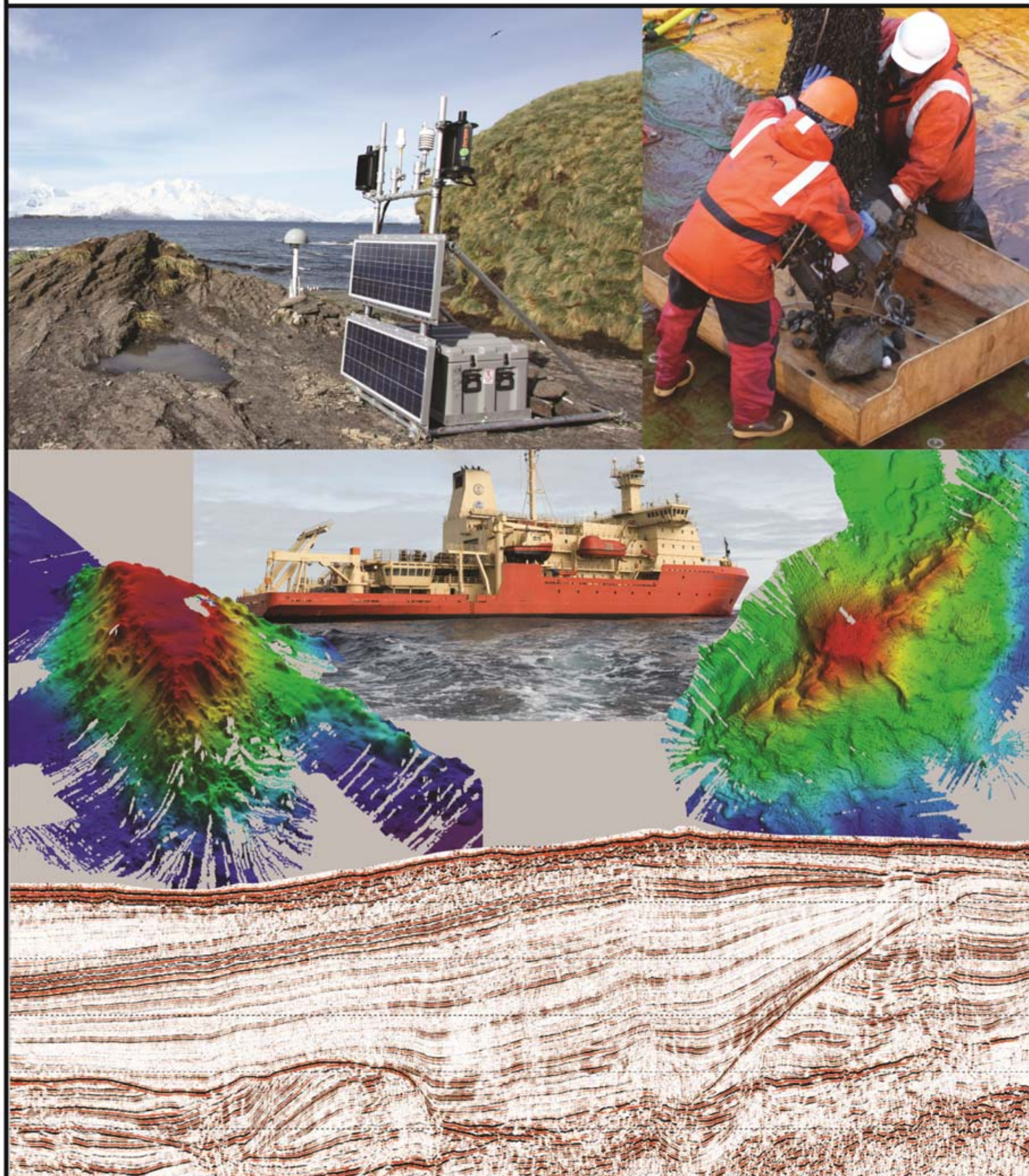
RVIB *Nathaniel B. Palmer* Cruise 1408, 22 September - 21 October 2014
Punta Arenas, Chile - Punta Arenas, Chile

Cruise Report



RVIB *Nathaniel B. Palmer* Cruise 1408: 22 September 2014 – 21 October 2014
Punta Arenas, Chile – Punta Arenas, Chile

Cruise Report

Executive Summary

RVIB Nathaniel B. Palmer Cruise 1408 took place between 22 September and 22 October 2014, stating and ending in Punta Arenas, Chile. One collaborative science project was supported: Role of the Scotia Sea Floor and North Scotia Ridge in the onset and Development of the Antarctic Circumpolar Current (ACC). The Principal Investigators are Ian Dalziel and Lawrence Lawver of the Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin and Robert Smalley Jr. of the Center for Earthquake Research and Information at the University of Memphis, Tennessee. Ian Dalziel was appointed Chief Scientist.

The cruise had three specific scientific objectives:

1. Geophysical investigation of the tectonic nature of the northern and southern boundaries of the South Georgia microcontinent;
2. Installation of continuous Global Positioning System (cGPS) stations at three sites distributed around the island; and
3.Targeted geophysical surveys in the unexplored zones of elevated crust in the eastern central Scotia Sea (CSS) with dredging for follow-up geochemistry and geochronology by our British colleagues.

We proposed to test two hypotheses with regard to the onset and development of the ACC:

Hypothesis 1: The topographic highs of the CSS are all part of an extensive ancestral submerged volcanic arc that would have served as a barrier to the flow of the ACC even after opening of a deep ocean gateway between South America and the Antarctic Peninsula in Drake Passage and the west Scotia Sea (WSS).
Hypothesis 2: The South Georgia microontinent collided with the Northeast Georgia Rise beginning at ~10 Ma, altering pathways for a developing ACC and starting a process in which the South Georgia microcontinent is transferring to the South American plate with the development of the plate boundary on the southern side of the microcontinent.

Weather on the outbound transit was excellent enabling valuable magnetic and multibeam bathymetric data to be obtained across a poorly understood area of the northeasternmost WSS spreading center. A period of exceptionally strong winds then precluded both landings to install GPS stations and seismic work along the margins of

the microcontinent. The weather ameliorated about one third of the way through the cruise, permitting both landings and seismic work, albeit with periods of interruption due to strong westerlies.

Regarding the cruise objectives:

1. Underway geophysical observations, including seismic data, were successfully conducted along both the northern and southern boundaries of the South Georgia microcontinent beyond the expectation of the Principal Investigators.
2. Global Positioning System stations were installed at the three planned locations and are operational at the time of writing towards the end of the cruise.
3. Geophysical surveys were carried out over elevated areas of the eastern central Scotia Sea and across the boundary between the central and eastern Scotia Sea as planned. Dredging results were somewhat disappointing, a large majority of the specimens collected being obvious glacial dropstones, but some volcanic material of likely local origin was obtained for study. Time limitations imposed by the early bad weather precluded planned study of the southern part of the Scotia Sea and dredging at a site targeted in that area.

The data obtained will permit evaluation of the two hypotheses that the cruise was planned to test.

Support of the science program fell short in that the multibeam bathymetric system was only functioning at 79% of capacity due to the failure of several TX 36 boards, reportedly due to problems with the hull-mounted transducers that were not repaired/upgraded at the time the 'topside' equipment was upgraded. In the event, this did not seriously detract from the achievements of the cruise, although it did mean that the full surveying capability of the vessel could not be employed in the course of an expensive cruise to a remote part of the Southern Ocean. More significant, further failure of the system due to the faulty transducers could have made all the marine geophysical goals of the cruise difficult or impossible to achieve, despite all the time involved in planning and mounting the cruise and the expense involved in conducting it.

Contents

1. Personnel

Scientific Personnel

Ian Dalziel, Principal Investigator, Chief Scientist (1)
Lawrence Lawver, Co-Principal Investigator (1)
Robert Smalley, Co-Principal Investigator (2)
Philip Leat, Geologist (3)
Marcy Davis, Multibeam coordinator (1)
Steffen Saustrup, Seismic technician (1)
Nicholas Bayou, Global Positioning System (GPS) engineer (4)

Jillian Worssam, PolarTREC teacher, Flagstaff, AZ

Joshua 'Bud Davis', Graduate Student, (1, 5)
Kory Kirchner, MSc Graduate (5)
Joel Lunsford, Graduate Student (1, 5)
Nick Benz, Undergraduate (1, 5)
Marissa Vara, BSc Graduate (1, 5)
Julie Zurbuchen, BSc Graduate (1, 5)

Christina Mehle, Protected Species Observer (PSO)
Alexandra Denby, Protected Species Observer

Graham Parker, Government of South Georgia and the South Sandwich Islands (GSGSSI) Observer

(1) Institute for Geophysics, Jackson School of Geosciences, The University of Texas at Austin
(2) The University of Memphis
(3) British Antarctic Survey
(4) UNAVCO, Boulder, CO
(5) Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin

Scientific/technical support (Antarctic Support Contract)

Eric Hutt, Marine Projects Coordinator
Shelton Blackman, Electronics Technician,
Kathleen Gavahan, Multibeam/ETech
Gabrielle Inglis, Electronics Technician
Joe Tarnow, Information Technician,
Valerie Warner, Information Tech
Hannah Gray, MT,
Mackenzie Haberman, MT
Jeremy Lucke, MT
Richard Thompson, MT
Amy Westman, Lab Supervisor

Ship's complement

Captain John Souza
Chief Engineer: Dave Munroe
First Mate: Rick Wiemken
First Asst. Engineer: J.P. Pierce
Second Mate: Drew Merget
2nd Asst. Engineer: Richard Johnson
Third Mate: Eric Thibodeau

3rd Asst. Engineer: David Zghaib

Ronnie Carpio, AB Seaman
Fernando Naraga, AB Seaman
Sam Villanueva, AB Seaman
Louie Andrada, AB Seaman
Lorenzo Sandoval, Cook
Mike Trombatore, Cook
Marcela Valenzuela, Cook

Danilo Plaza, QMED
Fredor Delacruz, QMED
Ric Tamayo, wiper

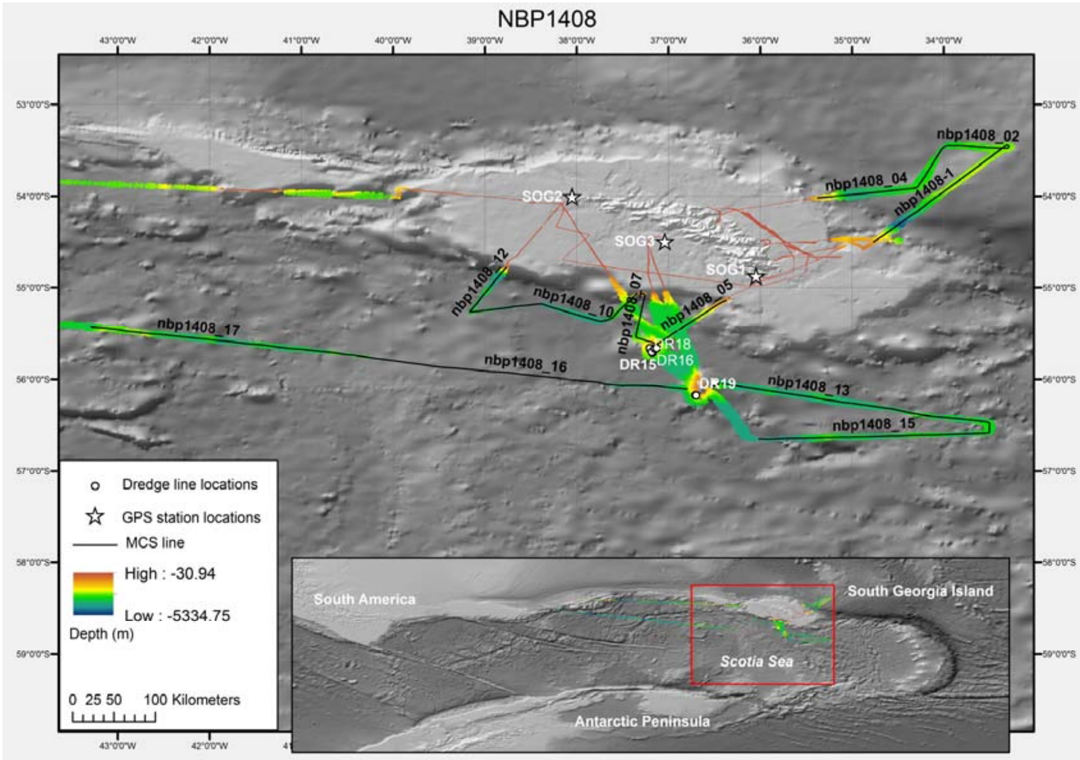
2. Science Goals

The cruise had three specific cruise objectives:
1. Geophysical investigation of the tectonic nature of the northern and southern boundaries of the South Georgia microcontinent;
2. Installation of continuous GPS stations at three sites distributed around the island; and
3.Targeted geophysical surveys in the unexplored zones of elevated crust in the eastern CSS with dredging for follow-up geochemistry and geochronology by our British colleagues.

We proposed to test two hypotheses with regard to the onset and development of the ACC:
Hypothesis 1: The topographic highs of the CSS are all part of an extensive volcanic arc that would have served as a barrier to the flow of the ACC even after opening of a deep ocean gateway between South America and the Antarctic Peninsula in Drake Passage and the WSS.
Hypothesis 2: The South Georgia microontinent collided with the Northeast Georgia Rise beginning at ~10 Ma, altering pathways for a developing ACC and is now part of the South American plate.

3. Track

The track of RBIV *Nathaniel B Palmer* in the main work area in the vicinity of the South Georgia microcontinent is shown below.



4. Time Line/Science Log

<u>Monday 22 September 2014</u>

Departed Punta Arenas 05.00 hours local time for Cabo Negro Fuel Pier. Arrived at fuel pier 07.00 hrs and commenced loading fuel. During the day attended safety, deck and laboratory briefings.

Departed fuel pier at 19.15 hrs after completing fueling and emigration formalities. Set course for eastern entrance to Strait of Magellan.

Underway science watchstanding commenced upon departure Cabo Negro.

<u>Tuesday 23 September 2014</u>

Exited eastern entrance of Strait of Magellan at 08.30hrs and turned onto course for Bird Island, South Georgia at 12.30 hrs, steering 095°. 'Abandon ship ' drill at 12.30 hrs, followed by talk on 'history of exploraion of the Scotia arc by Chief Scientist Ian Dalziel. Protected Species Observers (PSO's) commenced observations.

Held afternoon meeting regarding plans to deploy GPS station at Bird Island.

NOTE: The past four days, even prior to sailing, the Principal Investigators were involved in discussions with Antarctic Support Contract personnel, including the Marine Projects Coordinator, concerning the Kronsberg hull-mounted swath-mapping system. It failed several tests and it now appears that there is no choice but to proceed with the cruise with the system operating at 79% capacity, as we are advised that the procedure necessary to increase this percentage to a maximum of about 83% would likely result in further failure, reducing the capacity to 42%. Apparently the root cause of the problem lies in the hull mounted transducers and these can only be reached in drydock.

Wednesday 24 September 2014

En route to Bird Island, South Georgia in calm seas. PSO's on duty on the bridge. Ian Dalziel presented a follow-up talk on the results of NBP 0805 as a lead in to talks on the purpose of the present cruise. Conducted successful test of seismic streamer on the fantail.

Thursday 25 September 2014

Proceeding on same easterly course towards Bird Island. Robert Smalley presented a talk on active tectonics of the Scotia arc and the GPS goals of the project. Passed outer limit of Falkland Islands Exclusive Economic Zone at 1735 Z, commenced multibeam scanning. Imaged a NE-SW trending fabric on the northern margin of Davis Bank, possibly the effect of the fold-thrust belt between the Falkland Trough and the North Scotia Ridge. Deployed magnetometer for first time 2315Z. Resumed course for Bird Island.

Friday 26 September 2014

Continuing on easterly course for Bird Island. Crossed North Scotia Ridge onto northeasternmost segment of the west Scotia Sea spreading center, recording an excellent magnetic anomaly profile, The north-northeast-south southwest fabric of the oceanic lithosphere is clearly apparent in the multibeam record, even if the width of the swath is limited by the problems noted above. Graham Parker presented talk on the biota of the Southern Ocean and islands and conservation efforts

Saturday 27 September 2014

Continuing on easterly course to Bird Island. Held a meeting of scientific team, vessel and ASC personnel, PSO's and Government Observer on ramp-up to seismic shooting and deployed the seismic streamer for a successful test. Biosecurity checks were carried out preparatory to planned landings on Bird Island. Stood in towards the northwesternmost point of South Georgia.

Sunday 28 September 2014

Closed in on Bird Island, but wind too strong, at sustained 35 knots, to consider landings or setting up a GPS station at 2-300 meters elevation. Wind also too strong to contemplate seismic operations, so proceed southeastward towards vicinity of Cooper Bay where there should be more shelter and installation of a GPS station may be possible within 48 hours.

Monday 29 September 2014

Reconnoitered northeast coastline south of Iris Bay and Twitcher Glacier by Zodiac for a possible GPS site, Combination of heavy swell, steep shoreline, cliffs and katabatic wind off the glacier, together with small icebergs, made a landing unsafe. In addition, no suitable site for a GPS station was observed. Hence aborted the attempt and returned to vessel. Headed for the start of the seismic line planned for the north and east of South Georgia. However winds of 35-40 knots and seas over the fantail made seismic work impossible also. Returned to vicinity of Cooper Island for additional reconnaissance of the shoreline before dark. This, however, was precluded by poor visibility with driving snow and 40 knot winds. Another attempt will be made to find a GPS site in the morning. After that there is forecast to be a lull in the wind. This should allow seismic surveying on October 1.

<u>Tuesday September 30 2014</u>
Reconnoitered both Cape Charlotte and Harcourt Island with the vessel and the latter by Zodiac. Strong winds again hampered operations gusting to over 60 knots. We were unable to find a suitable combination of landing place, access and outcrop at either locality. Returned to vessel and prepared airguns for deployment early in the morning when weather is still predicted to be suitable for seismic work.

<u>Wednesday 1 October 2014</u>
Deployed air guns and started seismic surveying along line B*- B from the continental shelf of the South Georgia microcontinent to the Northeast Georgia Rise and back. Deployment and ramp up went smoothly. Commenced operating the airguns in just over 1000m of water as permitted. There were no marine mammal issues during the ramp up. A Sei whale surfaced near the vessel (off the bow) at ~1610 Z, but was not judged to be within the exclusion zone. There were many fur seals in the vicinity of the vessel. One brief shutdown was ordered during the afternoon when another whale entered the exclusion zone, but was quickly observed to leave. Resumed seismic work within 15 minutes. Data collected appear to be of high quality.

<u>Thursday 2 October 2014</u>
Continued seismic line across Northeast Georgia Rise and southwestward onto South Georgia microcontinent, obtaining excellent data.

<u>Friday 3 October 2014</u>
Completed seismic line onto South Georgia continental shelf. Sought shelter in Cumberland Bay due to strong westerly winds with a weather advisory for the seas west of the island. Pat Lurcock, Officer of the Government of South Georgia and the South Sandwich Islands came aboard to explain the local points of interest and environmental issues. Unfortunately the wind was too strong to permit landing, and workable weather is unlikely to return until the morning of 5 October. With our prime objectives unattainable, decided to spend the time surveying the northeast continental shelf of South Georgia, where possible beyond 12 kilometers where British coverage diminishes,

<u>Saturday 4 October 2014</u>
Winds continued strong throughout the night. At one point reaching in excess of 70 knots. Consequently continued swath mapping to the SE (lee) side of the island. The

swaths were run outboard of 7 miles in order to complement rather than duplicate existing coverage.

