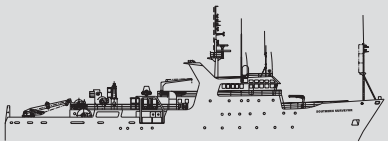

MARINE
NATIONAL FACILITY

RV *Southern Surveyor*

2004 program

CSIRO
MARINE RESEARCH

GEOSCIENCE AUSTRALIA SURVEY 270

voyage summary SS05/2004

SS05/2004 (Geoscience Australia Survey 270)

The geology of a large submerged continental block: the Kenn Plateau off northeast Australia.

Itinerary

Departed Sydney 1000hrs, Monday 3 May, 2004
Arrived Nouméa 1900hrs, Thursday 27 May, 2004

Principal Investigators

- Dr Neville Exon (Chief Scientist)
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Scientific Objectives

The scientific objectives of this voyage (Southern Surveyor Voyage S05/2004; Geoscience Australia Survey 270) were to improve our understanding of the geological evolution and modern environmental setting of the poorly known Kenn Plateau off northeast Australia.

Voyage Objectives

To acquire geoscience data from the Kenn Plateau to the abyssal plain

- 200-4500 m water depth
- 20 to 27° South, 154 to 159° East.
- Highest priorities were seismic profiling (3300 km at 7.5 knots) and dredging (40 dredges, 500-4000 m water depth)
- Secondary priorities were magnetic profiling (on seismic profiles), swath mapping, echosounder profiling, seabed sampling (10 cores, 500-4000 m water depth) and 10 grabs (200-1000 m water depth)
- Swath to be run the whole time, except on final transit to Nouméa
- Transits at 11 knots to and from work area

Twenty-two days were to be available for work in the study area. The first half of the survey as planned consisted of seismic and magnetic profiling, and swath-mapping of the sea floor at 7.5 knots. The seismic system was to use two airguns and a 600 m long, 24 channel solid streamer. The second half was to be devoted to geological sampling. About 40 dredge hauls or short gravity cores would be deployed for stratigraphic sampling of older targets. About 12 x 6 m Quaternary gravity cores were to be taken for sediment composition and palaeoceanographic studies.

Voyage Track

Figure 1: Figure 1. Regional setting of the Kenn Plateau, showing the *Southern Surveyor* SS05/2004 survey. Seismic lines in magenta, additional swath lines in green (thin), and dredge stations as red triangles.

