Weekly Science Report for NBP0701 covering the period of Dec 22 to Jan 5

The Nathaniel Palmer sailed from Lyttelton on the afternoon of December 22nd 2006 with a scientific party of 18 including geologists and geophysicists from Caltech, Scripps and Bowling Green College and foreign participants from New Zealand, Japan, China and Australia. The principal planned activities for the cruise are an underway marine geophysical survey of the seafloor east of Cape Adare using multi-channel seismics, magnetics, gravity and swathmap bathymetry and a seafloor sampling program of volcanic edifices and oceanic escarpments in the same region by dredging. In addition an auxiliary program was carried out during the transit south consisting of a series of calibration shots to test the International Monitoring System (IMS) for acoustic signals traveling through the Antarctic Convergence Zone.

Week 1 – December 22nd to December 29th

The first week of the project consisted of seven days of a nine day transit to the principal work area near Cape Adare. During the transit south we deviated the track slightly from a straight line to Cape Adare in order to collect geophysical data over interesting geological targets near the path. After the initial departure from Lyttelton, multibeam measurements were made along a profile parallel to the coast of South Island and about 35 km off Dunedin to extend the coverage of existing multibeam measurements in the region aimed at studying the formation of the head canyons of the major Bounty submarine canyon that extends about 800 km east through the Bounty Trough into the Pacific Ocean (Fred Davey).

Further along the transit we collected magnetics, gravity and multibeam data along a tectonic flowline adjacent to a major fracture zone generated by motion between the Pacific and Antarctic plates during the early Cenozoic. We then followed a tectonic flowline across the axis of the Pacific-Antarctic ridge. This is the fourth ridge segment that we have had the opportunity to map on transit crossings of the Pacific-Antarctic ridge between Lyttelton and McMurdo over the past several years. This section of the Pacific-Antarctic ridge is very unique and interesting because it consists of a staircase of short ridge segments and transform faults that formed when a long transform fault went into extension following a major clockwise change in Pacific-Antarctic plate motion between 10 and 6 Ma. The various ridge segments exhibit very different geomorphic characteristics, some with prominent rift valleys and others with axial highs, over a very short distance. The latest crossing exhibited an unexpected axial high. Following the crossing of the ridge axis we collected magnetics data along a short east-west striking line in a critical area for constraining early Cenozoic plate reconstructions just north of Scott Island.

In addition to collecting underway geophysical data during the transit south, a series of calibration shots were made for the IMS. Twice-daily hydroacoustic stations were occupied between ~54°S and 63°S. Following confirmation that the area around each station was clear of marine mammals, small calibration shots were triggered at depth and the signal propagated 1000's of kilometers in the sound channel. Signals from all but

one station were recorded at an IMS station off SW Australia. A few shots were also recorded at a IMS station in the Indian Ocean. Comparison between the source locations determined using techniques that are standard for nuclear test monitoring and the actual source locations will indicate the level of uncertainty in current IMS methods (Blackman and Jenkins).

Week 2 – December 29th to January 5th

The second week of the NBP0701 started with a two day transit through the ice from the vicinity of Scott Island to the principal work area east of Cape Adare. Satellite imagery suggested that there was a large area relatively free of ice immediately east of Cape Adare over the northern part of the Adare Basin and the southern end of the Adare Trough, two targets of high interest to this project. We deployed the recently refurbished 1200 m Teledyne seismic streamer and the 6 GI guns and started seismic acquisition, with the first data being acquired within a few minutes of the start of the New Year. We acquired four lines across the axis of the feature, starting with one across the southernmost end of the Adare trough and then three more lines across the buried southerly continuation of the trough. Although we planned to collect additional lines to the south, strong southerly winds started blowing large strings of ice floes across our planned track and we decided to run a strike parallel line up the axis of the Adare trough. We terminated this stage of the seismic work when we encountered the edge of the ice near the northern end of the Adare Trough. In addition to the vertical reflection data that we collected with the MCS streamer, we also acquired 10 seismic refraction lines using sonobuoys as a fixed hydrophone.

