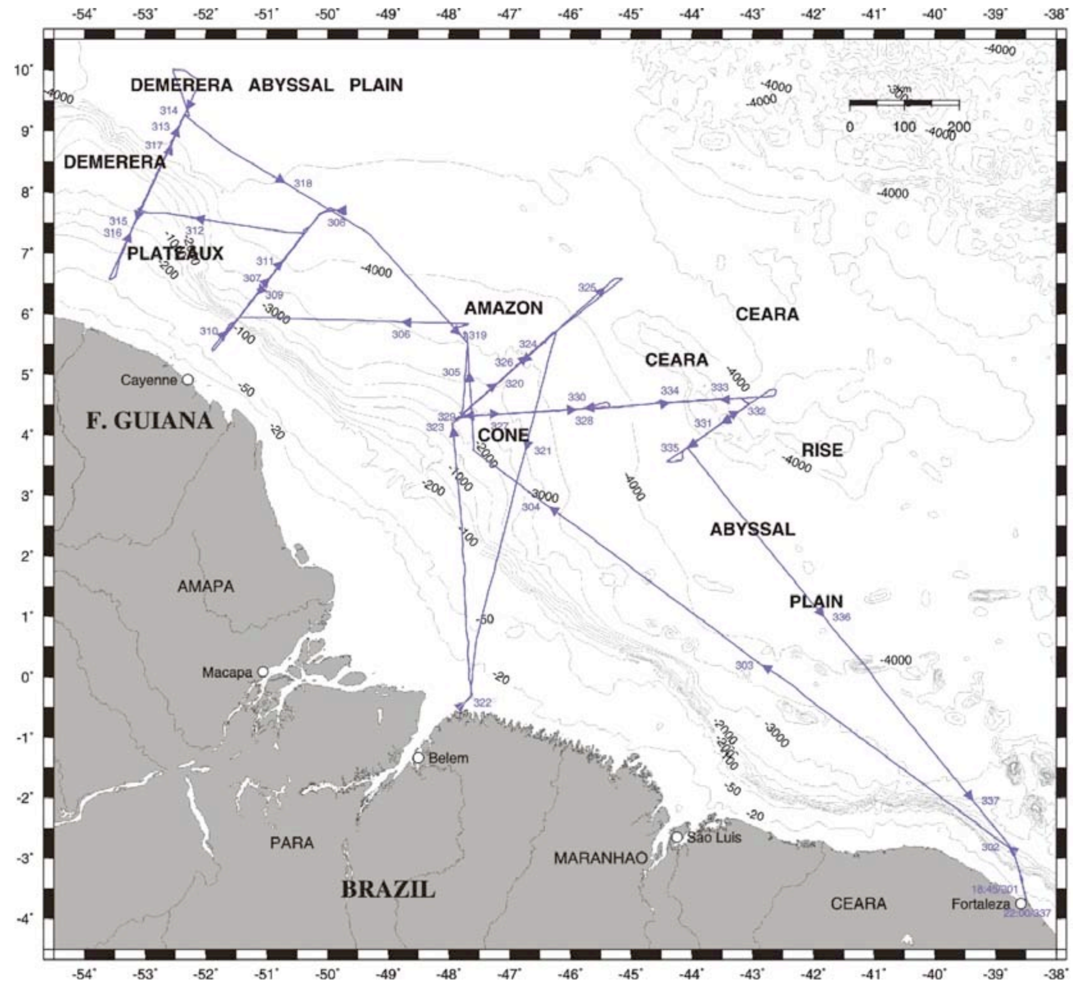
RRS Discovery D275

Cruise Report

Amazon Cone Seismic Experiment - ACE



25th October – 3rd December 2003

Fortaleza (Brazil) – Fortaleza (Brazil)

RRS Discovery D275

Cruise Report

Amazon Cone Seismic Experiment - ACE

Trials: 10th October - 16th October 2003
Lisbon, Portugal – Santa Cruz de Tenerife, Tenerife, Canary Islands

Cruise: 28th October – 3rd December 2003
Fortaleza, Brazil – Fortaleza, Brazil

Professor A.B. Watts

Department of Earth Sciences
University of Oxford
Parks Road
Oxford
OX1 3PR

tony.watts@earth.ox.ac.uk

Dr Christine Peirce

Department of Earth Sciences
University of Durham
South Road
Durham
DH1 3LE

christine.peirce@durham.ac.uk

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Summary

We carried out a marine geophysical survey of the NE Brazil and French Guiana continental margin onboard RRS Discovery (D275). The data is high-quality and includes multichannel seismic reflection and refraction, gravity, and magnetic profiles of the margin in the region of the Demerara Plateau, the Amazon deep-sea fan, and the Ceara Rise. Although clearance problems prevented us from surveying the Upper Amazon fan, we were able to acquire three seismic profiles of the Middle and Lower fan where we were able to image the mid-Miocene unconformity and the top of the flexed oceanic basement. We were also able to acquire an additional seismic profile over the Demerara Plateau and two seismic profiles over the Ceara Rise.

In general, all equipment worked well throughout the entirety of the cruise, with minimal failure or maintenance required above that which could be anticipated. Undoubtedly this was made possible by the equipment trials which took place during the passage of Discovery from the mobilisation port of Lisbon to Fortaleza – the pre-cruise port of call. It also became clear that major components of the geophysical equipment base have reached the end of their useful lives and need urgent replacement.

On the whole the cruise was very successful despite diplomatic clearance to work in Brazilian waters never being received. However, a number of recommendations have been drawn from this experience as to long-term equipment provision, the cruise planning process and life onboard Discovery in general.

1. Introduction and cruise objectives

1.1 Introduction

Plate reconstructions (e.g. *Blarez*, 1986) show that prior to rifting, the northeastern Brazil margin was conjugate to Liberia and Ghana, close to the point where the Saint Paul's Fracture Zone presently intersects both margins. The Ghana margin to the south of the intersection is a shear-type margin (e.g. *Peirce et al.*, 1996) while the Liberia margin to the north, appears to be of rift-type (e.g. *Mascle*, 1976). These along-strike differences in structural styles are mirrored in the conjugate margin off northeastern Brazil. To the north of the Amazon River, for example, the margin is a rift-type margin - similar to offshore Liberia - while to the south it is probably a shear-type margin.

The close proximity of rift-type and shear-type margins along-strike of the northeastern Brazil margin make it an ideal locality to compare and contrast the deep structure of these margin types. Unfortunately, existing seismic refraction data is limited to sonobuoy profiles (*Edgar and Ewing*, 1968; *Houtz*, 1977; *Houtz et al.*, 1978). These data were interpreted, however, using the slope-intercept method and so provide little information on the velocity structure of the crust below the syn- and post-rift sediments.

The only constraints on deep structure of the northeastern Brazil margin have come from gravity modelling. *Braga* (1991), for example, used the Bouguer anomaly to argue that the continental crust beneath the shelf is about 30-35 km thick and the oceanic crust beneath the Ceara Rise is about 10 km thick (Fig. 1). Gravity modelling cannot, however, determine the nature of the crust that underlies the 400 km wide region *between* the shelf break and the flank of the Ceara Rise or the location of the Ocean-Continental Boundary (OCB). Neither can it determine the role (if any) that magmatism may have played in the evolution of the margin.

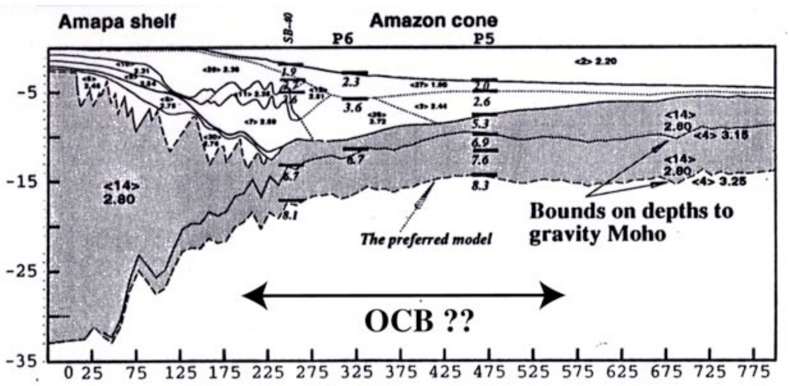

Figure 1 - Gravity modelling of crustal structure of the Amazon Cone (Braga, 1991).

This model has been constrained using sonobuoy velocities (e.g. *Houtz*, 1977) and illustrates the existing uncertainty in locating the Ocean-Continent Boundary (OCB).

The most striking morphological feature of the northeastern Brazil margin is the Amazon Cone (Fig. 2a). The Cone is a deep-sea fan system that forms the seaward extension of the vast (5 × 10^6 km^2) Amazon drainage basin. Extrapolation of sedimentation rates from piston cores (*Damuth*, 1975) suggest an age of 7.8 to 12.2 Ma for the Cone. These ages are in accord with Deep Sea Drilling Project (DSDP) drilling at Site 354 on the Ceara Rise which shows a cessation of pelagic sedimentation and an influx of terrigenous material at the base of the mid-Miocene and with the age of uplift in the Bolivian Andes (*Benjamin et al.*, 1987), suggesting that they are the major source for the Cone sediments. The volume of sediments in the Cone can be estimated by comparing a bathymetric profile across its centre, to an average bathymetry profile of the margin unaffected by the Cone load (e.g. Fig. 2b). The volume amounts to some 1.4 x 10^5 km^3 which, if we assume a sediment density of 2400 kg m^{-3}, corresponds to a mass of 3.5 x 10^{17} kg. The Cone is, therefore, one of the largest loads to have formed on the Earth's surface, exceeding that of Hawaii - the best studied load to date.

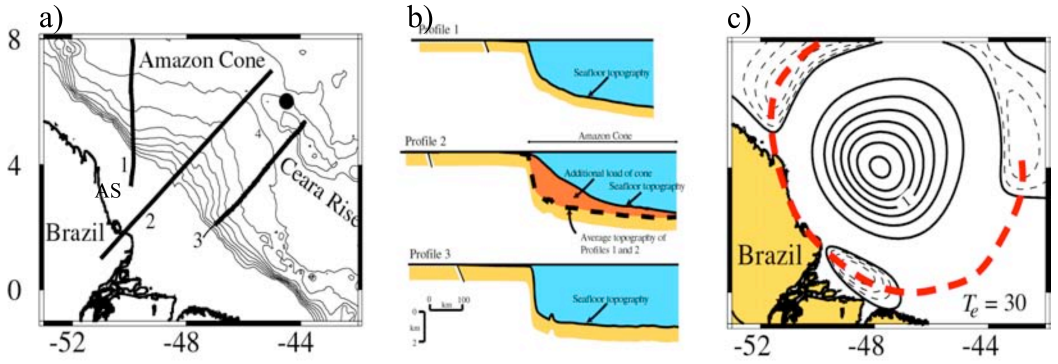

Figure 2 - Bathymetry, sediment load and flexure associated with the Amazon Cone.

a) Bathymetry at 500 m contour interval showing the location of Profiles 1-3.
b) Bathymetry Profiles 1-3 showing the additional sediment load associated with the Cone.
c) Flexure due to the Cone load based on T_e = 30 km. Contour intervals = 0.25 km (solid lines) and 5 m (dashed lines). Bold dashed line = flexural node. Note the coincidence of the node (which separates subsidence offshore from uplift onshore) with the coastline.

The significance of the Amazon Cone for flexural loading studies has been recognised by previous workers. *Cochran* (1973) and *Braga* (1993), for example, showed that the free-air gravity anomaly over the northeastern Brazil margin could be explained by a model in which the sediments underlying the Cone loaded an elastic plate with a thickness, T_e, in the range 12-31 km.

Driscoll and Karner (1994) were the first to consider the flexural effects of only the Cone load. They showed that the thickness of mid-Miocene and younger sediments offshore and the location of the drainage divide onshore were consistent with a T_e of 38 km. Their value, which represents the response of a margin to loading ~ 88-100 Myr after rifting, is higher than the average values of Cochran and Braga, and suggests that T_e of the extended continental lithosphere beneath the Cone load may have been low soon after rifting and then increased with time.

The T_e structure of extended continental lithosphere is currently a topic of much debate. Studies at the East Coast, USA (e.g. *Watts*, 1988) and Rockall Bank (e.g. *Fowler and McKenzie*, 1989) indicate that rifted margins are weak. Other margins appear to be strong (e.g. New Zealand - *Holt and Stern*, 1991; Canada - *Keen and Dehler*, 1997). The problem is that the T_e in these studies, like those of Cochran and Braga, reflect the *average* response of a margin to sediments with a long loading history.

The northeastern Brazil margin with its large, concentrated, Cone load is an ideal locality to study the thermal and mechanical properties of extended continental lithosphere. Moreover, there already exists a large, industry-standard, multichannel seismic (MCS) database which, if it could be converted to depth, would enable the flexure surface associated with the Cone load, as well as older margin loads, to be accurately determined. By careful backstripping of these surfaces using different models for T_e, restoring their position in time, and calculating their associated gravity, it should be possible to determine, for the first time, the T_e structure of the margin. The depth converted reflection data could also be used to determine the amount of yielding and the stress state in the basement deformed by the Cone load. If extended continental lithosphere is weak, for example, then we would expect large flexures and high curvatures and bending stresses in the deformed basement. Stresses would be expected to be compressional immediately beneath the Cone load which, in turn, may lead to inversion of syn-rift normal faults and, possibly, whole crustal failure.

Probably the most important implications of seismically constrained flexure modelling are for segmentation and the OCB. If extended continental lithosphere is weak and unable to re-gain its strength following a heating event, then its response to loads will be strikingly different from that of oceanic lithosphere. This difference has important implications for the across- and along-strike segmentation of continental margins - where weak lithosphere may abut strong - and might provide a powerful new method to locate the OCB - not only at the northeastern Brazil margin - but at other margins world-wide.

1.2 Scientific objectives of D275 – Amazon Cone Experiment (ACE)

The main aims of cruise D275 were as follows:

- To determine the **deep structure** of the crust beneath the Amazon Cone and the **shear-type** margin to the south and the **rift-type** margin to the north;
- To determine the thickness of **stretched** continental crust beneath the Cone load and, hence, its **thermal history;**
- To determine the role (if any) of **magmatism** at the margin;
- To determine the location of the **ocean-continent boundary**;
- To determine the **flexural rigidity**, **curvature,** and, hence, amount of **yielding** in the basement beneath the Cone load.

We proposed to determine the deep structure of the northeast Brazil margin using marine seismic, gravity and magnetic techniques. The planned field survey comprised three "transects" of the margin (Fig. 3): a centre profile through the Amazon Cone (Line A) and two "reference" profiles (Lines A and C) to the north and south, away from the influence of the Cone.

We proposed to deploy and recover 20 four-component ocean-bottom seismographs (OBSs) along Lines A, B and C. Each OBS would record the shots fired by a large-volume tuned airgun at 200 Hz sampling rates. The UKORS's mini-streamer and MCS reflection profiling system would be used to obtain normal incidence reflection data along each refraction profile, and between profiles if time permitted. The airgun array would be designed with dual functionality such that both refraction and reflection data could be obtained simultaneously, and such that it could be easily re-tuned solely for MCS acquisition in regions between the proposed refraction lines.

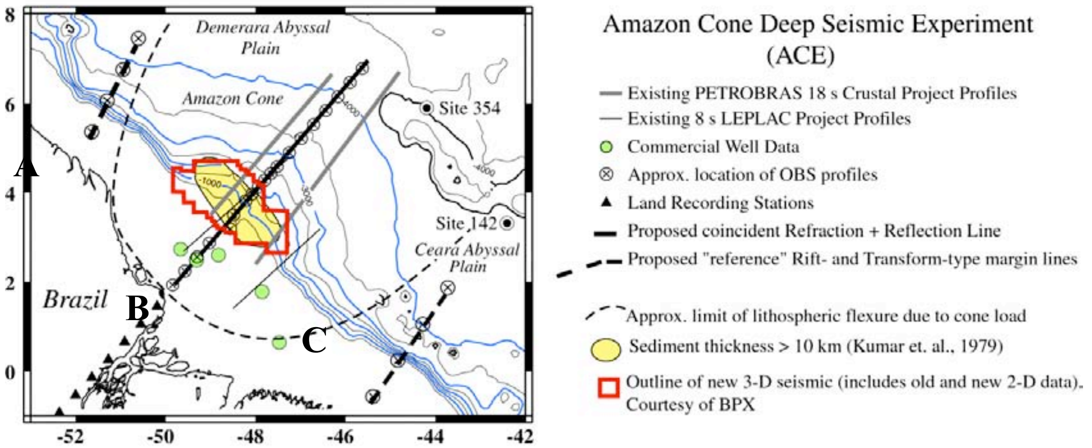

Figure 3 - The Amazon Cone Seismic experiment (ACE), as originally proposed to NERC/LINK.

1.3 Scientific plan

1.3.1 Pre-cruise changes to the scientific plan

The main pre-cruise changes to the scientific plan were to the ports of call (Fortaleza instead of Recife). Originally Recife was proposed due to its proximity to the work area. However, Fortaleza was chosen by RVOPs as it was deemed to have comparable facilities, but was viewed by the Foreign and ommonwealth Office to be safer. Fortaleza is located further from the work area than Recife and, thus, a few days were lost from the scientific programme as a result.

1.3.2 Intra-cruise changes to the scientific plan

The main changes to the scientific plan were caused by the inability to secure permission to work within the Brazil (200 nm) Economic Exclusion Zone (EEZ). We were able to complete Line A, offshore French Guiana, as planned since this straddles French Guianan and international waters for which we had permission. The UK-led land recording of Line A was also successful. We lost, however, the southern end of Line B and the whole of Line C. The Brazil-led land recording of Lines B and C were also lost.

The amended science programme was as follows:

- An additional line (Line D) offshore French Guiana.
- An additional lines over the middle Amazon fan (Line F).
- Two new lines over the Ceara Rise (Line G).

The location of all seismic profiles acquired during the cruise is shown in the figure below. Naming convention is ACEXXXY, where XXX is the day number when shooting commenced and Y is the line name.

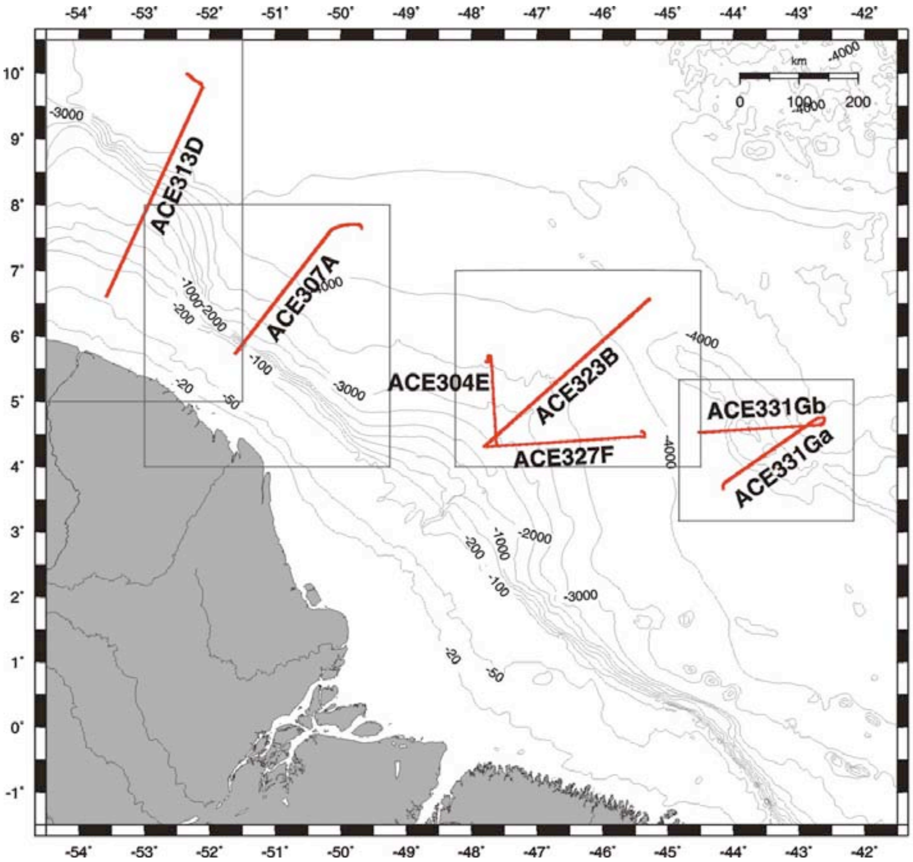

Figure 4 - Seismic lines shot during cruise D275-ACE.

1.4 Mobilisation and trials

Most geophysics cruises are very equipment and people intensive involving the mobilisation and operation of a wide variety of inter-dependent equipment that is expensive and often difficult to ship. Thus D275-ACE was mobilised in Lisbon prior to Discovery transiting across the Atlantic to the work area. This choice of mobilisation port offered the opportunity to ship the equipment by road and undertake a number of repairs to, and refurbishment of, the ship's fitted systems in port whilst mobilisation took place. It also offered the opportunity to load and set-up the ocean-bottom seismographs being operated by personnel from Geomar. In addition, major problems had been experienced with the UKORS' multichannel seismic equipment during its previous use, which had resulted in a major refurbishment or entire replacement of critical components such as the UKORS in-house developed shot firing system and the multichannel streamer. By mobilising in Lisbon, this provided an opportunity to run a short equipment trial during the Atlantic transect, where all systems could be tested under operational conditions. The trials took place as soon as Discovery entered international waters after leaving Lisbon and prior to its arrival off Santa Cruz de Tenerife where the personnel involved in the trails, and listed in table 1, were disembarked by boat transfer. A narrative of activities undertaken as part of the trails can be found in section 3.1 and report on equipment performance during the trials may be found in section 4.1.

For D275-ACE itself the mobilisation period in Fortaleza consisted mainly of recommissioning the sub-set of equipment that could not be left, post-trials, in a "ready to go" condition on deck due to likely deteriation as a result of exposure to a combination of salt water, the sun and the weather during the remaining transit across the Atlantic and checking thoroughly through all cabling, electrical contacts and air hoses. A report on equipment performance during D275-ACE may be found in section 4.2. Demobilisation also took place in Fortaleza and required the containerisation and packing of a large percentage of the equipment for shipping back to the UK. This process was severely hampered by significant delays in the supply of containers on arrival in Fortaleza and a delay in the vessel itself being allowed to dock due to liners and freight-carrying vessels occupying the entire length of the quay. The scientific party with flights home the following day were disembarked by boat transfer, with everyone else having to remain onboard. It proved impossible to secure the supply of a 40' container at all and so all items destined for this container were left on Discovery, which would be returning to the UK after its next cruise, together with the multichannel streamer and its winch. All other equipment was offloaded and packed into the delivered 20' containers, including the ocean-bottom seismographs which were to be shipped back to Kiel. A further delay of more than a month was experienced before the containers finally left Brazil.

2. Work conducted and data collected

2.1 Multichannel seismics

As already described in section 1.2, the original aim of D275-ACE was to acquire three margin transects (Fig. 1). The most southerly transect (Line C) was almost entirely located within Brazilian territorial waters, as was about a quarter of the Cone transect (Line B). As permission to work in Brazilian waters was never obtained as outlined in section 1.3.2, Line C was abandoned entirely and the length of Line B restricted to international waters only. A new profile, Line D, was designed to investigate the crustal structure beneath a smaller sedimentary fan system – the Demerera Fan. This profile is entirely contained within French Guyanan waters, for which we had permission, and international waters. Two further profiles were designed to investigate the 3-D architecture of the Amazon Cone (Line F) and the origin and development of the Ceara Rise (Line G). See Fig. 4.

2.1.1 Equipment

The seismic acquisition took two forms: multichannel reflection profiling, which will be described in this section, and wide-angle refraction, which will be described in section 2.2 in relation to ocean-bottom seismograph data acquisition. Both activities were undertaken contemporaneously and, thus, required the design of a seismic source suitably compatible with both data acquisition types.