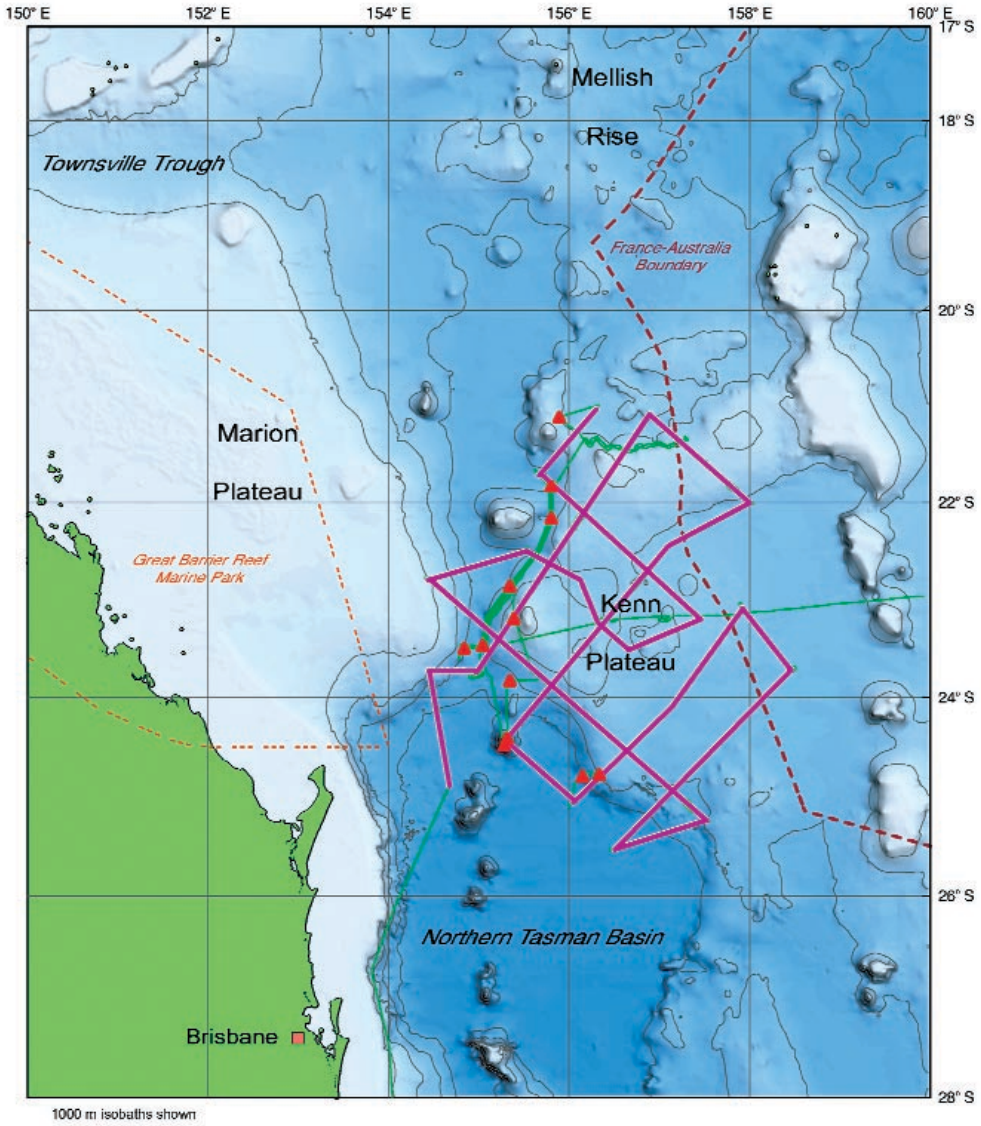
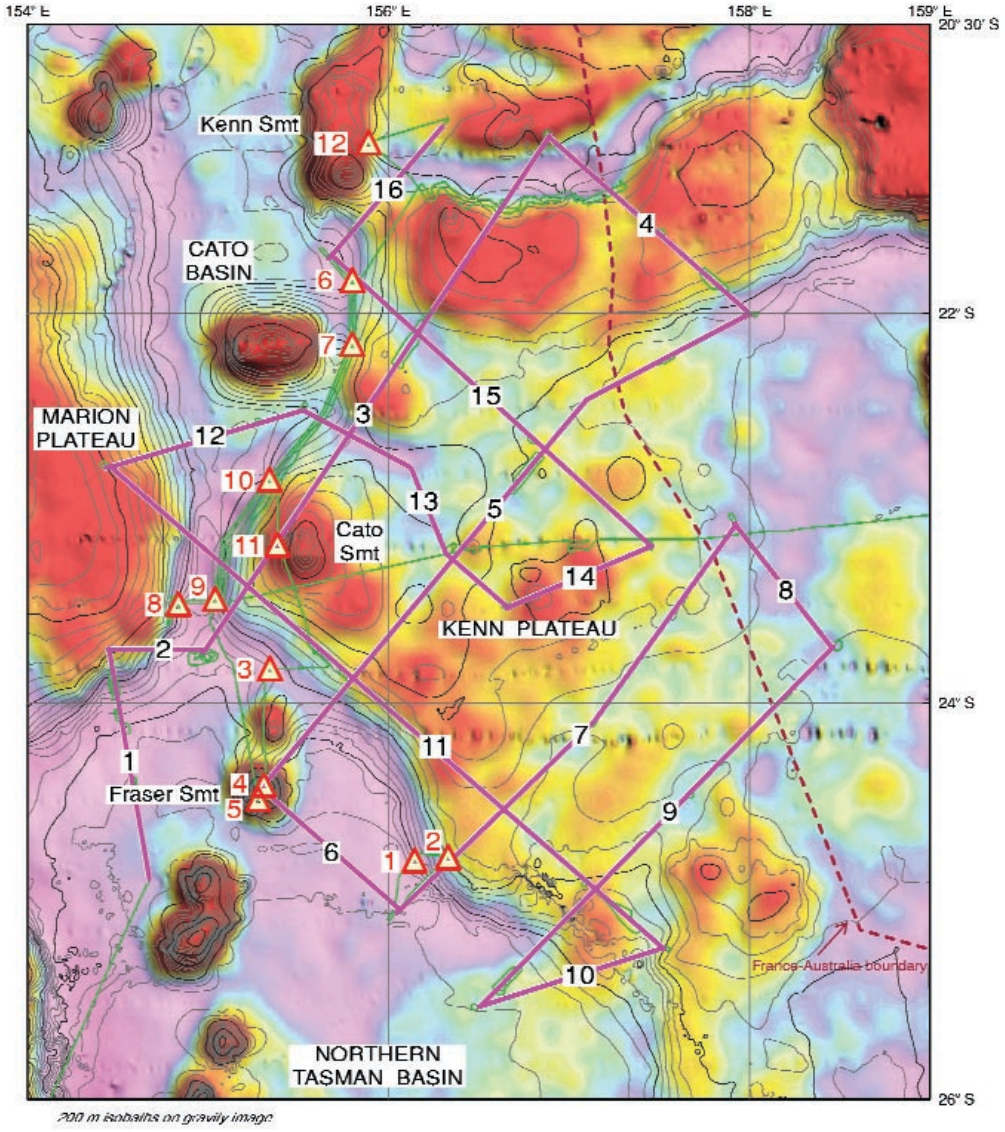