Sunday 5 October 2014
Hove to off Smaaland Cove at ~ 0500 hrs local time. After successful Zodiac reconnaissance landed a party to install a GPS station. Installation was successfully completed by ~1300 hrs. Immediately moved into position to commence a seismic line across the southwesten margin of the South Georgia microcontinent as planned. Successfully initiated the survey just before dark (~ 1800 hrs)and continued the line southwestward into the night.

Monday 6 October 2014
Continued seismic acquisition off the southwestern margin of the South Georgia microcontinent in weather unsuitable for landings. Planning installation of a second GPS station on or near Bird Island early on 8 October if weather ameliorates as predicted. Seismic gear functioning well and collecting excellent data.

Tuesday 7 October 2014
Continued multi-channel seismic profiling along the southwestern margin of the South Georgia microcontinent. Continued with a profile onto the margin in line with the northwestern end of the island. After reaching the 1000m contour, recovered air guns and the seismic streamer and headed for Bird Island to install second GPS station. Better weather as the day went on, raising hopes for tomorrow's installation.

Wednesday 8 October 2014
Hove to off Bird Island. With help of British Antarctic Survey at Bird Station, identified a site for GPS station. Full Scientific Party and BAS personnel helped carry station equipment up the stream and talus slope. Other Scientific Party and ASC personnel, including PSO's, came ashore for tour of the base and visits to penguin colony and albatross nesting ground. GPS station successfully installed despite ~3 hour delay due to lack of backup for drill battery.
Headed southeast to dredge seamounts off southwest margin of the South Georgia microcontinent.

Thursday 9 October 2014
Spent the morning after arrival at the northern seamount surveying it with multibeam for possible dredge sites. This seamount appears to have a guyot-like central volcanic (presumably) area and linear north-south 'protrusions' (dikes?). Selected two sites for dredging in 200-1000 meters of water. The first dredge was successful, yielding several large angular pieces of rock that at first examination may have been locally derived, together with some obviously ice rafted material, Some biologic samples were collected by the Government Observer for the Government of South Georgia and the South Sandwich Islands. The second dredge, about 4 nautical miles to the south, failed. A

strong tension ‘spike’ was indicated (~18,000 lbs) and the weak link was broken. This resulted in the spilling of any contents from the bag.
Given the ‘spikes’ visible in the dredge record, it was decided to repeat this dredge.

Friday 10 October 2014
The repeat dredge took longer than usual as the dredge was ‘caught up’ on some underwater obstacle, requiring the vessel to back down stern first for several hours in order to release it. A full dredge bag of rocks were brought on board, but they all look like glacial dropstones. After additional survey a third dredge was attempted in the northeast corner of the seamount, but only a few small dropstones were recovered.
At the end of the afternoon the airguns streamer and magnetometer were deployed for a study of the boundary between the central and east Scotia Seas.

Saturday 11 October 2014
Headed east to cross boundary into east Scotia Sea crossing magnetic anomalies recorded on a British Antarctic Survey cruise, the older of which are in some doubt. Proceeded east across the mapped anomalies C5C, C5B, C5A, C4A and C4. Then turned south for 15 minutes of latitude before returning to the west along one of the BAS lines. The westerly line will extend to 36 degrees west longitude where the vessel will turn north to perform additional dredges on the South Georgia southern seamounts. We will also position ourselves to take advantage of any weather window to install the third GPS station near or on Annenkov Island.

Sunday 12 October 2014
Completed westward leg of crossing from central Scotia Sea into east Scotia Sea. Recovered air guns and streamer and turned NNW towards Pickersgill and Annenkov islands. Multibeam data were collected en route, slight course deviations permitting filling of data gaps on southernmost of the two Southern South Georgia Seamounts.

Monday October 13 2014
Sailed north towards Annenkov Island and hove to on its northeastern side north of Hauge Reef. Reconnoitered the reef for suitable GPS site, but found none. Access to the flat top was barred by mostly vertical and elsewhere very steep slopes and the top is covered with tussock grass. Turned Zodiacwest to Annenkov Island where a site had just been authorized if Hauge Reef proved impractical. Despite the same problem with tussock grass coverage, a site was found in the Lower Tuff Member of the Annenkov Formation on the upper part of a beach. The station was successfully installed while the Marine Science Technicians conducted boat tours to the shores of the island by zodiac for the science party and interested ASC personnel. Recovered all personnel and headed SSE towards the southern seamounts of South Georgia for additional dredging as permitted by the Environmental Officer of the GSGSSI.

Tuesday 14 October 2014

Conducted dredging operations on each of the two southern South Georgia seamounts. The northern dredge was unsuccessful due to the basket having become entangled with the dredging wire. The southern one recovered mainly large drop stones with only two small fragments of volcanic material.
Commenced seismic operations for a final acquisition line to the NW across the central rise of the central Scotia Sea towards the 'Starfish' volcanic construct recognized and dredged in the course of NBP 0805.

Wednesday 15 October 2014
Continuing to acquire seismic and multibeam bathymetric data as well as gravity and magnetics as the vessel proceeds westward into the western part of the central Scotia Sea. Seismic data still valuable despite SW winds at over 30 knots. Multibeam data sub-standard.

Thursday 16 October 2014
Continuing to acquire seismic and multibeam bathymetric data as well as gravity and magnetics as the vessel proceeds westward into the western part of the central Scotia Sea. Now crossing the 'starfish' seamount. Data quality on seismic system and multibeam bathymetric system have improved markedly since wind and sea state improved. Completed seismic operations at 2200Z on top of the 'starfish' volcanic construct. Magnetometer and multibeam still operating as vessel headed for the eastern entrance to the Strait of Magellan.

Friday 17 October 2014
Acquisition of magnetometer and multibeam bathymetry data continues as the vessel proceeds towards the eastern end of the Strait of Magellan. The abandoned spreading center of the northeastern west Scotia Sea was clearly imaged.

Saturday 18 October 2014
Continued acquiring multibeam, magnetic and gravimetric data until the limits of the Falkland Islands Exclusive Economic Zone was reached at 1500Z. Magnetometer was recovered immediately after reaching this point. Watchstanding ceased.

Sunday 19 October and Monday 20 October 2014
Continued course to east entrance of Straits of Magellan.

Tuesday 21 October 2014
Entered Straits of Magellan and docked in Punta Arenas

5. Marine Geology and Geophysics
5a. Underway Measurements
5a.i. Gravity and Magnetics

Gravity Data

Gravity data were collected continuously during the cruise. The recently installed gravimeter is a Bell Aerospace TEXTRON BGM-3 gravity meter system (Figure 1). Initial QC is performed as part of daily data processing. Gravity data is displayed on the monitor screen above the watch standing desk. The green light was on during the entire cruise.

NBP1408 Gravity Operations Summary

Overview: NBP1408 sailed from Punta Arenas, Chile on 22 September, returning on 21 October, 2014 to Punta Arenas, Chile. The cruise did three GPS installs on or near South Georgia Island, Smaalen Cove, Bird Island, and Annenkov Island, and made one aborted courtesy call at King Edward Point, Grytviken, South Georgia. Only one gravimeter was operated on the cruise: a BGM3 on semi-permanent loan from the university-national oceanographic laboratory system (UNOLS). It was mounted in NBP's gravity room, a small closet-sized space at the aft of the aft dry lab.

BGM3 Serial Number S210

- Fastened down in the NBP gravity closet with a small real-time qc laptop plotting raw and filtered gravity (with the tie applied). See Figures 5a.1 and 5a.2.
- Scale factor relates output frequency to change in gravity (converts raw counts to mgals) based on the last instrument calibration:
    - Scale factor: 4.994070552 (from December, 2013 calibration)
- No real time GPS feed is required for the BGM3. There is a GPS RS232 connection to the optional laptop displayed in the figure below which is used for real time qc purposes but not required.

In general, the gravity values look quite reasonable although there is the note from the NBP0805 cruise which states:

Gravity data for the transit across the western Scotia Sea from Burdwood Bank to Elephant Island, essentially from 2008/04/23 09:33 -55.0211 -57.2616 to 2008/05/11 13:13 -60.754 -55.7904, were averaged and found to be approximately 24 mgal positive. The gravity data minus 24 mgal were plotted and found to be quite reasonable. The abandoned spreading center in the western Scotia Sea, crossed at 47˚ west, showed

Fig. 5a-1A View looking down on BGM3 gravimeter Serial number S210, showing gimble mount.

Fig. 5a-1B View of small real-time qc laptop plotting raw and filtered gravity (with the tie applied).

Fig. 5a-1C View of BGM3 electronics rack.

Fig. 5a-2 View of LaCoste and Romberg portable gravimeter used for base ties.

F

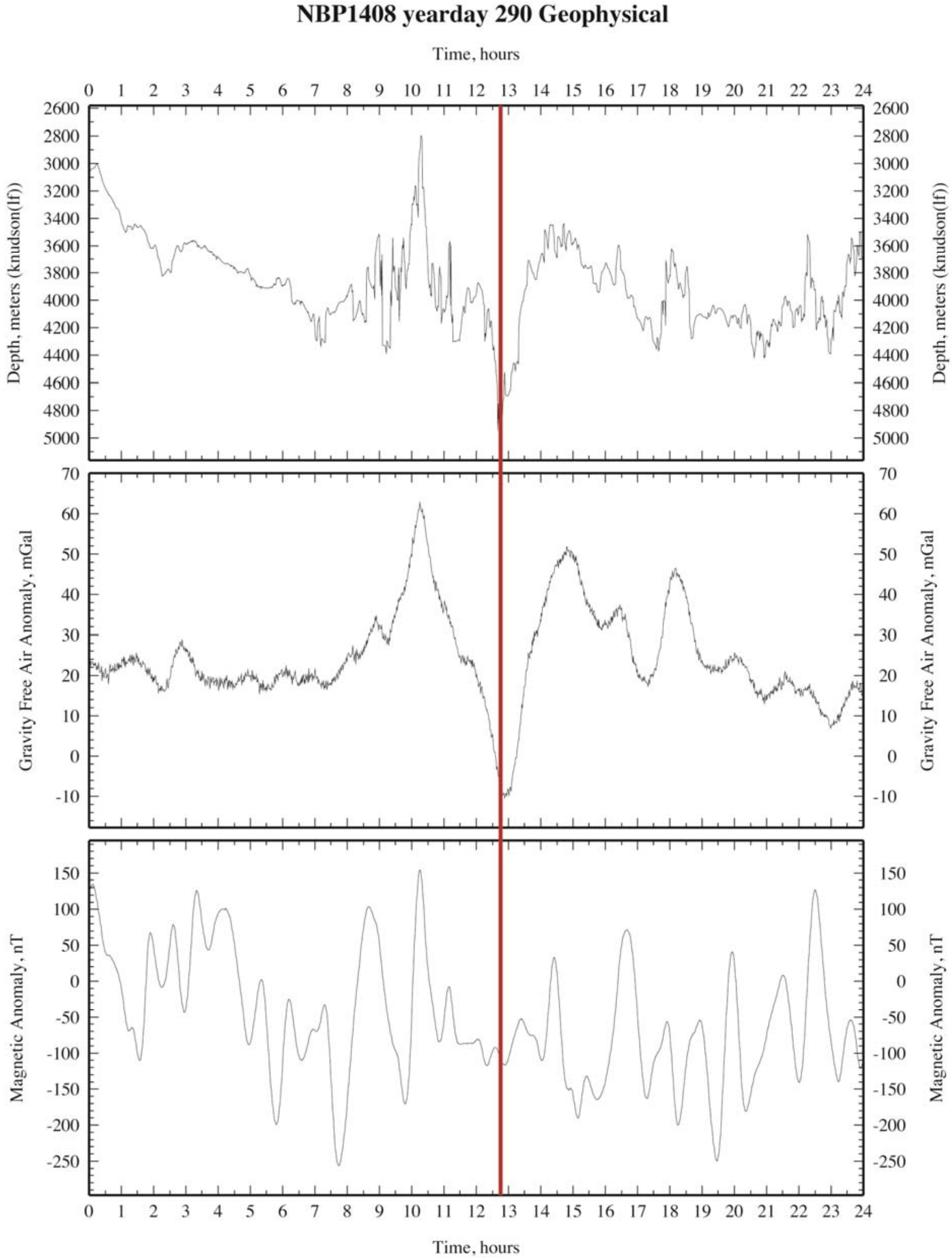


Fig. 5a.3 Underway data from JD 290 showing excellent depth and gravity signature of *a*

a textbook classic gravity profile with gravity highs over the two flanks and the abandoned spreading center 85 mgal less than the adjacent highs.

On NBP1408 when we crossed the similar abandoned spreading center from JD290-0700 to JD290-1900, see Figure 5a.3 we observed a very similar magnetic and gravity signature. Without the 24 mgal correction as suggested for the NBP0805 cruise, the gravity signal went from -10 mgal to +65 mgal. If it is assumed that the recently formed seafloor to either side of the abandoned spreading center is in isostatic equilibrium and should be about 0 mgal then the gravity data from NBP1408 may be offset by +20 mgal. The gravimeter for the NBP0805 cruise was a LaCoste and Romberg so this may not be a simple case of similar offsets.

Gravity Ties

Pre-cruise Punta Arenas, Chile gravity ties

- One gravity tie was completed between the pier next to the NBP and a separate monument near the steps of the warehouse, just off the pier in Punta Arenas.
-
- The pier was one meter above the level of the BGM3.
- Sheldon Blackman and Gabrielle Inglis did the tie.
- Tie 18 September 2014
    - Gravity at pier, nearest to gravimeter, about 1 meter above: 981276.9 mgal [before]
    - Gravity at pier, nearest to gravimeter, about 1 meter above: 981296.8 mgal [after]
-
    - The raw counts before and after the tie were 981276.9 [17:27] and 981296.8 [18:26]
        - Bias was calculated to be: 855466.15 mgal
        - As a result, the average raw counts can be derived as follows:
            - (981320.98-855466.15)/4.994070552 = 25200.35 counts
        - Heritage NBP software calls the bias “grav_offset” in their instrument coefficients file: gravity offset: 855459.39 mgal
        - The drift between the 18 September 2014 tie and the previous tie, also done at Punta Arenas was 2.04 mgal. Prior to the 16 August 2014 tie, the previous tie was the one done at the end of NBP1402 in Hobart, Tasmania on 16 March 2014, drift for the five months was a remarkable 4.27 mgal.

Gravimeter Corrections (taken from NBP1402 cruise report)

Latitude Corrections

- BGM3: This is not well documented on the NBP. Looking through code provided by Kathleen Gavahan ("rvxmerge.sh") revealed the following formula that they refer to as "theoretical gravity" but that is in fact, the latitude correction:

  latitude correction = $g_0*(1+a_1*\sin^2(lat) + a_3*\sin^4(lat))$

  g_0=978031.85

  a_1=0.005278895

  a_3=0.000023462
- Geosoft's Latitude Correction and constants are identical to the BGM3 implementation:

  latitude correction = g_0* (1+ a_1*slat2+ a_3*(slat2**2))

  g_0=978031.85

  a_1=0.005278895

  a_3=0.000023462

  r2d = 57.29578

  lat = Latitude/r2d

  slat2 = sin(lat)**2

Free Air Correction

- The ship's gravity code claims to put out the "Free Air Anomaly"
- Strictly speaking, the Free Air Anomaly would be the difference between the observed scalar gravity on the geoid (which we can assume to be MSL) and the theoretical gravity on the WGS84 ellipsoid. However, the code makes no mention of a the ellipsoid or an associated free air correction (0.3086*(height diff between WGS84 and MSL)
- The WGS-84/MSL difference for the Totten Glacier area was around ~20 meters.

Eotvos Corrections

- BGM3: Jamin Greenbaum was not familiar with the constants they've used and there are no comments in the code but this appears to be the eotvos correction in rvxmerge.sh:

  eotvos = 7.503*Veast*cos(lat)+0.004154*V^2

  Veast = east velocity component smoothed with a moving window of 1800 s

V = ship speed smoothed using a moving window of 1800 seconds

- Geosoft Eotvos correction formula

```
eotvos = 100000*(en+ea)

en = (a*latd2)*((3*slat2-2)*f+ha)

ea = (a*clat2*(longd2+2*w*longd))*(ha+f*slat2))

    a = 6378137.0

    f = 1/298.2572221

    w = 0.000072921151467

    ha = 1+ Height/a

    latd = LatitudeDerivative/r2d/td;

        lat = Latitude/r2d

        r2d = 57.29578 (180/pi)

        td = TimeDerivative*3600;  // assumes time in hours

    latd2 = latd**2;

    longd = LongitudeDerivative/r2d/td;

        long = Longitude/r2d

        td = TimeDerivative*3600;  // assumes time in hours

    longd2 = longd**2;

    slat2 = sin(lat)**2

    clat2 = cos(lat)**2
```

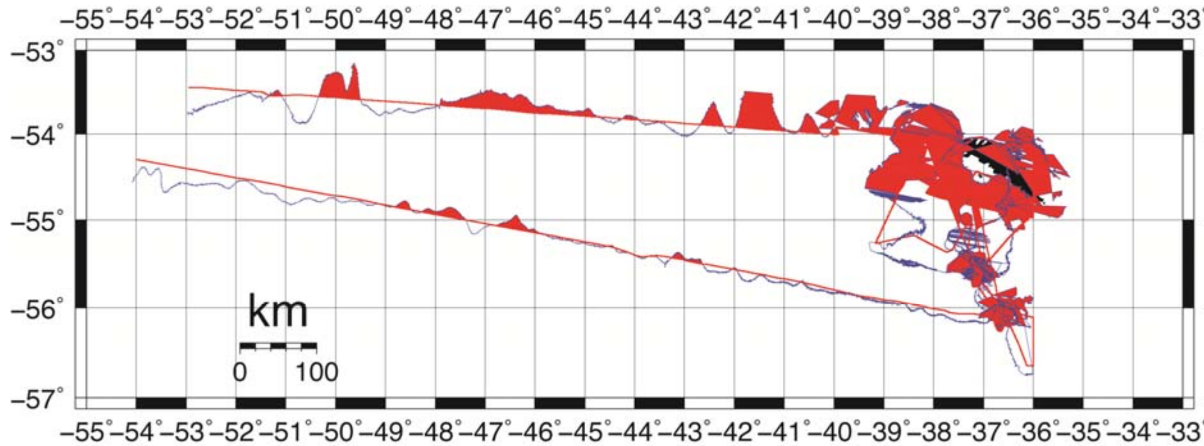


Fig. 5a.4 Gravity data collected with BGM3 gravimeter on NBP1408 with 24 mgal subtracted from gravity anomaly values. Note abandoned spreading center at -55.0 south, -47.0 west.

Magnetics Data

The magnetometer was deployed when science conditions permitted. The magnetometer is a SeaSPY Overhauser Magnetometer made by Marine Magnetics, a Canadian company based in Richmond Hill, Ontario [www.marinemagnetics.com]. According to their technical manual, the SeaSPY magnetometer is not what is commonly known as a 'proton magnetometer'; it is an Overhauser magnetometer. Although still relying on proton spin resonance, an Overhauser magnetometer is as different from a proton magnetometer as a gasoline engine is from a steam engine. Both devices are based on similar physics, but they perform their task completely differently, and this is apparent in their relative levels of performance. Total field magnetometers (like SeaSPY) measure only the magnitude of the magnetic field vector, independent of its direction with respect to the sensor. Vector magnetometers have the ability to measure the component of ambient magnetic field that is projected along one dimension in space. Flux gates, Magnetoresistive, and Hall-Effect sensors are all examples of vector magnetometers. In order to calculate the total field, three separate vector magnetometer sensors must be oriented at right angles to each other, and their outputs geometrically added by a signal processor. There are practical limitations to how precisely and how rigidly the three sensors can be fixed together at exactly right angles. For this reason, the total-field precision of even the best flux-gate magnetometers is limited to an order of magnitude less than a SeaSPY magnetometer. Furthermore, the output of all vector-field sensors will experience drift with time and with temperature. Vector magnetometers require periodic calibration with an accurate reference such as a proton-spin magnetometer. Proton-spin magnetometers never require calibration, even when first manufactured."