The source array comprised 14 Bolt 1500LL airguns ranging in capacity from 160-700 cu.in.. The array configuration was designed with two purposes in mind. Firstly, to provide a source signature for reflection profiling that is compatible with the exploration of the sedimentary column beneath each profile and, secondly, to provide sufficient energy at low frequencies to investigate the entire crust and upper mantle using a wide-angle refraction approach. The total array volume was designed to be 6250 cu.in. and to be fired every 40 s in a randomised manner (+/-128 ms) to minimise coherent ringing in the water column whilst still providing adequate fold reflection data to resolve the primary reflection targets.

Fig. 5 shows the predicted source signature and frequency spectrum designed for D275-ACE. Three guns are arranged on each of four parallel beams (an inner and outer beam on both the port and starboard side), with two single guns towed separately from the stern A-frame. The array was designed to be towed 75 m behind the ship at a target depth of 15 m. Fig. 6 shows individual gun position, numbering and size. High pressure air (at 2200 p.s.i.), provided by the four onboard compressors, was supplied to each gun through umbilical hoses. Additional compressors installed in a container were also available to provide air should one, or more, of the onboard containers fail.

For D275-ACE an industry standard shot firing system, Gunlink, was hired from Seamap UK. This system was accompanied by one of Seamap's personnel during both the trails and the cruise itself. This system provides not only an array management system, in terms of firing the guns themselves, but also a mechanism which enables component parts of the shot firing system and airgun array to be monitored for quality control and preventative maintenance. The system logs all parameters to a database and has a user-friendly front end which allows a "point and click" approach to turning guns on and off, array configuration and an automated soft-start that is now required to comply with international guidelines for cetacean awareness and monitoring. In addition, the system enables the randomising of shot times within a defined window whilst also controlling the individual fire time of each gun to ensure peak array output at the shot time. The time at which the acoustic pulse from each gun coincides is known as the *Aim Point* and for this system it is 50 ms after the triggering pulse to start the firing cycle and to start the recording devices is received.

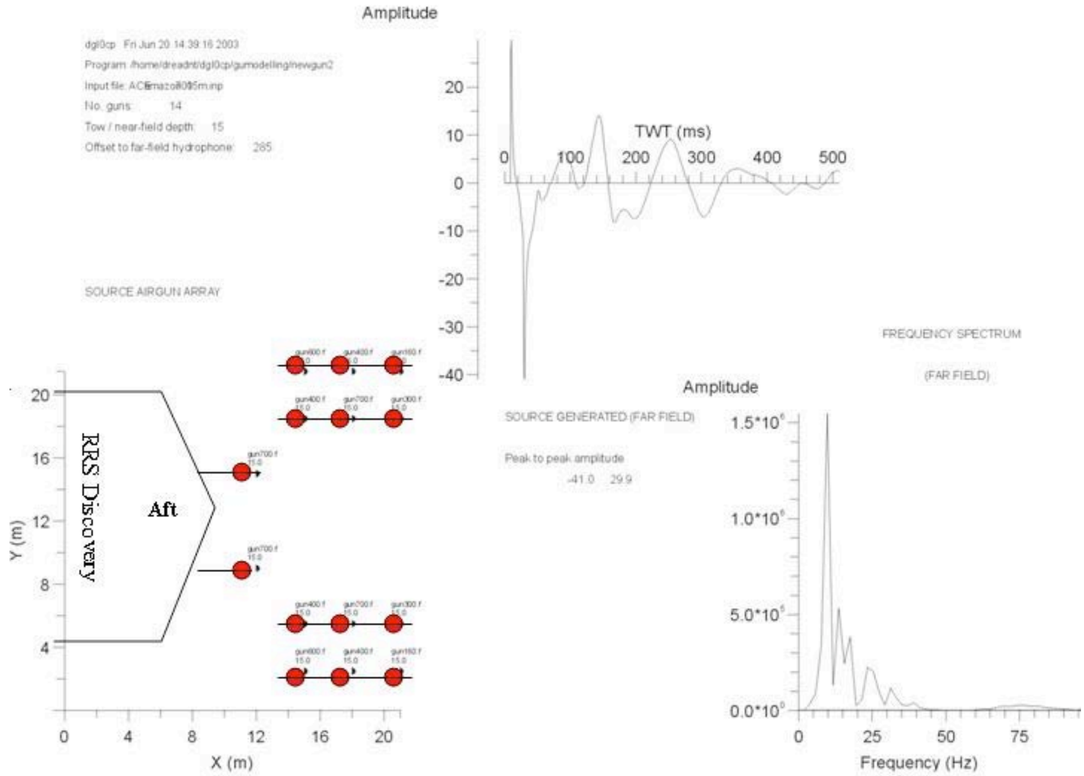

Figure 5 - Modelling of the source signature produced by the D275-ACE airgun array.

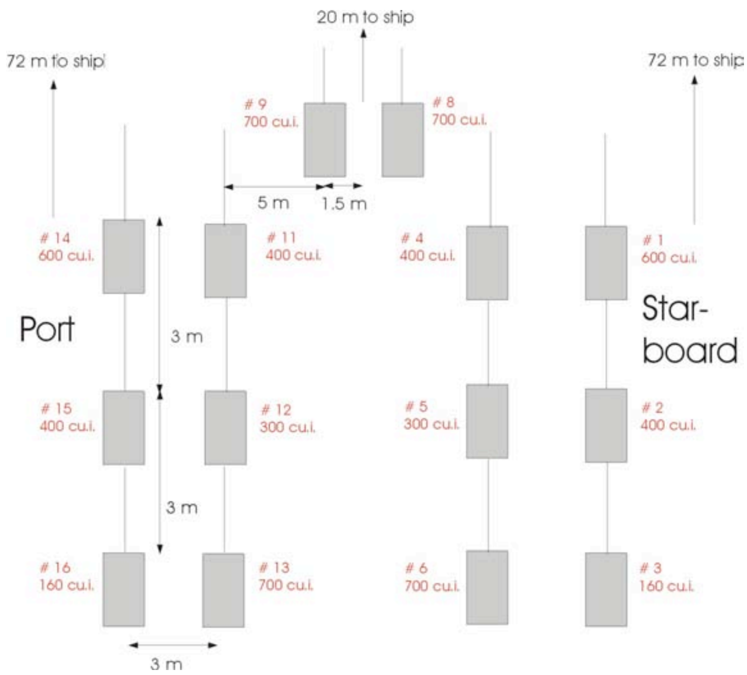

Figure 6 - Layout of the D275-ACE airgun array.

Gun numbers, sizes and distances are labelled. Note also that the GPS antenna is 47 m from the stern of the ship, i.e. 67 m from the single guns.

The UKORS' Teledyne multichannel streamer was used for reflection data acquisition. This streamer comprises moving vessel-ward:

a) a tailbuoy with GPS system, light and a radio transmitter;

b) a 50 metre isolator section;
c) 24 active sections 100m in length. Each active section consists of 4 groups, each 23.75m in length, separated by 1.25m. Each group is made up of 20 hydrophones at 1.25m intervals;
d) 13 altitude controllers (birds) with in built depth sensors and compasses;
e) 1 m long depth transducer section;
f) a 1 m water break section containing a hydrophone used for measurement of streamer offset via the direct wave from the airguns;
g) 4 spring/elastic sections each 50 m in length (total 200 m); and
h) a tow cable of 109 m length (measured to the fairings on aft deck).

The total length of the streamer from tailbuoy to tow-point is, thus, 2760m.

The data acquisition system used for D275-ACE is quite complex. The following provides an overview of this system. Beginning with the Seamap' Gunlink 2000 system, this provides the timing for shot firing, and is synchronised to the ship's master GPS clock. A pulse is sent at time zero to instruct various sub-systems to record the time, and to tell the Geode (shot hydrophone recording) and StrataView (streamer hydrophone recording) systems to begin recording. The pulse also commences the airgun firing process. Due to the varying gun sizes and the tuned nature of the array, the firing triggers are sent to each gun at slightly different times (smaller guns are triggered later) to result in the main energy release from the array to occur at the Aim Point, or 50 ms, after time zero. Thus, a 50ms static correction is required for all acquired seismic data. The Geode was set to record for 1 s, the StrataView system for 20 s. Data were recorded in SEG-D using DDS3 4 mm DAT magnetic tape on both the StrataView and Geode.

Since we were also recording each shot with ocean-bottom seismographs independently synchronised to the ship's master clock, the shot time data together with navigation data is also recorded on the ship's Level A-C systems for every shot. In addition, information from the streamer depth control birds and from the tailbuoy is also recorded by the Level A-C systems and information on the depths of the airguns stored in the Gunlink's database.

All recorded data were quality control processed onboard using ProMAX installed on two UNIX platforms supplied by the University's of Durham and Oxford. This QC formed part of the normal watch-keeping duties, and enabled monitoring of the source signature and ensured that data was actually being recorded to the field tapes in a re-readable manner. QC included: a) investigation of bad traces; b) analysis of overall noise content; and c) frequency analysis such that the need for any streamer or airgun array maintenance could be identified. Basic processing was also undertaken to ensure that the subsurface features of interested were being adequately resolved. The scheme adopted, by necessity, was fairly simple to keep up with the acquisition rate and available disk space, and included frequency filtering, a first-pass velocity picking and brute stacking.

A description of the performance of all equipment can be found in section 4.

2.1.2 Line overview

All lines were designated with a label that started with the acronym ACE, followed by a three digit number corresponding to the Julian day on which shooting commenced, and a final letter indicating the particular line (sometimes used alone as abbreviated line identification until shooting days were actually known). Fig. 4 shows a map of the work area with each of the six seismic lines added.

Table 9 contains an overview of the FFID numbers and shooting periods for each seismic line. A brief summary of each line follows. Lines are listed in order of acquisition.

Line ACE304E

Line ACE304E was shot during transit to the first pre-planned line (Line A), as an equipment test. Fig. 7 shows a close up of the line shot, and its location was chosen to contribute to a 3-D view through the Cone at the same time. This line was shot south to north and is approximately 177 km in length.

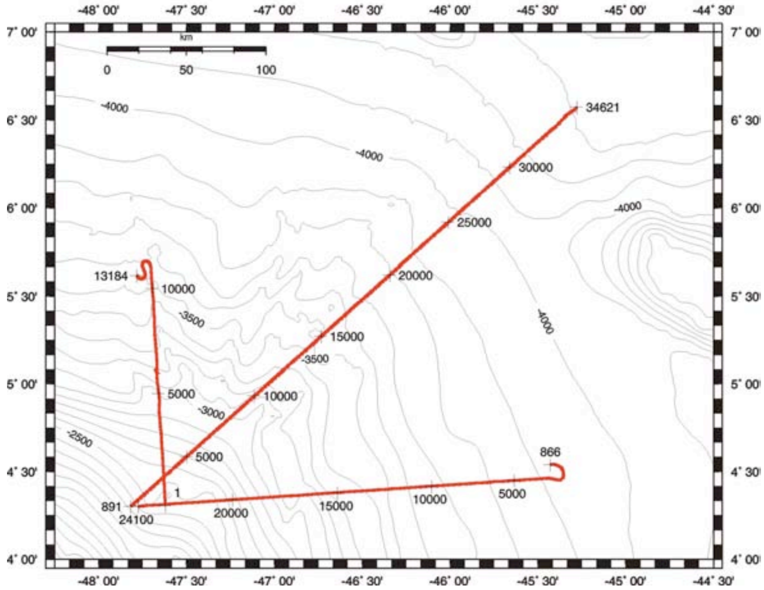

Figure 7 - Line ACE304E running south to north to the far left of the figure. CDP numbers are indicated.

Lines ACE323B (SW – NE) and ACE327F (E – W) are also shown.

Line ACE307A

Line ACE307A was shot off the coast of French Guiana, with 20 OBS/Hs deployed along its length at 10 km intervals. This line was shot in a north-east to south-west direction, i.e. towards the coast, (Fig. 8) and is approximately 330 km in length, and was shot in two distinct sections. The first, longer section was shot with the MCS streamer deployed. However, close to the coast where the water becomes shallower, the streamer was recovered and shooting was resumed into the OBS/H instruments only. Five land stations were deployed in-line with the on-land extension of this line. See section 2.4 for details. The shock-wave generated by the full volume array in the shallow shelf waters (<50 m) eventually resulted in line termination due to fears of damage to the vessel's propeller stern gland.

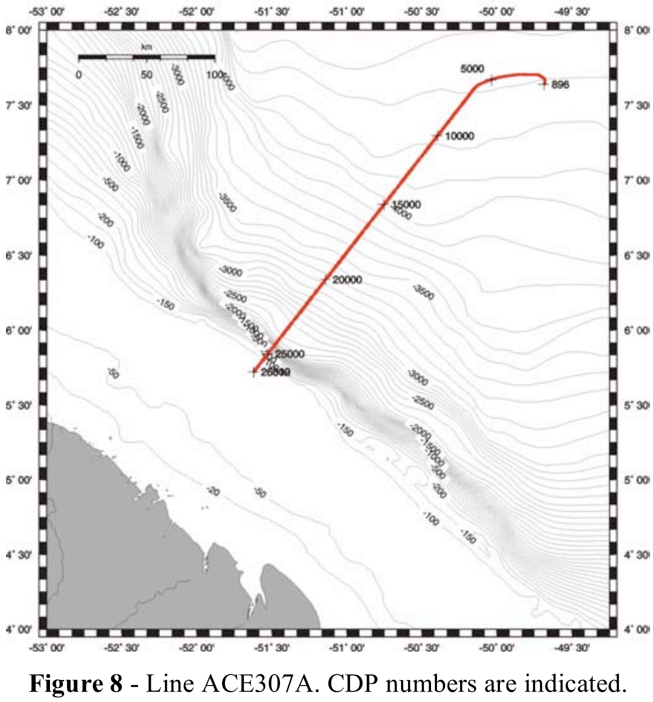

Figure 8 - Line ACE307A. CDP numbers are indicated.

Line ACE313D

Line ACE313D was shot to the north-west of line ACE307A, also offshore French Guiana. Similarly the line also had an accompanying deployment of 20 OBS/Hs each spaced 10 km apart, and was shot in the north-east to south-west direction, i.e. shoreward (Fig. 9). The line is approximately 451 km in length and its location was chosen, and the experimental programme designed, after sailing from Fortaleza when it became clear that diplomatic clearance might not be obtained in time to follow the original plan of shooting Line B directly after Line A. The land stations deployed for Line A were redeployed at the end of line D (see section 2.4).

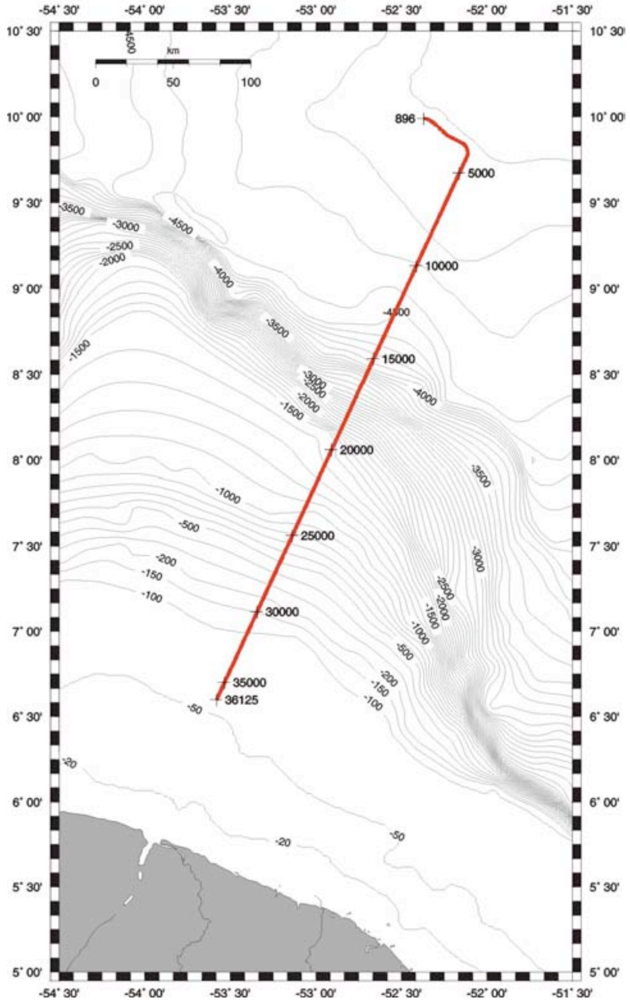

Figure 9 - Line ACE313D. CDP numbers are indicated.

Line ACE323B

Line ACE323B was shot perpendicular to the outflow of the Amazon River. Shooting began over the middle/lower Amazon Cone at a distance of approximately 200 nm from the Brazilian coast. The line was shot oceanward, from the south-west towards the north-east (Fig. 7). Note that this line crosses Line ACE304E near its beginning and is approximately 387 km in length, and was accompanied by the deployment of 19 OBS/H instruments spaced 12.5 km apart. Originally, this profile was planned to extend to within 20 nm of the coast and the shots fired to be recorded by land stations. In addition 39 OBS/H were to be deployed. However, two factors conspired to prevent either of these goals being achieved. Firstly the granting of permission to work within Brazilian waters was refused until personnel from their environmental agency ceased industrial action at some undeterminable date in the future. This ultimately confined us to international waters only and prevented the deployment of 7 OBS/Hs. Secondly, OBS/H deployment was terminated after only 19 instruments due to the necessity of an emergency boat transfer off Belem to disembark a crew member due to a family bereavement. The latter also resulted in the loss of several days of acquisition time.

Line ACE327F

Line ACE327F was shot in an east to west direction, heading landward towards the start of Lines ACE304E and ACE323B. Fig. 7 shows a close up of the line shot, which is approximately 284 km in length and was accompanied by the deployment of 8 OBS/H instruments. This profile was designed to provide input into a 3-D model of the toe of the Amazon Cone.

Line ACE331G

Line ACE331G was shot over the Ceara Rise, to the east of other MCS lines. The Ceara Rise is an aseismic ridge of unknown origin and has been drilled by the ODP and DSDP. Fig. 10 shows a track chart of this line together with its arrow-head shape. Shooting began from the most southerly point and proceeded in a north-east direction, before making a turn and altering course to an east to west direction heading along the same bearing as Line ACE327F. This line is approximately 442 km long, and was accompanied by the deployment of 12 OBS/H instruments; six on each leg of the line. Line ACE331G_a corresponds to the most southerly portion of the line (marked CDP 866 to 18220) and is approximately 230 km in length and Line ACE331G_b to the section running east to west (CDP 2594 to 22267), 212 km in length.

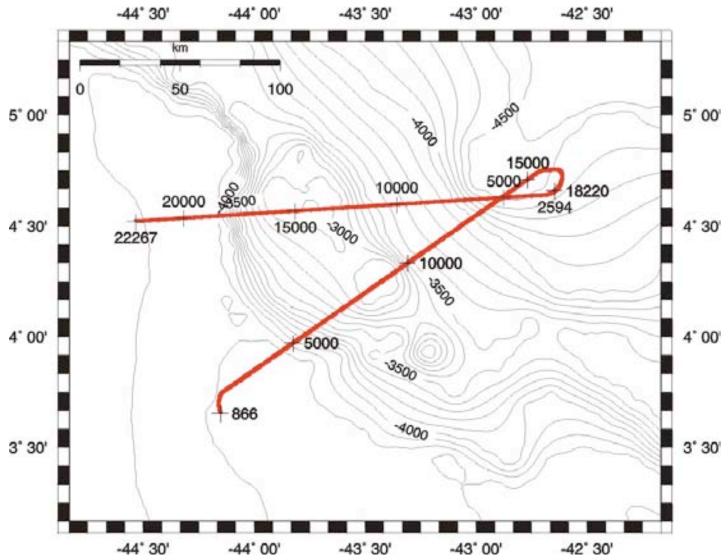

Figure 10 - Line ACE331G. CDP numbers are indicated.

2.2 Ocean-bottom seismograph deployments

A large volume of OBS/H data were collected in conjunction with the MCS data. For each seismic line (with the exception of Line ACE304E which was used primarily as a seismic equipment test) a number of OBS/Hs were deployed prior to seismic shooting and recovered after shooting ceased. The number of instruments deployed along each profile varied between 8 and 20, at separations of 10 to 25 km, and a mixture of OBSs and OBHs were used in combination to optimise the type and amount of data recorded relative to the available equipment. The OBS/H instrumentation was supplied and operated by Geomar under a hire contract.

A total of 79 deployments were made throughout the cruise and all instruments were recovered successfully. In some cases certain instruments failed to record on one, or more, channels although the reason for this was never resolved as the same instruments recorded on these failed channels on subsequent deployments. A summary of OBS/H deployment locations, relative to seabed depth, for each line is shown in Fig. 11, and example data from the hydrophone channel of Line ACE313D OBH 4 is shown in Figs. 12 and 13.

Figs. 14-17 show deployment locations and instrument numbers for each profile and exact deployment positions can be found in tables 3-8, with a summary of instrument numbers and types deployed along each line contained in table 2. As can be seen from Fig. 12, arrivals are observable for in excess of 200 km from an instrument location, while Fig. 13 shows the clarity and range of arrivals observable within ± 50 km of an instrument.

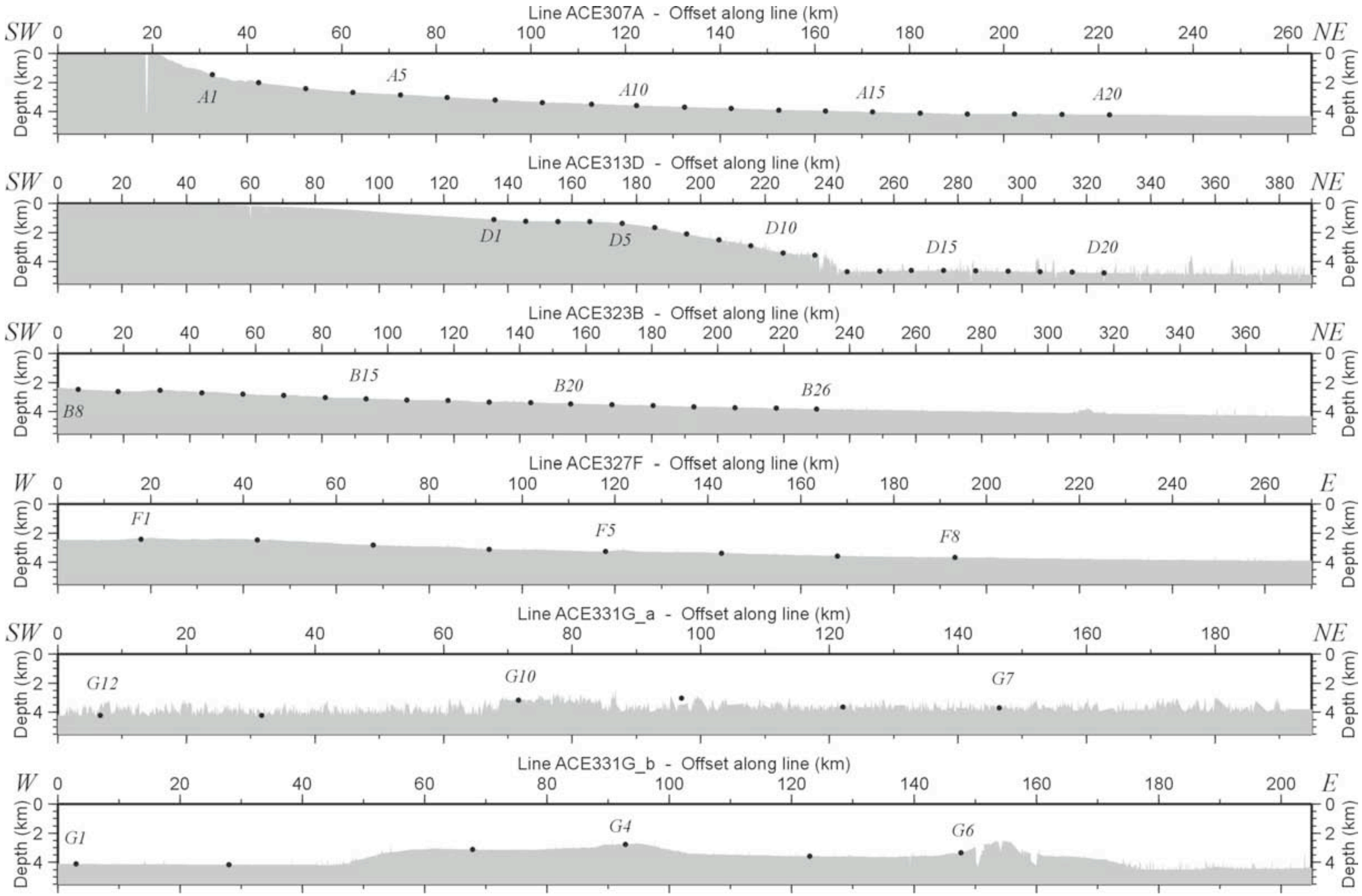

Figure 11 - OBS/H deployment locations for each line.