Figure 2: Detailed map of *Southern Surveyor* SS05/2004 survey of the Kenn Plateau, showing bathymetric contours overlain on satellite gravity map (after Sandwell and Smith, 1997. *Journal of Geophysical Research* 102, 10039–10054). Seismic profiles shown in magenta, additional multibeam sonar swath lines in green (thin), and dredge sites as triangles.



On the way north from Sydney, a swath line was recorded along the middle of the continental slope (Table 1). Within the survey area, the program was dominated by seismic and magnetic profiling at 7.5 knots, and swath-mapping of the sea floor. Considerable down time, caused by failures of the seismic compressor, led to seismic time being expanded from 10 to 14.5 days to carry out the necessary program (3090 km of data were recorded), and to a corresponding decrease in sampling time. Depletion of compressor spares stopped the program twice, leading to resupply activities from land: one by fishing boat and one by aeroplane. During the down time, swath-mapping and sampling at 13 stations (all but one were dredges) were carried out. The last 4.5 days in the area was to be devoted to dredging and coring but, after one more dredge, a hydraulic leak prevented all further use of the ship's winches and no more samples could be taken. After some further swath-mapping, the work was terminated and course set for Nouméa. Finally, twenty rather than twenty-two days were used for work in the study area.

Geophysical results

The equipment used on the geophysical leg is listed in Appendix 1, and a summary of data acquired is given in Table 2. The 16 new seismic profiles, located in Figures 1 and 2, and summarised in Table 3, were acquired at an average speed (while actually profiling) of 13 km/hour or 7.5 knots, with a 550 m cable (300 m active section). The profiles were processed aboard ship and proved to be of good quality, with penetration of as much as 3 seconds two-way-time (~ 4 km). 3090 km of seismic data were acquired in 14.5 days, rather than the hoped-for 11 days, because of problems with the compressor. There were two major periods of down time, during which swath-mapping and dredging went ahead. The magnetometer generally performed well, despite an occasional intermittent fault.

Shipboard analysis of the seismic sections showed that both the North and the South Kenn Plateaus are made up of several faulted and dissected blocks, generally trending northeast. A main NNE-trending tectonic lineament, interpreted as a major strike-slip fault, probably offsets eastern and western parts of the two plateaus. Both the North and South Plateaus underwent regional events such as rifting, with a rift-valley sequence overlain by post Late Paleocene deposits from the post-breakup phase, volcanism of likely Eocene-Oligocene age, and plateau subsidence.

Three main sedimentary sequences were established on board but their dating will have to be confirmed by further analysis on land. The two shallower ones were dated by correlation to DSDP Site 208 on the Lord Howe Rise. The sedimentary succession is (from youngest to oldest sediments):

- Seismic Unit I postdates the Upper Eocene - Upper Oligocene regional unconformity. It is characterised by low amplitude and continuity reflectors, and is continuous throughout the whole study area. Its thickness is relatively consistent and averages 0.6 s (twt).

- Seismic Unit II is variable in thickness, probably due to the uplift and erosion of high-standing features as a result of Middle to Late Eocene compressive events documented in New Caledonia. In the basins, Unit II is more consistent in thickness, averaging 0.3 s (twt) and is believed to include Late Paleocene to Late Eocene section.