We are delighted with the seismic data that we have collected so far. Preliminary processing aboard the ship shows that the data are of very high quality. Initial analysis of the seismic data suggests that the Adare Trough, which we believe is a fossil spreading center that developed when seafloor spreading in the Adare Basin ceased about 28 million years ago, cuts obliquely across the seafloor spreading fabric in the region where it disappears as a morphological structure and is buried by sediments, with the west wall of the trough heading in the direction of Cape Adare.

After the completion of the seismic line up the axis of the Adare Trough we retrieved the gear and shifted to the dredging program. Four sites were dredged in the central section of the Adare Trough. Samples from two adjacent sites in the western scarp of the trough include a couple of basaltic boulders that possibly came from the rifted oceanic crust. These are cemented together with highly altered volcanic materials and are coated with manganese. Samples from another site in the western scarp with an overlying seamount are more variable and include several ice-rafted rocks such as dolerite and metamorphic rocks. These are also coated with manganese. The last site is an intraplate volcano in the middle of the trough and the samples dredged from it are mainly angular pebbles and cobbles of vesicular basalts and ice-rafted rocks. The manganese coating of these are very thin when compared to the samples from the scarp (Castillo and Panter).

Equipment

The refurbished MCS streamer and the GI gun array have worked well as have the magnetometer and gravity meter. We did not deploy the magnetometer with the seismic gear during the initial seismic data activities reported here because the region of the data acquisition was recently the target of a dense aeromagnetic survey by BGR. Having one less cable to tow makes dealing with the ice floes a little less daunting. A concern is that one of the ship's two air compressors has suffered a failure that cannot be repaired at sea leaving us without a backup compressor.

Marine Mammal Observations

Marine mammal observations were carried out before and during the IMS calibration shots during the transit and before and during the MCS operations, closely following the recommended guidelines. No marine mammals were seen within the defined danger zone for the GI gun array during any of the operations. A penguin did enter the danger zone at one point during MCS operations and, following the written guidelines, 5 of the 6 guns were briefly turned off. After the penguin cleared the danger zone the guns were ramped back up to the full array.

Personnel

We have had excellent support by all of the Raytheon and Chouest personnel. This report period included both Christmas and New Years and the galley prepared excellent feasts for both occasions. The marine techs have done a superb job of deploying, recovering and maintaining the seismic equipment and the ETs and ITs have kept the logging and computer facilities smoothly operating. We are grateful for the care with which the Captain and officers have handled the ship in often tricky ice conditions. Jim Dolan, the MPC, has provided truly outstanding support.

Respectfully submitted,
Steven Cande

Science Report for NBP0701 covering the period of January 5th to January 17th

During the period covered by this report, scientists aboard the Nathaniel Palmer continued to use seismic reflection and refraction methods to explore the structural relationship between the Adare Trough, an unusual fossil spreading center north of Cape Adare, and the northern Ross Sea sedimentary basins. In addition, the dredging program continued with 13 new dredges of volcanic features in the Adare Basin bringing the total number of dredges for the cruise to 17. The first part of this report covers the results of the seismic work being carried out by Stock, Clayton, Davey, Ishihara, Cande and students, while the second part of the report covers the dredging program being carried out by Castillo, Panter and students.

Seismic reflection and refraction program

In our previous science report, we noted that we had collected four lines across the southern end of the Adare Trough and the buried continuation of it in the Adare Basin. These lines showed that the sedimentary structures in the area just south of the morphological expression of the Adare Trough, were very complicated, with both active and inactive normal faults. At that time, however, ice conditions prevented us from continuing our survey to the south and, instead, we ran a long line to the north, up the axis of the trough, and then spent some time dredging.

The start of this reporting period found us running an exploratory line over to the Central Basin, the basin to the east of our main target, the Adare Basin, but also of considerable tectonic interest, to see if it was possible to start collecting seismic data in that region. The satellite imagery showing the ice conditions in that area were ambiguous. We found, in fact, that ice conditions precluded the acquisition of seismic data in that region. We were able, however, to take advantage of the calm sea conditions to use the Simrad system to quickly and efficiently map a large seamount, the Marion seamount, situated along our path.