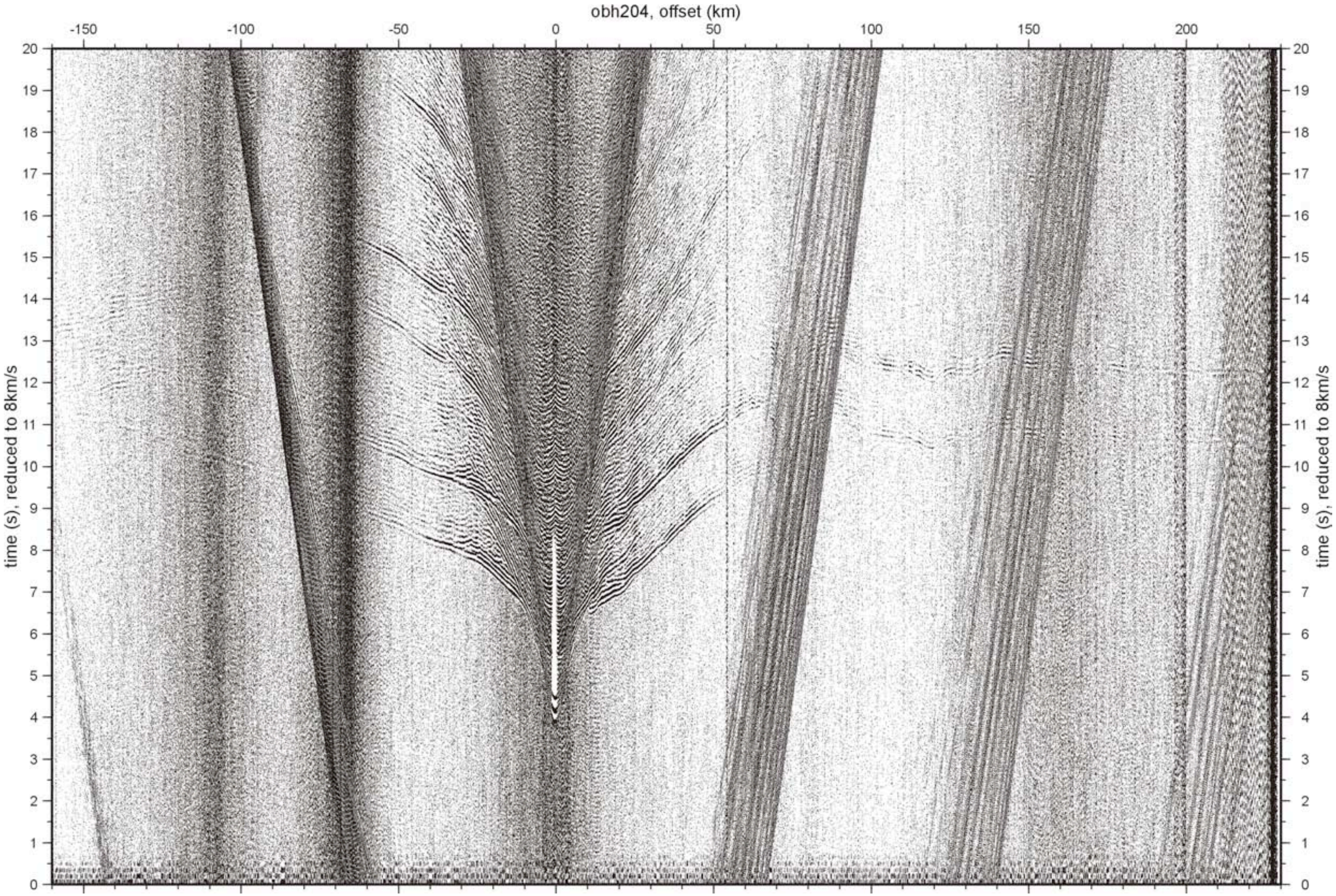

Figure 12 - Line ACE3313D OBH 4. Example data from the hydrophone channel.

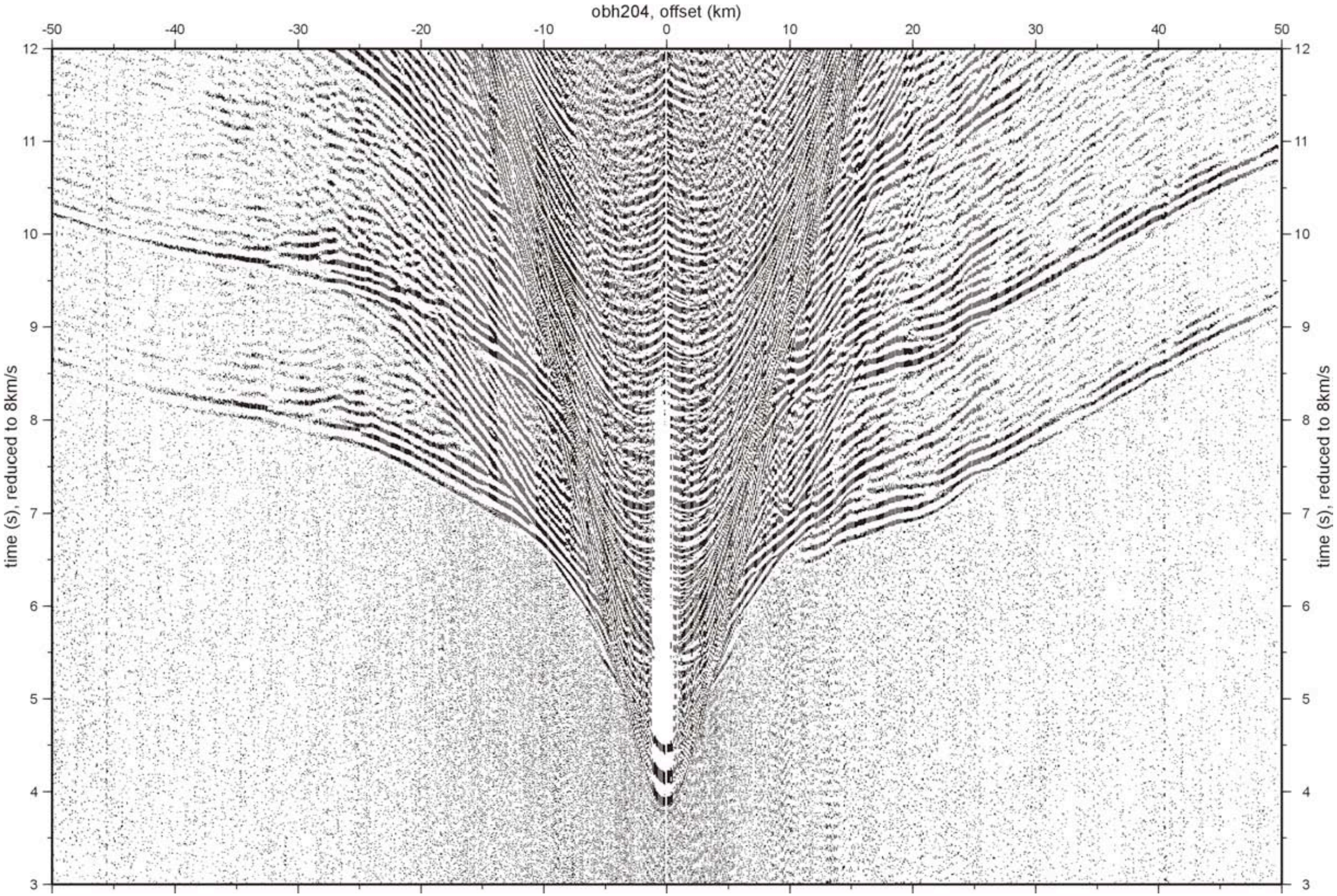

Figure 13 - Line ACE313D OBH 4. Example of the clarity of the arrivals.

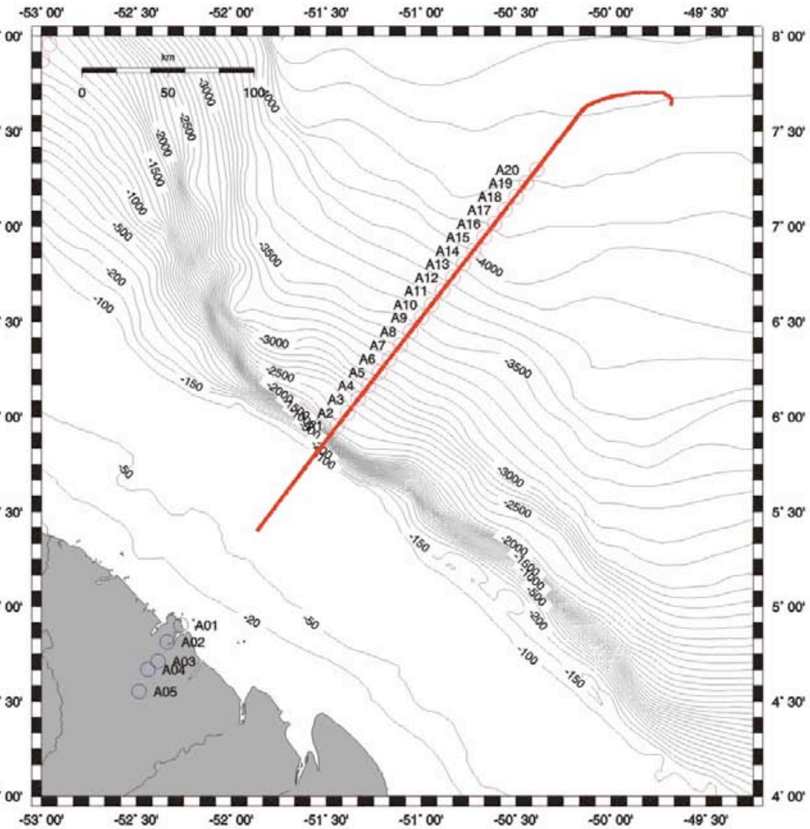

Figure 14 - OBS/H deployment locations for Line ACE307A.

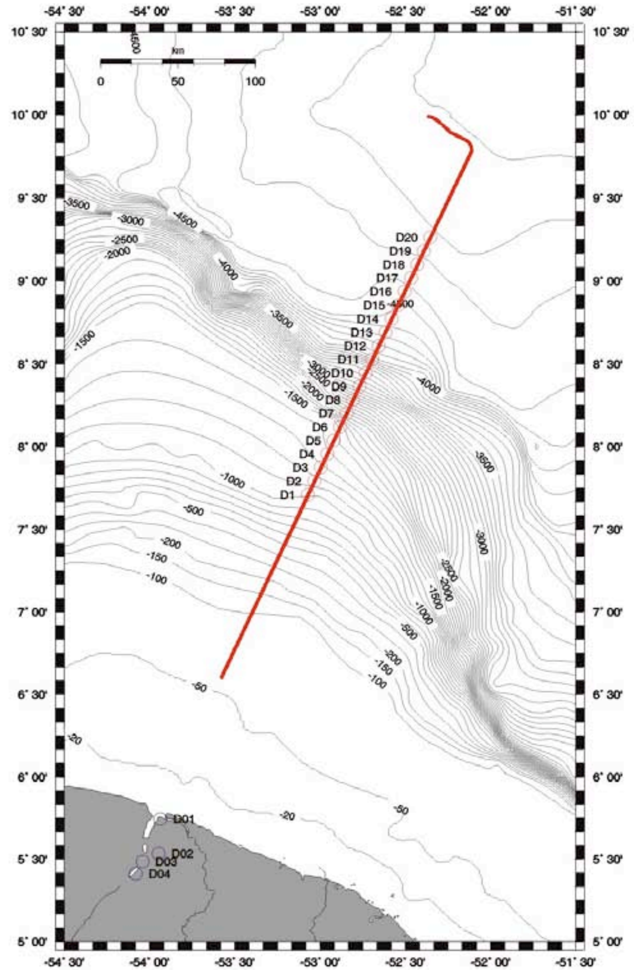

Figure 15 - OBS/H deployment locations for Line ACE313D.

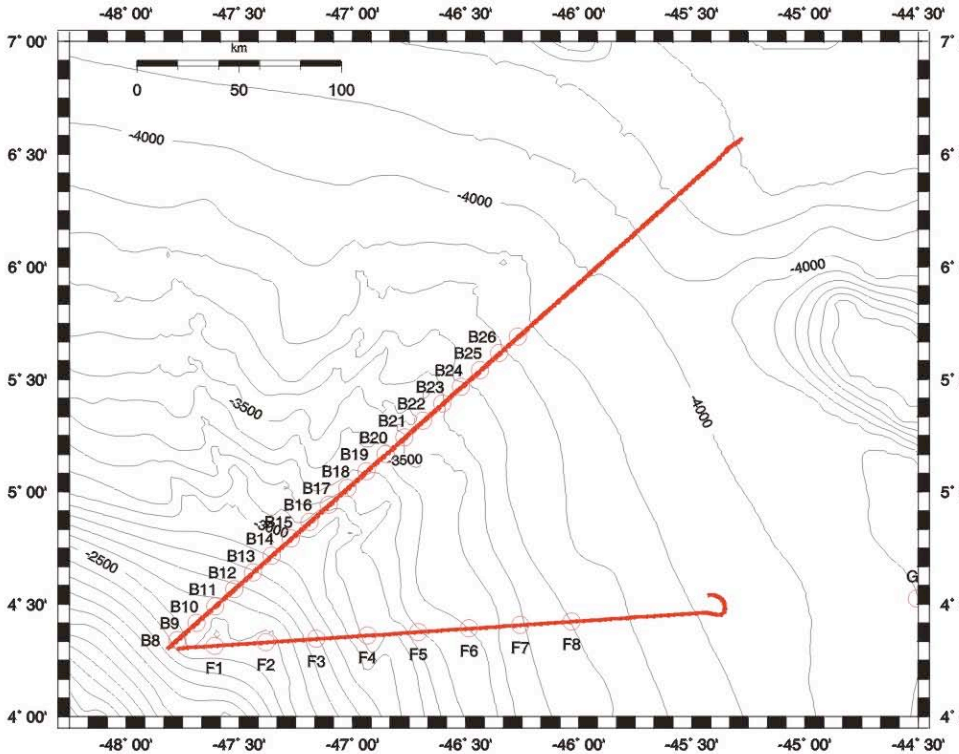

Figure 16 - OBS/Hdeployment locations for Lines ACE323B and ACE327F.

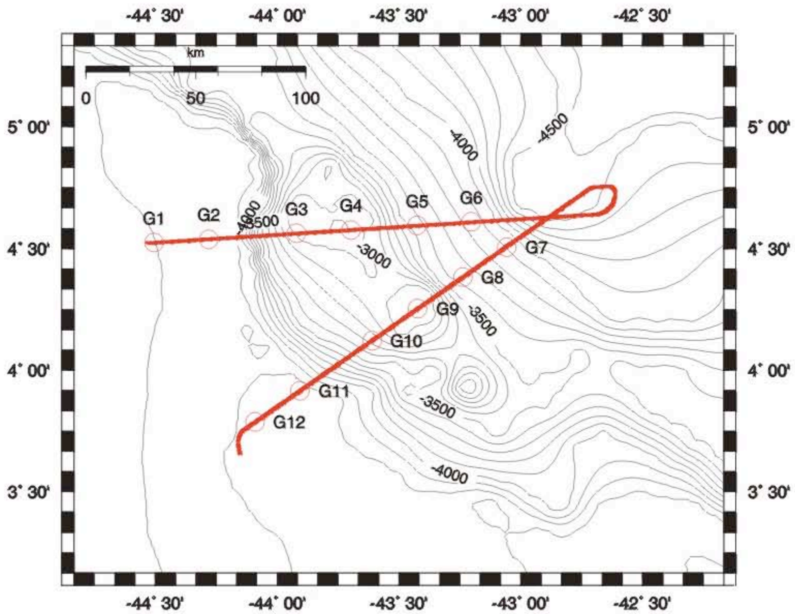

Figure 17 - OBS/H deployment locations for Line ACE331G.

2.3 Sound velocity profiling

Sound velocity profiling through the water column was attempted on four occasions during the cruise to collect information on the water column to inform ray-trace modelling of the wide-angle refraction data and by which to calibrate the more rapidly and more flexibly deployable expendable bathymetric thermographs.

The probe used, hired in especially for this cruise since the UKORS probe required repair, is designed to take measurements of sound velocity, pressure and temperature to a depth in excess of 2000 m. Fig. 18 shows the locations of sound velocity dips completed throughout the cruise, whose locations are given in table 10.

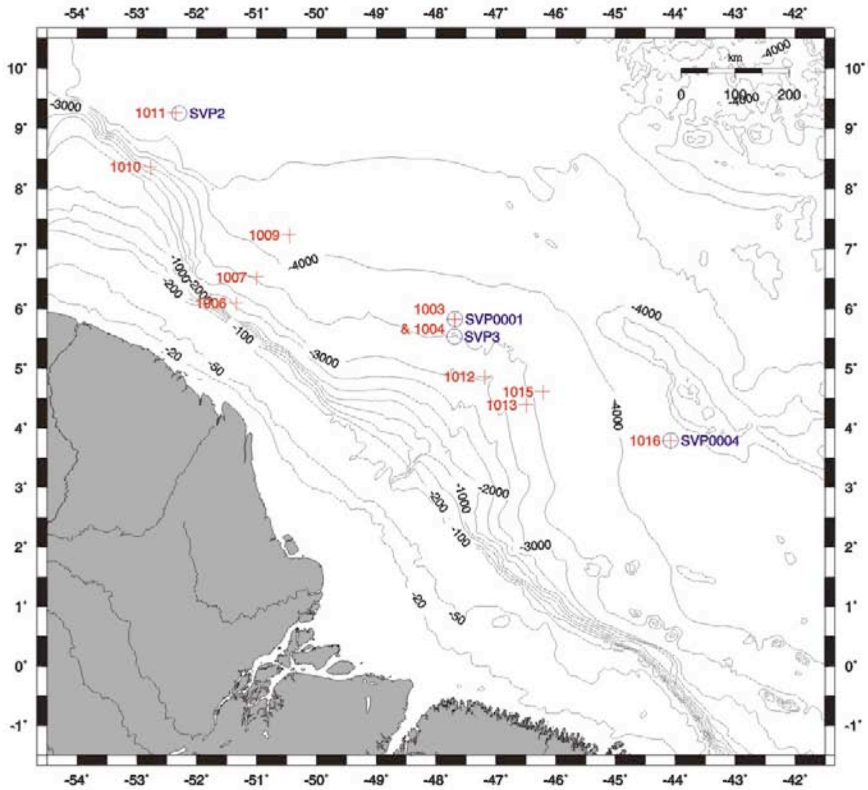

Figure 18 - XBT (light grey) and SVP (mid-grey) deployment locations.

2.4 Land recording

Simultaneous with the shooting of the offshore profiles a number of land stations were installed. The purpose of the land stations were to extend the velocity model landwards to ensure that a good estimate of crustal thickness and structure away from the extended continental margin could be obtained. Two groups were involved in the land acquisition: University of Durham (Richard Hobbs) using SEIS-UK equipment; University of Sao Paulo, (Prof Berrocal and team) using their own equipment. The work was scheduled in three parts to coordinate with the planned offshore activity. Hobbs was to run a profile on-land in French Guyana to compliment Line ACE307A using SEIS-UK equipment, then he was to move to Brazil and link up with Berrocal and record Line ACE323B using both Sao Paulo and SEIS-UK equipment, then finally to record Line C using SEIS-UK kit. In the event, due to changes in ship schedules, detailed elsewhere, the land recording plan was seriously modified.

Line ACE307A

Five SEIS-UK 6TD seismometers were deployed on an onshore extension to Line ACE307A extending from Cayenne to Cacao in French Guiana, profile length 46.8 km. Station locations were chosen in places were the Proterozoic bedrock was close to, or at, the surface and accessible by vehicle. Each station was installed by digging/augering a pit back-filling with wet sand to form a base, the 6TD was wrapped in a plastic bag and set in the pit, orientated to north, levelled and backfilled with wet sand. An external battery box was either buried nearby or left in shade of bushes, GPS antenna was located within 1 m of seismometer with a clear view of the sky. Station locations are given in table 12.

The stations recorded from Monday 3rd November 2003 (day 307) until Thursday 6th November 2003 (day 310), after which all stations were then recovered and checked. All stations had recorded for the full period. Later data downloading showed that all stations had recorded seismic data with clear events out to ranges of about 200 km and probable events at ranges of 400 to over 440 km, we believe this to be a record for single airgun source to single geophone station.

Line ACE313D

Line ACE313D was an additional line added to the program in the north of French Guiana. Four SEIS-UK 6TD seismometers were deployed on an onshore extension to Line ACE313D extending from Awala-Yalimapo to St. Jean, profile length 44.5 km. Station locations were more difficult on this profile as much of the coastal region is mangrove swamp with sand bars and the margins of the river are poorly consolidated mud. Two stations were located where bedrock was closer to the surface (D02 and D04), again each station was installed in a pit using the method above. Station locations are given in table 12.

Stations, D01 and D02, recorded from Saturday 8th November 2003 (day 312) and stations D03 and D04 recorded from Sunday 9th November 2003 (day 313) until Thursday 12th November 2003 (day 316), after which all stations recovered and checked. All stations had recorded for the full period. Later downloading showed that only two of the stations (D02 and D04) had recorded seismic data with clear events out to ranges of about 210 km, the other 2 stations had high levels of noise and possible poor coupling.

Fig. 19 shows the three-component data recorded at station A05. A strong P-wave arrive is seen on the vertical component with a distinct secondary arrival at near offsets (120-180 km) at 200 km, the events merge and have increasing delay possibly related to a change in water depth as the shooting ship passed over the continental shelf edge. There are no discernibile arrivals until 400 km when a coherent group of events at the noise threshold can be identified with a velocity of slightly more than 8 km/s at a reduced time of 9 s. S-wave arrivals were also recorded on the horizontal geophones, the N-S showing more coherency then the E-W component. Events can be identified that correspond to the arrivals seen on the vertical geophone for offsets of 120- 210 km.

After completing work in French Guiana, the SEIS-UK equipment was packaged and shipped to the UK and Hobbs travelled on to Belem, Brazil. The shipment of SEIS-UK equipment that had been sent to Belem was held in customs, after consultation with a lawyer arrangements were made to ship the kit to Macapa and Hobbs flew there to meet up with Barrocal. We moved to our field base at Tartaguralzinho and deployed Sao Paulo Ref-Tek seismometers. The SEIS-UK equipment remained impounded in customs. At this point it was clear that the permissions for operations in Brazilian waters would not be forthcoming. Hobbs and Berrocal returned to Belem and immediately initiated the return of the SEIS-UK equipment to the UK. Hobbs returned to the UK shortly after this was achieved.