A tabulation of magnetic data acquired follows (Table 5.1). The magnetic data showed significant anomalies throughout much of the area and will be useful in particular for mapping the subsurface extent and geometry of volcanic bodies. Close correlations between magnetic peaks, bathymetry, and gravity data were seen both in the return crossing of the western Scotia Sea (Figure 5a.4) and to some extent in the area to the east of the two Southern Seamounts of South Georgia. There seems to be some short period, moderate amplitude magnetic anomalies over what might be considered reasonable seafloor magmatic flows, particularly from the northern of the two seamounts (Fig. 5a.5). In addition there are some high amplitude, very short period magnetic anomalies along the southern edge of the South Georgia microcontinent (Fig. 5a.6).

Initial plots of the magnetic data show that there are some discrepancies at crossover points between lines, indicating that influence of variations in the Earth's magnetic field due to diurnal variations and/or magnetic storms. But in general, the three crossings were within <20 nT.

Table 5a.1. Magnetometer deployment NBP1408

Maggie deployed crossing northern end of west Scotia Sea *en route* Bird Island

On 2014/o9/25 23:40 -53.5441 -51.3334
Off 2014/09/27 23:42 -54.0459 -38.5774

Maggie retrieved upon approach to Bird Island
Maggie off for weather, steaming on South Georgia platform

Maggie on for seismic line to Northeast Georgia Rise

On 2014/10/01 12:19 -54.3747 -34.5882
Off 2014/10/03 07:41 -54.0226 -35.4161

Maggie retrieved while recovering seismic gear
Maggie off for weather, steaming on South Georgia platform
Install first GPS site, Smaalen Cove, east end of island
Deploy maggie and seismic enroute to southern SGI margin survey

On 2014/10/05 21:49 -55.1822 -36.4560
Off 2014/10/06 05:01 -55.4570 -36.9061

Maggie entangled with seismic gear, retrieved
Deployment of Maggie delayed until course change to starboard

On 2014/10/06 12:11 -55.5072 -37.3499
Off 2014/10/08 06:38 -54.0636 -38.1239

Maggie retrieved on approach to Bird Island, GPS site install – all ashore
Depart Bird Island, enroute surveying/dredging Sirius Seamount

On 2014/10/08 21:39 -54.1594 -38.1139
Off 2014/10/09 12:58 -55.6658 -37.0949

Maggie retrieved to dredge. Dredges 014, 015, 016. DR015 broke the weak link. DR016 hung up but was successful.

On 2014/10/10 06:32 -55.7495 -37.1184
Off 2014/10/10 11:50 -56.0530 -36.4412

Maggie retrieved for Dredge 17, returned four small rocks, never really hit bottom, dredge-wash.

On 2014/10/10 20:13 -56.0523 -36.3773
Off 2014/10/12 18:52 -56.6486 -36.0572

Maggie retrieved while seismic streamer retrieved, underway to Annenkov Island

On 2014/10/12 19:48 -56.6151 -36.1509
Off 2014/10/13 07:50 -54.7025 -37.1636

Annenkov Island, GPS Site #3 install

On 2014/10/13 21:38 -54.9339 -37.1995
Off 2014/10/14 01:48 -55.6355 -37.0822

Maggie retrieved for Dredge DR018 on northern seamount, DR019 on southern seamount.
Seismic deployed headed west to Starfish.

On 2014/10/14 13:23 -56.1037 -36.8218
Off 2014/10/18

End of data collection NBP1408

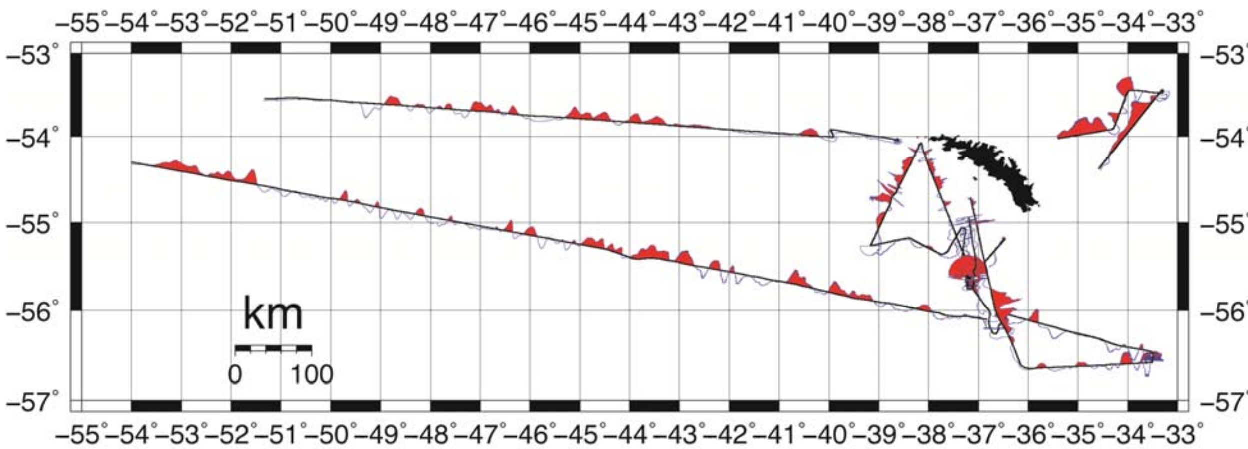


Fig. 5a.5 Central Scotia Sea free-air magnetic anomalies plotted along track with anomalies plotted perpendicular to track with orientation 010˚.

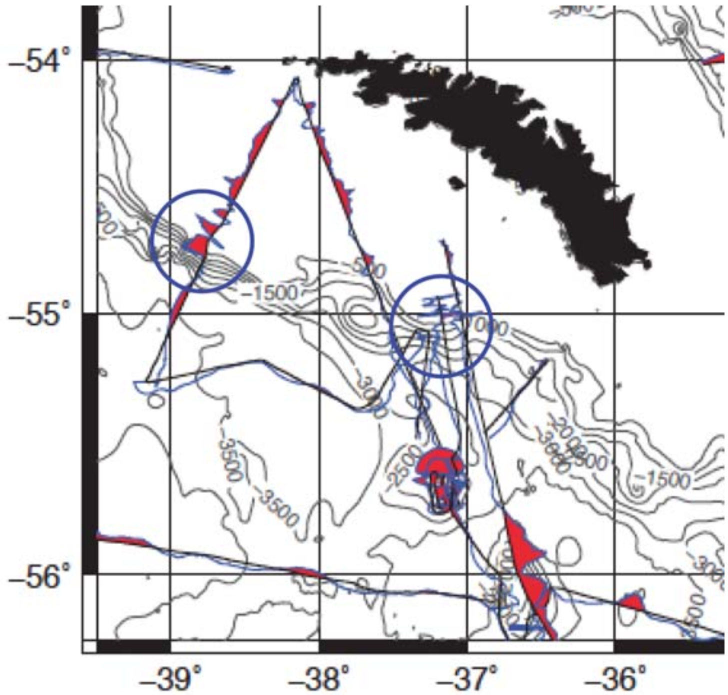


Fig.5a.6 Magnetic anomalies on margin of South Georgia microcontinent. Blue circles show high amplitude magnetic anomalies probably representing sub-surface dykes.

5a.ii. Multibeam bathymetry data

System Overview

Nathaniel B. Palmer recently upgraded the multibeam topside system from a Kongsberg EM 120 to the EM 122. The main difference between the two systems as summarized by the EM 122 manual is that “the EM 122 has up to four times the resolution in terms of sounding density through inclusion of multiplying capability and more than twice the number of detections per swath. High density signal processing is a major improvement, to keep the acoustic footprint size small even for the outer beams in the swath. In typical ocean depths a sounding spacing of about 50m across and along is achievable.” The EM 122 operates at 12kHz. The transducers are hull-mounted in linear arrays in a Mills Cross configuration with separate units for transmit and receive. The number of beams and soundings for each ping:

- 4 degrees receiver: 144 beams giving 216 soundings in High Density mode
- 1 or 2 degrees receivers: 288 beams or 567 beams in dual swath mode giving 432/864 soundings in High Density mode

Acquisition

The EM 122 was continuously operated (by Kongsberg’s Seafloor Information Software) for the cruise duration from outside the Falkland Island EEZ at GMT September 25 17:34. During small boat operations, the system was not recording in an effort to avoid unnecessary data duplication. The system was shut down at the Falkland Island EEZ at

GMT October 18 14:46 during our return transit. Multibeam data were collected over approximately 5,700 line kilometers.
Sound velocity corrections were done using XBT data when possible. When sea state or other factors inhibited a successful profile, velocities from the world ocean database were used.
Despite some system issues (see Recommendations section) multibeam data collection can be described as successful. However, the swath width was not nearly as wide as it should be due to transducer and failed TX36 cards. Data quality was best when operating at survey speeds (~4-5 knots) and with either following, head or calm seas. With higher transit speeds, stronger winds (we experienced winds up to 40 knots) and/or with seas approaching the ship's beam, data quality rapidly decreased probably due to bubbles under the hull.

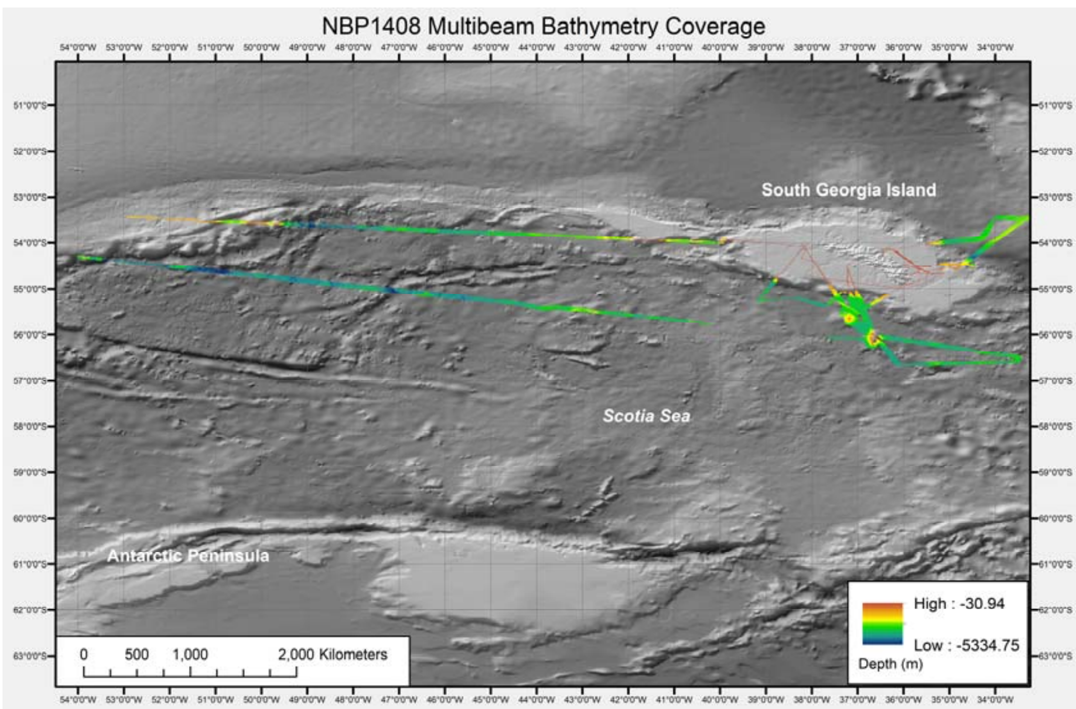


Fig.5a.7 *Nathaniel B. Palmer* 1408 cruise track with gray-scale GEBCO bathymetry

Data Processing

Multibeam bathymetry data were processed using the Caris (version 8.1.7) software package. Data were organized into hour-long files. Files were converted, "corrected" for tide using a zerotide file, and merged before data cleaning. Data were cleaned initially using the Swath Editor tool followed by the Subset Edit and Base Surface tools for final QC. Edited files were exported using the HIPS to ASCII mode both as individual files and collectively into one file for later use in other software such as GMT, Arc, and Fledermaus.

The EM 122 system also records water column data. These data were processed using a proprietary license of Qinsy's Fledermaus FM Midwater module.

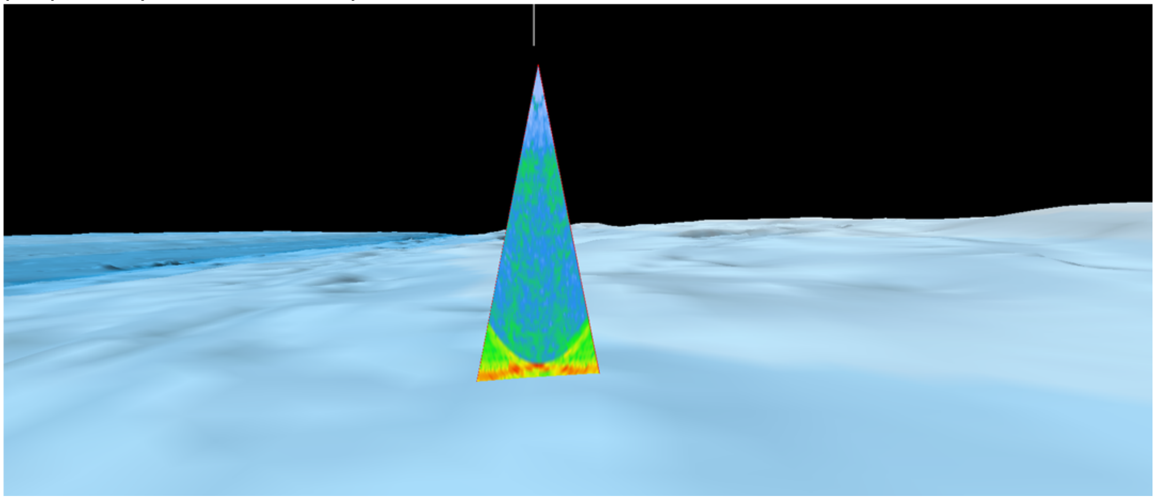


Fig. 5a.8 Example of midwater data.

<u>Notable Bathymetric Features</u>

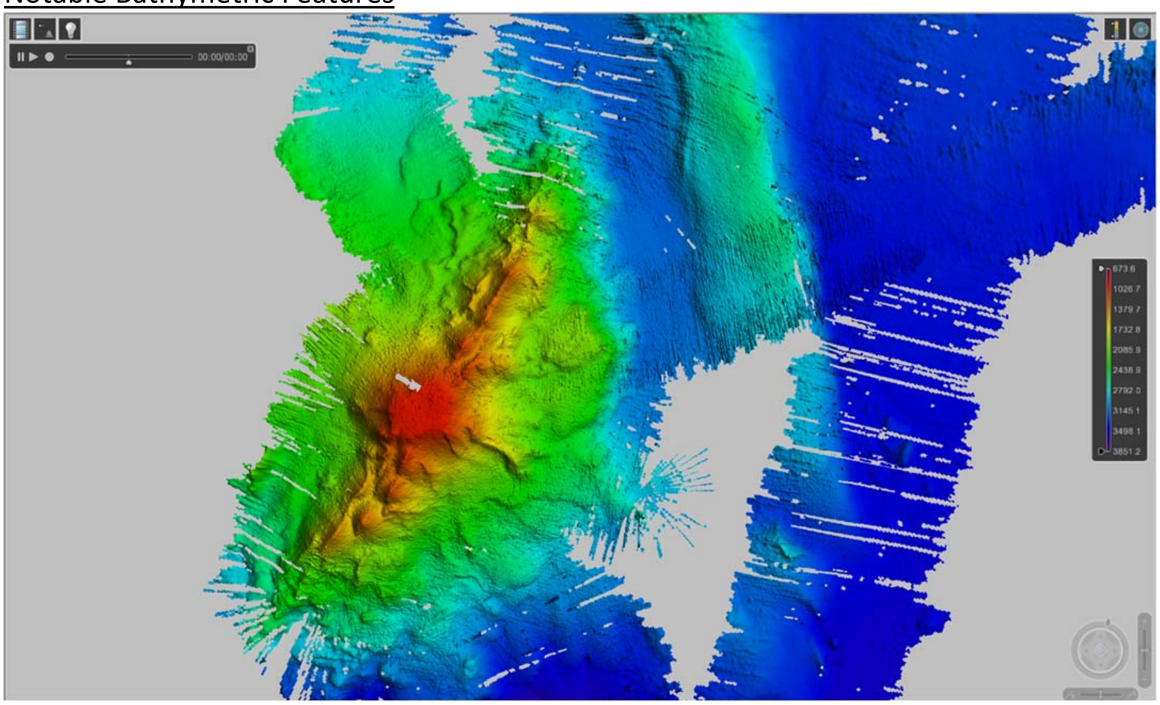


Fig. 5a.9a Northern of the two Southern South Georgia Seamounts

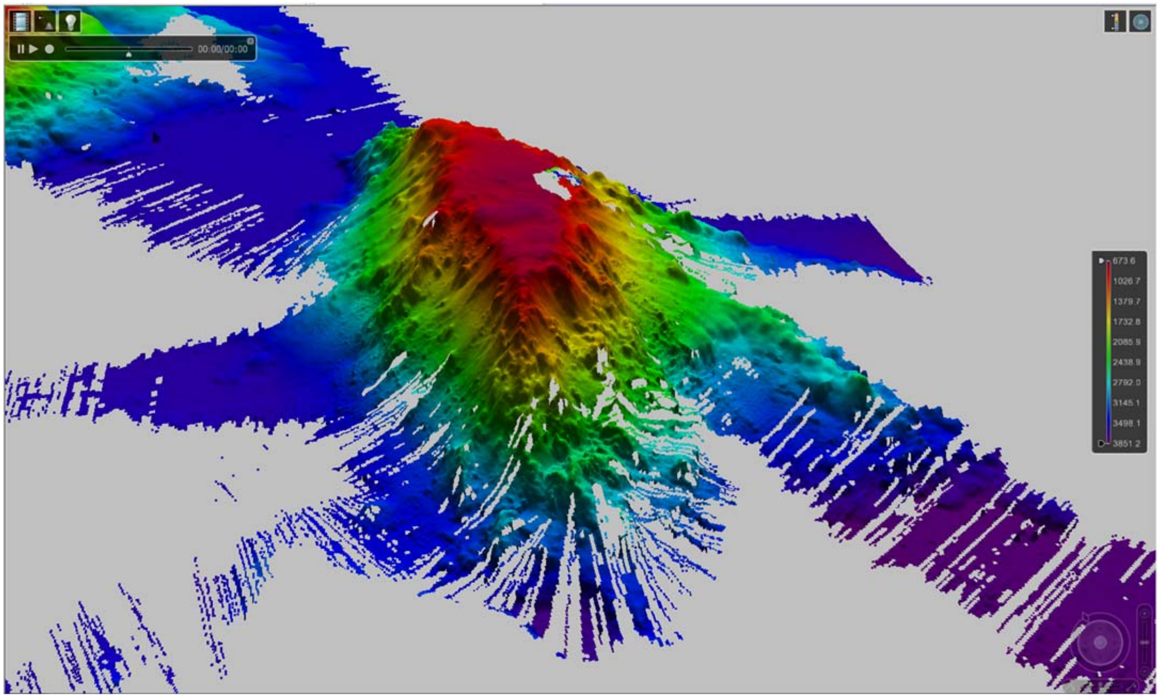


Fig. 5a.9b Southern of the two Southern South Georgia Seamounts

5b. High-Resolution Multichannel Seismic Reflection (MCS) Profiling

MCS data were acquired and processed aboard NBP1408 using combined components of the University of Texas Institute for Geophysics (UTIG) hi-res and RVIB *N.B. Palmer* shipboard systems:

<u>Seismic Source</u>

Two Sercel G.I. airguns (guns #1 and #2) were configured at 105/105 in^3 (harmonic mode) with in-line separation of 4.5m, towed at nominal depths of 3m. A third 105/105 in^3 airgun (gun #3) was towed midway between the two guns, serving as a hot spare. The in-line center of the two airguns was ~35m from the stern. The source was fired every 8-11s, for a nominal shot spacing of 16-25m. As noted in watch logs, at times the hot spare (gun #3) airgun was substituted for a primary airgun. For brief periods only one airgun was fired for protected species mitigation (ramp-up) or mechanical reasons. Source frequency content was approximately 20-400Hz,with maximum power at 100-160Hz (Fig. 5b.1).