- Seismic Unit III overlies acoustic basement and is topped by a strong reflector. It is characterised by strong and continuous seismic reflectors, and thickens toward the central feature of the surveyed area, the ENE-trending Observatory Basin, where it reaches a maximum of 1.2 s (twt). Sills and lava flows are present. On the basis of known regional tectonic history, the seismic sequence is thought to represent a rift phase between the Upper Cretaceous and the Paleocene, developed during Late Cretaceous rifting of the eastern Australian continental margin.

The Simrad EM300 swath-mapper behaved as it had on the Bremer Voyage SS03/2004 earlier in the year, giving useable data that were processed aboard using the Neptune system, to a standard that allowed us to plan dredge sites well. It operated from Sydney until the end of the Kenn Plateau survey, but not for the eastern part of the run to Nouméa. A detailed survey of the northwest margin of the plateau was carried out during seismic down time and after the ship's winches failed, and a detailed survey of potential dredge and core sites on the northern margin was carried out after the winch failure. The survey acquired 7584 km of swath data, 6753 km of which were processed on board. This provided high resolution bathymetric coverage in an area that was previously poorly known.

The new and pre-existing seismic data and our swath data were all used in planning the sampling program, which was aimed at providing a stratigraphic framework (and rocks for a variety of analytical purposes) for an assessment of basin development and geological history.

Geological results

The consolidated sampling results are given in Table 4. All dredge locations are shown in Figures 1 and 2. The sampling program was reduced by the extra time spent acquiring seismic data. It then was catastrophically reduced as the final sampling program, expected to yield a dozen key dredges and half a dozen key cores, was cut short by four days because of a hydraulic leak that made all winches inoperable. In the end, only 12 dredges of a planned 40 were taken, and no cores.

The dredge material was studied aboard ship in hand specimen, with the aid of sawn material. It was then sorted into various groups (lithotypes) for each dredge haul before specialist sampling began. For each dredge, each group was assigned a letter, and individual samples were given a numerical suffix; further subsamples were designated by another numerical suffix. Thus a typical designation for Survey 270 for the first subsample from the second sampled rock in group A, from dredge 2, might be 270/2/DR02/A2.1. The '2' before DR indicates that this was the second station (dredge, core or grab) occupied on the voyage.

Of the 12 dredges attempted, all returned sediments or rocks (see Table 4). The dredging program was concentrated on the northwestern and southwestern margins. Five dredges on the Kenn Plateau northwest margin, and one on the facing Marion Plateau margin, recovered well-lithified chalk from water depths of 2700-3300 m. Less consolidated chalks and calcareous oozes were also recovered from these stations. Two dredges were in deep water on the southwest margin: one, from a depth of 4000 m, contained calcareous claystone and the other ironstone breccia. Four dredges were on seamounts: one recovered hyaloclastite breccia, and the other three recovered reefal shallow water limestone.

Voyage Narrative

The conversion of the Southern Surveyor from a fisheries configuration to a geoscience configuration took place in Sydney from 31 April to 2 May. This included the installation of the large seismic winch, the hydraulic core cradle and the compressor by Geoscience Australia's technical team. The scientific contingent arrived on 1-2 May. The vessel sailed from Sydney at 1000 local time on Monday 3 May (Julian Day 124 at 0000: 10 hours behind local time of 1000) in good conditions, and headed north up the New South Wales coast. The Simrad EM 300 swath-mapping system functioned satisfactorily in shallow water. The bridge agreed to warn the operations room if a whale were sighted ahead, so that the swath mapper could then be turned off in accordance with EPBC requirements.

From 1530 on May 3 the seismic cable and the new airgun deployment system were deployed and tested, and a problem was identified with the airgun deployment system. Both airgun system and seismic cable were recovered by 1815, and further testing was deferred. Swath-mapping continued on the transit northward. At 2000 the vessel was at 33°20'S, 152°E on a course of 042°. Speed was 9.5 knots despite running into the south-flowing East Australian Current of 2.5 knots. Until 0900 on 4 May, swath-mapping continued on the transit to the north at speeds of 9.5 to 10.5 knots.

From 0900 to 1630 on 4 May, the seismic equipment had been deployed and tested while the ship continued its course to the north in very good conditions, largely at 7.5 knots. The airgun array was deployed satisfactorily, with a failed wire cable replaced with high-tensile chain. Each gun was tested separately so that acoustic output was well below the level that triggers EPBC regulations. No whales were seen. The seismic cable was also deployed and ran satisfactorily at about 8-10 m depth. The various components of the seismic acquisition system were tweaked until everything was working properly, and 50 good shots from a single gun were recorded for experimental processing.

