (" " " " " & " ")			
29,30	Year (" " " " " & " ")			
31 - 39	Null Bytes			
40	Recording Delay (Refraction)			
41	Null Byte			
42	Filters (On or Off Status)			
43 - 58	Additional Control Panel Information			
		fdata	ldata	
59,64	Position Number (3 times)		4	
65	Year			
66,67	Day			
68 !	Hours			
69	Mins			
70	Secs			
71				
72				
73,74	Ship ID	1,2		
75,76	Cruise Number	3		
77	Line Number	5		
78	Line Type	6		
79,80	Tape Number (actual)		3	
81 - 96	Client's Name	7-22		
97,98	Intended Ships Heading	23		
99,100	Actual Heading (Gyro)			
101,102	Tail Buoy Heading		6	
103	Ship's Speed (1/10s)			
104				
105,106	Latitude Degrees & tens Mins			
107,108	Latitude Mins (1/1000s)			
109,110	Longitude Degrees & tens Mins			
111,112	Longitude Mins (1/1000s)			
113	WB 1 Position	25		
114	WB 2 Position	26		
115,116	WB 1 Time (mS)			
117,118	WB 2 Time			
119,120	Length of first seismic block (mS)	32		
121	Record Length (Secs)		5	
222	Intended Shot Spacing (m)	27		
123	Reference to Stern distance	28		
124	Gun Sync Delay	29		
125	Manifold Pressure 1 (10 PSI)	30		
126	Manifold Pressure 2	31		
127,128	Strain Gauge Reading			

129	Depth (H'Phone)	1		
130	Depth	2		
131	Depth	3		
132	Depth	4		
133	Depth	5		
134	Depth	6		
135	Depth	7		
136	Depth	8		
137	Depth Position	1	Section No.	33
138	Depth	2		34
139	Depth	3		35
140	Depth	4		36
141	Depth	5		37
142	Depth	6		38
143	Depth	7		39
144	Depth	8		40
145	Gun Depth	1	(in m)	41
146	Guo Depth	2		42
147	Gun Depth	3		43
148	Gun Depth	4		44
149	Gun Depth	5		45
150	Gun Depth	6		46
151	Gun Depth	7		47
152	Gun Depth	8		48
153	Gun Depth	9		49
154	Gun Depth	10		50
155	Gun Depth	11		51
156	Gun Depth	12		52
157	Gun Depth	13		53
158	Gun Depth	14		54
159	Gun Depth	15		55
160	Gun Depth	16		56
161	Gun Position (X)	1	(in m)	57
162	Gun Position (X)	2		58
163	Gun Position (X)	3		59
164	Gun Position (X)	4		60
165	Gun Position (X)	5		61
166	Gun Position (X)	6		62
167	Gun Position (X)	7		63
168	Gun Position (X)	8		64
169	Gun Position (X)	9		65
170	Gun Position (X)	10		66
171	Gun Position (X)	11		67
172	Gun Position (X)	12		68
173	Gun Position (X)	13		69
174	Gun Position (X)	14		70
175	Gun Position (X)	15		71
176	Gun Position (X)	16		72

177	Gun Position (Y) 1	73	
178	Gun Position (Y) 2	74	
179	Gun Position (Y) 3	75	
180	Gun Position (Y) 4	76	
181	Gun Position (Y) 5	77	
182	Gun Position (Y) 6	78	
183	Gun Position (Y) 7	79	
184	Gun Position (Y) 8	80	
185	Gun Position (Y) 9	81	
186	Gun Position (Y) 10	82	
187	Gun Position (Y) 11	83	
188	Gun Position (Y) 12	84	
189	Gun Position (Y) 13	85	
190	Gun Position (Y) 14	86	
191	Gun Position (Y) 15	87	
192	Gun Position (Y) 16	88	
193	Gun Size 1 (x10 Cubic ins)	89	
194	Gun Size 2	90	
195	Gun Size 3	91	
196	Gun Size 4	92	
197	Gun Size 5	93	
198	Gun Size 6	94	
199	Gun Size 7	95	
200	Gun Size 8	96	
201	Gun Size 9	97	
202	Gun Size 10	98	
203	Gun Size 11	99	
204	Gun Size 12	100	
205	Gun Size 13	101	
206	Gun Size 14	102	
207	Gun Size 15	103	
208	Gun Size 16	104	
209	Guns Online Array 1	105	7
210	Guns Online Array 2	106	8

248-255 Record Number (5 Times)