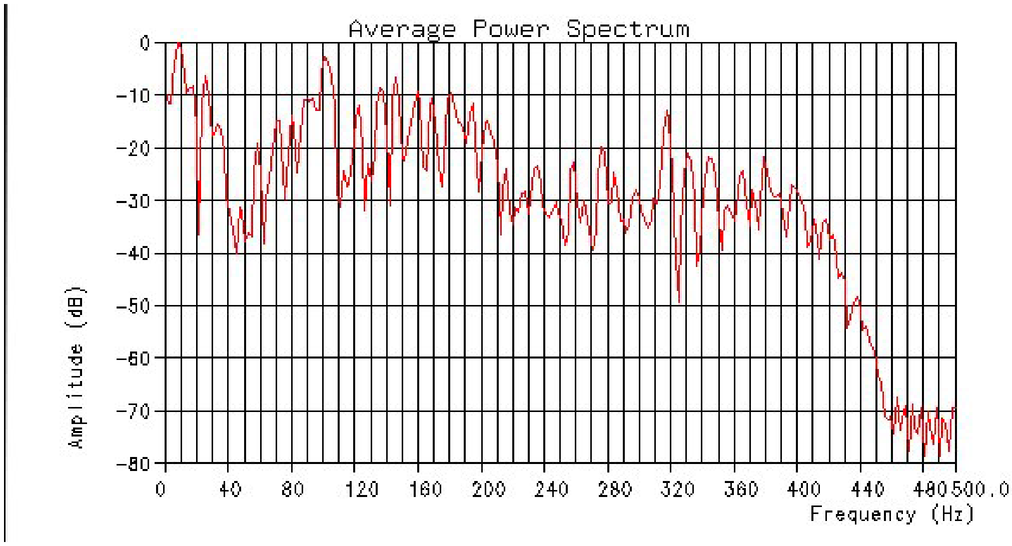


Fig. 5b.1 Representative Power Spectrum taken from MCS Line NBP1408-01

Firing Control

Airgun synchronization and timing were controlled by a *Real-Time Systems* HotShot shotbox and HotShot software running on a shipboard laptop. All injector delays were set to 39ms as per the Sercel manual. The HotShot was synchronized to the Geode recording system via contact closure. Individual airgun hydrophone returns were used for gun synchronization. Cycle time was controlled internally by the HotShot "cycle" feature.

Seismic Receiver

A gel-filled Teledyne 24-channel analog streamer was towed during MCS operations. Channel spacing was 3.125m, with 3 hydrophones per channel and total active length of 75m. An in-line extension cable (built for this leg) ran from the head of the streamer near the stern, through a bulkhead fitting and into the aft MT shack to the Geode recorder. A small PVC drogue was attached to the tail of the streamer by a ~15m line. Total streamer length was ~120m.

Seismic Recorder

Analog signals from the streamer were digitized by a Geometrics Geode and recorded on a laptop running Geometrics' Seismodule Controller software. Internally, the "A" and "B" jumpers were removed from all 3 Geode recording boards and the software was set to the "All Channels Low" setting – resulting in 12 dB recording gain. No recording filter was used. Data were recorded in SEGY format, with shot time information pulled from a serial GPS string taken from the ship's Kongsberg Seapath 330 navigation system.

Towing Configuration

The airgun umbilical was towed from the streamer winch and through the starboard side of the Palmer (Fig. 5b.2) stern doors. The streamer was deployed from the single channel streamer winch on the port side, passing through the port side of the stern doors. Lateral separation between source and receiver was 7.0 meters at the stern, varying between ~1m and ~10m at the airguns themselves depending on sea state and heading. The head of the airgun array was towed 30m astern of the vessel, with the center of the array ~33m astern. The center of the first active section of the streamer was towed 30m astern. Accordingly, the center of the airgun array was approximately even with channel 2 of the streamer.

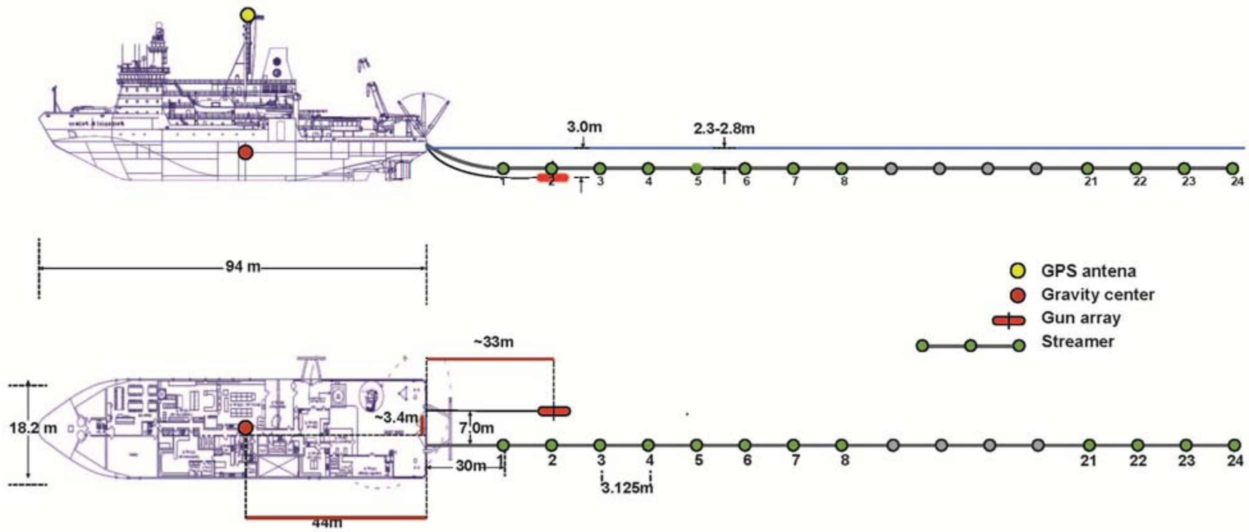


Fig. 5b.2 Multichannel Towing configuration for NBP1408

<u>Seismic Acquisition</u>

Approximately 1440 km (~27 Gbytes) of 24-channel MCS data were acquired in 17 seismic profiles (Table 5b.1) over some 194 hours during 4 acquisition sessions (Fig. 5b.3). Each MCS acquisition session initiated during daylight hours as per the cruise IHA, with continuous acquisition for roughly 2 days. Seismic operations in general went without a hitch, due in large part to the seasoned and capable technicians and well-functioning gear aboard R/V Palmer as well as recent seismic experience during NBP1402 and NBP 1208. Seismic operations were interrupted once for marine mammal mitigation; the interruption was brief and acquisition resumed as per IHA protocols. There were two brief (< 1 hour) data acquisition "slowdowns" (firing slowed to 60s intervals), one due to an air compressor malfunction and one caused by the magnetometer cable crossing the airgun string. In the first instance compressor #2 was quickly brought online by the engineering department, and in the second instance the Marine Techs were able to pull in the streamer and magnetometer and quickly redeploy the streamer. There were several "normal" maintenance data interruptions of 1-5 minutes to change Geode batteries and air manifold filters. R/V Palmer ET staff have constructed a battery-switching box to avoid future battery interruptions, and plans are in the works for the engineering department to build an air filter bypass to avoid future filter interruptions. One of the Palmer airguns (gun #291919) refused to seal and was never deployed (leaving 4 fully functioning airguns aboard), but otherwise the airguns performed flawlessly. It should be specially noted that all 4 Marine Techs were instrumental in the success of seismic operations.
Data acquisition weather conditions varied greatly, with winds observed between 10 and 35 knots. Ship speed during acquisition was nominally 4.0 knots, occasionally slowed to ~3 kt for especially deep water or important geologic features.

Sampling interval was 1.0ms for all data, with record length varying between 6.5 and 9s. Firing interval was 8-11s and was of constant concern because of the relatively short streamer (75m active) and deep water (1000-4700m). In order to cycle shots as quickly as possible (the Geode recorder has a ~2s cycle time in addition to record length), a deep water delay of 2.0-4.5s was applied during data acquisition. Seafloor arrivals were lost during a few brief intervals when watchstanders failed to change this deep water delay in response to abrupt shallowing.

A semi-randomly-occurring static shift was observed on some lines. This static shift was a constant 200ms and appeared to happen in increments of approximately 30 shots. This shift is presumed to be caused by some clock or cycling problem in either the Hotshot or the Geode and is likely related to either the deep water delay or cycling as rapidly as allowed by water depths. Shifts were manually noted and corrected during processing and did not affect data quality. Occasional shots were missed due to attempting to cycle shots faster than the Geode could accommodate.

Table 5b.1: NBP1408 MCS Profiles

Profile	Shots	Hours	Km	nm
	Session 1, 1-3 October 2014			
NBP1408-01	21-8506	20:19	153	83
NBP1408-02	8507-11521	6:43	48	26
NBP1408-03	1-3161	7:09	54	29
NBP1408-04	1-4066	10:57	72	39
	Session 2, 5-7 October 2014			
NBP1408-05	31-2571	7:46	48	26
NBBP1408-05a	2572-3598	3:01	21	11
NBP1408-06	1-953	2:20	16	9
NBP1408-07	1-2590	7:10	52	28
NBP1408-08	2591-2841	0:39	4	2
NBP1408-09	1-1699	5:19	41	22
NBP1408-10	1700-3763	6:57	49	26
NBP1408-11	5-2106	6:42	50	27
NBP1408-12	1-3001	8:55	60	32
	Session 3, 10-12 October 2014			
NBP1408-13	49-9869	5:10	187	101
NBP1408-14	1-694	1:46	12	6
NBP1408-15	1-7593	19:41	155	84
	Session 4, 14-16 October 2014			
NBP1408-16	86-13100	34:01	267	144
NBP1408-17	13100-20190	19:15	148	80
Totals	**73170**	**193:50**	**1437**	**776**

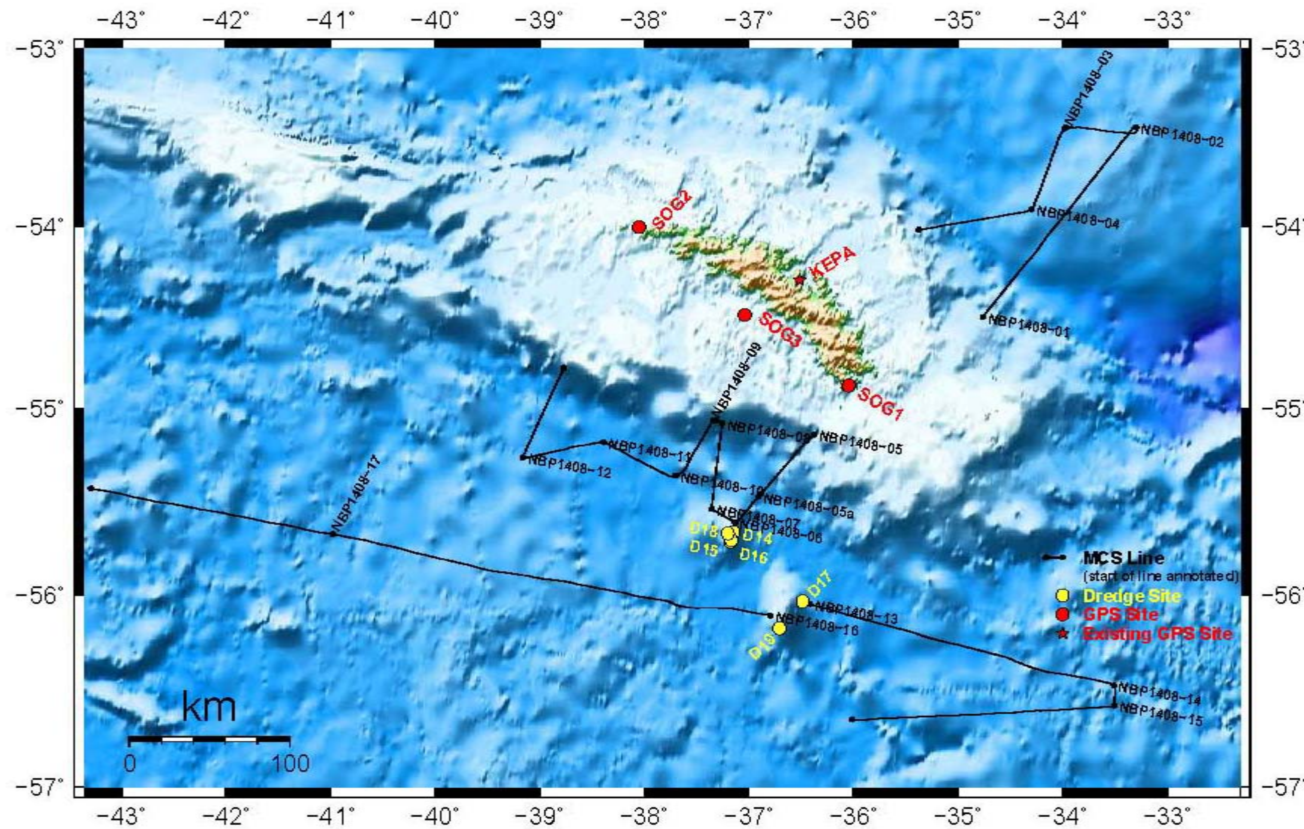


Fig. 5b.3 Basemap showing all MCS lines, Dredge locations, and GPS sites

MCS Data Processing

Multichannel processing was performed on laptops running Paradigm's Echos software. Data were initially processed in real-time using a "quickstack" sequence with a nominal shot spacing of 22m. Secondary shipboard processing was performed using an "fkstack" sequence, using correct shotpoint spacings as determined by GPS locations and GMT software. In all instances a nominal 1-D velocity function was found to be quite satisfactory because of the extreme relation of water depth to streamer length. The "fkstack" shipboard processing sequence included:

Conversion from SEGY format
Polarity Reversal (required by this streamer)
Static Shift (Delay Removal)
Static Shift (Sporadic 200ms)
Bandpass Filter (Butterworth 30-450Hz)
Geometry Definition
F/K filter (removal of water velocity arrivals)
Trace Balance
CDP Sort (3.125m cdp interval)
NMO Correction (nominal 1-D velocity)
CDP Stack (4 fold nominal)
F/K Migration (1480 m/s constant)
SEGY Output

Interpretation

Shipboard-processed NBP1402 MCS and Sub-bottom profiler data were incorporated with pre-existing MCS data into a laptop-based Landmark DecisionSpace project for preliminary shipboard interpretation.

Data Examples

Data quality was in general good-to-exceptional (Figs. 5b.4-5b.6). varying with weather conditions, water depth, and geology. It is presumed that data quality can be further improved with deconvolution, random noise reduction techniques, and improved velocity-based post-stack migration. Seafloor penetration of over 1 second was often observed, with imaging often down to presumed oceanic basement.

