MARINE
NATIONAL FACILITY

2006 program

RV Southern Surveyor

CSIRO

voyagesummarySS02/2006

SS02/2006

Geological and biological investigations of the Murray Canyons Group "AUSCAN 2006 and PALAEO-MURRAYS"

Itinerary

Depart: Port Lincoln, 1000hrs Wednesday 1 March, 2006
Arrive: Hobart, 0800hrs Wednesday 15 March, 2006

Principal Investigator

Professor Patrick De Deckker (Chief Scientist) – Department of Earth and Marine Sciences, The Australian National University, Canberra ACT 0200
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Scientific Objectives

There were 2 principal areas of investigations, plus 2 minor ones:

1. To study large holes that were found during the AUSCAN 2003 voyage offshore the Murray Canyons Group offshore Kangaroo Island. These holes occur along possible tectonic lineaments from depths between 4,500 and 5,500 m. Water samples (for water chemistry and microbiology) and short cores will be taken in some of the holes in an attempt to determine their mode of formation.

2. To determine, by means of swath mapping and sub-bottom profiling, the location of several of the ancient meanders of the River Murray that would have been formed during periods of low sea level on the very broad Lacepede Shelf. An attempt will be made to link the meanders with the heads of the various canyons of the Murray Canyons Group, and determine if 'erosion' is currently active at those locations. Short cores will be taken on the Lacepede Shelf in an attempt to find a high-resolution Holocene record of fluvial outwash of the Murray. CTD measurements will be taken along some of the meanders to determine whether they act as conduits of continental fresh waters.

3. To follow and map in several places, the low sea-level stand that occurred 20,000 years ago and dredge wherever possible suitable material for dating and geochemical analysis.

Voyage Objectives

Firstly, from Port Lincoln to station 10, we will track ancient river meanders in the southern end of both Spencer Gulf and Gulf St Vincent (Investigator Strait) as well as follow the 120-125 m contour line to identify the nature of the last glacial maximum low-sea level stand.

Secondly, we will travel over the du Couëdic Canyon, from the head down to the abyss, the same is planned for the Sprigg Canyon. Once the deeply-located holes have been swath-mapped in parallel with data on their sub-bottom profiles, water samples and short cores will be taken in 4 selected holes. These investigations will be performed between stations 11 and 29. A core is to be taken at the site (MD2611) where a core was taken in 2003 during the AUSAN voyage.

During the rest of the voyage, the Lacepede Shelf will be mapped using the sub-bottom profiling system and the swath mapper to determine the location of ancient meanders of the River Murray and the Onkaparinga River. Once this is achieved, the locations of transects near the mouth of the River Murray will be determined and shallow cores, grab and CTD samples will be taken.

Following from these investigations we will attempt to follow the 125m contour line and pass over the heads of several canyons, including the Bridgeport Canyon. At one station, located at 1000m, we will attempt to track the canyon that should occur offshore the Glenelg River, which is thought to have been an ancient course of the River Murray. Upon reaching the 50m contour line, the ship is to proceed to Hobart where the voyage will end.