We then proceeded back to the Adare Basin, where ice conditions had improved, and, building on the results of the previous week, started collecting additional seismic lines across the projected axis of the extinct spreading center at the southern end of the basin. After collecting two lines across the basin, seismic acquisition was suspended for two days while the ship made a round trip to the Italian Base at Terra Nova Bay in order to evacuate an ailing shipmate. After returning from Terra Nova Bay we started seismic data acquisition in the Northern Basin of the Ross Sea and ran a long tie line from the shelf, down the slope and up the presumed axis of the extinct spreading center in the Adare Basin. We then collected five additional seismic lines across the axis of the extinct spreading center, placing some of them between previous lines where the structures were observed to be the most complex. This concluded the seismic part of the program for this period. During the seismic surveying, 18 seismic refraction lines were collected using sonobuoys, bringing the total for the cruise to 28.

Preliminary processing of the seismic lines is being carried out during the cruise, with preliminary time migrated sections completed for all of the lines. Our analysis of the data shows that the structures are even more complicated than we originally thought based on the four lines we had first acquired. The original four lines, shot near the southern end of the Adare Trough, showed that there were large extensional structures, with both inactive and active faults, that trended obliquely across the axis of the original spreading center, heading southwest towards the continental margin near Cape Adare. One of our preliminary speculations was that perhaps this was the location of the original fossil spreading center south of the morphological Adare trough. The newer data collected in the southern part of the Adare Basin shows, however, that there is also a buried, relict fossil spreading center that follows the original axis of spreading in the Adare Basin, as determined from the magnetic anomalies, and which runs south towards the Northern Basin. The oblique trends observed in the seismic data near the south end

of the Adare Trough appear to be a later overprint, like a palimpsest. Our interpretation of these data is only beginning but the data clearly raise many interesting questions. One obvious issue is the relationship between the active normal faulting observed in this region and the active normal faulting observed in the Victoria Land Basin.

Dredging activities

The cluster of volcanic seamounts east of Cape Adare was dredged. The main strategy was to collect in-situ lavas from these seamounts with increasing distance from the continent. Thirteen seamounts were dredged and the shallowest ones, ~15 nautical miles away from Cape Adare, are only <500 mbsl and heavily covered with coralline materials. The farthest seamount, some 50 nautical miles away, is ~1700 mbsl and is free of coralline materials. A total of ~1,000 lbs of rocks were recovered. Ice-rafted drop stones are ubiquitous in all dredge sites, but angular fragments of fresh to slightly altered basalts were also recovered. The fragments are mainly from sheet flows; these are fine-grained, moderately to highly-vesicular and almost always aphyric with only a few containing microphenocrysts of altered olivine and occasional phenocrysts of plagioclase. None of the seamounts sampled appear to be active but the fact that some of the fragments are glassy and the lack of manganese coating on all fragments suggests that the volcanic activity in this region is relatively young. Attempts have been made to contact people who might be interested in the biological material brought up with the dredges.

Equipment

The refurbished Teledyne streamer and GI guns continue to operate very well. We have been very pleased with the quality of the data that has been coming back, even when the sea states are not ideal. The magnetometer and gravimeter also continue to function well. The Simrad swath bathymetry system continues to perform as it has on prior cruises, with excellent results in calm and low sea states, while its performance in moderate or heavy sea conditions is strongly related to the direction the seas are coming from.

Marine Mammal Observations

We continue to follow the procedures outlined in the Marine Mammal Mitigation Plan with observations starting at least half an hour before air gun operations are initiated, with a rampup period at the start of operations, and with a continuous watch during all seismic operations. No mammals were observed to enter the danger zone during seismic operations this period.

Personnel

We have continued to have excellent support by all of the Raytheon and Chouest personnel. During this period there was an emergency medical evacuation which was handled very smoothly and professionally with impressive coordination between many different groups on the ship and on land. We feel very fortunate to have an actual doctor

sailing with us. We are encouraged to hear that our ailing shipmate is doing better. The Marine Techs are terrific, the ETs and ITs do a great job and the MPC is outstanding. The advice and assistance from the Captain and officers are greatly appreciated.

Respectfully submitted,
Steven Cande