On 5 May, swath-mapping continued to the north in excellent conditions, but the ship was slowed by the East Australian Current. We ascertained that the seismic acquisition was satisfactory and that data could be read off the trial tape. However, it took time to get the new seismic processing system properly set up. Another problem was that the magnetometer developed an intermittent fault, which was eventually overcome later.

At 0400 of 6 May we started seismic profiling on Line 1, running north to the far southeastern corner of the Marion Plateau. Compressor problems were common during all our seismic acquisition, so production was not what we had hoped for. A whale watching routine was in place. The 135 km of Line 1 was completed at 0400 on 7 May. The swath-mapping data were of useful quality, although noisy, and on-board processing had started. A humpback whale was seen during one period of downtime. Line 2, about 55 km long and running eastward, was completed in the middle of the Cato Trough at 0800. Line 3 to the NNE, 350 km long, and passing west of Cato Reef and crossing Coriolis Bank, was started at 1515 on 7 May and was completed at 0332 on 9 May. Data quality was good in the first three lines, with processing showing penetration of up to three seconds (twt).

Seismic Line 4 to the southeast, 150 km long, started at 0405 on 9 May and was completed at 2028. Line 5 to the southwest, 390 km long, started at 2118 and was completed at 0857 on 11 May at Fraser Seamount, which is a guyot whose flat top was measured to be 377 m below sea level. At 1001 we started Line 6 to the SE, 110 km long, on the abyssal plain just south of Kenn Plateau and completed it at 1726. While we were turning onto long Line 7 to the NE, two leaks were identified in the fourth stage heat exchanger on the compressor, and major repairs started. We recovered the seismic gear and magnetometer and headed toward Dredge Site 1 on the southern margin of Kenn Plateau.

The equipment was in the water for Dredge 1 at 2246 on May 11. Recovery from 4000 m was of calcareous claystone. Dredge 2, some 17 km to the east, recovered hard breccia of sandstone set in ironstone, plus manganese crusts, from 2800 m.

Once the compressor was fixed, we headed back to the start of the 290 km long Line 7 to the northeast and were shooting again at 1548. We did not deploy the magnetometer. Line 7 was completed at 1342 on May 13. During a loop for compressor checks before starting Line 8, several whales were sighted heading northwest on a reciprocal course while we were not shooting. At 1442 we started the 90 km long Line 8 to the southeast, which we finished at 2106. At 2215 we started on the 285 km long Line 9 to the SW, and it was completed at 0342 on May 15.

We started the 110 km Line 10 to the ENE at 0433 on May 15 and completed it at 1410. The 410 km long Line 11 to the northwest started at 1247, and stopped at 1433 to pull gear in preparation for bringing aboard compressor parts coming from Bundaberg by fishing boat. We rendezvoused with the fishing boat at 1645. We were shooting again on Line 11 at 2000 but stopped because a critical compressor part failed at 1508 on May 16, with about 260 km of data acquired.

At 1726 on May 16, we headed toward Dredge 3 on the western corner of Kenn Plateau. Dredge 3 recovered chalk and calcareous ooze from 3280 m. Dredges 4 and 5 and Grab 1 were all on Fraser Seamount, south of western Kenn Plateau. Dredge 4 recovered reefal biostromal limestone from 450 m depth, Dredge 5 recovered basaltic hyaloclastite breccia from 1600 m depth, and Grab GR1 recovered a handful of biogenic sand and gravel from the seamount top in 390 m depth.

At 1230 on May 17 we headed north for a swath survey of the foot of the slope (~3000 m depth) of the northwest margin of Kenn Plateau, trailing the magnetometer. We mapped a number of steep slopes and small canyons that are suitable dredge targets. At 0813 on May 18, at 21°39.9'S, 155°36.9'E we turned onto the reciprocal course to the southwest. Dredge 6 recovered foraminiferal limestone, chalk and calcareous ooze from 2800 m in a canyon. Dredge 7, on a steep slope further south, recovered foraminiferal chalk, semi-lithified chalk, and calcareous ooze from 2700 m on May 18.