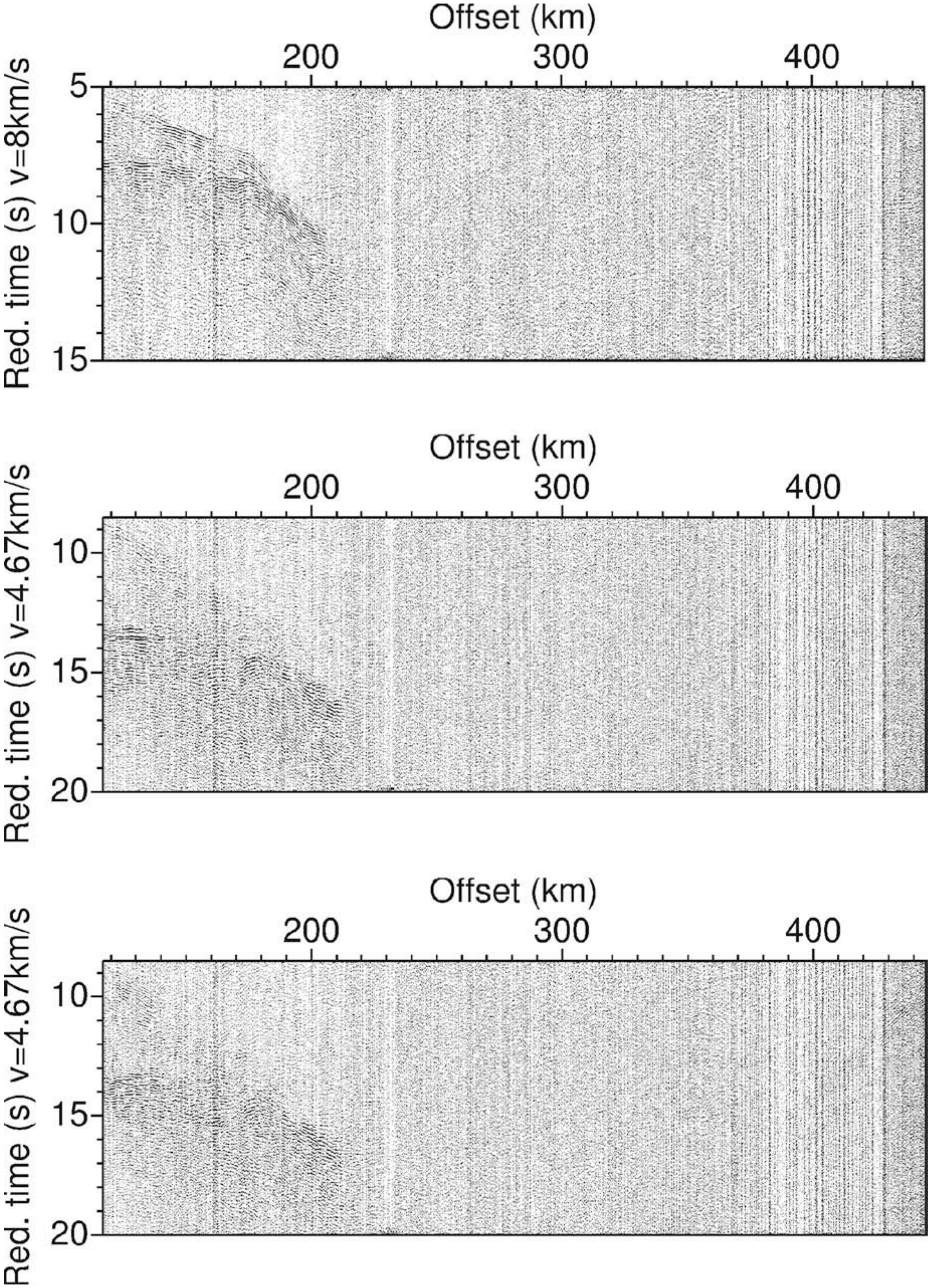

Figure 19 - Three-component data from land station A05.

Top: Vertical component reduced at 8 km/s;
Middle: N-S horizontal component reduced at 4.67 km/s; and
Bottom: E-W horizontal component reduced at 4.67 km/s.

On all three components arrivals can be mapped from 120-210 km and on the vertical component and a coherent packet of arrivals can be seen between 400 and 440 km offset.

2.5 Expendable bathymetric thermographs

A series of T5 expendable bathymetric thermographs were deployed throughout the cruise to map the temperature and velocity (once normalised to the sound velocity profile) of the water column in a rapid and more versatile manner than is possible using a sound velocity probe alone. Generally several probes were deployed along each line, each in areas of shallow, deep and intermediate depth waters. Once cross-calibrated against the sound velocity profile these could thus provide water column velocity through the work area and for every seismic profile. Fig. 18 and table 11 show deployment locations and Fig. 20 the profiles acquired.

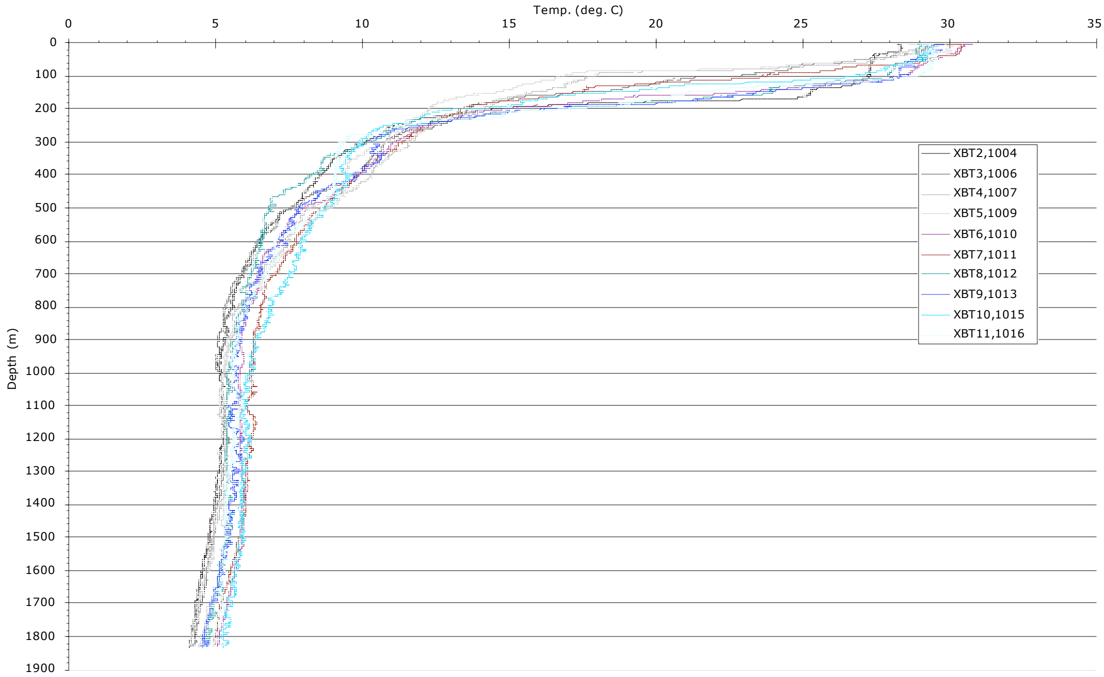

Figure 20 - XBT profiles acquired during D275-ACE.

2.6 Gravity

Gravity data were acquired using a Lacoste-Romberg air-sea gravimeter (Model S-84) mounted on a gyrostabilised platform. The sensor comprises a highly damped invar beam. Changes in g were obtained by time-averaging the beam motions (thereby eliminating the accelerations due to ship motions) using a 4 min 13 s delay filter.

The gravimeter was "tied-in" to a gravity base station in Fortaleza. The original Fortaleza base station was located at the airport, but has been destroyed. We therefore used a base station established by HMS *Hecate* at Berth 2, Bollard 10 (Fortaleza Docks) in 1987 where g had been determined as 978076.52 ± 0.20 mGal. We used a Worden land gravimeter (1 meter unit = 0.9967 mGal) to undertake the base station readings at the start and end of the cruise. The difference between the expected value of g at the end of the cruise and the actual value was attributed to a linear drift of the gravimeter, which we determined to be 0.088 mGal/day.

The accuracy of the data is reflected in the discrepancies in the free-air gravity anomalies at intersecting ship tracks. We found a total of 500 intersections that yielded a mean cross-over error of 0.97 mGal and a standard deviation of 6.91 mGal (Fig. 21). The relatively high standard deviation is attributed partly to the fact that the largest number of intersections occurred during OBS/H recovery/deployment (where there were large uncertainties in the Eotvos calculation) and partly to the fact that the gravity data has not yet been corrected for the cross-coupling error between the (vertical) beam motion and the ship's horizontal accelerations.

The instantaneous beam motion and ship's accelerations required to calculate the cross-coupling error have, however, been logged and we plan to calculate the error, filter it in the same way as the gravity data, and then apply it.

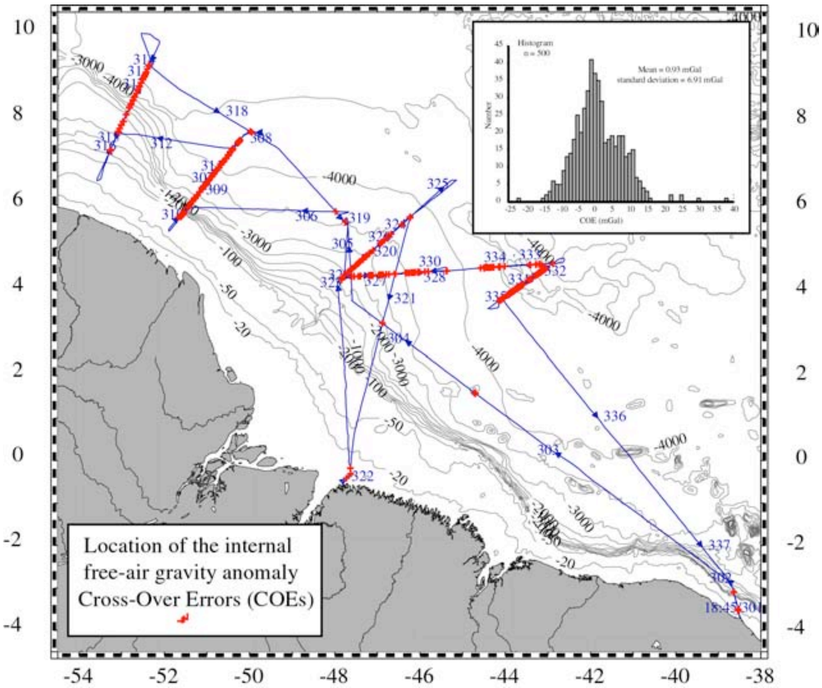

Figure 21 - Location of intersecting ship tracks of D275-ACE.

Note the large number of intersections along seismic Lines A, D, B, F and G. The inset shows a histogram of 500 intersections.

An example of the free-air gravity anomaly data acquired during and immediately following the shooting of seismic Line ACE313D is shown in Fig. 22. Note that noise levels in the gravity data are relatively low during the shooting of Line ACE313D, but relatively high following shooting when the OBS/Hs were being recovered. The mean free-air gravity over the deep sea is ~ -40 mGal. This low is present in maps of the long-wavelength (wavelength > 2000 km) free-air gravity anomaly field and forms part of a low that extends from the Brazilian shield, to east of the Caribbean, and into central Canada. At the Demerera Plateau margin, there is a distinct free-air "edge effect" high and low of about +/- 30 mGal, that is superimposed on the regional low. We attribute the edge effect anomaly to the transition between thick (continental ?) crust beneath the Demerara Plateau and the thin (oceanic ?) crust that underlies the adjacent ocean floor.

2.7 Magnetics

Magnetic data were acquired using a Varian proton precession magnetometer towed 200 m behind ship.

Fig 22 shows an example of the magnetic anomaly data acquired while shooting Line ACE313D. The line shows several prominent anomalies with amplitudes of ± 100 nT and wavelengths of 100-200 km. Similar amplitude and wavelength anomalies have been described by *Cochran* (1973) on north-south crossings of the St Paul's and Romanche Fracture Zones where they have been interpreted in terms of lateral changes in magnetization due to intrusion of ultra-basic rocks.

Other prominent magnetic anomalies were identified on the Demerera Plateau and over the deep seafloor to the west of the Ceara Rise. We attribute a large-amplitude magnetic anomaly low of ~ 600 nT along seismic Line ACE323B to basaltic rocks associated one edge of the buried western extension of the Ceara Rise.

2.8 Bathymetry – 10 kHz

Initially, 10 kHz bathymetry data were acquired using a towed fish and SIMRAD EA 500 hydrographic echo sounder. Almost from the moment of first deployment the fairing on the tow cable became damaged and had to be repaired at every available opportunity whilst other equipment was being deployed. Inevitably, the hull-mounted transducers had to be used instead as the fish tow cable fairing damage became irreparable due to the lack of spares, despite efforts to build completely new fairing from a fire hose. It appears the newly refurbished fairing supplied for the cruise had been constructed of a material that became very soft in the saline, warm waters of the work area, such that the fittings simply pulled straight through when under tow.

Fig. 22 shows an example of the 10 kHz bathymetry data acquired during and following the shooting of Line ACE313D. The data show considerable scatter due to the inability to achieve a consistent bottom fix using the hull-mounted transducers. However, the morphology of the Demerara Plateau and its adjacent ocean basin are clearly visible.

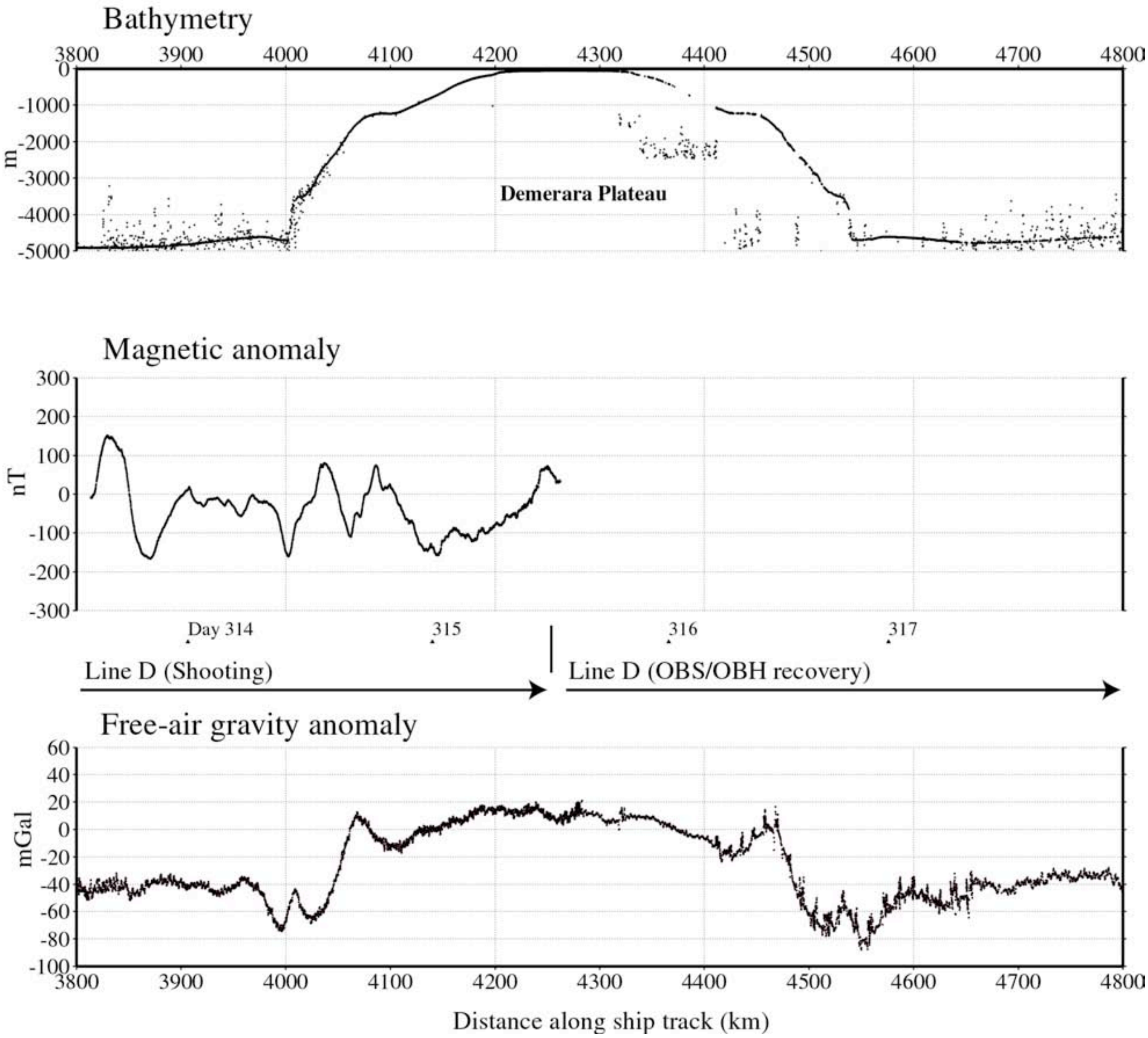

Figure 22 - Bathymetry, magnetic and free-air gravity anomaly profiles along Line ACE313D.

2.9 Sub-bottom profiling – 3.5 kHz

3.5 kHz sub-bottom data were acquired with a towed fish with four MASSA TR109F transducers, an Ocean Data TDU-850 recorder, and a Raytheon Ocean Systems PTR-105B transmitter. The output is in digital format and is written to 2 Zip drives.

The data are presently being translated to SEG-Y by Luiz Drehmer (Rio) using scripts based on UNIX data translation commands, the Seismic Unix (SU) package and the Generic Mapping Tools. Further processing and display are being undertaken using ProMAX. Preliminary results (e.g. Fig. 23) show some penetration of the seabed, especially in the regions of the middle and lower fan.

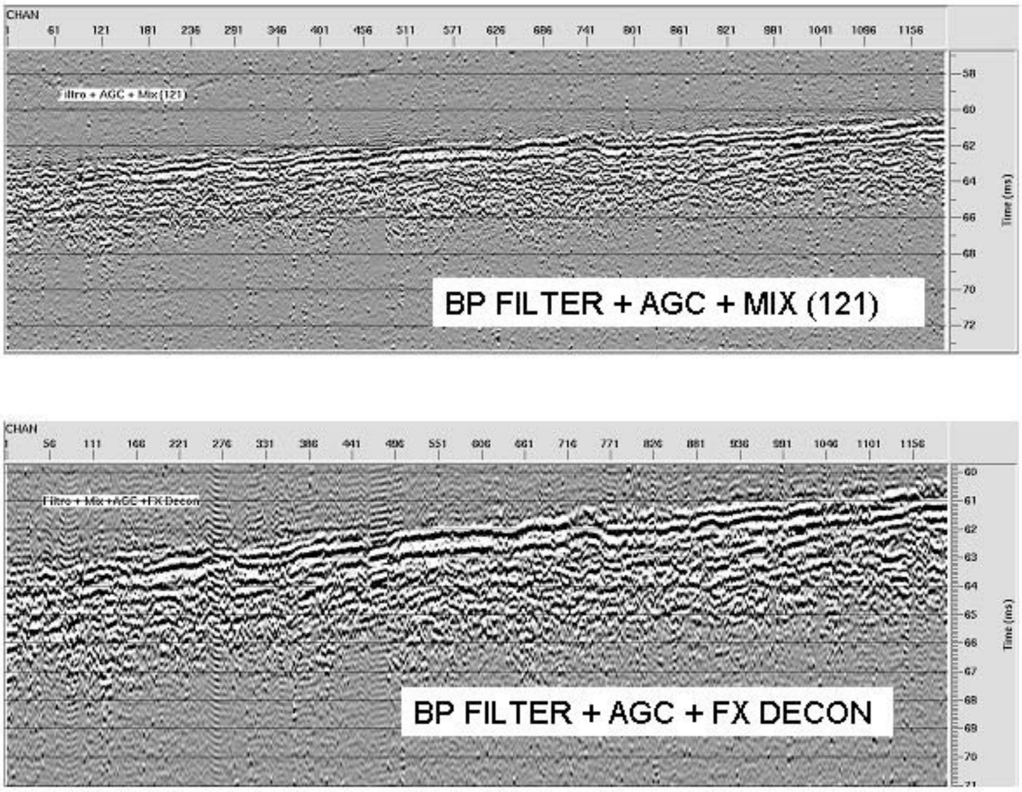

Figure 23 - Example 3.5 kHz record after some preliminary processing using ProMax.

2.10 Navigation

The primary navigation system used during D275-ACE was a Trimble 4000 Geodetic Surveyor. This digital Global Positioning System (GPS) produced positions every second to an accuracy of about 2 m. Data were logged by the UKORS' Level A-C systems and also input into the underway track chart plotting system during seismic acquisition.

2.11 Meteorological data

The weather during D275-ACE was generally excellent. Temperatures during the day were ~ 27 ^{o}C, falling to ~ 20 ^{o}C at night. Most days were sunny, but there was the occasional heavy downpour. Seas were calm during most of the cruise. The heaviest seas (Force 4/5) were encountered on the northern extremities of the main seismic lines and on the Ceara Rise where strong counter-currents associated with the Brazil current were encountered.

Meteorological data recorded during D275-ACE included sea surface temperature, air pressure, wind direction and humidity.

2.12 Satellite imagery

Satellite images were routinely acquired during D275-ACE and processed by Rob Lloyd. The principal sources were Chinese and NOAA satellites. The satellite images showed changes in cloud cover, sediment discharge at the estuary of the Para and Amazon rivers, and vegetation and were extremely useful for weather prediction since no forecasts were available throughout the cruise. An example is shown in Fig. 24.

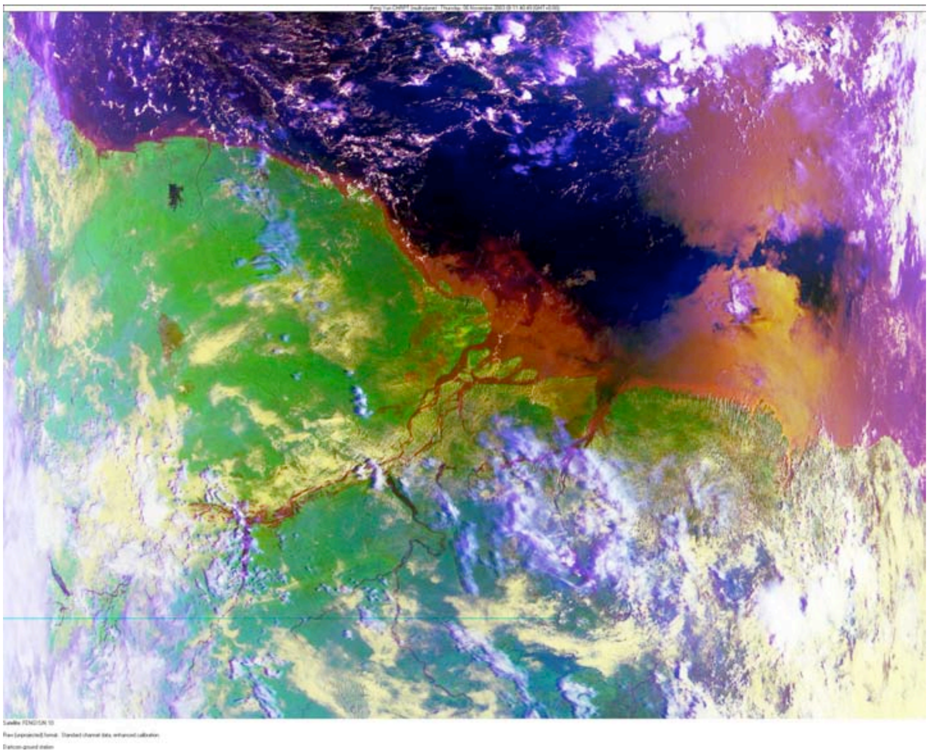

Figure 24 - Example false-colour satellite image showing sediment out-flux from the Amazon and regional weather systems.

3. Trials cruise and cruise narrative

3.1 Trials narrative

The equipment trials lasted a total of 1 day and 3.5 hours, divided into several daylight periods, and were undertaken during the transit of Discovery from Lisbon, via the Canaries, to Fortaleza for D275-ACE.

A summary of the events that took place appears below. All times are in GMT. A cruise track chart is shown in Fig. 25.