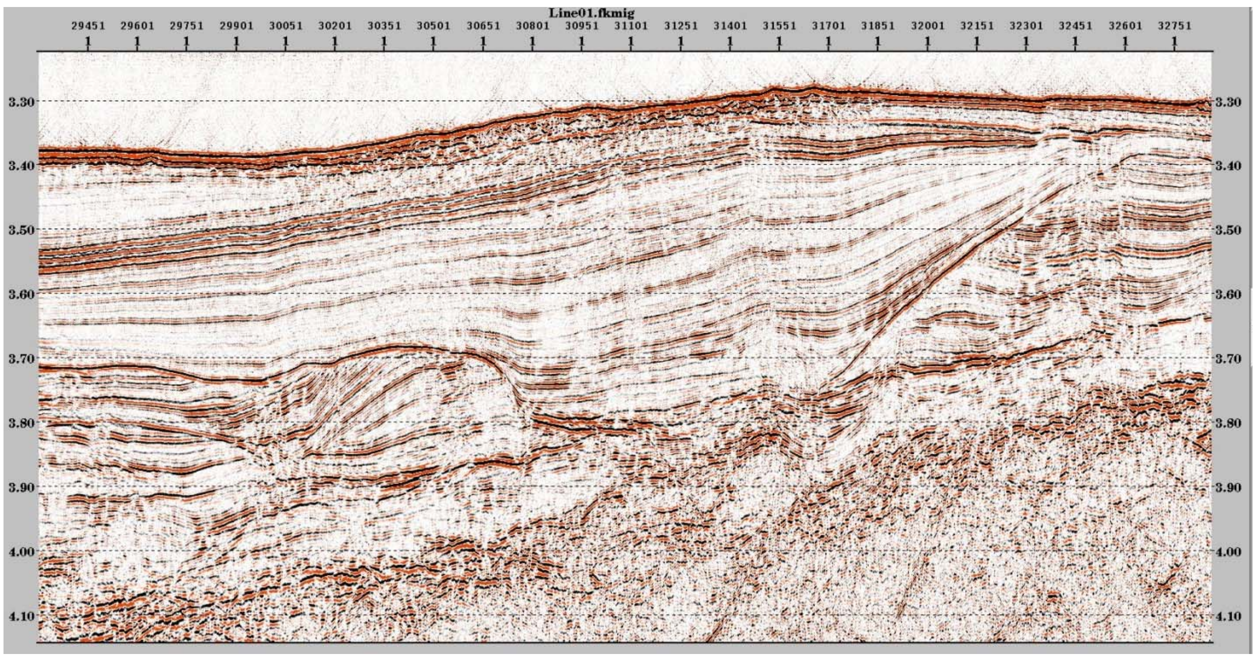


Fig. 5b.4 Data example from Profile NBP1408-01

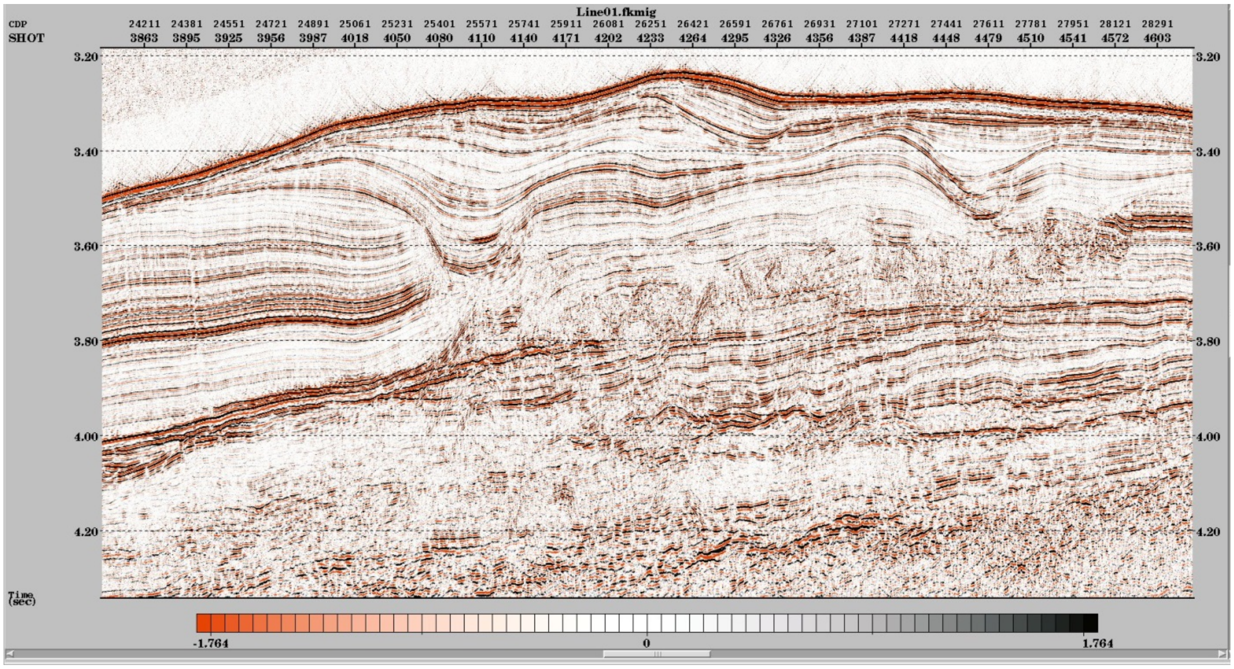


Fig. 5b.5 Data example from Profile NBP1408-01

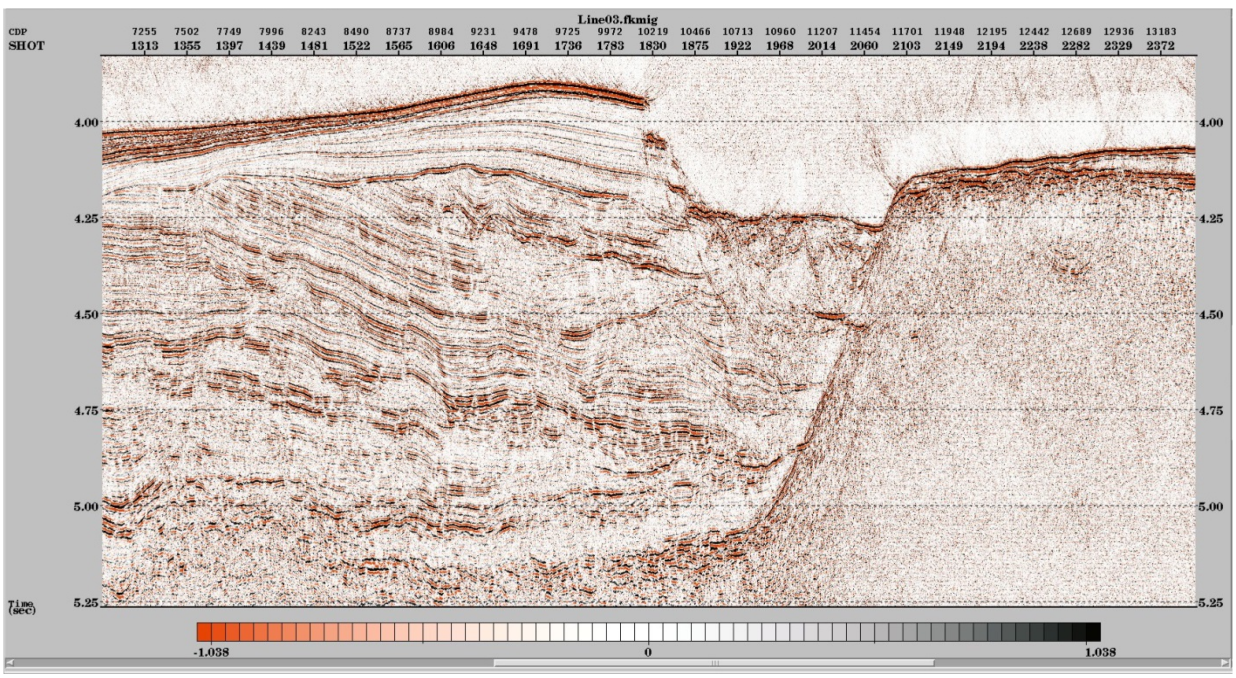


Fig. 5b.6 Data example from Profile NBP1408-03

5c. NBP1408 Subbottom (CHIRP) Profiling

Approximately 19 Gbytes of subbottom data were acquired on NBP1408 using the Palmer's onboard Knudsen 3260 subbottom profiler and hull-mounted Ocean Data Equipment Corp TR-109 transducer system. The profiler was configured in 3.5 kHz (swept frequency 2.308-5.308 kHz) mode. Data were recorded in both KEA/KEB and

SEGY formats. Data quality varied greatly depending on sea state and water depth, with penetration of up to 50m observed.

5d. Rock Dredging

Seafloor dredging for rock samples was carried out at the two large Southern Seamounts of South Georgia with the objective of obtaining samples for dating and geochemical analysis to determine the tectonic relationship for the seamounts to South Georgia collision with the Northeast Georgia Rise.

Both seamounts are prominent features rising above a basement depth of ca. 3000 m. The northern one, centered on 55°39'S, 37°10'W rises to a flat plateau at ca. 1000 m depth, and has ridges (dike-fed constructs?) extending to both north and south. The southern seamount is centered on 56°04'S, 36°39'W and has a flat summit plateau at ca. 800 m. The guyot-like bathymetric form of both indicates that they were formerly eroded at or near sea level, and have since subsided.

<u>Choice of sites</u>
The summit areas of the seamounts were surveyed using multibeam bathymetry before sites were chosen. Sites were chosen with regard to wind/wave direction, steepness of slope and location within the seamount edifice. Processed bathymetry data sets were examined using ArcGIS and Fledermaus software. It was found useful to examine the slope derivative of the bathymetry (available within the ArcGIS package) to identify the steepest slopes. Few slopes greater than 30-35° (over a horizontal distance of about 200-300 m) length of were identified, and this gradient was considered adequate for a reasonable expectancy of cliffs and steep slope sections exposing bedrock or in-situ fragments beneath recent sediment. The southern seamount had been previously sampled by two dredges, DR08 and DR09 during cruise NBP08-05. The northern seamount was, as far as we were aware, previously unsampled. Dredge sites are shown in Fig. 5b.3 and 5d.1

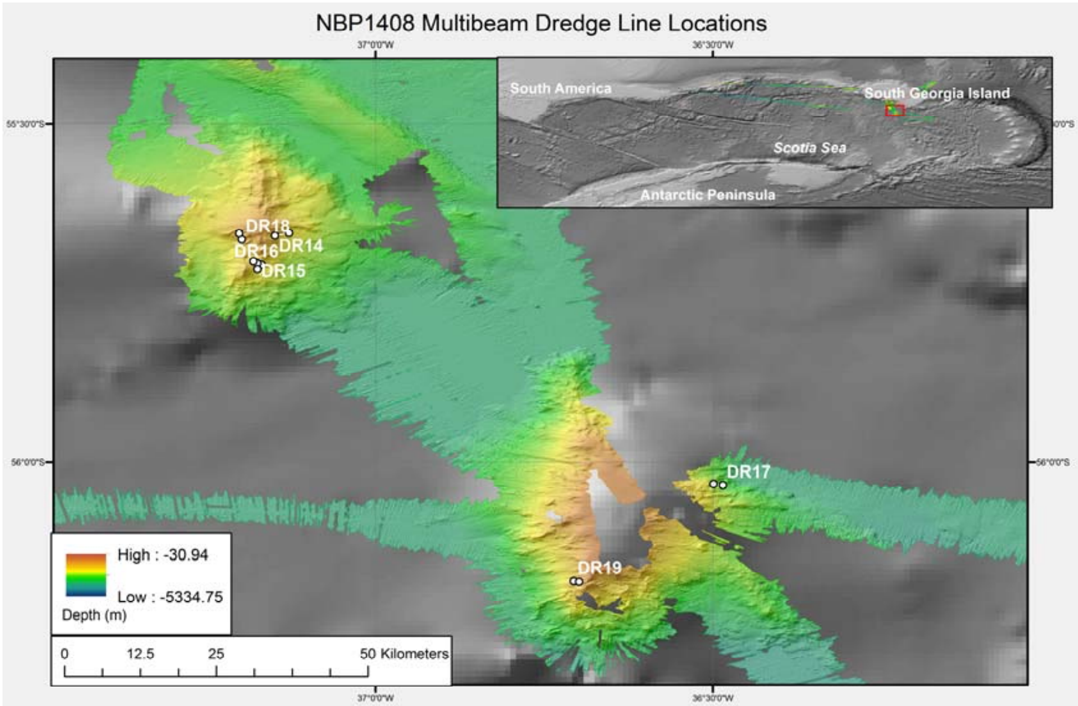


Fig. 5d.1. Multibeam bathymetric map showing positions of dredges.

<u>Equipment</u>

The dredges were standard Scripps Institute of Oceanography (SIO) rock dredges with a rectangular mouth and chain and rope netting Fig. 5d.2). The dredge frame was connected to the cable by a swivel and a 14500 lbs tension weak link, with a recovery wire rope connected from above the weak link to the far end of the chain netting. The dredges were operated from the aft A-frame. No pingers were used, it being judged by the marine technical staff that they would merely be damaged or lost in the type of operation planned.


Fig. 5d.2 Recovering the SIO dredge onto the aft deck.

Dredging operations

Dredging was carried out with the ship moving upslope and into the wind, and sites were chosen accordingly. Where wave direction differed slightly from wind direction, it was the wave direction that determined the orientation of the ship. The ship was able to move crab-wise by a few degrees out of wave direction, but ability to do this was restricted by the limits of the bow-thruster.

For all dredges, the procedure was to lower the dredge to the seafloor using the winch. When the dredge had landed on the bottom (usually observable by a drop in tension on the cable), the ship then moved forward at a speed of about 1.5 knots for a distance of about 0.5 nautical mile, while paying out cable at the same rate. The ship then remained stationary on Dynamic Positioning (DP) while the dredge was hauled in using the winch at a rate of generally 5-15 m/minute, increasing to about 30-40 m/minute once the dredge had left the bottom. This system gives better protection to the winch gear than the alternative of dragging the dredge using the forward motion of the ship. In operation, using this method, the winch haul rate could be rapidly slowed when cable tension peaked. If the dredge became jammed on the seafloor, the ship was reversed along the line of the dredge while cable was slowly hauled in to maintain tension. This is an effective method of recovering jammed dredges, and no dredges were lost.

Samples recovered

Good rock recovery was achieved at three sites, DR14, DR16 and DR19. Dredge DR17 recovered only 5 drop stones and dredges DR15 and DR18 recovered no rocks. There was therefore good recovery of rock from at least one site on both seamounts. zDredge sites are listed I Appendix C. Photos of numbered samples are listed in Appendix D.

Northern Seamount

Dredge DR14 sampled the upper east-facing flank of the seamount, terminating short of the summit plateau. Recovery was good. Most of the rocks were a variety of continent-derived material, including granites, amphibolites and other high-grade metamorphic rocks, sandstones, bedded siliciclastic sediments, compacted mudstones and slates which were all interpreted as ice-rafted drop stones. Several basalts were recovered. Sample DR14.1 is a reddish-brown scoriaceous clast with a poorly vesicular rind similar to a pillow rind (Fig. 5d.3). The sample has angular and friable points, and cannot have been transported far. It is likely to have come from an in-situ lava flow. Other basalt samples include DR14.2 (Fig. 5d.3), which is angular and with glassy patches and also likely to have originated on the seamount. Samples DR14.3 and DR14.4 are also fresh, black, vesicular, angular basalts likely to be in-situ.

Fig. 5d.3 Possible in-situ basalts from dredge DR14.

Dredge DR15 attempted to sample the south-east-facing slope of a dome within the north-south trending ridge south of the seamount, but failed as the weak-link broke and the dredge was recovered empty.

DR16 sampled the same slope and recovered a large haul. Most of the samples were ice-rafted drop stones. A very dominant size-distribution peak at 7-10 cm across (Fig. 5d.4) suggests that the dredge scooped a large part of the haul from re-deposited and crudely sorted material, possibly concentrated in a gully forming the west slope of the dome and possibly fanning out at its base. A few basalt samples were recovered which may be in-situ, for example sample DR16.4, an angular fragment of fresh basalt with glassy patches. However, this dredge was disappointing in returning little likely in-situ material.

Fig. 5d.4 Dredge 16 showing the predominance of drop stones ca. 7-10 cm across, and large drop stones up to 40 cm across at the back.

Dredge DR18 was an attempt to sample the upper slopes on the west side of the seamount. The dredge became tangled in the cable, possibly during paying out of slack immediately after the dredge was lowered onto the seafloor, and there was no recovery.

<u>Southern Seamount</u>

Dredge DR17 attempted to sample to lower east-facing slope of the seamount. This dredge recovered only five drop stones and no basalt fragments. It is not clear why this dredge failed to recover more. Possibly the identified steep sections were missed by the dredge track, or the slopes were heavily sedimented. If the latter, it is possible that sedimentation is high on the lower east-facing slopes of the seamount, as these are in the lee of the seamount for prevailing easterly currents.

Fig. 5d.5 Vesicular basalt sample DR19.1

Dredge DR19 recovered one good sample of highly vesicular, angular basalt, sample DR19.1 (Fig. 5d.5). This sample has patchy covering of Mn crust but is otherwise moderately fresh and is unlikely to have been transported far. It is likely that this is an in-situ sample of basalt from near the summit area of the seamount. Other rocks in DR19 were all certain or likely drop stones.

6. Global Positioning Systems Stations

Three continuous GPS sites were installed at Bird Island, Smaaland Cove on South Georgia, and Annenkov Island (locations in Table 1, map Figure 1). Together with the existing and collaborating station KEPA at King Edward Point, they will provide optimal sampling of the movement and deformation of the South Georgia block.

Station	Latitude			Longitude			Ellipsoidal	Above
	D	M	S	D	M	S	Height (m)	Height(m)
								Derived
								Geoid
SOG1	-54	52	27.80894	-36	02	37.51547	63.226	39.927
SOG2	-54	00	11.63025	-38	02	54.36125	181.427	162.667
SOG3	-54	29	38.18459	-37	02	16.30859	29.126	6.331

A)

Station	X (m)	Y (m)	Z (m)	ITRF2008 @	± (m) (total)
SOG1	2973973.630	-2164190.170	-5193402.338	17/10/2014	0.011
SOG2	2958624.314	-2315560.951	-5137101.965	17/10/2014	0.010
SOG3	2963547.612	-2236265.362	-5168892.009	17/10/2014	0.012

B)

Table 6.1 Station locations in ITRF08 on 2014/10/17, 12:00 Z. A) Geodetic, GRS80 Ellipsoid, ITRF2008. B) Cartesian, ITRF2008. These results were obtained using IGS Rapid Orbits and the Bernese GPS processing software by the AUSPOS GPS processing service and data downloaded from the stations at the UNAVCO Facility over the iridium satellite link in Boulder, CO. Improved results will be available with publication of IGS Precise Orbits that have a 2 week delay.

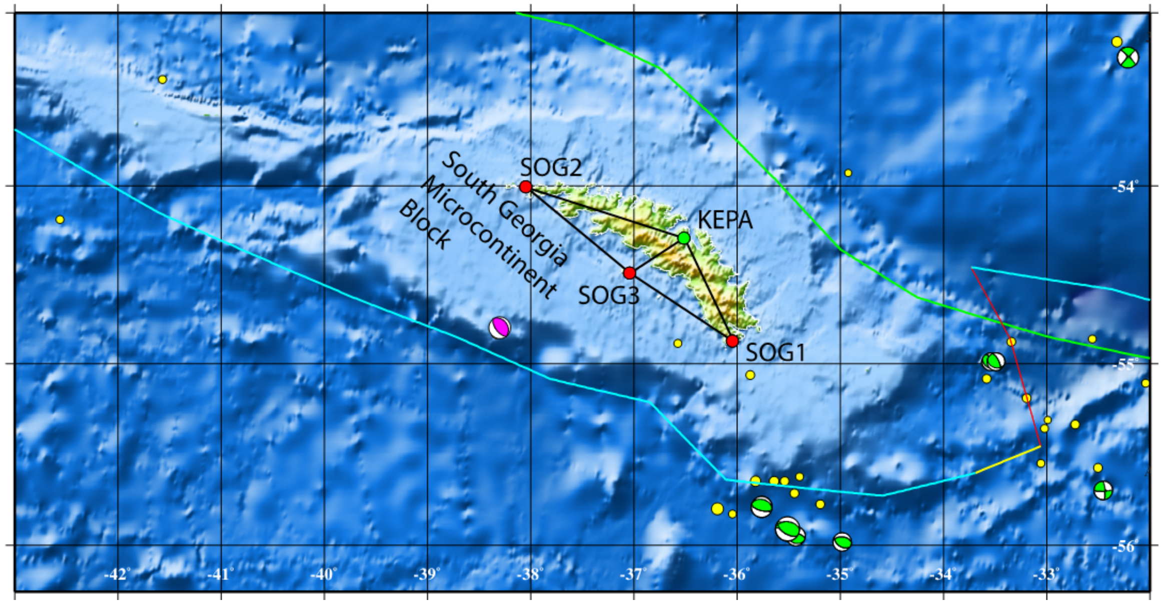


Fig. 6.1 South Georgia Island microcontinental block and surrounding South America Plate and Scotia Plate sea floor with color shaded topography and bathymetry. Green line across north side of the South Georgia block shows the traditional strike-slip Scotia-South America plate Cyan, yellow, and red lines show plate boundary from Bird (2001) along the southern side of the South-Georgia block with postulated oceanic compression (cyan), oceanic strike slip (yellow) and spreading (red) segments. One of the foci of the project is to test the hypothesis that the plate boundary is switching, or has switched, to the southern side of the block. Yellow circles show earthquake epicenters from body waves. The "beachball" symbols show the focal mechanisms (type of earthquake) and location based on surface waves. The size of the yellow circles and beachballs is proportional to the earthquake magnitude. Note that only the larger events have focal mechanisms, so there are more yellow circles than beachballs. In addition the locations produced by the two methods may be different and an event may be shown twice or the symbols may cover one another. The cluster of events near 56.75° S and -35.5° W actually represents 9 earthquakes, not 12. Of these 9 events, all but one occurred in 2012 with 6, including the largest M6.6 event, occurring over 4 a day period in November, and the other two within 3 weeks. An additional event occurred in 2012. This cluster therefore represents a single earthquake and its aftershocks. The largest earthquake released ~84% of the total seismic energy released by all earthquakes shown on the map. The purple beachball to the WNW of this cluster is a 1965 M6.1 earthquake that released an additional ~15% of the seismic energy, leaving ~1% for the remaining earthquakes. The focal mechanisms along the southern side of the island are all thrust, indicating that the ocean crust to the south is underthrusting the South Georgia microcontinental block.

SGO1: Smaaland Cove. Site has excellent crystalline basement bedrock with acceptable sky view for a site in mountainous terrain. Protected landing on small rock ramp, with an easy, ~100 m hike to site at ~20 m altitude.