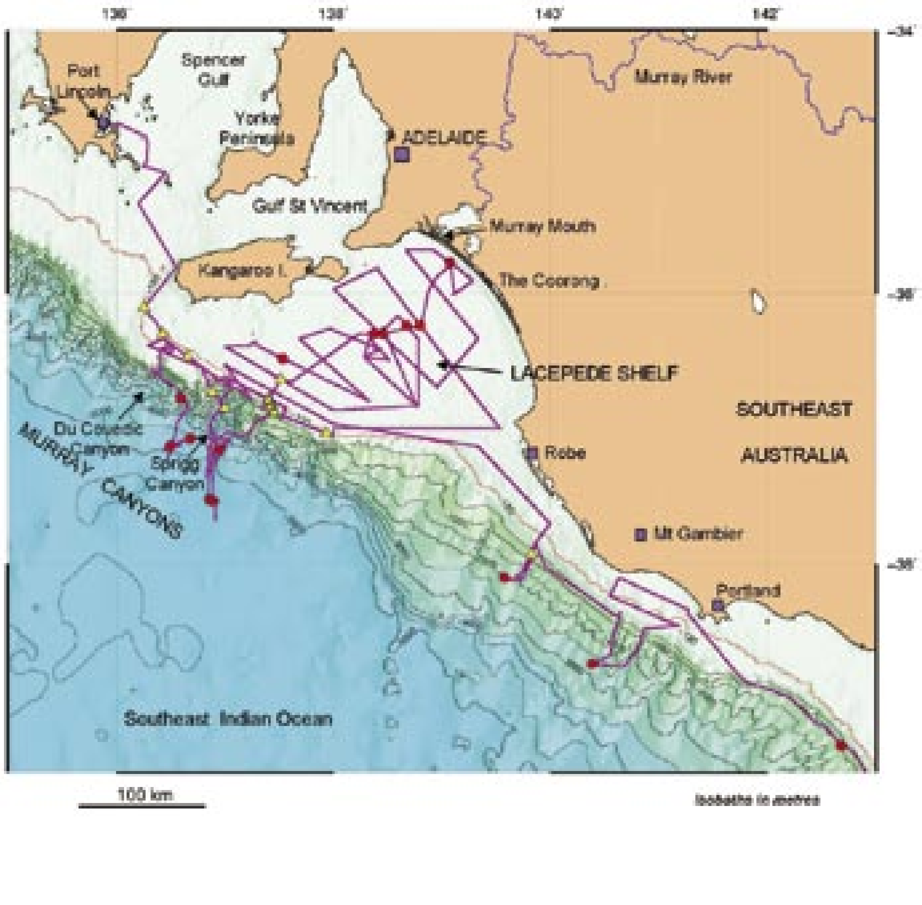

Figure 1 shows survey lines (Topas PS18 sub-bottom profiler/EM300 swath) and geological sampling sites of voyage SS02/2006. Red dots denote gravity core stations and yellow triangles indicate dredge sites. The -120 m isobath (in red) represents the palaeo-shoreline at the Last Glacial Maximum about 20,000 [calibrated] years ago. Map prepared by Peter Hill. It is obvious that the numerous transects over the Lacepede Shelf have helped us delineate the position of an ancient lake deposit in the middle of the Shelf [for more information, see text below].

Results

We met most of the objectives of the voyage.

1. We completed the mapping of some of the canyons that was commenced during the AUSTREA AND AUSCAN voyages on the *L'Atalante* and *Marion Dufresne* vessels in 1999/2001 and 2003 respectively.

2. We are now able to produce a high-resolution map of the Sprigg Canyon. We have identified that some of the conduits [channels] of the Sprigg Canyon are definitely used for transporting upper slope material downwards. Additional investigations will be carried out in the laboratory at the ANU. Thanks especially to Michele Spinoccia for his superb support with matters dealing with swath mapping. He worked very hard to make sure our data would be of top quality.

3. We found, by attempting to core the large, deep holes located at great depths [> 4.5km] below the canyons that they are not sites of substantial sedimentation. In addition, we did not find any hydrochemical anomaly that could have been generated by fluid/gas emission, although we were not able to rest the CTD equipment on the floor of the holes.

4. We located the position of ancient courses of the Murray across the Lacepede Shelf and discovered the presence of a large lake that would have been dammed by outcrops and possibly a large dune field. A map of the extent of the lake and associated prodelta, dune fields and various courses of the river system was completed. Unfortunately, we did not manage to retrieve cores from the Lacepede Shelf that would help us confirm our discovery as a thin, hard layer consisting of medium fine, brown sand covered the entire Lacepede Shelf. We anticipate that the lake occurred at approximately the 60m isobath.

5. We could only trace the ancient courses of the River Murray for the last glacial-interglacial period. No evidence was found for much older geomorphic features, we assume either that they were eroded away or that the sub-bottom profiling equipment did not permit us to penetrate deeper into the sedimentary sequences. However, in most cases, recognised fluvial features did sit directly on the basement.

6. We found evidence of an ancient drainage system on the shelf opposite the Glenelg River that deserves further investigations.

7. I used my air filtering apparatus at the bow of the vessel and, hopefully, I will have collected sufficient material for microbiological analysis.

8. We obtained good CTD data down to great depths in the canyons and these will prove very useful for future research on deep water.

Voyage Narrative

1 MARCH 2006 Departed from Port Lincoln at 1000hrs.

The day before we left Port Lincoln much time was spent (by Craig Wintle of Geoscience Australia and Nigel Craddy of ANU) installing the coring gear on the rear deck of the ship, and this allowed us to depart earlier than planned.