We then continued swath mapping southward on the northwest margin of the plateau, before crossing to and surveying the area of Dredge 8 on the southeast Marion Plateau. The successful drop of a compressor valve by air occurred at 1000 on May 19. Dredge 8, on a steep slope, recovered foram nanno chalk and foram nanno claystone from 3050 m. Dredge 9, on a steep slope on the western corner of Kenn Plateau recovered highly lithified and weakly lithified chalk from 3200 m. Dredge 10, on a very steep slope on the northwest margin of Kenn Plateau recovered highly lithified and weakly lithified chalk from 3100 m, early on May 20. Dredge 11 was taken on the flank of a satellite guyot to Cato Island whose flat top is at 450 m. The dredge recovered reefal framework limestone from 1000-800 m. The base of the limestone is at ~1100 m on seismic profile evidence. This was the end of this round of sampling.

At 0920 on May 20 we headed southeast toward the restart point on seismic Line 11. The seismic gear and magnetometer were deployed from 1215, and shooting to the northwest commenced at 1430. The remaining 210 km of Line 11, to the northwest across the Cato Trough to the southeast corner on Marion Plateau, was completed at 0150 on May 21. We started the 115 km Line 12, to the ENE back across the Cato Trough toward the Kenn Plateau, at 0255 and completed it at 1151. The 70 km Line 13A to the ESE back across the Kenn Plateau margin started at 1248 and was completed at 1800. We went straight into the 55 km Line 13B to the SSE across the Kenn Plateau at 1800 and completed it at 2146. The 40 km Line 13C to the SE started at 2309 and was completed at 0234 on May 22.

Time constraints meant that we had to cut off the eastern ends of the planned lines 13 and 15, and accordingly we designed a new Line 14 to the ENE for this purpose. This 90 km line was started at 0325 on May 22 and completed at 0949. The 240 km Line 15 to the NW started at 1041 and was completed in the Cato Basin at 0535 on May 23. The 90 km Line 16 to the NE started at 0807 and ended on the Chesterfield Rise at 1350. This ended the seismic program. Productivity of 290 km/day on the second seismic leg was far better than the 210 km/day on the first leg. Overall, we had recorded 3090 km of seismic data, roughly what we had planned.

By 1520, we were heading WSW at 10 knots toward Kenn Reef. Dredge 12, on a very steep slope on the eastern flank of Kenn Seamount recovered unweathered calcarenite from 1900 m depth. It was on deck at 2000, and it was discovered that a hydraulic leak in the pipe work on deck was serious. We headed SSE toward the next dredge station while the engineers studied the problem. It was then realised that the hydraulic leak could not be fixed at sea and had put all winches out of action for this voyage. It seemed possible that some of the dredge sites could be picked up on the Mellish Rise voyage late this year. Accordingly, we swath-mapped the potential basement dredge sites on the northern margin of Coriolis Ridge, while we tried to find a way of deploying the seismic gear without the disabled winches. This proved to be impossible because of safety concerns, so we decided to run a swath line right down the northwest margin of Kenn Plateau to southwest of Cato Island. This was completed at 0800 on May 25, and then we headed east across three potential basement dredge sites on the way to Noumea.

CSIRO staff and the ship's personnel carried out a series of acoustic tests, at different speeds and with various pieces of ship's equipment on and off, with the swath-mapper turned off but recording noise, between 1400 and 1600 on May 26. These suggested that the 28 kHz echosounder on the bridge could be interfering with the 30 kHz Simrad EM300 swath-mapper. Tests were then run with swath-mapper on, and bridge echosounder on and off, which further suggested that the previous performance of the swath-mapper was in part related to interference from the bridge echosounder. In particular, the major problem of central area mismatch (amplitude results different from phase) vanished with the bridge sounder off.

We berthed in Noumea at night on Thursday June 27, two days early, allowing three days for winch repairs before the next voyage was due to depart on Monday June 31.

Summary

In general, we met the scientific objective of this voyage in improving our understanding of the geological evolution and modern environmental setting of the poorly known Kenn Plateau off northeast Australia. The voyage was an overall success, but the sampling program was greatly curtailed for two reasons: problems with the Geoscience Australia seismic compressor increased the amount of seismic time needed, and the ship's winches failed with 4 sampling days to go.

As Chief Scientist for the Mellish Rise voyage scheduled for November-December 2004, I gratefully accepted the offer of an additional two days' ship time to allow some key Kenn Plateau dredges to be taken. This will enable us to meet all our pre-voyage objectives, albeit late.