Fig. 6.2 GPS "frame" containing the electronics (GPS receiver, iridium modem, power controllers), solar panels, wind generators, weather station and iridium antenna) foreground, GPS antenna and mounting mast in background. View ~SE.

Fig. 6.3 View ~NW with GPS antenna in foreground and frame in background.

SG02: Bird Island. Site has heavily weathered sedimentary bedrock with excellent sky view. The site has a protected landing at the BAS base pier. Site is moderate hike up drainage from BAS base to vegetation line, and then continues up scree to rocky ridge. It is 660 m line of sight, 810 m by the route taken to the site at 190 m elevation.

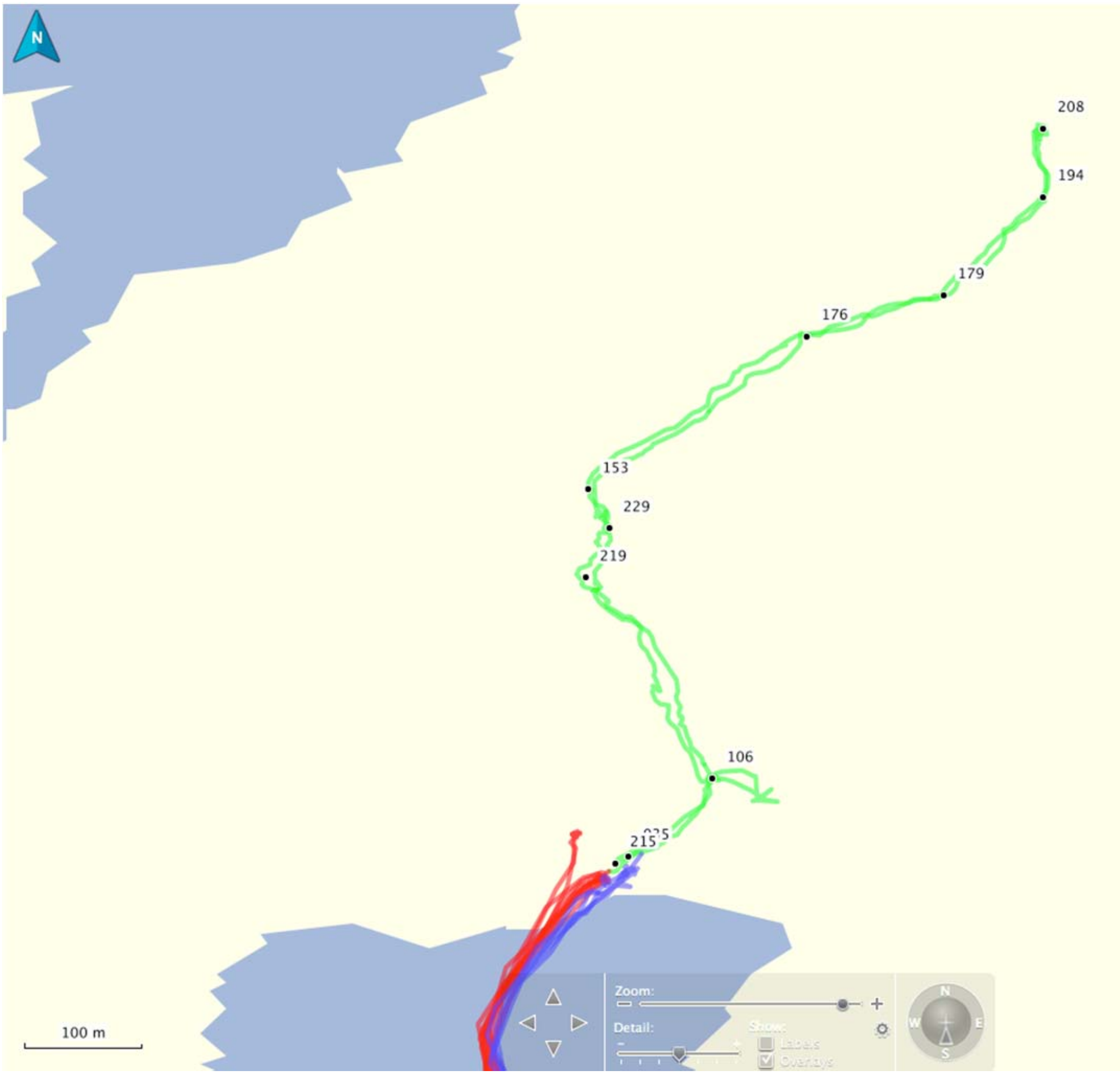


Fig. 6.4 GPS track (green) from BAS base on Bird Island to GPS site SGO2.

Fig. 6.5 View ~ ENE of site SGO2 showing GPS antenna and mast and GPS frame.

Fig. 6.6 View ~ S of site SGO2 showing GPS antenna and mast and GPS frame.

SGO3: Annenkov Island. Site has very heavily weathered volcano-sedimentary bedrock with very good sky view. It has a relatively protected landing on a moderately sized ~NE facing beach. Site is on bedrock that outcrops on the beach. It is low (4-5 m asl), but there is a small amount of tussock on the outcrop between the site and the beach.

Fig. 6.7. View slightly N of E showing GPS frame, antenna and mast of SGO3. Small area of tussock behind site.

Fig. 6.8 View ~S of site SGO3 showing GPS frame, antenna and mast. Figure 9 is view to NW from hill in background.

Fig. 6.9 View ~NW of site SGO3 showing GPS frame, antenna and mast, outcrop and beach. RVIB *Nathaniel B Palmer* and S. Georgia Island can be seen in the background.

7. Education and Outreach

Contributed by PolarTREC Educator Jillian Worssam: Sinagua Middle School, Flagstaff, Arizona

<u>Pre-Cruise</u>

Through a partnership with PolarTREC, Dr. Larry Lawver and Dr. Ian Dalziel requested and received an educator to document, disseminate and highlight the scientific cruise NBP 1408. The following outreach model has three major components: pre-cruise, cruise and post cruise.

Prior to departure Jillian Worssam completed a variety of outreach projects designed to engage and elicit participation from students, children, schools, families and individuals from throughout America and abroad as well as through her own school district. The count of participants engaged prior to departure includes: 46 America states, and three international

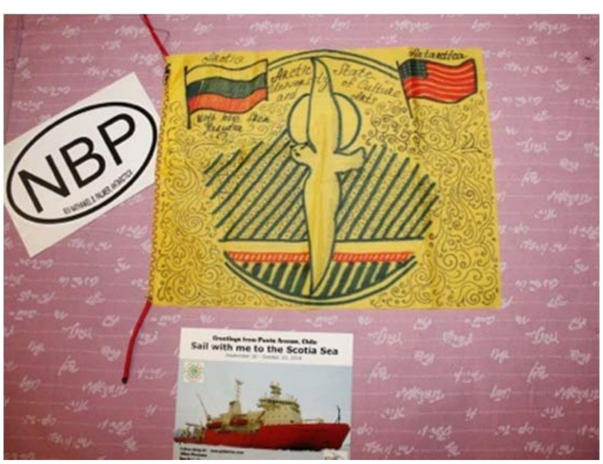


Fig. 7.1 Russian Flag and "Flag Kit"

locations: Russia, England and two schools in Australia. To establish contact with such a wide base Ms. Worssam used networking and social media. Once a possible partner was identified Ms. Worssam sent out a "Flag Kit." Each participating partner received: directions to design an expedition flag, a NBP (*Nathaniel B. Palmer*) bumper sticker, a NBP post card, a personal expedition business card and directions on how to return the expedition flag to Ms. Worssam.

Ms. Worssam also participated in over five community, school outreach events and state level events to encourage participation from individuals in Arizona.

Upon departure Ms. Worssam had over 150 flags from all afore mentioned locations, and 96 addressed and labeled post cards to be mailed back to the participants from Chile at Ms. Worssam's expense.

In another component prior to the cruise departure Ms. Worssam arranged for a series of articles written by her to be published in the local *Arizona Daily Sun.* One article each: pre-cruise, cruise and post cruise. Ms. Worssam also scheduled a series of phone calls to different participating classrooms, as well as a public event in partnership with the *Flagstaff Festival of Science*.

<u>Cruise</u>
During the 30 day cruise Ms. Worssam actively participated in maintaining a daily blog highlighting the science of the cruise, translating the science of exploration into terminology to be understood by the general public as well as by her 14 year old students. Part of the journal goal was also to engage, excite and explain to all readers the importance of scientific exploration and its relevance to their lives even though the research was being conducted many thousands of miles away.

Through photographic documentation Ms. Worssam also used the individual expedition flags provided by schools, students and community members from around the world to show the equipment being used to document sea floor changes in the Scotia Sea. Each component of the research was included in daily blogs at a rate of 8 -10 pictures daily: many of the pictures were actually collages of multiple pictures.

During the cruise Ms. Worssam had an hour long "teleconference" with the Flagstaff Festival of Science." The event was scheduled prior to departure and the entire Flagstaff community invited. Approximately 200 people attended this public event, which included a slide presentation on the nature of the research science, and discussion on science in polar ecosystems. There was also a lengthy question and answer session conducted by Ms. Worssam

The daily blog entries focused predominantly on the four forms of data collection used during the research cruise: multibeam bathymetry, Knudsen echo sounder (chirp), ~~a~~ Multichannel Seismic system and the installation of three GPS stations.

Fig. 7.1 Phone conversation with the Flagstaff Festival of Science event

Ms. Worssam also managed to schedule five different phone visits to classrooms and school clubs while on board.

While on board Ms. Worssam in partnership with Dr. Ian Dalziel (UTIG) and scientist Steffen Saustrup (UTIG) conducted a 45 minute live "PolarConnect" web event. This event focused on the science of the expedition specifically the four techniques for collecting data and the importance and reasons for collecting this data. There was also a section on the protected species observers who were aboard and the representative from the Government of South Georgia to provide insights into the wildlife and biology of South Georgia.

Post Cruise

Upon completion of the cruise Ms. Worssam will continue with scientific outreach through a variety of strategies.

-Ongoing construction of lesson plans to teach about the science on the cruise and enhance the importance of polar science to a high elevation desert community.

Fig. 7.2 British Antarctic Survey biologist

Cian Luck at work on Bird Island

-Scheduled phone call with British Antarctic Survey Bird Island South Georgia research team, oceanography club and school research building partnership.

-Work with school oceanography club to develop better understanding of sea floor structure and implications for changes to the ACC.

-November 2014 final article installment for the *Arizona Daily Sun* as a conclusion to the research expedition and discussion on: “What now?”

-In April 2015 Ms. Worssam will present to the Flagstaff Unified School District Science Alliance a summary of her research experience and strategies for dissemination into local classrooms

-August 2015 Ms. Worssam will continue with her Scientists in the Classroom mentor program with the addition of new science mentors: Steffen Saustrup (pending), Marcy Davis, Bud Davis, Nina Mehle, and Graham Parker.

-September 2015 Ms. Worssam will present an evening discussion as part of the 26th anniversary of the Flagstaff Festival of Science, hopefully in partnership with one of the scientists from the cruise.

8. Referenced Material

Bird, P., 2003. An updated digital modelof plate boundaries/ Geochemistry, Geophysics, Geosystems, 4 (3), 1027, doi:10.1029/200IGC000252,2003.
Dalziel, I.W.D., et al., 2008. RVIB Nathaniel B. Palmer Cruise 0805, 18 April – 25 May 2008, Punta Arenas, Chile – Punta Arenas, Chile.

9. Recommendations

Multibeam bathymetry

A cruise dependent on multibeam bathymetry for interpretation of other underway geophysical data and for the identification of dredge sites should commence with a fully functional multibeam system. At the start of the cruise TX 36 boards #11-15 were malfunctioning and #8 went bad during the final few days. Hence, as we were led to understand from the manufacturer the system was operating at only 79% of capacity for most of the cruise and slightly lower towards the end.

Dredging

The weak links of 14500 lbs restricted efficiency. During operation, tension peaks on the cable were commonly up to 11000 lbs, which required precautionary reductions in haul rate. A higher weak link setting would enable more tension to be applied to the dredge to break and dislodge rocks.

It would be useful to install additional TV monitors in the Winch Room to display the geographical plot from the EM122 multibeam, ship’s gyro and wind speed and direction. At the moment the two monitors in the room are used to display winch data and the cable spool.

When lowering the dredge to the sea floor, it is advisable to maintain tension in the cable by starting to move the ship forward as soon as the dredge hits the bottom. This is to avoid generating loops in the cable on top of the dredge which can tangle with the dredge when tension is applied.

When choosing dredge sites on sediment-covered seamounts, choose sites that (1) are high, (2) are close to the summit area, (3) face into the prevailing current, (4) traverse radial ridges, (5) avoid gullies that trap sediment and drop stones.

APPENDICES

Appendix A. Magnetometer Log and Gravity Ties

NBP 1408 Magnetometer Log					
On/Off	Date	Julian Day	Time (GMT)	Latitude	Longitude
on	2014/09/25	268	23:40	-53.5441	-51.3334
off	2014/09/27	270	23:42	-54.0459	-38.5774
on	2014/10/01	274	12:19	-54.3747	-34.5882
off	2014/10/03	276	07:41	-54.0226	-35.4161
on	2014/10/05	278	21:49	-55.1822	-36.456
off	2014/10/06	279	05:01	-55.457	-36.9061
on	2014/10/06	279	12:11	-55.5072	-37.3499
off	2014/10/08	281	06:38	-54.0636	-38.1239
on	2014/10/08	281	21:39	-54.1594	-38.1139
off	2014/10/09	282	12:58	-55.6658	-37.0949
on	2014/10/10	283	06:32	-55.7495	-37.1184
off	2014/10/10	283	11:50	-56.053	-36.4412
on	2014/10/10	283	20:13	-56.0523	-36.3773
off	2014/10/12	285	18:52	-56.6486	-36.0572
on	2014/10/12	285	19:48	-54.6151	-36.1509
off	2014/10/13	286	07:50	-54.7025	-37.1636
on	2014/10/13	286	21:38	-54.9339	-37.1995
off	2014/10/14	287	01:48	-55.6355	-37.0822
on	2014/10/14	287	16:57	-56.1037	-36.8218
off	2014/10/18	291	14:48	-54.2968	-54.0108

Gravity Tie Spreadsheet

The fields outlined in BOLD MUST BE FILLED IN for this spreadsheet to operate properly. The automatically calculated values show up in the shaded fields.

Date: 8/16/14
Location: Punta Arenas, Chile
Station: Harbour Admin. Bldg.
Latitude: 53 09 S
Longitude: 070 55 W
Elevation:
Gravity: 981320.82

Reference Code Numbers:
Station no. 9337-50
ISGN no. 51230N

	Value	Time (GMT)
Ship's meter before gravity tie (Filt Counts)	25200.68	16:32
Ship's meter after gravity tie (Filt Counts)	25200.63	17:39
Average	25200.66	
Ship Gravimeter's Calibration Constant	4.99407055	
Corrected ship's meter (QC Grav (mgal))	125853.85	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	N/A	
Ship's meter after gravity tie (serial, RVDAS)	N/A	
Average (for comparison check only)	#DIV/0!	

Portable Gravimeter Interval Factor: 1.01007 From Table 1 of Model G #807 Meter

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	4917.46	17:25	54	August 16, 2014	
Pier measurement 2	4917.44	17:26	54	August 16, 2014	4966.98
Pier measurement 3	4917.49	17:28	54	August 16, 2014	
Average	4917.46				
Station measurement 1	4918.33	17:06	54	August 16, 2014	
Station measurement 2	4918.26	17:10	54	August 16, 2014	4967.81
Station measurement 3	4918.26	17:13	54	August 16, 2014	
Average	4918.28				
Pier measurement 4	4917.45	17:30	54	August 16, 2014	
Pier measurement 5	4917.50	17:31	54	August 16, 2014	4967.00
Pier measurement 6	4917.48	17:33	54	August 16, 2014	
Average	4917.48				

Gravity Bias from last tie: 855461.88
Drift since last tie: 4.27

OBS Differences

Station to Pier (1, 2, & 3 averaged)	-0.83
Station to Pier (4, 5, & 6 averaged)	-0.81
Averaged Differences	-0.82
Gravity at pier	981320.00
Elevation of pier above gravimeter, meters	0.0
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	981320.00
Gravity Bias (Offset for RVDAS)	855466.15

Comments

Tie done by Sheldon Blackman, Barry Bjork and Mark Dalberth. Crane ops prevented doing the first set of pier measurements until after the station measurements. After that there was very little dock activity and readings were relatively stable and Barry got cold.
Note: RVDAS not available at time of tie.

Note about Elevation of Pier: *If pier is below the ship's gravimeter, this value is negative. If above, positive.*

Gravity Tie Spreadsheet

The fields outlined in BOLD MUST BE FILLED IN for this spreadsheet to operate properly. The automatically calculated values show up in the shaded fields.

Date: 9/18/14
Location: Punta Arenas, Chile
Station: Harbour Admin. Bldg.
Latitude: 53 09 S
Longitude: 070 55 W
Elevation:
Gravity: 981320.82

Reference Code Numbers:
Station no. 9337-50
ISGN no. 51230N

	Value	Time (GMT)
Ship's meter before gravity tie (Filt Counts)	25200.35	17:26
Ship's meter after gravity tie (Filt Counts)	25200.35	18:26
Average	25200.35	
Ship Gravimeter's Calibration Constant	4.99407055	
Corrected ship's meter (QC Grav (mgal))	125852.33	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	981276.9	17:27
Ship's meter after gravity tie (serial, RVDAS)	981296.8	18:26
Average (for comparison check only)	981286.9	

Portable Gravimeter Interval Factor: 1.01007 From Table 1 of Model G #807 Meter

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	4918.31	17:39	53	September 18, 2014	
Pier measurement 2	4918.28	17:40	53	September 18, 2014	4967.82
Pier measurement 3	4918.29	17:42	53	September 18, 2014	
Average	4918.29				
Station measurement 1	4919.03	18:02	53	September 18, 2014	
Station measurement 2	4918.98	18:05	53	September 18, 2014	4968.53
Station measurement 3	4918.98	18:10	53	September 18, 2014	
Average	4919.00				
Pier measurement 4	4918.51	18:19	53	September 18, 2014	
Pier measurement 5	4918.49	18:20	53	September 18, 2014	4968.03
Pier measurement 6	4918.49	18:22	53	September 18, 2014	
Average	4918.50				

Gravity Bias from last tie: 855466.15
Drift since last tie: 2.04

OBS Differences	
Station to Pier (1, 2, & 3 averaged)	-0.71
Station to Pier (4, 5, & 6 averaged)	-0.51
Averaged Differences	-0.61
Gravity at pier	981320.21
Elevation of pier above gravimeter, meters	1.0
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	981320.51
Gravity Bias (Offset for RVDAS)	855468.19

Comments

Dock was pretty stable, done by Gabby and Sheldon.