Julian Day	Date	Time (GMT)	Activity
285	Sunday 12th October	19:00	Sailed from Lisbon.
286	Monday 13th October	07:30 08:00 09:15 10:00 10:10 10:20 12:15 12:50 12:50 13:25 18:00 21:30	Deployed 3.5 kHz and 10 kHz fish. Commenced deployment of multichannel streamer. Streamer deployment complete and towed at survey speed to investigate balancing. Compressors started. Deployed 700 cu.in. starboard gun. Commenced firing of 700 cu.in. starboard gun. Commenced deployment of port outer beam. Deployment of port outer beam complete. Commenced deployment of starboard outer beam. Deployment of starboard outer beam complete and initiated soft start of all deployed airguns. Commenced recovery of all seismic equipment. Recovery complete.
287	Tuesday 14th October	09:00 – 17:00	Commissioned and tested CTD winch with test load to 2000m depth.
288	Wednesday 15th October	08:30 –	Sound velocity dip tests.

		15:00 09:26 14:00	 XBT test. Recovered 10 kHz and 3.5 kHz fish. End of trials.
289	Thursday 16th October	09:00	Boat transfer off Santa Cruz de Tenerife.

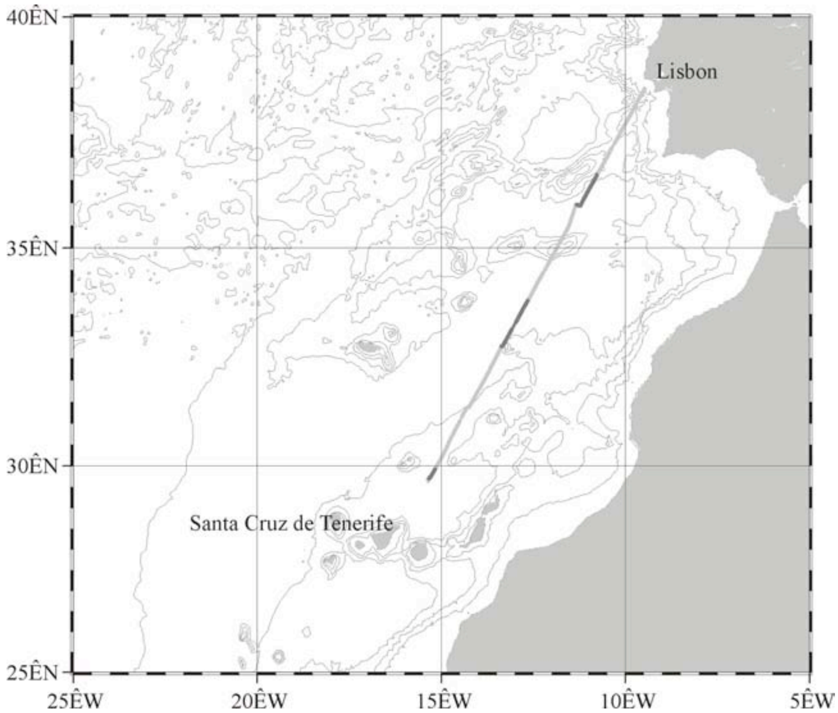

Figure 25 - Trials cruise track chart.

Dark grey lines show locations where equipment was deployed during daylight hours.

3.2 Cruise narrative

The duration of the cruise was 35 days and 16 hours. Of this, 4 days were spent on passage to and from Fortaleza to the work area, leaving a total of 29 days and 6 hours in the work area. Of the latter ~8 days were spent shooting, ~9 days on OBS/H deployment and recovery, ~ 8 days on MCS equipment deployment, recovery and repairs to the streamer and ~3 days on the boat transfer off Belem.

A summary of the events that took place appears below. All times are in GMT and all way points (WPxxx – where xxx is the way point number) are listed in table 15 and a cruise track chart in Fig. 26.

Julian Day	Date	Time (GMT)	Activity
301	Tuesday 28th October	18:45	Sailed from Fortaleza.
302	Wednesday 29th October	All day	Transit to WP002.
303	Thursday 30th October	11:08 13:01 14:35	Deployed 10 kHz and 3.5 kHz fish. Calibration of ship's Cherikof log using measured mile. Recommenced transit to WP002.
304	Friday 31st October	08:03 08:21 13:30	Arrival at WP002. Commenced deployment of MCS equipment and magnetometer whilst heading towards WP003. Deployment complete.

		16:06 16:11	Commence test firing of airguns using soft start. Soft start complete - SOL ACE304E.
305	Saturday 1st November	04:30 07:22 12:00 13:30 15:25 16:00 16:25 16:27 17:53 18:53	Passed WP003 – continuing until first light for end of line and equipment recovery. EOL ACE304E. Commencing recovery of airguns and magnetometer. Commencing recovery of streamer. Streamer recovery complete. Sound velocity dip – SV01 - deployed. XBT01 deployed. XBT02 deployed. Sound velocity dip completed. Heading towards WP004.
306	Sunday 2nd November	13:35 14:46 15:51 15:58 17:14 18:00 19:06 21:09 22:09 23:10 23:11	WP004 – deployment of OBS/H 1A. WP005 – deployment of OBS/H 2A. WP006 – deployment of OBS/H 3A. WP006 – deployment of XBT03. WP007 – deployment of OBS/H 4A. WP008 – deployment of OBS/H 5A. WP009 – deployment of OBS/H 6A. WP010 – deployment of OBS/H 7A. WP011 – deployment of OBS/H 8A. WP012 – deployment of OBS/H 9A. WP012 – deployment of XBT04.
307	Monday 3rd November	00:06 01:05 01:56 02:46 03:36 04:26 05:14 06:02 06:48 07:37 07:38 08:33 08:40 10:52 11:25 12:40 12:55 18:03 18:30 20:38 18:56 21:07 21:30	WP013 – deployment of OBS/H 10A. WP014 – deployment of OBS/H 11A. WP015 – deployment of OBS/H 12A. WP016 – deployment of OBS/H 13A. WP017 – deployment of OBS/H 14A. WP018 – deployment of OBS/H 15A. WP019 – deployment of OBS/H 16A. WP020 – deployment of OBS/H 17A. WP021 – deployment of OBS/H 18A. WP022 – deployment of OBS/H 19A. WP022 – deployment of XBT05. WP023 – deployment of OBS/H 20A. Transit to WP024 to start MCS equipment deployment. Passing WP024. Heaving to for maintenance to an oil pump on a main engine. Maintenance complete. Streamer tailbuoy deployed. Problems with bird communications. Fault traced and streamer section replaced. Streamer deployed. Commencing airgun array deployment. Deployment complete. Commencing soft start. Soft start complete.
308	Tuesday 4th November	04:42 05:50	On line heading SW towards WP024. Passing WP024 – SOL ACE307A.
309	Wednesday 5th November	08:22 10:00	Commencing recovery of single airguns before turning into wind to recover main array. Commencing recovery of airgun array.

		11:08 12:02 15:33 15:38 20:07 21:28	Airgun array recovered. Streamer recovered. Airgun array redeployed. Soft start commencing whilst turning back onto line near WP025. Heading towards WP026. EOL ACE307A. Recovering airgun array whilst heading back towards OBS/H 1A WP027.
310	Thursday 6th November	02:30 04:07 05:50 08:07 10:15 11:45 13:20 15:02 17:01 18:32 19:56 21:24 22:54	WP027 - OBS/H 1A recovered. WP028 - OBS/H 2A recovered. WP029 - OBS/H 3A recovered. WP030 - OBS/H 4A recovered. WP031 - OBS/H 5A recovered. WP032 - OBS/H 6A recovered. WP033 - OBS/H 7A recovered. WP034 - OBS/H 8A recovered. WP035 - OBS/H 9A recovered. WP036 - OBS/H 10A recovered. WP037 - OBS/H 11A recovered. WP038 - OBS/H 12A recovered. WP039 - OBS/H 13A recovered.
311	Friday 7th November	00:57 03:20 05:08 06:50 08:45 10:50 12:37 17:21	WP040 - OBS/H 14A recovered. WP041 - OBS/H 15A recovered. WP042 - OBS/H 16A recovered. WP043 - OBS/H 17A recovered. WP044 - OBS/H 18A recovered. WP045 - OBS/H 19A recovered. WP046 - OBS/H 20A recovered. Heading towards WP172 for OBS/H deployment along ACE – Line D. Recovered 3.5 kHz fish for repairs.
312	Saturday 8th November	09:08 10:04 10:55 11:59 12:55 13:50 14:50 15:48 16:33 16:35 17:24 18:13 18:58 20:12 20:59 21:50 22:38 23:29	WP172 – deployment of OBS/H 1D. WP173 – deployment of OBS/H 2D. WP174 – deployment of OBS/H 3D. WP175 – deployment of OBS/H 4D. WP176 – deployment of OBS/H 5D. WP177 – deployment of OBS/H 6D. WP178 – deployment of OBS/H 7D. WP179 – deployment of OBS/H 8D. WP180 – deployment of OBS/H 9D. WP180 – deployment of XBT06. WP181 – deployment of OBS/H 10D. WP182 – deployment of OBS/H 11D. WP183 – deployment of OBS/H 12D. WP184 – deployment of OBS/H 13D. WP185 – deployment of OBS/H 14D. WP186 – deployment of OBS/H 15D. WP187 – deployment of OBS/H 16D. WP188 – deployment of OBS/H 17D.
313	Sunday 9th November	00:25 01:27 02:35 02:54 03:48 05:58 06:13	WP189 – deployment of OBS/H 18D. WP190 – deployment of OBS/H 19D. WP191 – deployment of OBS/H 20D. WP191 – deployment of XBT07. Hove-to for sound velocity dip SV02. Sound velocity dip SV02 complete. Heading towards WP192 for MCS equipment deployment.

		10:46 10:58 13:48 13:56 14:14 11:14 18:27 19:43	3.5 kHz fish deployed. Commencing MCS equipment deployment. Deployment of MCS equipment complete. Start of soft start. Magnetometer deployed. Turning onto ACE Line D, heading towards WP192. Online heading towards WP192. Passing WP192 – SOL ACE313D. Heading towards WP193.
314	Monday 10th November	All day	Online heading towards WP192. Shooting ACE313D.
315	Tuesday 11th November	15:00 15:08 16:05 19:20 19:57	EOL ACE313D at 50m bathymetric contour. Magnetometer recovered. Commencing MCS equipment recovery. MCS equipment recovery complete. Heading to WP195 for OBS/H 1D recovery.
316	Wednesday 12th November	03:16 04:38 05:49 07:00 08:10 09:28 10:50 12:50 14:26 16:52 18:20 19:53 21:50 23:51	WP195 - OBS/H 1D recovered. WP196 - OBS/H 2D recovered. WP197 - OBS/H 3D recovered. WP198 - OBS/H 4D recovered. WP199 - OBS/H 5D recovered. WP200 - OBS/H 6D recovered. WP201 - OBS/H 7D recovered. WP202 - OBS/H 8D recovered. WP203 - OBS/H 9D recovered. WP204 - OBS/H 10D recovered. WP205 - OBS/H 11D recovered. WP206 - OBS/H 12D recovered. WP207 - OBS/H 13D recovered. WP208 - OBS/H 14D recovered.
317	Thursday 13th November	01:55 03:40 05:27 07:13 09:19 10:47 11:22	WP209 - OBS/H 15D recovered. WP210 - OBS/H 16D recovered. WP211 - OBS/H 17D recovered. WP212 - OBS/H 18D recovered. WP213 - OBS/H 19D recovered. WP214 - OBS/H 20D recovered. Heading towards WP003 for OBS/H deployment along ACE – Line B.
318	Friday 14th November	All day	Transit to WP003.
319	Saturday 15th November	01:00 01:17 03:09 03:10 16:11 17:20 18:24 19:30 20:40 21;49 22:59	Arrival at WP003. Sound velocity dip - SV03 - deployed. Sound velocity dip SV03 complete. Transit to WP054 for deployment of OBS/H 8B just outside the Brazilian 200 nm limit. WP054 – deployment of OBS/H 8B. WP055 – deployment of OBS/H 9B. WP056 – deployment of OBS/H 10B. WP057 – deployment of OBS/H 11B WP058 – deployment of OBS/H 12B WP059 – deployment of OBS/H 13B WP060 – deployment of OBS/H 14B
320	Sunday 16th November	00;16 00:18	WP061 – deployment of OBS/H 15B WP061 – deployment of XBT08.

		01:33 02:45 03:50 04:55 05:58 07:03 08:18 09:31 10:45 12:45 13:51 14:10	WP062 – deployment of OBS/H 16B. WP063 – deployment of OBS/H 17B. WP064 – deployment of OBS/H 18B. WP065 – deployment of OBS/H 19B. WP066 – deployment of OBS/H 20B. WP067 – deployment of OBS/H 21B. WP068 – deployment of OBS/H 22B. WP069 – deployment of OBS/H 23B. WP070 – deployment of OBS/H 24B. WP071 – deployment of OBS/H 25B. WP072 – deployment of OBS/H 26B. Deployments ceased and heading to Belem for boat transfer of crew member due to family bereavement.
321	Monday 17th November	20:30	Arrival at Belem pilot station.
322	Tuesday 18th November	00:00 00:05	Boat transfer completed. Transit to WP053 to deploy MCS equipment.
323	Wednesday 19th November	00:14 00:23 00:31 03:00 03:45 04:10	Arrival at WP054. 3.5 kHz fish deployed. Commencing deploying MCS equipment. Equipment deployment complete. Start of soft start. All guns firing SOL ACE323B, heading towards WP086.
324	Thursday 20th November	All day	Shooting ACE323B.
325	Friday 21st November	02:30 03:00 05:25 05:30 14:34 16:03 17:25 18:57 20:33 22:00 23:37	EOL ACE323B. Commencing MCS equipment recovery. Equipment recovery completed. Heading to WP114 to start OBS/H recovery. WP114 - OBS/H 26B recovered. WP113 - OBS/H 25B recovered. WP112 - OBS/H 24B recovered. WP111 - OBS/H 23B recovered. WP110 - OBS/H 22B recovered. WP109 - OBS/H 21B recovered. WP108 - OBS/H 20B recovered.
326	Saturday 22nd November	00:58 02:48 04:14 05:52 07:28 09:15 10:41 12:15 13:50 15:21 17:15 18:42 18:48 20:26 22:19	WP107 - OBS/H 19B recovered. WP106 - OBS/H 18B recovered. WP105 - OBS/H 17B recovered. WP104 - OBS/H 16B recovered. WP103 - OBS/H 15B recovered. WP102 - OBS/H 14B recovered. WP101 - OBS/H 13B recovered. WP100 - OBS/H 12B recovered. WP099 - OBS/H 11B recovered. WP098 - OBS/H 10B recovered. WP097 - OBS/H 9B recovered. WP096 - OBS/H 8B recovered. Heading for WP335 for OBS/H 1F deployment. WP335 – deployment of OBS/H 1F. WP336 – deployment of OBS/H 2F.
327	Sunday 23rd November	00:02 01:45 03:20	WP337 – deployment of OBS/H 3F. WP338 – deployment of OBS/H 4F. WP339 – deployment of OBS/H 5F.

		05:03 05:05 06:48 08:26 08:30 10:01 10:15 15:57 16:11 17:08 21:31	WP340 – deployment of OBS/H 6F. WP340 – deployment of XBT09. WP341 – deployment of OBS/H 7F. WP342 – deployment of OBS/H 8F. Heading towards WP343 for MCS equipment repair and deployment. 3.5 kHz fish deployed. Commencing MCS equipment deployment MCS equipment deployment completed. Start of soft start – SOL ACE327F. Magnetometer deployed. Passing WP343.
328	Monday 24th November	All day	Shooting ACE327F.
329	Tuesday 25th November	00:17 01:13 03:50 03:55 03:58 06:35 08:45 11:01 13:40 15:51 18:06 20:19 23:00 23:03	Passing WP344 EOL ACE327F. Start of MCS equipment recovery. MCS equipment recovery completed. 3.5 kHz fish recovered. Heading for OBS/H 1F WP345. WP345 - OBS/H 1F recovered. WP346 - OBS/H 2F recovered. WP347 - OBS/H 3F recovered. WP348 - OBS/H 4F recovered. WP349 - OBS/H 5F recovered. WP350 - OBS/H 6F recovered. WP351 - OBS/H 7F recovered. WP352 - OBS/H 8F recovered. Heading towards WP353 for deployment of OBS/H 1G ACE Line G.
330	Wednesday 26th November	08:05 09:40 12:01 13:33 15:20 16:53 17:05 18:26 20:23 22:52	WP353 – deployment of OBS/H 1G. WP354 – deployment of OBS/H 2G. WP355 – deployment of OBS/H 3G. WP356 – deployment of OBS/H 4G. WP357 – deployment of OBS/H 5G WP358 – deployment of OBS/H 6G. WP358 – deployment of XBT10. WP359 – deployment of OBS/H 7G. WP360 – deployment of OBS/H 8G. WP361 – deployment of OBS/H 9G.
331	Thursday 27th November	01:02 03:41 05:34 05:36 08:12 08:15 12:49 12:50 12:52 14:15	WP362 – deployment of OBS/H 10G. WP363 – deployment of OBS/H 11G. WP364 – deployment of OBS/H 12G. Heading towards WP365 for MCS equipment repair and deployment. 3.5 kHz fish deployed. Commencing MCS equipment deployment MCS equipment deployment completed. Magnetometer deployed. Start of soft start. Passing WP365, SOL ACE331G_a, heading for WP366.
332	Friday 28th November	05:00 06:30 08:00 08:50	Passing WP366, commencing turn, EOL ACE331G_a. Turn complete, heading for WP367. Turning onto Line ACE331G_b. SOL ACE331G_b, heading towards WP368.

333	Saturday 29th November	18:05 18:16 18:20 21:20 21:22 23:01	EOL ACE331G_b. Commencing MCS equipment recovery. 3.5 kHz and 10 kHz fish recovered. Completed MCS equipment recovery. Heading for WP369 for OBS/H 1G recovery. WP369 - OBS/H 1G recovered.
334	Sunday 30th November	01:25 03:52 05:45 07:52 09:50 11:47 14:13 16:27 18:43 22:20	WP370 - OBS/H 2G recovered. WP371 - OBS/H 3G recovered. WP372 - OBS/H 4G recovered. WP373 - OBS/H 5G recovered. WP374 - OBS/H 6G recovered. WP375 - OBS/H 7G recovered. WP376 - OBS/H 8G recovered. WP377 - OBS/H 9G recovered. WP378 - OBS/H 10G recovered. WP379 - OBS/H 11G recovered.
335	Monday 1st December	00:41 01:02 01:03 02:20 02:30	WP380 - OBS/H 12G recovered. WP380 – deployment of XBT11. Sound velocity dip - SV04 - deployed. Sound velocity dip SV04 complete. End of data acquisition. Heading for Fortaleza.
336	Tuesday 2nd December	All day	Passage to Fortaleza.
337	Wednesday 3rd December	10:00	Arrival in Fortaleza. End of cruise.

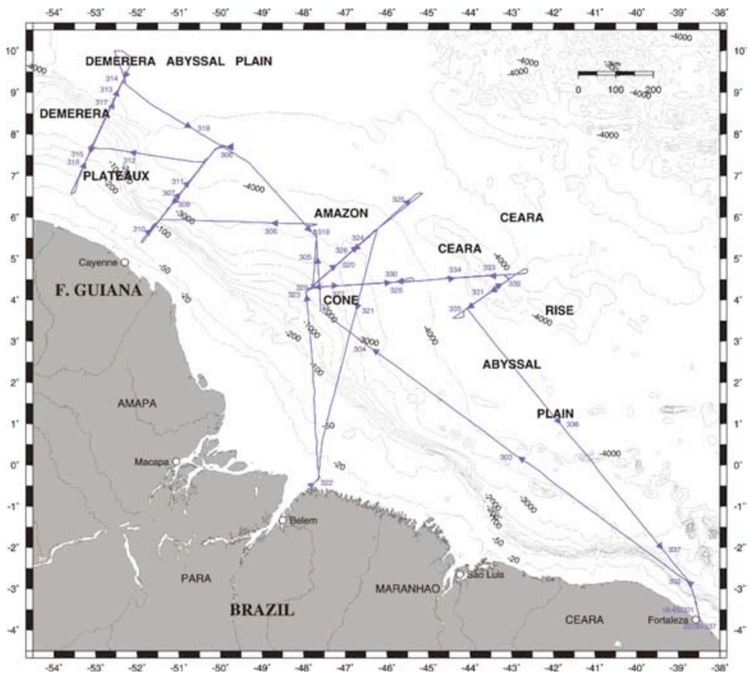

Figure 26 - D275-ACE track chart.

4. Equipment performance

4.1 Trials cruise

The trials provided an opportunity to test all equipment to be used during D275-ACE except for the ocean-bottom seismographs.

4.1.1 Seismic equipment

4.1.1.1 Onboard data quality control and processing

A small network of UNIX workstations, a laptop and two postscript laser printers were installed in the main lab by the scientific party to undertake underway quality control and basic processing of the acquired data. Two of the UNIX workstations had a version of ProMAX installed to facilitate this processing. During the trials this QC capability was used to read test tapes written by both the StrataView and Geode acquisition systems. No equipment problems were experienced and the networking capability operated as required. However, the capability to undertake this operation proved invaluable. The original intention for the cruise was to record all data in SEG-Y format on DDS-3 4 mm DAT tapes. The SEG-Y tapes written by both acquisition systems during the trials proved unreadable by any of the standard seismic data processing software installed on this network of machines, or by any standard UNIX data file or tape command or utility. If this test had not been undertaken, or the capability to read tapes while at sea had not been available, the entire cruise data tapes would have been unreadable post-cruise.

Subsequent testing by writing tapes in the only other format choice, SEG-D, proved these tapes to be readable and hence, this option had to be adopted for the actual cruise.

One of the reasons this installation and testing was undertaken during the trials was to enable the actual source signature generated by the component of the array to be trailed, to be recorded and compared with that synthetically generated from array characteristic modelling, which is used to underpin the array design process – a ground-truthing exercise. Since not only the individual gun signature but also the streamer data tapes were unreadable this process was not possible before the cruise while there was still an opportunity to modify the array design if necessary.

4.1.1.2 Airgun array

During the trails only the outer beams and the starboard single towed gun of the configuration shown in Fig. 6 were tested since

i) they had all been serviced and commissioned in an identical manner and if these seven guns proved problem free then the array as a whole could be considered problem free; and
ii) after the trial each gun would require stripping and servicing before storage for the remainder of the passage. Undertaking this operation on the entire array would not be feasible, nor practical, given the length of the passage to the Canaries.

After soft start, the 600 cu.in. starboard gun had an intermittent fault in its electrical cabling and the 160 cu.in. port gun did not fire at all due to a failed solenoid. The 160 cu.in. gun was replaced in its entirety with a spare which fired reliably on redeployment. Investigation of the cabling problem was noted for action during the port call in Fortaleza or the passage to the work area.

The specified tow depth for the array was 15 m. The beams were found to tow at 17 m and the single gun at 9 m. Only the latter was considered to be problematic and the only available course of action, due to the nature of the towing mechanism, would be to move the tow point on the aft deck nearer to the stern. Again this was noted as an action for the port call in Fortaleza or the passage to the work area.

4.1.1.3 Multichannel streamer

The 2.4 km Teledyne analogue streamer performed reasonably well considering its age, although it was only towed for a relatively short period of time during the trials to test its general balancing. During the pre-cruise refurbishment, the streamer had been ballasted based on a prediction of its inherent buoyancy in the salinity and temperature conditions likely to be experienced at the mouth of the Amazon and the shallow shelf waters where a significant volume of fresh water flux could be anticipated, and for work in the deeper offshore waters. The applied ballast represented the compromise position between the two extremes but which also would place the streamer within the buoyancy range for which its depth would be controllable using the birds.

Although it would not be possible to tow the streamer through shallow shelf waters as part of the trial, a warm deep water test would be possible and if the tow depth matched the deep water predictions then we could be largely confident that its predicted tow depth in shallow shelf waters would have some accuracy.