The RV *Southern Surveyor's* acquisition program can be summarised as:

- Successful seismic program with 3090 km of high-quality seismic data collected.
- Successful swath-mapping program with 7584 km of bathymetric data using the SIMRAD EM 300 multibeam sonar system.
- Only 12 dredge hauls and one grab were obtained.

The seismic results will enable us to greatly improve our geological understanding of this very poorly known part of Australia's marine jurisdiction. The swath mapping results will improve existing bathymetric maps and also our understanding of sedimentary processes on the plateau margins. The sampling results will allow us to start to build up a reliable geological history of this region. This survey recovered the first ancient rocks from this large frontier offshore region.

The performance of the vessel and equipment was generally good. The entire ship's crew performed very well, being professional, helpful and courteous. The CSIRO support technicians did everything that could be expected of them. Steve Thomas was an excellent voyage manager, always looking for and finding ways to help the Geoscience Australia science contingent in their work.

Personnel

Scientific Participants

Neville Exon	GA	Chief Scientist
Peter Hill	GA	Senior Geophysicist
Alix Post	GA	geologist
Georgina Burch	GA	geologist
Yves Lafoy	New Caledonian	geologist
Christian Heine	Sydney University	geologist
Lydia Taylor	Sydney University	geophysicist
Jon Stratton	GA	science technician
Petar Vujovic	GA	geophysical technician
Craig Wintle	GA	mechanical technician
Franz Villagran	GA	electronic technician
Stephen Thomas	National Facility	electronics & Voyage Manager
Bernadette Heaney	National Facility	computing

Marine Crew

Ian Taylor	Master
Arthur Staron	Chief Officer
Tim Sharpe	2nd Officer
John Morton	Chief Engineer
David Jonker	1st Engineer
Seamus Elder	Electrical Engineer
Tony Hearne	Bosun
Graham McDougall	Integrated Rating
Bruce Noble	Integrated Rating
Fiona Perry	Integrated Rating
Philip French	Greaser
Andrew Goss	Chief Cook
Allan Sessions	Second Cook
David Willcox	Chief Steward

Acknowledgements

We thank the National Facility Science Advisory Committee and Steering Committee for granting us ship time on the Southern Surveyor. We are very grateful to the Master, Ian Taylor, the Mates, Arthur Staron and Tim Sharpe, the engineers led by John Morton, and all the P&O marine crew for their wholehearted support and professional seamanship throughout the voyage, and to the engineers for their support during our struggles with the recalcitrant compressor. The deck crew, led by bosun Tony Hearne, were efficient and helpful at all times. The excellent food helped keep spirits up. We thank the CSIRO Marine Division staff of Steve Thomas and Bernadette Heaney for ensuring that all the necessary scientific support was provided. The Geoscience Australia technical group did an excellent job.

Neville Exon
Chief Scientist

Table 1

Transit way points on swath survey to study area

Way point	Latitude (S)	Longitude (E)
1	33°48.50′	151°25.75′
2	33°15.50′	152°27.00′
3	33°09.50′	152°40.50′
4	32°48.00′	153°01.00′
5	32°27.50′	153°08.50′
6	31°51.00′	153°20.00′
7	31°40.00′	153°22.50′
8	31°01.75′	153°28.00′
9	30°50.75′	153°26.75′
10	30°10.50′	153°35.00′
11	29°37.00′	153°49.50′
12	29°15.50′	153°56.00′
13	28°21.00′	153°56.50′
14	28°06.50′	154°03.00′
15	27°29.92′	154°00.48′
16	26°45.09′	153°48.61′
17	26°07.78′	154°03.60′
18	24°53.33′	154°40.44′

Table 2

Summary of data and samples gathered

Data type	Results
Seismic profiles	3090 km of 24 channel (3 fold) data
Magnetic profiles	~ 2000 km
Multibeam sonar lines	7584 km of swath data
Bathymetric profiles	~ 8500 km
Dredges	12 dredge hauls
Grabs	1 grab