Note about Elevation of Pier: *If pier is below the ship's gravimeter, this value is negative. If above, positive.*

Appendix B, Multichannel Seismic SEGY file list

	Date	Seis. Line #	SEGY File Name	Delay (s)	Record(s)	Shot Intl(s)	SEGY Start Shot	SEGY End Shot	Comments
MAV	10/1/2014	1	1.SGY	0	6.5		1	195	
BUD	10/1/2014	1	196.SGY	0	6.5	9	196	295	
MAV	10/1/2014	1	296.SGY	0	6.5	9	296	395	
MAV	10/1/2014	1	396.SGY	0	6.5	9	396	595	
BUD	10/1/2014	1	596.SGY	0	6.5	9	596	1273	
BUD	10/1/2014	1	1274.SGY	0	7.5	10	1274	1287	
BUD	10/1/2014	1	1288.SGY	4	4	10	1288	1709	
MAV	10/1/2014	1	1710.SGY	4	3	9	1710	2034	corrected-conflict in segy report
KK	10/1/2014	1	2035.SGY	3	4	9	2035	2049	
KK	10/1/2014	1	2050.SGY	2	5	9	2050	2243	
KK	10/1/2014	1	2244.SGY	4	3	9	2244	2937	
KK	10/1/2014	1	2938.SGY	3	3	8	2938	8506	
JDL	10/2/2014	2	8507.SGY	3	3	8	8507	11521	
MAV	10/2/2014	3	1a.SGY	3	3	8	1	121	
MAV	10/2/2014	3	122.SGY	3.5	3	8	122	1121	
NJB	10/2/2014	3	1122.SGY	3	3	8	1122	1250	
NJB	10/2/2014	3	1251.SGY	3.5	3	8	1251	3161	
KK	10/2/2014	4	1b.SGY	3.5	3	8	1	467	
KK	10/2/2014	4	468.SGY	4	3	8	468	1497	
JMZ	10/2/2014	4	1498.SGY	4	3	8	1498	1753	
JMZ	10/3/2014	4	1754.SGY	4	4		1754	1835	Shot int. variable, 16 for a while
JMZ	10/3/2014	4	1836.SGY	4	5	11	1836	3086	
JMZ	10/3/2014	4	3087.SGY	3	5	10	3087	3437	
BUD	10/3/2014	4	3438.SGY	2	5	9	3438	4066	
BUD	10/3/2014	4	4067.SGY	2	5	10	4067	4070	
KK	10/5/2014	5	2.SGY	1		8	31	759	test pre-lines
KK	10/5/2014	5	760.SGY	2	5	8	760	774	
KK	10/5/2014	5	775.SGY	1.5	5	8	775	885	
KK	10/5/2014	5	886.SGY	2	5	8	886	910	
KK	10/5/2014	5	911.SGY	1.5	5	8	911	977	
JDL	10/5/2014	5	978.SGY	2	5	9	978	1102	Slowed to 3 knts
JMZ	10/5/2014	5	1103.SGY	3	5	9	1103	1348	

JMZ	10/6/2014	5	1349.SGY	2	5	9	1349	1501	
JMZ	10/6/2014	5	1502.SGY	2.5	5	9	1502	1653	
JMZ	10/6/2014	5	1654.SGY	3	5	9	1654	1829	Changed to 10 at 1811ish
JMZ	10/6/2014	5	1830.SGY	3.5	5	10	1830	1955	
JMZ	10/6/2014	5	1956.SGY	4	5	11	1956	2571	Int change later (5min) end line5
JMZ	10/6/2014	5a	2572a.SGY	4	5	11	2572	3032	
BUD	10/6/2014	5a	3033.SGY	3	3	8	3033	3470	
BUD	10/6/2014	5a	3471.SGY	2	5	8	3471	3598	
BUD	10/6/2014	6	1c.SGY	2	5	8	1	17	New line
BUD	10/6/2014	6	18.SGY	1.5	5	8	18	320	
BUD	10/6/2014	6	321.SGY	2	5	8	321	416	
BUD	10/6/2014	6	417.SGY	3	3	8	417	935	
BUD	10/6/2014	7	2a.SGY	3	3.5	8	2	93	1d before delay change, 3d 3r 8si
BUD	10/6/2014	7	94.SGY	3.5	3	8	94	289	
BUD	10/6/2014	7	290.SGY	4	5	11	290	621	
BUD	10/6/2014	7	622.SGY	3.5	5	11	622	898	
BUD	10/6/2014	7	899.SGY	3	5	10	899	982	
BUD	10/6/2014	7	983.SGY	2.5	5	10	983	1051	
MAV	10/6/2014	7	1052.SGY	2	5	9	1052	1605	
NJB	10/6/2014	7	1606.SGY	3	5	10	1606	2341	Change made from estimating bottom with MCS first arrived
NJB	10/6/2014	7	2342.SGY	2	5	9	2342	2590	
JDL	10/6/2014	8	2591.SGY	2	5	9	2591	2841	New line
NJB	10/6/2014	9	1e.SGY	1	7	10	1	560	
KK	10/6/2014	9	561.SGY	3	7	10	561	588	
KK	10/6/2014	9	589.SGY	2	7	11	589	1699	
JDL	10/7/2014	10	1700.SGY	2	7	11	1700	2504	New line
JDL	10/7/2014	10	1700.SGY	2	7	60	2505	2531	Compressor fix
JDL	10/7/2014	10	1700.SGY	2	7	11	2532	3763	Back up to full

BUD	10/7/2014	11	1f.SGY	2	7	11	5	2106	5-60 Test 2 Guns & turning, 1-5=1 gun
BUD	10/7/2014	12	1g.SGY	2	7	11	1	57	
BUD	10/7/2014	12	62.SGY	2	2	11	62	1680	
NJB	10/7/2014	12	1681.SGY	4	4	10	1681	2362	Shelf!
NJB	10/7/2014	12	2363.SGY	3	4	9	2363	2523	
KK	10/7/2014	12	2524.SGY	2	4	8	2524	2773	
JDL	10/7/2014	12	2774.SGY	1	5	8	2774	3001	End Line12
KK	10/10/2014	13	1h.SGY	2.5	4	9	1	48	
NJB	10/10/2014	13	49.SGY	3.5	4	9	49	397	Begin firing 2 guns
KK	10/10/2014	13	398.SGY	4	3.5	9	398	2357	Change battery
JDL	10/10/2014	13	2358.SGY	4	3.5	9	2358	7095	
BUD	10/11/2014	13	7096.SGY	3.5	3.5	9	7096	7178	
BUD	10/11/2014	13	7179.SGY	3	3.5	9	7179	7208	
BUD	10/11/2014	13	7209.SGY	3.5	3.5	9	7209	7334	
MAV	10/11/2014	13	7335.SGY	4	3.5	9	7335	9869	
NJB	10/11/2014	14	1i.SGY	4	3.5	9	1	249	Start of 14
KK	10/11/2014	14	250.SGY	3	3.5	9	250	304	
KK	10/11/2014	14	305.SGY	3.5	3.5	9	305	695	
NJB	10/11/2014	15	1j.SGY	3.5	3.5	9	1	1158	
JMZ	10/12/2014	15	1159.SGY	3.5	4	9	1159	2611	
JDL	10/12/2014	15	2612.SGY	3	4	9	2612	2793	lowered delay to 3
JDL	10/12/2014	15	2794.SGY	3.5	4	9	2794	3742	
BUD	10/12/2014	15	3743.SGY	4	3.5	9	3743	5053	
BUD	10/12/2014	15	5054.SGY	4	3.5	9	5054	5113	
MAV	10/12/2014	15	5114.SGY	3.5	4	9	5114	5417	
BUD	10/12/2014	15	5418.SGY	3	4	9	5418	5562	
BUD	10/12/2014	15	5563.SGY	3.5	4	9	5563	5647	
MAV	10/12/2014	15	5648.SGY	4	3.5	9	5648	6339	
BUD	10/12/2014	15	6340.SGY	4	4	10	6340	7593	End Line15
KK	10/14/2014	16	1k.SGY	2	4	8	1		Start Line16 - data starts at 86
KK	10/14/2014	16	172.SGY	4	3	9	172	424	
NJB	10/14/2014	16	425.SGY	4.5	3	10	425	722	
KK	10/14/2014	16	723.SGY	4.5	3.5	10	723	2341	
KK	10/14/2014	16	2342a.SGY	4	3.5	10	2342	2873	

JDL	10/14/2014	16	2874.SGY	4	4	10	2874	4584	replaced geode battery
JMZ	10/15/2014	16	4585.SGY	4	4	10	4585	5159	
JDL	10/15/2014	16	5160.SGY	3.5	4	10	5160	5244	
BUD	10/15/2014	16	5245.SGY	3	4	9	5245	10919	
KK	10/15/2014	16	10920.SGY	3.5	3.5	9	10920	11231	
KK	10/15/2014	16	11232.SGY	4	3	9	11232	11822	
JDL	10/15/2014	16	11823.SGY	3.5	3.5	9	11823	12047	
JDL	10/15/2014	16	12048.SGY	3	4	9	12048	12178	
JMZ	10/16/2014	16	12179.SGY	3.5	3.5	9	12179	12249	
JMZ	10/16/2014	16	12250.SGY	4	3	9	12250	13100	
JDL	10/16/2014	17	13101.SGY	4	3	9	13101	13193	New line
JDL	10/16/2014	17	13194.SGY	4	4	10	13194	14596	
JDL	10/16/2014	17	14597.SGY	3.5	4.5	10	14597	14838	
MAV	10/16/2014	17	14839.SGY	4	4	10	14839	16074	
BUD	10/16/2014	17	16075.SGY	3.5	4.5	10	16075	16543	
MAV	10/16/2014	17	16544.SGY	4	4	10	16544	17551	
KK	10/16/2014	17	17552.SGY	3.5	4	10	17552	18038	
KK	10/16/2014	17	18039.SGY	3	4	9	18039	18134	
KK	10/16/2014	17	18135.SGY	2.5	4	9	18135	18251	up the starfish
KK	10/16/2014	17	18252.SGY	3	4	9	18252	19232	starfish
KK	10/17/2014	17	19233.SGY	3	4	9	19233	19610	battery changed, starfish
KK	10/18/2014	17	19611.SGY	2.5	4	9	19611	2008	starfish

								8	
NJB	10/16/2014	17	20089.SGY	3	4	9	20089	2015 9	
NJB	10/16/2014	17	20160.SGY	4	4	10	20160	2019 0	

Appendix C. Dredge sample and specimen logs

Cruise Nathaniel B Palmer NBP 14-08

Dredge log

Dredge station numbers follow consequtively from those of cruise NBP08-05

			Dredge on bottom			Dredge off bottom				
Dredge Number	Date	Julian Day	Time	Latitude	Longitude	Time	Latitude	Longitude	Location description:	Haul description
DR14	9-Oct-14	282	17:56	-55.665	-37.149	20:26	-55.661	-37.128	SE flank of summit area of North Southern Seamount of South Georgia. The dredge track stopped short of the flat pateau forming the seamount summit.	Large haul of varied rocks. Includes many drop stones. Some samples of fine-grained aphyric vesicular basalt. Minor biological material consisting of one anenome, two other unidentified idividuals and encrustations.
DR15	10-Oct-14	283	21:37	-55.715	-37.175	00:33	-55.703	-37.181	SE flank of small volcanic dome on southern axis of ridge south of summit area of North Southern Seamount of South Georgia	Weak link broke. Bag recovered inverted. No rock recovery. Biological material - one small polyp-like individual.
DR16	10-Oct-14	283	1:31	-55.708	-37.169	5:27	-55.706	-37.175	SE flank of small volcanic dome on southern axis of ridge south of summit area of North Southern Seamount of South Georgia. Re-run on same track as DR15.	Very large haul of varied rocks. Includes many drop stones. Very minor biological material including encrustations.
DR17	10-Oct-14	283	13:45	-56.034	-36.485	16:45	-56.032	-36.499	Steep part of east-facing slope on east flank of South Southern Seamount of South Georgia. The dredge is close to the track of dredge DR08 obtained during NBP 08-05.	5 small drop stones. No biological material.
DR18	14-Oct-14	287	2:39	-55.6706	-37.1981	5:29	-55.6617	-37.202	West-facing slope on west side of North Southern Seamount of South Georgia.	Dredge tangled in wire and recovered inverted. No rock recovery. One coral individual.
DR19	14-Oct-14	287	10:45	-56.176	-36.706	13:17	-56.177	-36.698	Steep part of west-facing flank on west side of South Southern Seamount of South Georgia.	Haul consisting of 3 large blocks and several other rocks, mostly drop stones. One vesicular basalt. Biology - several diverse individuals

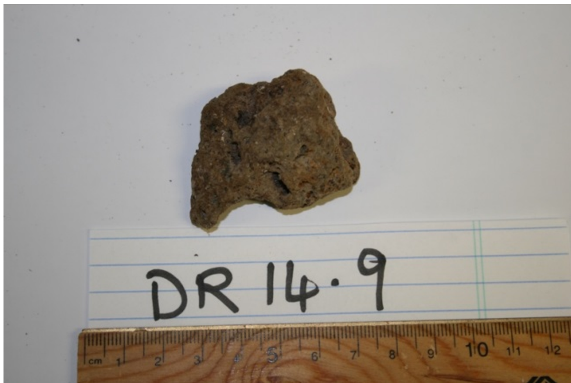
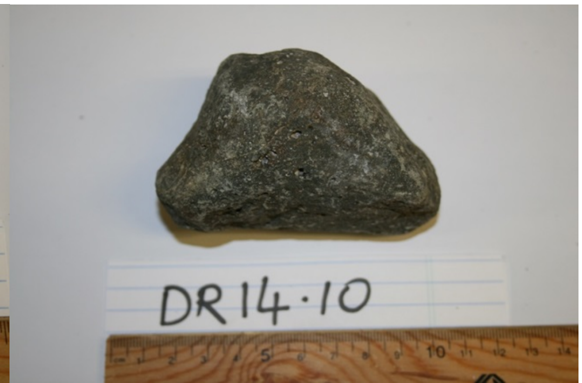
Cruise Nathaniel B Palmer NBP 14-08
Specimen log

Angularity key	
6:Very angular: corners sharp and jagged	3: Sub-rounded
5:Angular	2: Rounded
4: Sub-angular	1: Well-rounded: corners completely rounded

Dredge number	Specimen number	size (cm)	lithology	angularity	comments
DR14	1	8x7x7	Red vesicular basalt with pillow-like rind. Minor vesicle infilling.	6	Very friable, angular rock likely to be in-situ. No Mn crust.
DR14	2	6x5x5	Fresh black vesicular basalt with glassy patches	6	Very angular rock likely to be in-situ. No Mn crust.
DR14	3	6x4x2	Fresh black vesicular basalt. Minor vesicle infilling.	5	Very thin Mn crust. Likely to be in-situ.
DR14	4	5x4x4	Fresh black vesicular basalt. Minor vesicle infilling.	6	Very angular rock likely to be in-situ. No Mn crust.
DR14	5	5x4x3	Fresh black vesicular basalt. Minor vesicle infilling. Yellow patches may be altered glass.	4	Distinct rounding. Likely to have been reworked. Minor Mn crust. Vesicles may be partly in-filled by sediment.
DR14	6	6x5x4	Red-brown vesicular basalt.	4	Very friable. Minor Mn crust. Possibly in-situ.
DR14	7	7x4x3	Fresh black vesicular basalt. Minor vesicle infilling. Yellow patches may be altered glass.	3	Distinct rounding. Likely to have been reworked.
DR14	8	4x3x3	Pumice. Brown, plagioclase-phyric.	6	Resembles 1962 Protector Shoal pumice.
DR14	9	5x4x2	Pumice. Brown, plagioclase-phyric.	4	Resembles 1962 Protector Shoal pumice.
DR14	10	9x6x5	Vesicular basalt	2	Distinct rounding. Likely to have been reworked. Minor Mn crust. Vesicles may be partly in-filled by sediment.
DR14	11	5x4x3	Gritstone. Brown matrix. Silty matrix, polymict.	1	Well-rounded, friable. Unlikely to be in-situ.
DR14	12	14x10x4	Sediment with thick Mn crust	3	
DR14	13		8 samples of sediments		

DR16	1	9x8x5	Basalt. Vesicular with minor filling of vesicles. Plagioclase-phyroxene-phric.	5	Minor Mn staining. Possibly in-situ.
DR16	2	12x6x6	Basaltic volcaniclastite. Clasts up to 2.5 cm across. Dominantly sand-grade.	5	Very minor Mn staining.
DR16	3	9x6x5	Basalt. Plagioclase-phyric. Non-vesicular.	3	Minor Mn staining.
DR16	4	6x5x3	Fresh basalt. Glassy patches.	6	Possibly in-situ.
DR16	5	6x5x3	Fine-grained volcanic rock, possibly andesite. Non-vesicular, aphyric.	5	Minor Mn staining. Probably not in-situ.
DR16	6	8x6x3	Fine-grained volcanic rock, possibly basalt.	3	Minor Mn staining.
DR16	7	11x8x6	Volcanic rock. Non-vesicular. Greenish (prevasive cholorite?) alteration.	4	Minor Mn staining. Probably not in-situ.
DR16	8	6x4x4	Volcanic rock. Non-vesicular. Greenish (prevasive cholorite?) alteration.	5	Minor Mn staining.
DR16	9	7x7x4	Volcanic rock. Non-vesicular. Greenish (prevasive cholorite?) alteration. Weak folation.	3	Minor Mn staining. Probably not in-situ.
DR16	10	6x4x4	Volcanic rock. Non-vesicular. Fresh.	5	Minor Mn staining. Possibly in-situ.
DR16	11	7x4x4	Basalt. Vesicular with minor filling of vesicles. Olivene (?) phyric.	3	Minor Mn staining. Possibly in-situ.
DR16	12	5x4x3	Fresh basalt. Glassy patches. Non-vesicular. Aphric.	6	Possibly in-situ.
DR16	13	5x3x3	Volcanic rock. Non-vesicular. Greenish (prevasive cholorite?) alteration.	3	Minor Mn staining. Probably not in-situ.
DR16	14	5x3x3	Basalt. Non-vesicular. Aphric.	4	Minor Mn staining.
DR19	1	6x5x2	Vesicular basalt.	5	Mn crust. Probably in-situ.
DR19	2	7x4x3	Probable basalt.	5	Mn crust.
DR19	3	12x7x7	Bedded sediment. Finely bedded. Brown. Possibly volcaniclastic.	4	Mn crust.
DR19	4	15x8x5	Possible lava. Greenish (pervasive cholorite?)	4	Mn crust. Probably not in-situ.
DR19	5	12x7x6	Mudstone? Dark grey	3	Mn crust. Probably not in-situ.