The streamer specified tow depth was 10 m, and during the trials it towed consistently between 9- 10 m and, most importantly, it towed horizontally within acceptable error. The bird altitude control system also operated without fault.

The streamer tailbuoy has a flashing light, radar reflector and GPS beacon to allow its location to be tracked behind the vessel. On deployment of the streamer it soon became apparent that the GPS aerial was located in a "shadow" if more than one third of the streamer length was deployed. Originally this aerial was attached to the top of the handrail on the forecastle deck aft of the container slot adjacent to the funnel. Relocation of the aerial to the top of the stern A-frame solved this problem and the tailbuoy location could be monitored when it was fully deployed.

The UKORS' in-house system to log the streamer depths was not operational at the start of the trials and remained inoperational at the end of the trials. There also appeared to be no output from the waterbreak channel. Both of these were noted for action during the port call in Fortaleza or the passage to the work area.

4.1.1.4 Compressors

The shipboard compressors operated according to specification and provided adequate air at 2000 p.s.i. to fire the sub-array on demand. The chosen array volume and the firing were primarily selected to optimise the data acquisition. However, as part of this selection a 100% redundancy in air volume delivery capability based on the onboard capacity alone was included. Thus the full array could be fired at 40 s intervals using only 2-3 of the onboard compressors running at low speed. Therefore, there would always be capacity to shutdown one onboard compressor at any one time for maintenance or repair before having to increase the remainder to high speed running or supplement with the containerised compressors.

4.1.1.5 StrataView acquisition system

The StrataView is a 96-channel acquisition system used to monitor the output from the multichannel streamer and record it to magnetic tape in a standard industry SEG format. Apart from the inability to read the SEG-Y format data tapes created by this system, it otherwise operated without problem for the duration of the trials, except for operator error in setting the initial shot number and in the number of shots to be recorded on each tape before automatic change over to a new tape.

4.1.1.6 Gunlink shot firing and airgun array logging

Gunlink is a system which controls and fires airgun arrays and provides parameter performance information which can be used to monitor hardware and plan and target maintenance and repair. The system was hired from Seamap UK and was accompanied by an engineer. To be able to interface with the UKORS airgun array a suite of cables and a patch box needed to be fabricated. These were delivered within days of the start of the trials and shipped straight to Lisbon for mobilisation without checking that they complied with the specification. On installation the cables were found to be completely mis-wired relative to specified pin numbers and had to be completely rebuilt whilst in-port before the system as a whole could be completely installed and test fired with the array itself. This activity took several days of rather stressful activity to resolve. However, once resolved the system functioned according to specification throughout the trials.

4.1.1.7 Geode gun signature logging

The Geode acquisition system is a 24-channel version of the StrataView and is used to monitor the output from the individual airgun shot hydrophones and record it to magnetic tape in a standard industry SEG format. Apart from the inability to read the SEG-Y format data tapes created by this system, it otherwise operated without problem for the duration of the trials.

4.1.2 Expendable bathymetric thermographs

A set of 12 expendible bathymetric thermographs (XBTs) were supplied by the scientific party for D275-ACE. As a test of the system one of these probes would be deployed during the trials. The logging system for XBTs is a rather ancient PC. When this system was powered up it did not boot. The cause of this problem was found to be the hard disk which was completely detached from its interface and sitting loose on top of the motherboard. Once installed and configured the PC was bootable. The system also required setting up to receive date, time and location information, including cabling, before it could be tested. These problems took several hours to resolve. However, once resolved the system, including the supplied probe, functioned according to specification. The test probe was deployed at one of the sound velocity dip trials. See section 4.1.3 below.

4.1.3 Sound velocity probe

The sound velocity probe was hired especially for D275-ACE as the UKORS' probes were otherwise unavailable. The sound velocity probe did not work as well as hoped. On one occasion the probe failed to record any data. On all other occasions the probe returned from depths of around 2000 m, having only recorded information on the pressure and temperature of the water column. In each case the velocity measurements failed. One possible cause of this failure could be due to the coupling of ship's motion to the probe through the CTD cable upon which it was deployed. The hired probe only records whilst travelling in one direction, so either up or down, and the jerking of the ship's motion down the cable was thought to result in the logging being essentially turned off. Later attempts to increase the weight of the anchor and increasing the pay-out speed of the cable failed to rectify this problem.

4.1.4 Ship's machinery and fitted equipment

No problems with the ship's fitted equipment and machinery that affected the trialing of the scientific equipment were experienced during the trials.

4.2 Cruise

4.2.1 Seismic equipment

4.2.1.1 Onboard data quality control and processing

All of the installed data processing hardware performed without problems except for the newest of the machines – a Sun Blade. This machine experienced total failure during a period of shooting. On opening the base unit the cause of the problem soon became apparent. The main processor board had become unseated. Once reseated, this machine worked without further fault for the remainder of the cruise.

4.2.1.2 Airgun array

The airguns themselves worked without significant failure throughout. One or two problems were encountered that were more annoying than fundamentally data quality damaging. However, by the end of the cruise practically all of the spares had been used and most of the larger chamber guns had had some form of strip down and refurbishment. The new Bolt 1500 LL guns are reliable and their maintenance and repair was greatly assisted by the Seamap Gunlink system – see section 4.2.1.6 below.

The main problems experienced revolved around the 700 cu.in. guns towed from the stern A-frame. The starboard of these two guns required constant repair of its air hoses and electrical cables and when towing the gun could often be found on the opposite side of the streamer tow cable than was intended. The main reason for this is thought to be propeller wash. However, the consequences are that a lot of cables and hoses had to be replaced and eventually repaired before replacement and this towing characteristic is potentially a cause of damage to the streamer.

The incorporation of vulcanised hoses around the gun suspension chains to act as shock absorbers does seem to prevent considerable damaged to the guns towed from the 4 beams. However, these hoses appear to be one deployment only and supplies were almost entirely consumed by the end of the cruise.

To deploy the full array requires the use of two "cherry picker" cranes which are fitted to the aft quarters for seismic cruises. These systems are at the limit of what they can safely lift and manoeuvre. The process of array deployment and recovery is greatly hampered by this limitation.

Apart from more spares and a refurbishment or replacement of the deployment cherry pickers, the array equipment largely functioned within operational parameters (fixed at the end of the trials) for the entire cruise.

4.2.1.3 Multichannel streamer

The 2.4 km Teledyne analogue streamer performed reasonably well considering its age. The main problems encountered here were the ingress of water into a considerable number of sections resulting in loss of channels or noisy sections and the disruption of bird communications. All of the spare sections were used by the end of the cruise. In addition, one third of the winch slip ring connections failed and had to be "hardwired" and the spare lead-in cable required replacement of its connectors. This system now requires a major refurbishment before it is usable. However, allied to this system is a UKORS' in-house system for logging streamer bird depths. This system was not functional by the end of the trials and its construction and programming only completed just before the first seismic acquisition was undertaken. This system had a number of on-going problems ranging from incomplete logging of all channel though to becoming completely hung requiring operator reboot. As the cruise went on the latter problem became worse and more frequent. This system is not considered to be a viable solution to streamer logging.

4.2.1.4 Compressors

Apart from one or two minor repair and maintenance issues an adequate supply or air at 2000 p.s.i. was supplied during all shot firing periods without recourse to the containerised back-ups. Again the Seamap' Gunlink system provided a means by which to identify leaking gun hoses and a system-wide drop in air pressure which required urgent compressor attention on one occasion.

4.2.1.5 StrataView acquisition system

Once resigned to recording in SEG-D format (see section 4.1.1.1 above) and once the system parameters had been properly set for the length of tape being used, the StrataView system operated without fault for the entirety of the cruise.

4.2.1.6 Gunlink shot firing and airgun array logging

On testing in port, a major failure of all i/o boards occurred and all onboard spares had to be used to affect a repair. The problem was traced to shorting due to the ingress of salt water into the cable connectors housed in distribution boxes fitted to the umbilical winch drums located on the aft deck. These connections were made and testing during the trials, but had not survived the passage. Cleaning and remaking these connections took some time. No spares were thus available for the cruise. However, no other problems were experienced with this system. Once a number of operator-induced set-up errors related to settings for the start of lines had been resolved the Gunlink system operated without fault for the entirety of the cruise. Only one minor operational problem was encountered with its databasing system which became full to capacity and the system had to be restarted.

4.2.1.7 Geode gun signature logging

The Geode system operated without fault for the duration of the cruise.

4.2.1.8 Ocean-bottom seismographs

Throughout the cruise 79 successful OBS/H deployments and recoveries were undertaken. Deployment locations can be found in tables 3-8. Some minor equipment damage was experienced due to the snagging of stray-lines around geophone arms during recoveries and not every channel on every instrument recorded data. However, the instruments that did record data on some or all channels do provide the coverage necessary to address the aims of D275-ACE.

As a whole, the instruments were operated in an efficient and impressive manner by their accompanying personnel, who were assisted by two members of the scientific party during each 12 hour shift work, the Principal Scientists undertaking the watchkeeping duties during deployment and recovery periods.

4.2.1.9 Land seismographs

All SEIS-UK 6TD equipment worked flawlessly, and data were recovered from all instruments deployed.

4.2.2 Expendable bathymetric thermographs

The supplied probes and the PC logging system operated without problem for the duration of the cruise.

4.2.3 Sound velocity probe

Despite numerous attempts throughout the cruise to get the probe to operate and record velocity information, and despite contacting the manufacturers for advice, a successful velocity measurement through the entire water column was never achieved.

4.2.4 Gravity

The gravimeter worked well for the entire cruise. We found during the cruise that no cross-coupling correction was being calculated and applied to the free-air gravity anomaly data. The reason for this was not clear, but it appears to be the result of a missing software package. The instantaneous beam motion and the horizontal and vertical accelerations experienced by the platform were, however, continuously recorded and so it should be possible to compute the cross-coupling correction and apply it to the gravity data at a later stage.

4.2.5 Magnetics

The main problems were encountered with the magnetometer occurred early in the cruise. During the shooting of Line ACE304E, the magnetizing solenoid (which is also the detector coil) in the magnetometer fish worked loose. The fish was subsequently stripped down and the cable shortened and no further problems were encountered during the cruise.

4.2.6 Bathymetry – 10 kHz

We had major problems with both the 10 kHz fish and the 10 kHz hull-mounted echo sounder during D275-ACE. Both systems failed to work at a wide range of operational speeds and water depths. The bathymetry was scattered (e.g. Fig. 22) and along some underway profiles the seabed could not be imaged at all, which is critical when deploying seabed instrumentation. The precise problem with the 10 kHz systems is not known, but it was variously attributed to the towing fairing being constructed out of material which proved to be soft and supple in warm seawater and simply became torn off affecting the tow characteristics of the fish which ultimately became unusable and, for the hull mounted transducers, this system is practically unusable except when the vessel is stationary, which suggests that the transducers may be mounted in a location where cavitation occurs under the hull when the vessel is in motion. In addition, on several occasions boards within the lab control system failed and had to be repaired since the spare was not in a fully operational condition either.

4.2.7 Sub-bottom profiling – 3.5 kHz

We had many problems with the 3.5 kHz sub-bottom profiler during D275-ACE. Bathymetry data as displayed on the laboratory monitor was scattered and the seafloor return on some profiles was barely visible. The 3.5 kHz system uses fish mounted transducers. This fish is towed very close to the 10 kHz fish and, thus, a significant degree of 'cross-talk' was experienced making this data unusable. Even if the 10 kHz fish was in a usable condition, we would not have been able to use it due to its affect on the quality of the 3.5 kHz data. In the event we were forced to use the 10 kHz hull transducers anyway which improved the 3.5 kHz data quality a little to the detriment of bathymetry measurements. The 3.5 kHz data has, of course, been logged so it might be possible to eliminate some of the noise. Despite the problems, we did observe sub-bottom penetration on many of the 3.5 kHz profiles, particularly over the middle and lower Amazon fan.

This system needs replacement in its entirety including the data logging, the data storage and the data display equipment.

4.2.8 Navigation and underway track plotting

We encountered no major problems with navigation and underway track chart plotting. It would be helpful if chart underlays could be added in standard formats, which might include OBS/H positions, the start and end of lines, the regional bathymetry and so on. This facility would be useful to multiple cruise types and not just seismic acquisition.

At the start of the cruise the Chernikof log was found to be reading more than 2 knots too low. Thus, at the start of the cruise it was necessary to devote time to undertaking several standard measured miles at specific speeds to calibrate it fully.

4.2.9 Meteorological

We encountered no major problems with the measurement and logging meteorological data throughout the entire cruise.

4.2.10 Satellite imagery

This system was used during the cruise as a means of providing weather information since no other forecasts were receivable for the entirety of the cruise. The satellite receiver and the image processing systems were originally purchased from a Joint Infrastructure Fund research grant submitted by the scientific community. When the system isn't in use it has also been "adopted" by the ship's crew as a means by which to receive satellite television signals. On the passage from the Canaries to Fortaleza the satellite TV receiver/decoder apparently developed a fault. Thus, inevitably a conflict of interest eventually came to the fore and the system was often "retuned" to the television satellite(s) to try and repair the receiver/decoder fault, without the knowledge of those acquiring and using the images for weather and other applications causing satellite passes to be missed. The desire to resolve the television reception fault was compounded by the Rugby World Cup being underway at the time with England ultimately winning.

4.2.11 Ship's machinery and fitted equipment

The ship's fitted equipment and machinery only experienced a few problems throughout the entire cruise as outlined below.

a) winches

Since none of Discovery's onboard winches were operational at the time of the cruise, a mobile CTD winch was installed on the forecastle deck aft container slot next to the funnel, to be used to deploy the sound velocity probe. Although this winch was installed and tested during the trials, when used under operational conditions it soon overheated and it was never possible to pay out more than 2000-3000 m of cable. Also it was not possible to have any fine control over the pay-out speed. The jerkiness of the pay-out, when coupled with the roll and pitch of the vessel may have contributed to the inability to complete a successful sound velocity dip.

b) side gantry A-frame

Part way through the cruise, during OBS/H recovery, the side gantry failed in multiple ways – two on-going and one a one-off once properly repaired. Firstly a control system joystick failed and needed several attempts at replacement before fully repaired, the hydraulic control failed and needed parts replacing and finally the electrical supply to the entire system failed. The main fuse was found to have been replaced at sometime in the past with something akin to a nail. In the latter instance the failure occurred as recovery of an OBS/H was being attempted in a strong surface current. In an attempt to prevent damage or loss of the instrument, or damage to the vessel, the instrument was secured until the crane could be powered up and used for its recovery.

c) engine room repairs

A lubricant pump failed near the beginning of the cruise and two opportunistic windows in the science programme were made available to affect repairs. This failure and planned down-time had no affect on the scientific outcome of the cruise.

d) Autopilot – rate of turns at slow speed

A new autopilot has recently been fitted to Discovery which was initially used to perform the 2°/min turns necessary when towing the multichannel streamer. At the 4.5 knots tow speeds necessary for seismic acquisition this autopilot was found to turn at rates and speeds far in excess of this, at one point achieving 60° in approximately 5 minutes. This characteristic was tested and proved on several occasions and ultimately manual control of the turns was deemed necessary.

e) Duty mess and cigarette smoke

A welcome change since the PI's last sailed on Discovery is that the vessel accommodation and communal spaces are smoking-free zones except for a few specified locations. One of these locations is the duty mess next to the main scientific laboratory space. Although it is totally appropriate that such spaces should be provided, they should also be fitted with extraction to prevent smoke billowing out through doors and pervading the scientific laboratory spaces and the accommodation.

5. Other factors affecting cruise outcome

5.1 Effectiveness of cruise planning procedures

For D275-ACE, the cruise planning process was divided amongst several meetings with the PIs, UKORS and RVSOPs. In addition, further meetings were called at relatively short notice to address problems occurring in the run up to the mobilisation. The planning process was effective and open and honest. For equipment intensive cruises such as D275-ACE, additional regular meetings are vital and this is to be encouraged to become normal practise. However, it would be preferable for scientists writing grant applications if more detailed notes are available on what equipment is actually available within the pool and, more importantly, exactly what it can do. The ship time application form is rather generic in format and is reliant to some extent in the applicant having detailed operational knowledge of systems, new additions and what systems can do and what it takes to operate them. The satellite imaging system and its use for weather forecasting being a good example.

5.2 Diplomatic clearance

There was no problem securing permissions to work offshore French Guiana. The main problems encountered were with Brazil. A detailed chronology of the communications with Brazil concerning clearance have already been outlined in the Cruise Appraisal Form and so will only be briefly outlined here.

The initial approaches to the authorities in Brazil were made by RVOPs in September 2002, more than 1 year prior to the cruise. By September 2003, Brazil Decree 96000 was signed, notarised and submitted to the British Embassy in Brasilia.

In early November, we learnt from the Embassy that our cruise had been classified as having a 'petrochemical element'. This meant that we would be considered commercial vessel and would therefore have to apply for permission to both the National Agency of Petroleum of Brazil (ANP) and the Brazil Agency of the Environment (IBAMA).

We had already established some informal contacts with the ANP and IBAMA earlier in 2003 and thanks to the help of Dr Jesus Berrocal (Sao Paulo) and, particularly, Prof. Cleverson Silva and Prof. Alberto Figueiredo at UFF/LAGEMAR (Rio de Janeiro) we obtained ANP permission on November 14th.

The IBAMA permission was conditional on first acquiring the ANP permission.

On November 13th (i.e. one day prior to our obtaining ANP permission) we learnt that IBAMA had gone on strike. Despite repeated efforts by Profs Silva and Figueiredo, we were not able to contact IBAMA again until November 25th. IBAMA then indicated that they would only give us permission after we had secured permission from another agency, the Directory of Ports and Coasts (DPC). Since we just completed seismic Line ACE327F and were advised that this permission normally took 10-15 days, we had no choice but to abandon the Brazil clearance.

5.3 Mobilisation/Demobilisation

It is clear from the mobilisation periods in Lisbon and Fortaleza, how important adequate time in port prior to a cruise is to ensure all systems are operational and that all necessary systems and spares are installed or available. Cruises so entirely dependent on such volumes and complexities of equipment should always have mobilisation periods dedicated to them as dedicated to this cruise. Demobilisation in Forteleza was hampered by the non-delivery of containers on arrival and the poor performance of the ship's agent in making arrangements as discussed in section 1.4.

5.4 Trials cruise

The equipment performance throughout is testament to the absolute necessity of a trials cruise for seismic cruises of this kind in the future. We have no doubt that the trials greatly contributed to the equipment success of this cruise and allowed participating personnel to concentrate on repair and maintenance and not have to struggle against the odds to get complicated and multicomponent systems to function at all.

5.5 Time management

There were no issues with man management and compliance with working hours directives. The science programme was planned for the entire cruise from the beginning and these plans adjusted as the cruise progressed. Plans for activities for a minimum of at least 5 days were supplied to the TLO for consultation on equipment use and manning issues and posted on a noticeboard in the main laboratory spaces so that everyone knew what was happening at all times. In this way everyone could plan and comply with work and rest periods, whilst still enabling 24 hour per day working.

6. Preliminary results

The marine geophysical data acquired during D275-ACE, although not all in the location that was originally planned, is nevertheless high quality. The highlights of this acquisition are as follows:

- obtaining 1522.6 km of normal incidence seismic reflection profile data in the region of the continental margin offshore French Guiana and Brazil and the Ceara Rise;
- obtaining wide-angle seismic refraction profile data at 79 OBS/H sites in the region of the continental margin offshore French Guiana and Brazil and the Ceara Rise;
- obtaining wide-angle seismic refraction profile data at 5 land recording stations onshore French Guiana; and
- obtaining ~11,000 km of gravity, 2000 km of magnetic, 1000 km of 3.5 kHz, and 8250 km of bathymetry data in the region of the continental margin offshore French Guiana and Brazil and the Ceara Rise.

The data acquired during D275-ACE has not yet been fully processed so it is only possible to make a preliminary interpretation at this time. The highlights of this interpretation are as follows:

- showing that the **Demerera Plateau** is a transform margin that formed following the early opening of Equatorial Atlantic.
- showing that the margin is characterised by a free-air edge effect anomaly that is superimposed on a regional 'low' of about –40 mGal over the continental rise and a regional 'high' of about +30 mGal over the continental shelf.
- showing that top of oceanic crust and top Cretaceous are associated with a distinct pattern of seismic reflectors that should be correlatable over large distance along- and across-strike of the margin.
- showing that the middle and lower parts of the **Amazon deep-sea fan** are underlain, at least in part, by oceanic crust. The oceanic crust appears to dip downwards towards the Brazil coast which we attribute to flexural loading.
- showing that the fan is underlain by a prominent unconformity at 6-7 s Two-Way Travel Time (TWTT). We attribute the unconformity to the rapid influx of sediment to the north-east Brazil margin by the Amazon and Para rivers due to uplift in the Bolivian Andes during the mid-Miocene.
- showing that the **Ceara Rise** is characterised by unusually shallow oceanic crust, relatively small amplitude gravity anomalies, and short-wavelength, high amplitude magnetic anomalies. We attribute these observations to formation of the rise at or near the Mid-Atlantic ridge during the late Cretaceous.

7. Recommendations and comments

7.1 Recommendations

For every seismic cruise additional pre-cruise planning meets should be scheduled as was the case here. The availability of key personnel to sit down and discuss issues at very short notice with the Principal Scientists present contributed greatly to the successful outcome of this cruise.

For every seismic cruise a post-mobilisation trials period should always be included. We have no doubt that this is the main reason this cruise was successful, Also the opportunity for members of the scientific party to observe the trials first-hand greatly contributes to any form of confidence that a successful outcome is possible.

The UKORS' in-house shot firing and logging system should be permanently replaced by a Seamap Gunlink, or something very similar.

The UKORS' in-house streamer parameter logging system should also be replaced by an industry equivalent.

The Teledyne 96-channel streamer is at the end of its useful life and should be replaced, preferably with a high resolution, small diameter, solid (i.e. oil-free) equivalent.

The streamer birds have in-built compasses, whose output is not recorded, although it is displayed on the bird control system. This parameter would allow the modelling of the streamer's lateral trajectory and, coupled with the logged depth measurements, this would allow modelling in 3-D of its tow, or feathering, through the water which is particularly important in areas of strong currents, which was the case here. A rigorous and reliable method of recording the data in a standard format must also be procured.

Any sea-going transducer fish should come with adequate spares to allow the multiple replacements of fairings and tow cables and their primary and spare parts be constructed of appropriate materials to provide some form of longevity.

Discovery's hull 10 kHz echo sounder transducers should be relocated and the control unit refurbished or replaced.

The magnetometers have reached the end of their useful life should be replaced with modern long-tow digital, self-logging systems.

The underway track plotting system should be better integratable with digital maps and charts of recognised formats, e.g. bathymetry databases available in the public domain built in as base maps.

The satellite imaging system should be available to anyone who can make any form of scientific use out of it as a priority over social applications. Should access to satellite television be considered of paramount importance, then a dedicated receiving system should be purchased for it. This system and its television should also be relocated to somewhere more appropriate than the mess, e.g. to a dedicated room.

A rapid extraction ventilation system should be installed in the duty mess to prevent clouds of cigarette smoke entering the accommodation and more importantly the laboratory spaces.

7.2 Comments

Both Principal Scientists have been sea-going using the NERC fleet of ships and marine equipment pool for many years and have had the full spectrum of experiences from total equipment failure to things going according to plan. Both Principal Scientists have also experienced the pre- and post- move to Southampton and the effects this has had on staff motivation and sense of security and appreciation by their employers and the user community.

We are very pleased to see the motivation and enthusiasm of the new staff and the more efficient and thorough planning and preparation that now takes place with the TLO and the Head of the Marine Equipment Pool. We now get the impression that they collectively care about the outcome of a cruise and have a sense of involvement in the science being undertaken. We also get the impression that they now consider they are providing a service which should have quality and the scientists shouldn't just take or leave what they get given which seemed to be the case in the past. This state of affairs is a great step forward and we can but encourage its continuation as there is still some way to go.