Table 3

Seismic line statistics

Line S270/	Direction	Start WP (lat S/long E)	End WP (lat/long)	Length (km)
1	north	24°53.3′S, 154°40.4′E	23°43.5′S, 154°27.0′E	132
2	east	23°43.5′S, 154°27.0′E	23°43.5′S, 154°59.0′E	55
3	northeast	23°43.5′S, 154°59.0′E	21°05.0′S, 156°53.3′E	351
4	southeast	21°05.0′S, 156°53.3′E	21°52.9′S, 157°36.0′E	152
5	southwest	21°52.9′S, 157°36.0′E	24°25.8′S, 155°17.6′E	390
6	southeast	24°25.8′S, 155°17.6′E	25°02.8′S, 156°03.8′E	104
7	northeast	25°02.8′S, 156°03.8′E	23°05.3′S, 157°55.3′E	292
8	southeast	23°05.3′S, 157°55.3′E	23°43.1′S, 158°27.3′E	90
9	southwest	23°43.1′S, 158°27.3′E	25°32.0′S, 156°30.4′E	285
10	east	25°32.0′S, 156°30.4′E	25°14.4′S, 157°31.2′E	109
11	northwest	25°14.4′S, 157°31.2′E	22°47.4′S, 154°27.6′E	414
12	east	22°47.4′S, 154°27.6′E	22°29.9′S, 155°31.2′E	116
13	southeast	22°29.9′S, 155°31.2′E	23°30.6′S, 156°39.6′E	168
14	east	23°30.6′S, 156°39.6′E	23°11.8′S, 157°27.3′E	90
15	northwest	23°11.8′S, 157°27.3′E	21°41.9′S, 155°41.0′E	244
16	northeast	21°41.9′S, 155°41.0′E	21°01.8′S, 156°17.8′E	98

Total = 3090 km

Table 4

Dredges and grab

Station/ Dredge	Latitude (S) Longitude (E)	Location	Depth (m)	Recov. (kg)*	Description	Seismic Line
01/DR1	24°47.8′ 156°08.6′	SE Kenn	4000	10	Calcareous claystone	BMR 15/37
02/DR2	24°46.8′ 156°19.8′	SE Kenn	2800	10	Breccia of sandstone in ironstone, with thick Mn crust	GA 270/7
03/DR3	23°49.4′ 155°20.5′	W Kenn	3280	30	Chalk, calcareous ooze	BMR 12/23
04/DR4	24°24.8′ 155°18.5′	Fraser Seamount	450	4	Reefal biostromal limestone	GA 270/5
05/GR1	24°25.01′ 155°17.98′	Fraser Seamount	390	handful	Biogenic sand and gravel	GA 270/5
06/DR5	24°29.1′ 155°16.6′	Fraser Seamount	1600	5	Basaltic hyaloclastite breccia	GA 270/5
07/DR6	21°49.6′ 155°48.0′	NW Kenn canyon	2800	20	Pelagic foraminiferal limestone, chalk, calcareous ooze	BMR 13/42
08/DR7	22°09.5′ 155°47.9′	NW Kenn slope	2700	50	Pelagic foraminiferal chalk, semi-lithified chalk, calcareous ooze	BMR 13/40
09/DR8	23°29.6′ 154°50.1′	SE Marion slope	3050	80	Foram nanno chalk, foram nanno claystone, calcareous ooze	BMR 13/29
10/DR9	23°27.7′ 155°02.4′ 23°28.4′ 155°02.6′	W Kenn slope	3300-3100	100	Highly and weakly lithified foram nanno chalk, yellow claystone, calcareous ooze	BMR 13/29
11/DR10	22°51.3′ 155°20.4′	W Kenn slope	3100	5	Highly and weakly lithified foram nanno chalk, calcareous ooze	BMR 13/35
12/DR11	23°11.35′ 155°23.0′	Cato satellite guyot	1000-800	10	Reefal framework limestone	GA 270/3
13/DR12	21°68.8′ 155°53.3′	Kenn reef east slope	1900	8	Calcarenite (packstone)	BMR 13/46

* Only lithified material considered

Appendix 1: Key equipment

- *Kongsberg-Simrad EM 300* multibeam sonar swath-mapper
- Scientific echosounder (12 kHz)
- *Charge-Air* DC330/2000 diesel compressor of 2000 psi capacity for airguns
- 2 x GI airguns, each of capacity 45/105 cubic inches
- Seismic winch
- *Stealtharray* solid seismic cable 550 m long, with 300 m active section and 24 channels
- *Stratavisor* seismic acquisition system
- Seismic processing work station
- Plotter for seismic profiles and sampling locations
- MMC *Seaspy Overhauser* magnetometer and towing winch
- Gravity corer, 1 tonne, for 4-6m cores
- Dredges, chain bag and pipe
- Ship's winches and deck machinery
- Coring cradle
- DGPS navigation