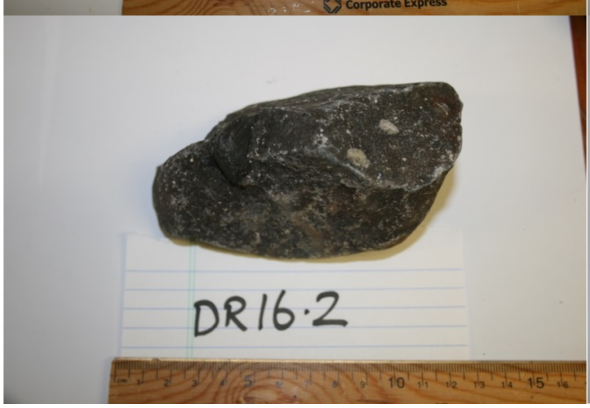
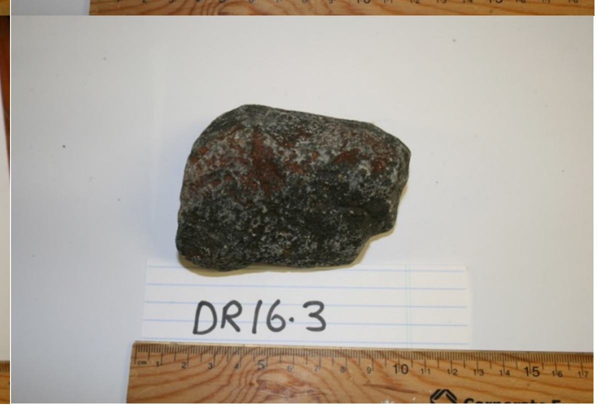
Appendix D. Photographs of numbered dredge samples

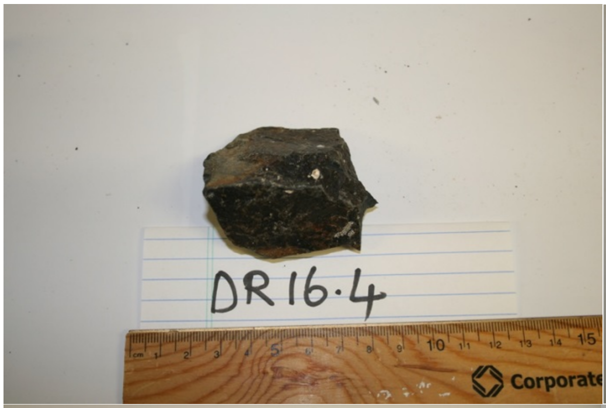

DR 14·9

DR14·10

DR14·11

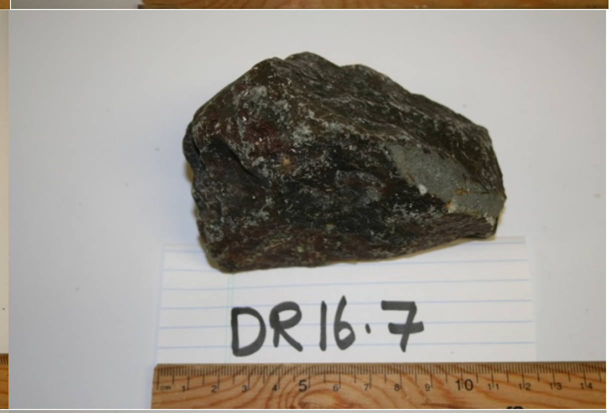
DR14·12
Corporate Express

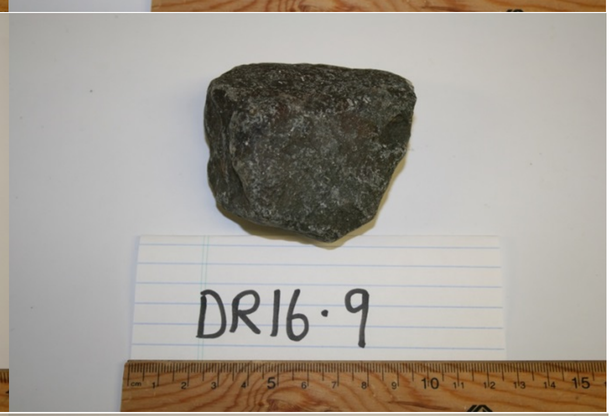
DR14·13
Corporate Express

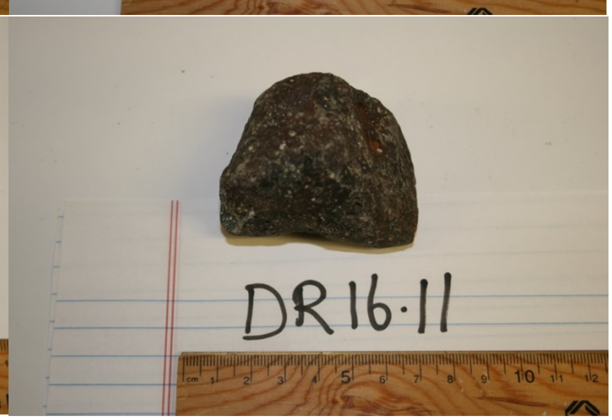
DR16·1

DR16·2

DR16·3

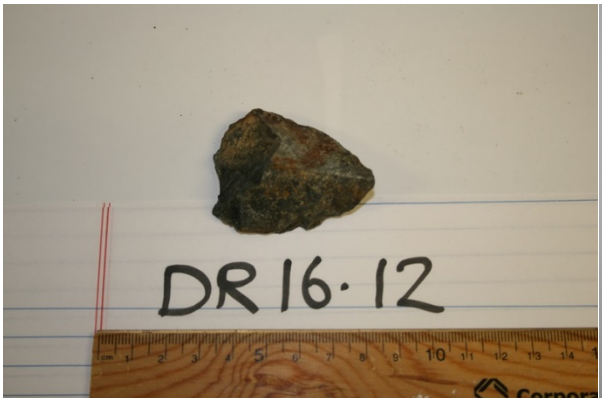

DR16.4
Corporate

DR16.5
Corporate Exp

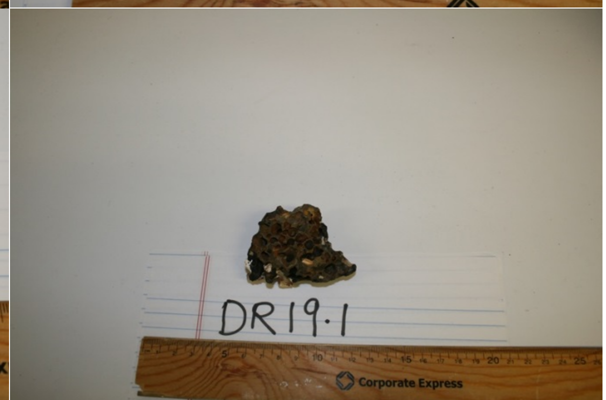
DR16.6

DR16.7

DR16.8

DR16.9

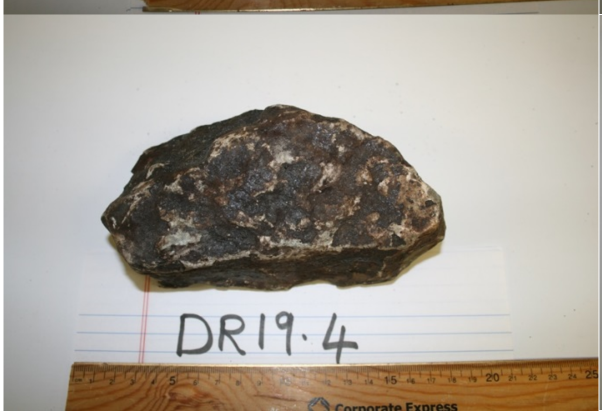
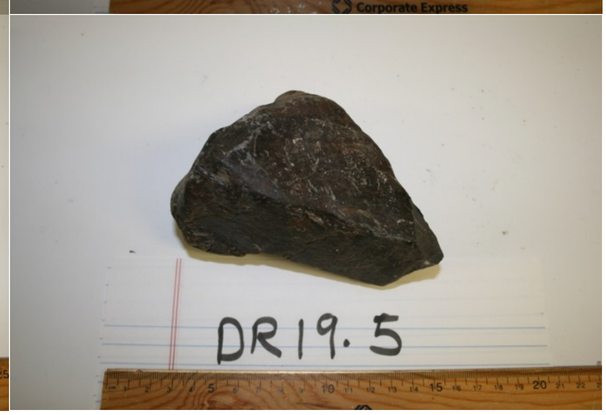
DR16.10
Corporate

DR16.11


DR16·12

DR16·13

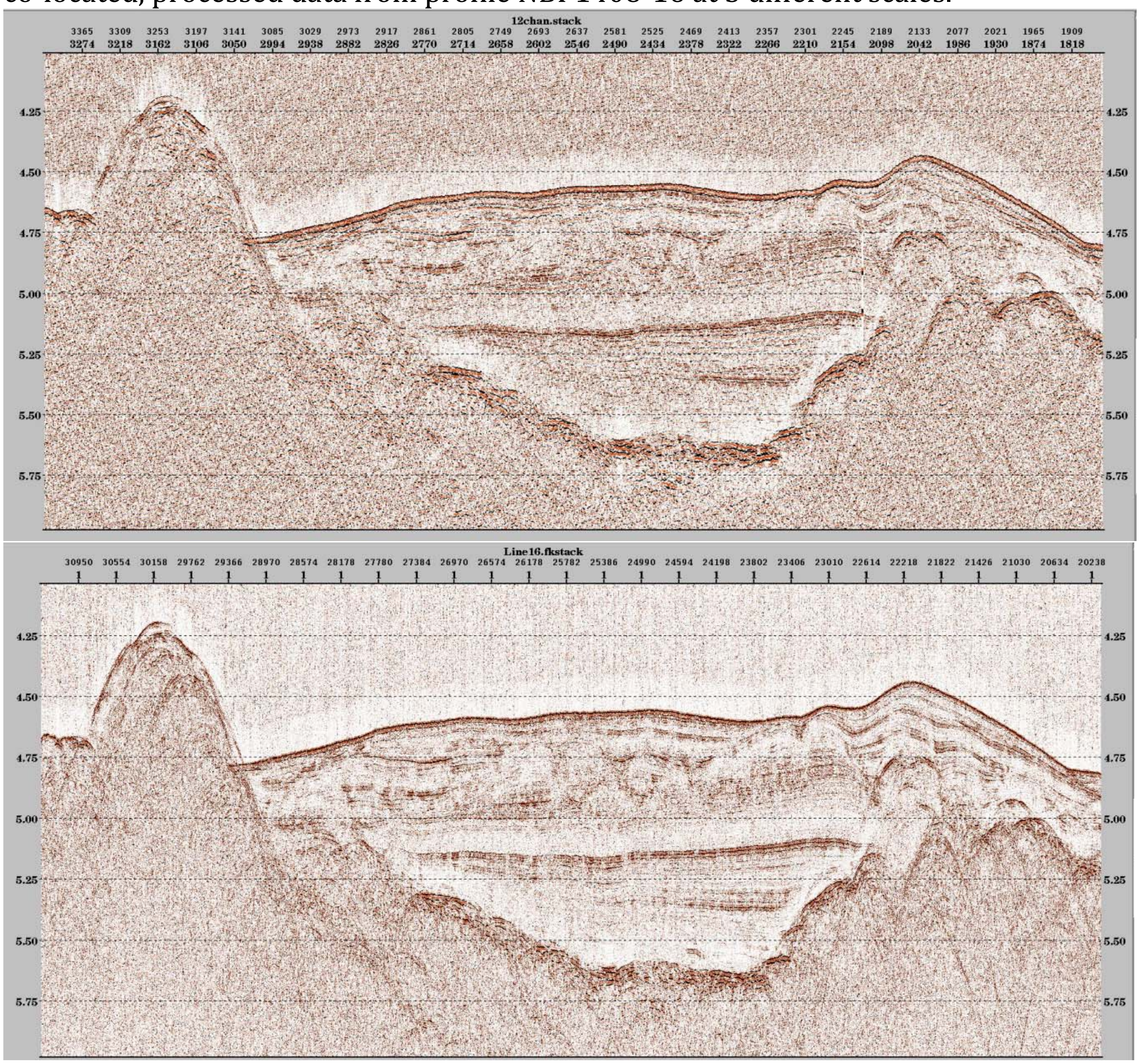
DR16·14
Corporate Ex

DR19·1
Corporate Express

DR19·2
Corporate Express

DR19·3
Corporate Express

DR19·4

DR19·5

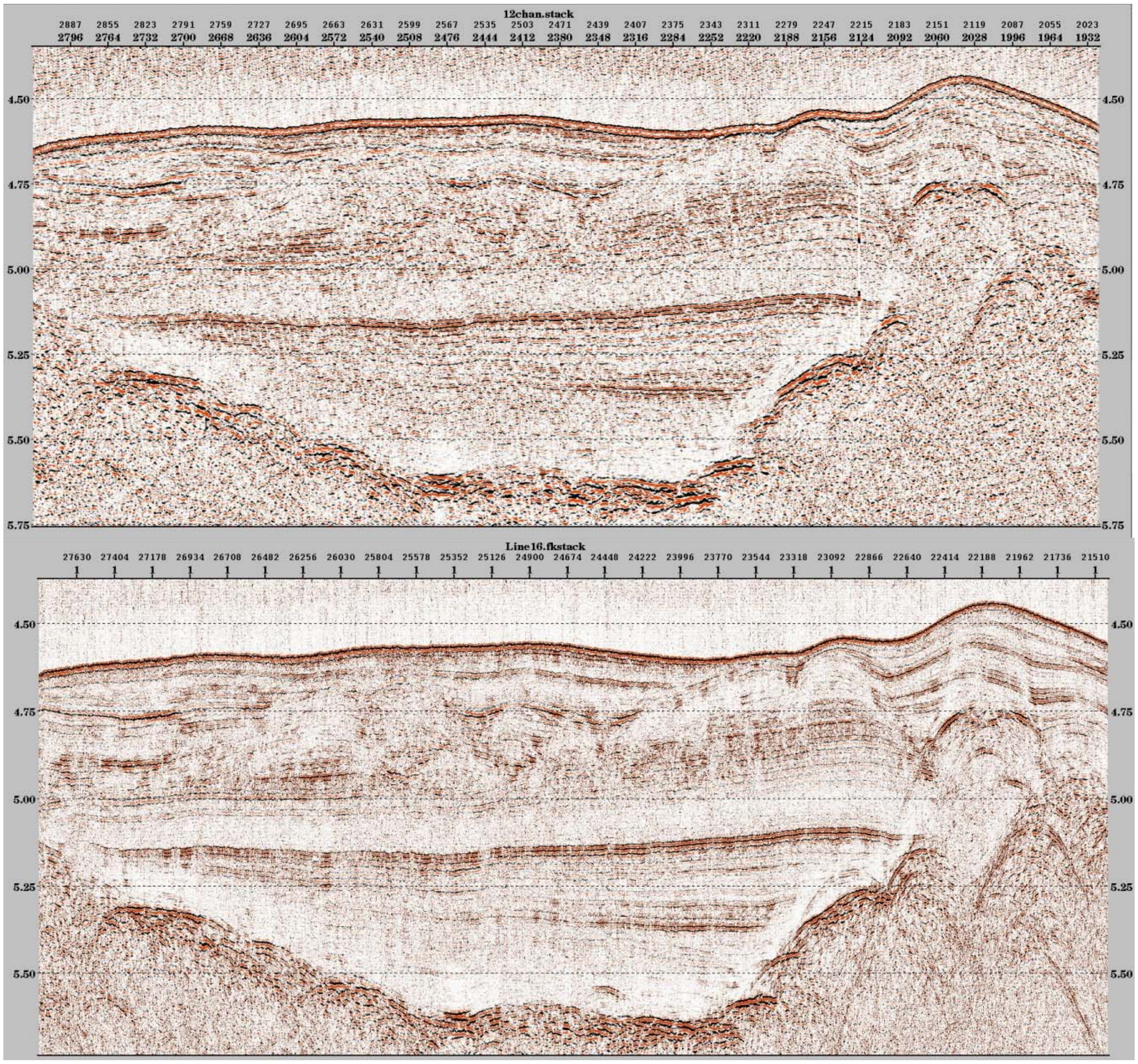
Appendix E. Comparison of 24-channel and 12-channel streamer data

As proposed in the cruise Research Support Plan, the 12-channel solid-state multichannel streamer owned by USAP and kept aboard RVIB *Palmer* was towed for several hours on the afternoon of 15 October 2014, and data were acquired simultaneously with UTIG 24-channel streamer data. The USAP streamer was towed an estimated 150 meters astern of the vessel. Data were acquired on the UTIG Geode Seismic recorder configured with all A,B,C, and D jumpers removed internally, and both Geodes were triggered simultaneously using contact closure from the HotShot firing controller. USAP streamer data were subsequently processed to produce a 12-channel stack. These data are here compared with co-located, processed data from profile NBP1408-16 at 3 different scales.



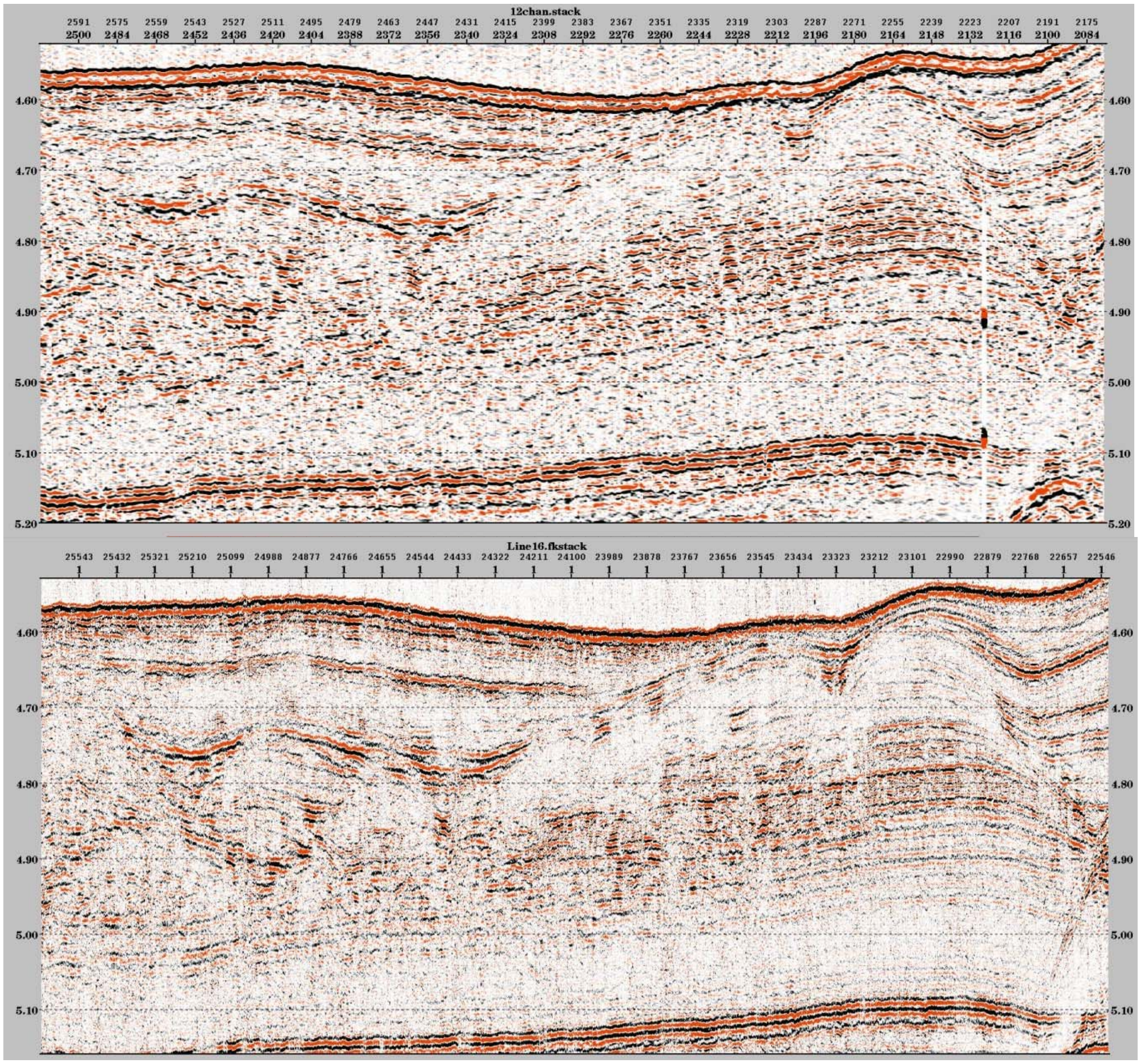
12 Channel USAP (top) and 24 Channel UTIG (bottom) data

35 km. x 2.0 sec.



12 Channel USAP (top) and 24 Channel UTIG (bottom) data

20 km. x 1.4 sec.



12 Channel USAP (top) and 24 Channel UTIG (bottom) data

10 km. x 0.7 sec.