We sailed past Thistle Island and then to the west of Gambier Islands. Eventually, we turned southwest towards Neptune Island, veered towards Cape Borda at the eastern tip of Kangaroo Island and remained in shallow water at a depth of around 30 metres. We had to change course because of the presence of lobster pots.

By 1400hrs, local time, I installed the first aerosol filter container at the bow of the ship. We noted also that salinity reached high values up to 36.11 due to the high evaporation rates in the region.

We saw on the display of the Topas sub-bottom profiler (an important instrument that will play a significant role during the entire voyage) channels between Thistle and Gambier Islands. These must have formed during periods of low sea levels, a feature characteristic of the Quaternary Era that spanned approximately the last 2 million years of the geological history. The first dredge located near 36° 05'S 136° 15'E returned soft sponges and small bryozoans, just like the Baudin expedition did some 200 years ago. A second dredge was taken at a depth of 120 metres and this time we collected a colonial coral about 20 cm across which we think may have grown about 20,000 years ago at the time of the last glacial maximum. Its chemistry and exact date may prove important for palaeoenvironmental reconstruction of the glacial period. In the same dredge we collected large beach-rock type slabs and many sponges as well as ascidians. We also preserved 3 different types of echinoderms.

2 MARCH 2006

In the middle of the night we attempted coring the sediments at the site where we obtained a suitable core with the Marion Dufresne in 2003 (core MD 2611), but due to winch problems we did not reach the sea floor. While this was being rectified, we directed the ship to another site nearby and thus we obtained our first gravity core GC1 which was 377 cm long. It appears that the upper part of the corer consisting of the 1 tonne weight (which we call the 'bomb') may have over-penetrated the sea floor as we found some mud stuck to it.

We also towed a plankton net for 5 minutes with the ship moving at 1 knot and after that headed towards the deep holes and decided to take a CTD down to a depth of 5,100 m. We eventually took a second core GC2. This was obtained during the night into the early morning of 3 March.

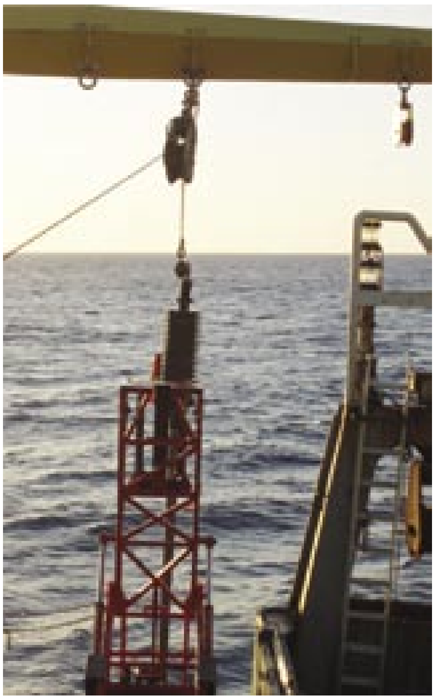

Figure 2: Photograph showing the corer with its heavy weight in the process of being lowered down to the sea floor. The corer was on loan from Geoscience Australia.

3 MARCH 2006

Core GC2 was obtained at a depth of 5,078m. The following core GC 3 was taken in order to determine the nature of the floor of one of the deep holes and we only recovered 58 cm at a depth of 4,630m. It is likely that the sea floor was very hard at this location and the material recovered on the outside of the core barrel was green leading us to believe that the sediment is made of glauconite; this will have to be verified in the laboratory at the ANU.

We took another CTD in order to determine the nature of the water column in the region with respect to metals and nutrients, simply because of the paucity of information for this part of the ocean. The depth reached with the CTD was 5219.5m, being perhaps the deepest CTD ever taken with the Southern Surveyor.

4 MARCH 2006

During the night we eventually obtained a core that was 69 cm long and it contained much sandy material. The pipe dredge we used at this site returned sediments on both occasions. The second pipe dredge contained a mixture of sediments, some fairly well consolidated and others very soft. Both dredges contained the remains of pteropods (pelagic carnivorous molluscs closely allied to gastropods) which have an aragonitic skeleton. Since aragonite should be dissolved at such great depths, we interpret the presence of the shells in the sediment to be the result of turbiditic flows, and their rapid burial prevented their dissolution from aggressive CO2-enriched waters. This observation finally answers one important question about the nature of the canyons: they are definitely conduits of sedimentary flow of material down-slope.