The support staff taking part in the trials and in the cruise its self were, in general, very helpful and accommodating of the whims of the scientists and undertook their roles with great enthusiasm and consummate skill. We wish to express our gratitude to them for all their efforts.

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We wish to thank the master, officers and crew of the *RRS Discovery* and the support staff and sea-going technicians of NERC's United Kingdom Ocean Research Services (UKORS) for their efforts and good humour throughout this cruise; Tom Oliva from Seamap UK whose assistance on all matters seismic was also greatly appreciated and Anne Krabbenhoeft and Cord Papenberg from Geomar for extremely proficient and professional ocean-bottom instrument support. We hope that they will sail with us again as we would with them.

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Much of the technical detail in this cruise report is derived from the end of cruise data summary compiled by the NERC-funded ACE Ph.D. students Chris Greenroyd and Matt Rodger.

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Tables

Table 1 - Scientific personnel

The RRS Discovery carried a total crew of 38 people for cruise D275 as named below:

Master	R Chamberlain
Chief Officer	R Warner
2nd Officer	P Oldfield
3rd Officer	D White
Chief Engineer	B McDonald
2nd Engineer	S Bell
3rd Engineer	J Hartnett
3rd Engineer	C Uttley
MMIA	D MacDiarmid
ETO	D Corbett
CPO(D)	M Drayton
PO(D)	A Maclean
Seaman	R Dickenson
Seaman	M Moore
Seaman	S Smith
Seaman	G Cooper
SCM	K Curtis
Chef	A Nagle
Assistant Chef	D Caines
Steward	J Giddings
PSO	A Watts
Co-PSO	C Peirce
Scientist	C Greenroyd
Scientist	M Rodger
Scientist	T Cunha
Scientist	D Close
Scientist	L Drehmer
OBS Support	A Krabbenhoeft
OBS Support	C Papenberg
Techical Liaison Officer	J. Scott
Technical Support	R Brown
Technical Support	J Bicknell
Technical Support	D Booth
Technical Support	R Phillips
Technical Support	D Young
Technical Support	R Lloyd
Technical Support	C Hunter
Seamap UK	T Oliva

For the trials cruise the scientific party and technical staff were as named below:

PSO	C Peirce
Techical Liaison Officer	J. Scott
Technical Support	C. Day
Technical Support	J Bicknell
Technical Support	D Booth
Technical Support	R Phillips
Technical Support	D Young
Technical Support	D Mountiford
Technical Support	E Northrop
Seamap UK	T Oliva

Table 2 - Summary of OBS deployments

MCS line	Number of OBHs deployed	Number of "Klapp" OBSs deployed	Number of "Neu" OBSs deployed	Number of deployed geophone Klapp OBSs deployed	Total instruments deployed
ACE307A	6	9	5	0	20
ACE313D	10	10	0	0	20
ACE323B	11	5	3	0	19
ACE327F	4	2	2	0	8
ACE331G	4	7	0	1	12
Total	35	33	10	1	79

Table 3 – OBS/H deployment locations - Line ACE307A

0-360 Long. °	Lat. °	OBS	Offset km	Deg.	Min.	Deg.	Min.	+/-180 Long. °	Lat. °	-ive = west and south Deg.	Min.	Deg.	Min.	Depth m	Deployment time	Day	OBS/H
308.5583	5.9533	A1	0.00	308	33.498	5	57.198	-51.442	5.953	-51	26.502	5	57.198	1464	13:45	306	OBS
308.6133	6.0217	A2	10.00	308	36.798	6	1.302	-51.387	6.022	-51	23.202	6	1.302	2009	14:47	306	OBS
308.6683	6.0925	A3	20.00	308	40.098	6	5.550	-51.332	6.093	-51	19.902	6	5.550	2413	15:51	306	OBS
308.7228	6.1640	A4	30.00	308	43.368	6	9.840	-51.277	6.164	-51	16.632	6	9.840	2677	17:14	306	OBH
308.7792	6.2352	A5	40.00	308	46.752	6	14.112	-51.221	6.235	-51	13.248	6	14.112	2840	18:10	306	OBS
308.8338	6.3050	A6	50.00	308	50.028	6	18.300	-51.166	6.305	-51	9.972	6	18.300	3027	19:03	306	OBH
308.8900	6.3767	A7	60.00	308	53.400	6	22.602	-51.110	6.377	-51	6.600	6	22.602	3189	21:09	306	OBH
308.9450	6.4483	A8	70.00	308	56.700	6	26.898	-51.055	6.448	-51	3.300	6	26.898	3383	22:09	306	OBS
309.0017	6.5233	A9	80.00	309	0.102	6	31.398	-50.998	6.523	-50	59.898	6	31.398	3480	23:05	306	OBS
309.0550	6.5900	A10	90.00	309	3.300	6	35.400	-50.945	6.590	-50	56.700	6	35.400	3581	0:05	307	OBS
309.1117	6.6617	A11	100.00	309	6.702	6	39.702	-50.888	6.662	-50	53.298	6	39.702	3684	1:05	307	OBH
309.1667	6.7317	A12	110.00	309	10.002	6	43.902	-50.833	6.732	-50	49.998	6	43.902	3780	1:57	307	OBS
309.2233	6.8033	A13	120.00	309	13.398	6	48.198	-50.777	6.803	-50	46.602	6	48.198	3889	2:46	307	OBH
309.2768	6.8742	A14	130.00	309	16.608	6	52.452	-50.723	6.874	-50	43.392	6	52.452	3946	3:36	307	OBS
309.3320	6.9453	A15	140.00	309	19.920	6	56.718	-50.668	6.945	-50	40.080	6	56.718	4022	4:27	307	OBS
309.3880	7.0162	A16	150.00	309	23.280	7	0.970	-50.612	7.016	-50	36.720	7	0.970	4097	5:14	307	OBS
309.4430	7.0873	A17	160.00	309	26.580	7	5.238	-50.557	7.087	-50	33.420	7	5.238	4152	6:03	307	OBH
309.4988	7.1582	A18	170.00	309	29.928	7	9.492	-50.501	7.158	-50	30.072	7	9.492	4159	6:49	307	OBS
309.5547	7.2292	A19	180.00	309	33.282	7	13.752	-50.445	7.229	-50	26.718	7	13.752	4186	7:38	307	OBH
309.6108	7.2998	A20	190.00	309	36.648	7	17.988	-50.389	7.300	-50	23.352	7	17.988	4205	8:34	307	OBS

Table 4 – OBS/H deployment locations - Line ACE313D

0-360 Long. °	Lat. °	OBS	Offset km	Deg.	Min.	Deg.	Min.	+/-180 Long. °	Lat. °	-ive = west and south Deg.	Min.	Deg.	Min.	Depth m	Deployment time	Day	OBS/H
306.9293	7.7108	D1	0.00	306	55.758	7	42.648	-53.071	7.711	-53	4.242	7	42.648	1108	9:08	312	OBS
306.9660	7.7920	D2	10.00	306	57.960	7	47.520	-53.034	7.792	-53	2.040	7	47.520	1226	10:04	312	OBH
307.0040	7.8740	D3	20.00	307	0.240	7	52.440	-52.996	7.874	-52	59.760	7	52.440	1238	10:55	312	OBS
307.0423	7.9550	D4	30.00	307	2.538	7	57.300	-52.958	7.955	-52	57.462	7	57.300	1259	11:59	312	OBH
307.0795	8.0372	D5	40.00	307	4.770	8	2.232	-52.921	8.037	-52	55.230	8	2.232	1381	12:55	312	OBS
307.1175	8.1195	D6	50.00	307	7.050	8	7.170	-52.883	8.120	-52	52.950	8	7.170	1671	13:50	312	OBH
307.1552	8.2010	D7	60.00	307	9.312	8	12.060	-52.845	8.201	-52	50.688	8	12.060	2105	14:50	312	OBS
307.1940	8.2830	D8	70.00	307	11.640	8	16.980	-52.806	8.283	-52	48.360	8	16.980	2511	15:48	312	OBH
307.2305	8.3646	D9	80.00	307	13.830	8	21.876	-52.770	8.365	-52	46.170	8	21.876	2912	16:33	312	OBS
307.2679	8.4462	D10	90.00	307	16.074	8	26.772	-52.732	8.446	-52	43.926	8	26.772	3394	17:24	312	OBH
307.3063	8.5282	D11	100.00	307	18.378	8	31.692	-52.694	8.528	-52	41.622	8	31.692	3551	18:13	312	OBS
307.3443	8.6098	D12	110.00	307	20.658	8	36.588	-52.656	8.610	-52	39.342	8	36.588	4690	18:58	312	OBH
307.3830	8.6917	D13	120.00	307	22.980	8	41.502	-52.617	8.692	-52	37.020	8	41.502	4654	20:12	312	OBS
307.4195	8.7733	D14	130.00	307	25.170	8	46.398	-52.581	8.773	-52	34.830	8	46.398	4610	20:59	312	OBH
307.4571	8.8547	D15	140.00	307	27.426	8	51.282	-52.543	8.855	-52	32.574	8	51.282	4611	21:50	312	OBS
307.4954	8.9367	D16	150.00	307	29.724	8	56.202	-52.505	8.937	-52	30.276	8	56.202	4635	22:38	312	OBH
307.5332	9.0185	D17	160.00	307	31.992	9	1.110	-52.467	9.019	-52	28.008	9	1.110	4669	23:29	312	OBS
307.5706	9.1000	D18	170.00	307	34.236	9	6.000	-52.429	9.100	-52	25.764	9	6.000	4698	0:25	312	OBH
307.6087	9.1815	D19	180.00	307	36.522	9	10.890	-52.391	9.182	-52	23.478	9	10.890	4724	1:27	312	OBS
307.6473	9.2634	D20	190.00	307	38.838	9	15.804	-52.353	9.263	-52	21.162	9	15.804	4760	2:35	312	OBH

Table 5 – OBS/H deployment locations - Line ACE323B

0-360 Long. °	Lat. °	OBS	Offset km	Deg.	Min.	Deg.	Min.	+/-180 Long. °	Lat. °	-ive = west and south Deg.	Min.	Deg.	Min.	Depth m	Deployment time	Day	OBS/H
312.2255	4.3403	B8	87.50	312	13.530	4	20.418	-47.775	4.340	-47	46.470	4	20.418	2484	16:11	319	OBH
312.3103	4.4158	B9	100.00	312	18.618	4	24.948	-47.690	4.416	-47	41.382	4	24.948	2610	17:20	319	OBS
312.3935	4.4913	B10	112.50	312	23.610	4	29.478	-47.607	4.491	-47	36.390	4	29.478	2533	18:24	319	OBH
312.4772	4.5666	B11	125.00	312	28.632	4	33.996	-47.523	4.567	-47	31.368	4	33.996	2711	19:30	319	OBS
312.5610	4.6416	B12	137.50	312	33.660	4	38.496	-47.439	4.642	-47	26.340	4	38.496	2802	20:40	319	OBH
312.6441	4.7169	B13	150.00	312	38.646	4	43.014	-47.356	4.717	-47	21.354	4	43.014	2878	21:49	319	OBS
312.7283	4.7921	B14	162.50	312	43.698	4	47.526	-47.272	4.792	-47	16.302	4	47.526	3019	22:59	319	OBH
312.8109	4.8671	B15	175.00	312	48.654	4	52.026	-47.189	4.867	-47	11.346	4	52.026	3107	0:16	320	OBS
312.8952	4.9422	B16	187.50	312	53.712	4	56.532	-47.105	4.942	-47	6.288	4	56.532	3215	1:33	320	OBH
312.9777	5.0171	B17	200.00	312	58.662	5	1.026	-47.022	5.017	-47	1.338	5	1.026	3243	2:45	320	OBH
313.0623	5.0924	B18	212.50	313	3.738	5	5.544	-46.938	5.092	-46	56.262	5	5.544	3352	3:50	320	OBS
313.1461	5.1674	B19	225.00	313	8.766	5	10.044	-46.854	5.167	-46	51.234	5	10.044	3363	4:55	320	OBH
313.2295	5.2421	B20	237.50	313	13.770	5	14.526	-46.771	5.242	-46	46.230	5	14.526	3458	5:58	320	OBH
313.3131	5.3167	B21	250.00	313	18.786	5	19.002	-46.687	5.317	-46	41.214	5	19.002	3517	7:03	320	OBS
313.3976	5.3924	B22	262.50	313	23.856	5	23.544	-46.602	5.392	-46	36.144	5	23.544	3576	8:18	320	OBH
313.4797	5.4669	B23	275.00	313	28.782	5	28.014	-46.520	5.467	-46	31.218	5	28.014	3670	9:31	320	OBS
313.5637	5.5419	B24	287.50	313	33.822	5	32.514	-46.436	5.542	-46	26.178	5	32.514	3712	10:45	320	OBH
313.6480	5.6172	B25	300.00	313	38.880	5	37.032	-46.352	5.617	-46	21.120	5	37.032	3762	12:45	320	OBH
313.7310	5.6908	B26	312.50	313	43.860	5	41.448	-46.269	5.691	-46	16.140	5	41.448	3819	13:51	320	OBS

Table 6 – OBS/H deployment locations - Line ACE327F

0-360 Long. °	Lat. °	OBS	Offset km	Deg.	Min.	Deg.	Min.	+/-180 Long. °	Lat. °	-ive = west and south Deg.	Min.	Deg.	Min.	Depth m	Deployment time	Day	OBS/H
312.3908	4.3150	F1	0.00	312	23.448	4	18.900	-47.609	4.315	-47	36.552	4	18.900	2405	20:26	327	OBH
312.6170	4.3305	F2	25.00	312	37.020	4	19.830	-47.383	4.331	-47	22.980	4	19.830	2486	22:19	327	OBS
312.8411	4.3458	F3	50.00	312	50.466	4	20.748	-47.159	4.346	-47	9.534	4	20.748	2821	0:02	327	OBH
313.0660	4.3613	F4	75.00	313	3.960	4	21.678	-46.934	4.361	-46	56.040	4	21.678	3121	1:45	327	OBS
313.2911	4.3768	F5	100.00	313	17.466	4	22.608	-46.709	4.377	-46	42.534	4	22.608	3266	3:20	327	OBH
313.5161	4.3921	F6	125.00	313	30.966	4	23.526	-46.484	4.392	-46	29.034	4	23.526	3376	5:03	327	OBS
313.7411	4.4075	F7	150.00	313	44.466	4	24.450	-46.259	4.408	-46	15.534	4	24.450	3565	6:48	327	OBH
313.9688	4.4226	F8	175.00	313	58.128	4	25.356	-46.031	4.423	-46	1.872	4	25.356	3678	8:26	327	OBS

Table 7 – OBS/H deployment locations - Line ACE331G_a

0-360 Long. °	Lat. °	OBS	Offset km	Deg.	Min.	Deg.	Min.	+/-180 Long. °	Lat. °	-ive = west and south Deg.	Min.	Deg.	Min.	Depth m	Deployment time	Day	OBS/H
316.9432	4.5062	G7	205.00	316	56.592	4	30.372	-43.057	4.506	-43	3.408	4	30.372	3701	18:26	330	OBH
316.7621	4.3828	G8	230.00	316	45.726	4	22.968	-43.238	4.383	-43	14.274	4	22.968	3640	20:23	330	OBH
316.5769	4.2533	G9	255.00	316	34.614	4	15.198	-43.423	4.253	-43	25.386	4	15.198	3035	22:52	330	OBS
316.3891	4.1225	G10	280.00	316	23.346	4	7.350	-43.611	4.123	-43	36.654	4	7.350	3160	1:02	330	OBH
316.0940	3.9161	G11	320.00	316	5.640	3	54.966	-43.906	3.916	-43	54.360	3	54.966	4228	3:41	331	OBS

Table 8 – OBS/H deployment locations - Line ACE331G_b

0-360 Long. °	Lat. °	OBS	Offset km	Deg.	Min.	Deg.	Min.	+/-180 Long. °	Lat. °	-ive = west and south Deg.	Min.	Deg.	Min.	Depth m	Deployment time	Day	OBS/H
315.4944	4.5245	G1	0.00	315	29.664	4	31.470	-44.506	4.525	-44	30.336	4	31.470	4104	8:05	330	OBS
315.7190	4.5384	G2	25.00	315	43.140	4	32.304	-44.281	4.538	-44	16.860	4	32.304	4150	9:40	330	OBS
316.0781	4.5627	G3	65.00	316	4.686	4	33.762	-43.922	4.563	-43	55.314	4	33.762	3124	12:01	330	OBH
316.3031	4.5772	G4	90.00	316	18.186	4	34.632	-43.697	4.577	-43	41.814	4	34.632	2769	13:33	330	OBS
316.5736	4.5945	G5	120.00	316	34.416	4	35.670	-43.426	4.595	-43	25.584	4	35.670	3591	15:20	330	OBH
316.7972	4.6095	G6	145.00	316	47.832	4	36.570	-43.203	4.610	-43	12.168	4	36.570	3352	16:53	330	OBH

Table 9 - Multichannel seismic profiles

Line Number	ACE303E	ACE307A	ACE313D	ACE323B	ACE327F	ACE331G
First FFID	1	1001	1015	996	971	971
Last FFID	1638	4168	5416	5204	3857	5760
First FFID Time	Day 303, 15:58.25	Day 307, 21:07.32	Day 313, 14:05.42	Day 323, 03:44.25	Day 327, 16:09.09	Day 331, 12:52.06
Last FFID Time	Day 304, 10:10.27	Day 309, 08:21.05	Day 315, 14:59.36	Day 325, 02:29.39	Day 329, 00:13.45	Day 333, 18:05.20
Total FFIDs	1638	3168	4402	4209	2887	4790

Table 10 - Sound velocity profiles

SV Number	Day	Time GMT	Latitude (N)	Longitude (W)
SV01	305	16:31	5° 49.59’	47° 41.50’
SV02	313	03:48	9° 15.57’	52° 18.14’
SV03	319	01:17	5° 31.84’	47° 41.62’
SV04	335	01:02	3° 47.45’	44° 04.67’

Table 11 - Expendable bathymetric thermographs

XBT Number	Day	Time	Latitude (N)	Longitude (W)
01	305	16:36.21	5° 49.740’	47° 41.040’
02	305	16:46.00	5° 49.740’	47° 41.040’
03	306	15:58.08	6° 05.550’	51° 19.900’
04	306	23:14.24	6° 31.450’	50° 59.850’
05	307	07:38.35	7° 13.738’	50° 26.760’
06	312	16:44.42	8° 22.190’	52° 46.010’
07	313	03:01.09	9° 16.300’	52° 20.800’
08	320	00:29.49	4° 52.060’	47° 11.310’
09	327	05:08.55	4° 23.531’	46° 29.040’
10	330	17:03.46	4° 36.585’	46° 12.121’
11	335	01:08.01	3° 47.220’	44° 04.800’

Table 12 - Land station deployment locations

MCS Line	Station Number	Latitude (N)	Longitude (W)	GPS Elevation (m)
ACE307A	A01	04° 54.114	52° 15.943	14
	A02	04° 48.884	52° 20.260	14
	A03	04° 42.762	52° 23.223	20
	A04	04° 40.117	52° 26.398	25
	A05	04° 33.103	52° 29.119	9
ACE313D	D01	05° 44.710	53° 56.156	14
	D02	05° 32.025	53° 56.825	12
	D03	05° 29.204	54° 02.457	37
	D04	05° 24.708	54° 04.818	5

Table 13 - MCS acquisition parameters

Parameter	Value
Energy Source	Airguns
Number of guns	14
Total volume	6520 cubic inches
Shot point time interval	40 s
Shot point distance interval	Varies – approximately 80 to 100 m
Source Depth	Varies – aimed to be 17 m
Receiver Depth	Varies – aimed to be 10 m
Number of Groups	96
Group Interval	25m
Near Trace Offset	242.5 m
Far Trace Offset	2617.5 m
Active Streamer Length	2400 m
CDP interval	12.5 m
Shot to CDP Ratio	Varies – approximately 8
Fold (= No. of groups / Shot to CDP Ratio)	12
Sample interval	4 ms
Record Length	20 s

Table 14 - 3.5 kHz profiles

Deployment		**Recovery**	
Day	**Time**	**Day**	**Time**
303	11:28	304	01:00
304	08:25	306	11:00
308	03:27	311	17:00
313	12:26	315	15:00
323	01:22	325	03:02
327	15:31	329	00:00
331	12:43	333	18:00

Table 15 - Cruise way points

0-360 Long.	Lat.	No	Deg.	Min.	Deg.	Min.	+/-180 Long.	Lat.	-ive = west and south Deg.	Min.	Deg.	Min.		
316.1410	0.4932	WP1	316	8.460	0	29.593	-43.859	0.493	-43	51.540	0	29.593		
312.4130	3.7389	WP2	312	24.780	3	44.335	-47.587	3.739	-47	35.220	3	44.335	Line E	start
312.3070	5.5293	WP3	312	18.420	5	31.756	-47.693	5.529	-47	41.580	5	31.756	SV XBT	end
308.5580	5.9504	WP4	308	33.480	5	57.026	-51.442	5.950	-51	26.520	5	57.026	1A	deployment
308.6130	6.0216	WP5	308	36.780	6	1.294	-51.387	6.022	-51	23.220	6	1.294	2A	
308.6680	6.0927	WP6	308	40.080	6	5.560	-51.332	6.093	-51	19.920	6	5.560	3A	
308.7230	6.1638	WP7	308	43.380	6	9.826	-51.277	6.164	-51	16.620	6	9.826	4A	
308.7790	6.2349	WP8	308	46.740	6	14.095	-51.221	6.235	-51	13.260	6	14.095	5A	
308.8340	6.3059	WP9	308	50.040	6	18.356	-51.166	6.306	-51	9.960	6	18.356	6A XBT	
308.8890	6.3770	WP10	308	53.340	6	22.620	-51.111	6.377	-51	6.660	6	22.620	7A	
308.9450	6.4481	WP11	308	56.700	6	26.887	-51.055	6.448	-51	3.300	6	26.887	8A	
309.0000	6.5192	WP12	309	0.000	6	31.150	-51.000	6.519	-51	0.000	6	31.150	9A	
309.0550	6.5902	WP13	309	3.300	6	35.412	-50.945	6.590	-50	56.700	6	35.412	10A	
309.1110	6.6612	WP14	309	6.660	6	39.673	-50.889	6.661	-50	53.340	6	39.673	11A	
309.1660	6.7322	WP15	309	9.960	6	43.934	-50.834	6.732	-50	50.040	6	43.934	12A XBT	
309.2220	6.8032	WP16	309	13.320	6	48.194	-50.778	6.803	-50	46.680	6	48.194	13A	
309.2770	6.8742	WP17	309	16.620	6	52.453	-50.723	6.874	-50	43.380	6	52.453	14A	
309.3320	6.9452	WP18	309	19.920	6	56.711	-50.668	6.945	-50	40.080	6	56.711	15A	
309.3880	7.0162	WP19	309	23.280	7	0.970	-50.612	7.016	-50	36.720	7	0.970	16A	
309.4430	7.0871	WP20	309	26.580	7	5.227	-50.557	7.087	-50	33.420	7	5.227	17A	
309.4990	7.1581	WP21	309	29.940	7	9.487	-50.501	7.158	-50	30.060	7	9.487	18A	
309.5540	7.2290	WP22	309	33.240	7	13.738	-50.446	7.229	-50	26.760	7	13.738	19A XBT	
309.6100	7.2999	WP23	309	36.600	7	17.992	-50.390	7.300	-50	23.400	7	17.992	20A	
309.7930	7.5393	WP24	309	47.580	7	32.356	-50.207	7.539	-50	12.420	7	32.356	Line A	start
308.4050	5.7549	WP25	308	24.300	5	45.292	-51.595	5.755	-51	35.700	5	45.292	Line A	
307.9350	5.1345	WP26	307	56.100	5	8.071	-52.065	5.135	-52	3.900	5	8.071	Line A	end
308.5580	5.9504	WP27	308	33.480	5	57.026	-51.442	5.950	-51	26.520	5	57.026	1A	recovery
308.6130	6.0216	WP28	308	36.780	6	1.294	-51.387	6.022	-51	23.220	6	1.294	2A	

308.6680	6.0927	WP29	308	40.080	6	5.560	-51.332	6.093	-51	19.920	6	5.560	3A	
308.7230	6.1638	WP30	308	43.380	6	9.826	-51.277	6.164	-51	16.620	6	9.826	4A	
308.7790	6.2349	WP31	308	46.740	6	14.095	-51.221	6.235	-51	13.260	6	14.095	5A	
308.8340	6.3059	WP32	308	50.040	6	18.356	-51.166	6.306	-51	9.960	6	18.356	6A	
308.8890	6.3770	WP33	308	53.340	6	22.620	-51.111	6.377	-51	6.660	6	22.620	7A	
308.9450	6.4481	WP34	308	56.700	6	26.887	-51.055	6.448	-51	3.300	6	26.887	8A	
309.0000	6.5192	WP35	309	0.000	6	31.150	-51.000	6.519	-51	0.000	6	31.150	9A	
309.0550	6.5902	WP36	309	3.300	6	35.412	-50.945	6.590	-50	56.700	6	35.412	10A	
309.1110	6.6612	WP37	309	6.660	6	39.673	-50.889	6.661	-50	53.340	6	39.673	11A	
309.1660	6.7322	WP38	309	9.960	6	43.934	-50.834	6.732	-50	50.040	6	43.934	12A	
309.2220	6.8032	WP39	309	13.320	6	48.194	-50.778	6.803	-50	46.680	6	48.194	13A	
309.2770	6.8742	WP40	309	16.620	6	52.453	-50.723	6.874	-50	43.380	6	52.453	14A	
309.3320	6.9452	WP41	309	19.920	6	56.711	-50.668	6.945	-50	40.080	6	56.711	15A	
309.3880	7.0162	WP42	309	23.280	7	0.970	-50.612	7.016	-50	36.720	7	0.970	16A	
309.4430	7.0871	WP43	309	26.580	7	5.227	-50.557	7.087	-50	33.420	7	5.227	17A	
309.4990	7.1581	WP44	309	29.940	7	9.487	-50.501	7.158	-50	30.060	7	9.487	18A	
309.5540	7.2290	WP45	309	33.240	7	13.738	-50.446	7.229	-50	26.760	7	13.738	19A	
309.6100	7.2999	WP46	309	36.600	7	17.992	-50.390	7.300	-50	23.400	7	17.992	20A	
311.6420	3.8136	WP47	311	38.520	3	48.817	-48.358	3.814	-48	21.480	3	48.817	1B	deployment
311.7250	3.8889	WP48	311	43.500	3	53.336	-48.275	3.889	-48	16.500	3	53.336	2B	
311.8090	3.9643	WP49	311	48.540	3	57.855	-48.191	3.964	-48	11.460	3	57.855	3B XBT	
311.8920	4.0396	WP50	311	53.520	4	2.377	-48.108	4.040	-48	6.480	4	2.377	4B	
311.9760	4.1149	WP51	311	58.560	4	6.895	-48.024	4.115	-48	1.440	4	6.895	5B	
312.0590	4.1902	WP52	312	3.540	4	11.411	-47.941	4.190	-47	56.460	4	11.411	6B	
312.1430	4.2654	WP53	312	8.580	4	15.926	-47.857	4.265	-47	51.420	4	15.926	7B	
312.2260	4.3407	WP54	312	13.560	4	20.441	-47.774	4.341	-47	46.440	4	20.441	8B	
312.3100	4.4160	WP55	312	18.600	4	24.959	-47.690	4.416	-47	41.400	4	24.959	9B	
312.3930	4.4912	WP56	312	23.580	4	29.471	-47.607	4.491	-47	36.420	4	29.471	10B XBT	
312.4770	4.5664	WP57	312	28.620	4	33.983	-47.523	4.566	-47	31.380	4	33.983	11B	
312.5610	4.6416	WP58	312	33.660	4	38.494	-47.439	4.642	-47	26.340	4	38.494	12B	
312.6440	4.7167	WP59	312	38.640	4	43.003	-47.356	4.717	-47	21.360	4	43.003	13B	
312.7280	4.7919	WP60	312	43.680	4	47.515	-47.272	4.792	-47	16.320	4	47.515	14B	
312.8110	4.8671	WP61	312	48.660	4	52.023	-47.189	4.867	-47	11.340	4	52.023	15B	
312.8950	4.9422	WP62	312	53.700	4	56.529	-47.105	4.942	-47	6.300	4	56.529	16B	
312.9780	5.0172	WP63	312	58.680	5	1.034	-47.022	5.017	-47	1.320	5	1.034	17B	
313.0620	5.0924	WP64	313	3.720	5	5.542	-46.938	5.092	-46	56.280	5	5.542	18B	
313.1460	5.1674	WP65	313	8.760	5	10.045	-46.854	5.167	-46	51.240	5	10.045	19B	
313.2290	5.2424	WP66	313	13.740	5	14.546	-46.771	5.242	-46	46.260	5	14.546	20B XBT	

313.3130	5.3174	WP67	313	18.780	5	19.046	-46.687	5.317	-46	41.220	5	19.046	21B	
313.3970	5.3924	WP68	313	23.820	5	23.545	-46.603	5.392	-46	36.180	5	23.545	22B	
313.4800	5.4675	WP69	313	28.800	5	28.047	-46.520	5.467	-46	31.200	5	28.047	23B	
313.5640	5.5424	WP70	313	33.840	5	32.543	-46.436	5.542	-46	26.160	5	32.543	24B	
313.6480	5.6173	WP71	313	38.880	5	37.039	-46.352	5.617	-46	21.120	5	37.039	25B	
313.7310	5.6922	WP72	313	43.860	5	41.532	-46.269	5.692	-46	16.140	5	41.532	26B	
313.8150	5.7671	WP73	313	48.900	5	46.024	-46.185	5.767	-46	11.100	5	46.024	27B	
313.8990	5.8420	WP74	313	53.940	5	50.519	-46.101	5.842	-46	6.060	5	50.519	28B	
313.9820	5.9168	WP75	313	58.920	5	55.009	-46.018	5.917	-46	1.080	5	55.009	29B	
314.0660	5.9916	WP76	314	3.960	5	59.497	-45.934	5.992	-45	56.040	5	59.497	30B XBT	
314.1500	6.0664	WP77	314	9.000	6	3.983	-45.850	6.066	-45	51.000	6	3.983	31B	
314.2330	6.1411	WP78	314	13.980	6	8.468	-45.767	6.141	-45	46.020	6	8.468	32B	
314.3170	6.2159	WP79	314	19.020	6	12.955	-45.683	6.216	-45	40.980	6	12.955	33B	
314.4010	6.2906	WP80	314	24.060	6	17.437	-45.599	6.291	-45	35.940	6	17.437	34B	
314.4840	6.3653	WP81	314	29.040	6	21.917	-45.516	6.365	-45	30.960	6	21.917	35B	
314.5680	6.4399	WP82	314	34.080	6	26.396	-45.432	6.440	-45	25.920	6	26.396	36B	
314.6520	6.5146	WP83	314	39.120	6	30.873	-45.348	6.515	-45	20.880	6	30.873	37B	
314.7360	6.5892	WP84	314	44.160	6	35.353	-45.264	6.589	-45	15.840	6	35.353	38B	
314.8190	6.6638	WP85	314	49.140	6	39.826	-45.181	6.664	-45	10.860	6	39.826	39B	
315.0000	6.8202	WP86	315	0.000	6	49.210	-45.000	6.820	-45	0.000	6	49.210	Line B	start
310.4950	2.7722	WP87	310	29.700	2	46.330	-49.505	2.772	-49	30.300	2	46.330	Line B	
309.8210	2.1558	WP88	309	49.260	2	9.349	-50.179	2.156	-50	10.740	2	9.349	Line B	end
311.6420	3.8136	WP89	311	38.520	3	48.817	-48.358	3.814	-48	21.480	3	48.817	1B	recovery
311.7250	3.8889	WP90	311	43.500	3	53.336	-48.275	3.889	-48	16.500	3	53.336	2B	
311.8090	3.9643	WP91	311	48.540	3	57.855	-48.191	3.964	-48	11.460	3	57.855	3B	
311.8920	4.0396	WP92	311	53.520	4	2.377	-48.108	4.040	-48	6.480	4	2.377	4B	
311.9760	4.1149	WP93	311	58.560	4	6.895	-48.024	4.115	-48	1.440	4	6.895	5B	
312.0590	4.1902	WP94	312	3.540	4	11.411	-47.941	4.190	-47	56.460	4	11.411	6B	
312.1430	4.2654	WP95	312	8.580	4	15.926	-47.857	4.265	-47	51.420	4	15.926	7B	
312.2260	4.3407	WP96	312	13.560	4	20.441	-47.774	4.341	-47	46.440	4	20.441	8B	
312.3100	4.4160	WP97	312	18.600	4	24.959	-47.690	4.416	-47	41.400	4	24.959	9B	
312.3930	4.4912	WP98	312	23.580	4	29.471	-47.607	4.491	-47	36.420	4	29.471	10B	
312.4770	4.5664	WP99	312	28.620	4	33.983	-47.523	4.566	-47	31.380	4	33.983	11B	
312.5610	4.6416	WP100	312	33.660	4	38.494	-47.439	4.642	-47	26.340	4	38.494	12B	
312.6440	4.7167	WP101	312	38.640	4	43.003	-47.356	4.717	-47	21.360	4	43.003	13B	
312.7280	4.7919	WP102	312	43.680	4	47.515	-47.272	4.792	-47	16.320	4	47.515	14B	
312.8110	4.8671	WP103	312	48.660	4	52.023	-47.189	4.867	-47	11.340	4	52.023	15B	
312.8950	4.9422	WP104	312	53.700	4	56.529	-47.105	4.942	-47	6.300	4	56.529	16B	

312.9780	5.0172	WP105	312	58.680	5	1.034	-47.022	5.017	-47	1.320	5	1.034	17B	
313.0620	5.0924	WP106	313	3.720	5	5.542	-46.938	5.092	-46	56.280	5	5.542	18B	
313.1460	5.1674	WP107	313	8.760	5	10.045	-46.854	5.167	-46	51.240	5	10.045	19B	
313.2290	5.2424	WP108	313	13.740	5	14.546	-46.771	5.242	-46	46.260	5	14.546	20B	
313.3130	5.3174	WP109	313	18.780	5	19.046	-46.687	5.317	-46	41.220	5	19.046	21B	
313.3970	5.3924	WP110	313	23.820	5	23.545	-46.603	5.392	-46	36.180	5	23.545	22B	
313.4800	5.4675	WP111	313	28.800	5	28.047	-46.520	5.467	-46	31.200	5	28.047	23B	
313.5640	5.5424	WP112	313	33.840	5	32.543	-46.436	5.542	-46	26.160	5	32.543	24B	
313.6480	5.6173	WP113	313	38.880	5	37.039	-46.352	5.617	-46	21.120	5	37.039	25B	
313.7310	5.6922	WP114	313	43.860	5	41.532	-46.269	5.692	-46	16.140	5	41.532	26B	
313.8150	5.7671	WP115	313	48.900	5	46.024	-46.185	5.767	-46	11.100	5	46.024	27B	
313.8990	5.8420	WP116	313	53.940	5	50.519	-46.101	5.842	-46	6.060	5	50.519	28B	
313.9820	5.9168	WP117	313	58.920	5	55.009	-46.018	5.917	-46	1.080	5	55.009	29B	
314.0660	5.9916	WP118	314	3.960	5	59.497	-45.934	5.992	-45	56.040	5	59.497	30B	
314.1500	6.0664	WP119	314	9.000	6	3.983	-45.850	6.066	-45	51.000	6	3.983	31B	
314.2330	6.1411	WP120	314	13.980	6	8.468	-45.767	6.141	-45	46.020	6	8.468	32B	
314.3170	6.2159	WP121	314	19.020	6	12.955	-45.683	6.216	-45	40.980	6	12.955	33B	
314.4010	6.2906	WP122	314	24.060	6	17.437	-45.599	6.291	-45	35.940	6	17.437	34B	
314.4840	6.3653	WP123	314	29.040	6	21.917	-45.516	6.365	-45	30.960	6	21.917	35B	
314.5680	6.4399	WP124	314	34.080	6	26.396	-45.432	6.440	-45	25.920	6	26.396	36B	
314.6520	6.5146	WP125	314	39.120	6	30.873	-45.348	6.515	-45	20.880	6	30.873	37B	
314.7360	6.5892	WP126	314	44.160	6	35.353	-45.264	6.589	-45	15.840	6	35.353	38B	
314.8190	6.6638	WP127	314	49.140	6	39.826	-45.181	6.664	-45	10.860	6	39.826	39B	
321.4170	-3.7500	WP171	321	25.020	-3	44.999	-38.583	-3.750	-38	34.980	-3	44.999	Fortaleza	
306.9290	7.7099	WP172	306	55.740	7	42.595	-53.071	7.710	-53	4.260	7	42.595	1D	deployment
306.9660	7.7917	WP173	306	57.960	7	47.504	-53.034	7.792	-53	2.040	7	47.504	2D	
307.0040	7.8735	WP174	307	0.240	7	52.412	-52.996	7.874	-52	59.760	7	52.412	3D	
307.0420	7.9554	WP175	307	2.520	7	57.321	-52.958	7.955	-52	57.480	7	57.321	4D	
307.0790	8.0372	WP176	307	4.740	8	2.230	-52.921	8.037	-52	55.260	8	2.230	5D	
307.1170	8.1190	WP177	307	7.020	8	7.138	-52.883	8.119	-52	52.980	8	7.138	6D	
307.1550	8.2008	WP178	307	9.300	8	12.045	-52.845	8.201	-52	50.700	8	12.045	7D	
307.1930	8.2825	WP179	307	11.580	8	16.952	-52.807	8.283	-52	48.420	8	16.952	8D	
307.2300	8.3643	WP180	307	13.800	8	21.859	-52.770	8.364	-52	46.200	8	21.859	9D XBT	
307.2680	8.4461	WP181	307	16.080	8	26.766	-52.732	8.446	-52	43.920	8	26.766	10D	
307.3060	8.5279	WP182	307	18.360	8	31.672	-52.694	8.528	-52	41.640	8	31.672	11D	
307.3440	8.6096	WP183	307	20.640	8	36.578	-52.656	8.610	-52	39.360	8	36.578	12D	
307.3820	8.6914	WP184	307	22.920	8	41.483	-52.618	8.691	-52	37.080	8	41.483	13D	
307.4190	8.7731	WP185	307	25.140	8	46.388	-52.581	8.773	-52	34.860	8	46.388	14D	

307.4570	8.8549	WP186	307	27.420	8	51.293	-52.543	8.855	-52	32.580	8	51.293	15D	
307.4950	8.9366	WP187	307	29.700	8	56.197	-52.505	8.937	-52	30.300	8	56.197	16D	
307.5330	9.0184	WP188	307	31.980	9	1.101	-52.467	9.018	-52	28.020	9	1.101	17D	
307.5710	9.1001	WP189	307	34.260	9	6.004	-52.429	9.100	-52	25.740	9	6.004	18D	
307.6090	9.1818	WP190	307	36.540	9	10.907	-52.391	9.182	-52	23.460	9	10.907	19D	
307.6470	9.2635	WP191	307	38.820	9	15.809	-52.353	9.263	-52	21.180	9	15.809	20D XBT	
307.8370	9.6719	WP192	307	50.220	9	40.312	-52.163	9.672	-52	9.780	9	40.312	Line D	start
306.4030	6.5641	WP193	306	24.180	6	33.848	-53.597	6.564	-53	35.820	6	33.848	Line D	
306.1780	6.0730	WP194	306	10.680	6	4.381	-53.822	6.073	-53	49.320	6	4.381	Line D	end
306.9290	7.7099	WP195	306	55.740	7	42.595	-53.071	7.710	-53	4.260	7	42.595	1D	recovery
306.9660	7.7917	WP196	306	57.960	7	47.504	-53.034	7.792	-53	2.040	7	47.504	2D	
307.0040	7.8735	WP197	307	0.240	7	52.412	-52.996	7.874	-52	59.760	7	52.412	3D	
307.0420	7.9554	WP198	307	2.520	7	57.321	-52.958	7.955	-52	57.480	7	57.321	4D	
307.0790	8.0372	WP199	307	4.740	8	2.230	-52.921	8.037	-52	55.260	8	2.230	5D	
307.1170	8.1190	WP200	307	7.020	8	7.138	-52.883	8.119	-52	52.980	8	7.138	6D	
307.1550	8.2008	WP201	307	9.300	8	12.045	-52.845	8.201	-52	50.700	8	12.045	7D	
307.1930	8.2825	WP202	307	11.580	8	16.952	-52.807	8.283	-52	48.420	8	16.952	8D	
307.2300	8.3643	WP203	307	13.800	8	21.859	-52.770	8.364	-52	46.200	8	21.859	9D	
307.2680	8.4461	WP204	307	16.080	8	26.766	-52.732	8.446	-52	43.920	8	26.766	10D	
307.3060	8.5279	WP205	307	18.360	8	31.672	-52.694	8.528	-52	41.640	8	31.672	11D	
307.3440	8.6096	WP206	307	20.640	8	36.578	-52.656	8.610	-52	39.360	8	36.578	12D	
307.3820	8.6914	WP207	307	22.920	8	41.483	-52.618	8.691	-52	37.080	8	41.483	13D	
307.4190	8.7731	WP208	307	25.140	8	46.388	-52.581	8.773	-52	34.860	8	46.388	14D	
307.4570	8.8549	WP209	307	27.420	8	51.293	-52.543	8.855	-52	32.580	8	51.293	15D	
307.4950	8.9366	WP210	307	29.700	8	56.197	-52.505	8.937	-52	30.300	8	56.197	16D	
307.5330	9.0184	WP211	307	31.980	9	1.101	-52.467	9.018	-52	28.020	9	1.101	17D	
307.5710	9.1001	WP212	307	34.260	9	6.004	-52.429	9.100	-52	25.740	9	6.004	18D	
307.6090	9.1818	WP213	307	36.540	9	10.907	-52.391	9.182	-52	23.460	9	10.907	19D	
307.6470	9.2635	WP214	307	38.820	9	15.809	-52.353	9.263	-52	21.180	9	15.809	20D	
312.3910	4.3146	WP335	312	23.460	4	18.876	-47.609	4.315	-47	36.540	4	18.876	1F	deployment
312.6160	4.3303	WP336	312	36.960	4	19.815	-47.384	4.330	-47	23.040	4	19.815	2F	
312.8410	4.3458	WP337	312	50.460	4	20.750	-47.159	4.346	-47	9.540	4	20.750	3F	
313.0660	4.3614	WP338	313	3.960	4	21.681	-46.934	4.361	-46	56.040	4	21.681	4F	
313.2910	4.3760	WP339	313	17.460	4	22.560	-46.709	4.376	-46	42.540	4	22.560	5F XBT	
313.5160	4.3922	WP340	313	30.960	4	23.531	-46.484	4.392	-46	29.040	4	23.531	6F	
313.7410	4.4075	WP341	313	44.460	4	24.449	-46.259	4.407	-46	15.540	4	24.449	7F	
313.9660	4.4227	WP342	313	57.960	4	25.364	-46.034	4.423	-46	2.040	4	25.364	8F	
314.4150	4.4530	WP343	314	24.900	4	27.181	-45.585	4.453	-45	35.100	4	27.181	Line F	start

312.2560	4.3052	WP344	312	15.360	4	18.311	-47.744	4.305	-47	44.640	4	18.311	Line F	end
312.3910	4.3146	WP345	312	23.460	4	18.876	-47.609	4.315	-47	36.540	4	18.876	1F	recovery
312.6160	4.3303	WP346	312	36.960	4	19.815	-47.384	4.330	-47	23.040	4	19.815	2F	
312.8410	4.3458	WP347	312	50.460	4	20.750	-47.159	4.346	-47	9.540	4	20.750	3F	
313.0660	4.3614	WP348	313	3.960	4	21.681	-46.934	4.361	-46	56.040	4	21.681	4F	
313.2910	4.3768	WP349	313	17.460	4	22.608	-46.709	4.377	-46	42.540	4	22.608	5F	
313.5160	4.3922	WP350	313	30.960	4	23.531	-46.484	4.392	-46	29.040	4	23.531	6F	
313.7410	4.4075	WP351	313	44.460	4	24.449	-46.259	4.407	-46	15.540	4	24.449	7F	
313.9660	4.4227	WP352	313	57.960	4	25.364	-46.034	4.423	-46	2.040	4	25.364	8F	
315.4940	4.5245	WP353	315	29.640	4	31.471	-44.506	4.525	-44	30.360	4	31.471	1G	deployment
315.7190	4.5392	WP354	315	43.140	4	32.353	-44.281	4.539	-44	16.860	4	32.353	2G	
316.0780	4.5626	WP355	316	4.680	4	33.754	-43.922	4.563	-43	55.320	4	33.754	3G	
316.3030	4.5771	WP356	316	18.180	4	34.624	-43.697	4.577	-43	41.820	4	34.624	4G	
316.5720	4.5944	WP357	316	34.320	4	35.662	-43.428	4.594	-43	25.680	4	35.662	5G	
316.7970	4.6087	WP358	316	47.820	4	36.521	-43.203	4.609	-43	12.180	4	36.521	6G XBT	
316.9430	4.5094	WP359	316	56.580	4	30.562	-43.057	4.509	-43	3.420	4	30.562	7G	
316.7590	4.3805	WP360	316	45.540	4	22.830	-43.241	4.381	-43	14.460	4	22.830	8G	
316.5740	4.2516	WP361	316	34.440	4	15.095	-43.426	4.252	-43	25.560	4	15.095	9G	
316.3890	4.1226	WP362	316	23.340	4	7.357	-43.611	4.123	-43	36.660	4	7.357	10G	
316.0940	3.9162	WP363	316	5.640	3	54.971	-43.906	3.916	-43	54.360	3	54.971	11G	
315.9090	3.7871	WP364	315	54.540	3	47.228	-44.091	3.787	-44	5.460	3	47.228	12G	
315.4670	3.4773	WP365	315	28.020	3	28.636	-44.533	3.477	-44	31.980	3	28.636	Line G	start
317.4240	4.8442	WP366	317	25.440	4	50.650	-42.576	4.844	-42	34.560	4	50.650	Line G	
317.4250	4.6484	WP367	317	25.500	4	38.906	-42.575	4.648	-42	34.500	4	38.906	Line G	
315.0900	4.4979	WP368	315	5.400	4	29.874	-44.910	4.498	-44	54.600	4	29.874	Line G	end
315.4940	4.5245	WP369	315	29.640	4	31.471	-44.506	4.525	-44	30.360	4	31.471	1G	recovery
315.7190	4.5392	WP370	315	43.140	4	32.353	-44.281	4.539	-44	16.860	4	32.353	2G	
316.0780	4.5626	WP371	316	4.680	4	33.754	-43.922	4.563	-43	55.320	4	33.754	3G	
316.3030	4.5771	WP372	316	18.180	4	34.624	-43.697	4.577	-43	41.820	4	34.624	4G	
316.5720	4.5944	WP373	316	34.320	4	35.662	-43.428	4.594	-43	25.680	4	35.662	5G	
316.7970	4.6087	WP374	316	47.820	4	36.521	-43.203	4.609	-43	12.180	4	36.521	6G	
316.9430	4.5094	WP375	316	56.580	4	30.562	-43.057	4.509	-43	3.420	4	30.562	7G	
316.7590	4.3805	WP376	316	45.540	4	22.830	-43.241	4.381	-43	14.460	4	22.830	8G	
316.5740	4.2516	WP377	316	34.440	4	15.095	-43.426	4.252	-43	25.560	4	15.095	9G	
316.3890	4.1226	WP378	316	23.340	4	7.357	-43.611	4.123	-43	36.660	4	7.357	10G	
316.0940	3.9162	WP379	316	5.640	3	54.971	-43.906	3.916	-43	54.360	3	54.971	11G	
315.9090	3.7871	WP380	315	54.540	3	47.228	-44.091	3.787	-44	5.460	3	47.228	12G	