After this, we reached shallower waters and sailed for the head of the Sprigg Canyon.

5 MARCH 2006

We completed a successful dredge of the sea floor and recovered several slabs of beach rock material, with one block yielding a large specimen of the foraminifer resembling *Marginopora* which is a warm water, benthic foraminifer that lives in shallow water as it hosts photosymbionts in its test. It will be interesting to correctly identify the nature of this foram to also obtain an age for it as this will have implication for the timing of warm water reaching this area.

Figure 3: Photograph showing the corer that is on the rear deck and people are extracting tube full of sediments from the inside of the canyons. On left is Dan Wilkins holding one section of the core, in middle is Patrick De Deckker and to the right is Nigel Craddy, all of ANU. The sediments, once analysed, will tell the story of changes that occurred in the canyon and also about discharges of the River Murray through time.

During the morning, we sailed northwards past the Sprigg Canyon and discovered a prodelta at approximately 130m water depth. We also recognised evidence of neotectonism with small escarpments in many places in shallow depths on the Lacepede Shelf. Interesting also is that our plankton tow in this region returned less plankton in our jar than those samples taken over greater depths. A subsequent pipe dredge around 120m water depth did not return any rocks for the first time.

Late in the evening, we noticed that both sea-surface and air temperatures had dropped by the order of 2 degrees, and we attributed this to local upwelling. We then sailed towards the coast and could see the lights in the vicinity of Kingston.

6 MARCH 2006

We have been swath mapping the sea floor for the entire night and this continued for another 24 hours. The purpose of this work is to determine the location of the ancient courses of the River Murray. We only found one large set of channels in the line parallel to the Coorong Lagoon. This was a surprise. We also sailed along a line south of Backstairs Passage and failed to find any evidence of a channel on the sea floor there. Our interpretation at this stage is that the present strong currents experienced in this Passage have only occurred since the late Holocene, and it is likely that during lower sea levels, the waters of the Onkaparinga River must have flowed along the northern end of Kangaroo Island. After this we travelled south of the eastern corner of Kangaroo Island (False Cape) and we headed south east and witnessed the large sand banks to the west of the Tide Race. Once again, salinity increased significantly due to local evaporation and the area being more isolated than for the waters above the canyons. The upper salinity reading gave a value of 36.419 and temperature reached 19.981. Surprisingly, air temperature was 3 degrees lower.

Soon after this, during the afternoon, we discovered sediment layering on the sea floor reminiscent of a large lacustrine deposit. After quite a lot of swath mapping, we realised that the ancient lake may have been quite extensive, perhaps reaching 30 km across. As a result of this discovery we revised our voyage track to criss-cross the ancient lake to determine its periphery and identify suitable core sites. We decided therefore to continue swath mapping and sub-bottom profiling to also determine the connections between the lake and the ancient courses of the River Murray. The lengthy process of mapping continued well into the night.

7 MARCH 2006

Overall, a disappointing day. At first, we took a core near the mouth of the modern River Murray and we obtained a 210cm long core. Much of the material appears to belong to an estuarine facies that overlays a red, fine grained sand with some obvious mottling. This is where our luck stopped as we were unable to obtain any suitable cores thereafter. Most core barrels returned only a few spoonfuls of red sediment in the core catcher. We also tried two dredges using pipe dredges and they returned the same red sand and no rocks and few organisms. Only once did we recover small slabs of 'beach rock' heavily burrowed by either sponges or bivalve molluscs.

It appears that the entire northern end of the Lacepede Plain was covered with a sand sheet that was very uniform in thickness. This 'sand cover' is impenetrable with the coring device we have on board.

8 and 9 MARCH 2006

We attempted one core in the morning of the 8th but no recovery. The swath mapping exercise as well as the sub-bottom profiling continued in search of suitable coring sites, and with the purpose of mapping the different sedimentary facies so as to prepare a map of the sea floor for before and after the glacial period. Our interpretation is that the lake facies would have developed during the period when the River Murray was experiencing greater flows than today (from 50 to 35 K years BP). In places, the large channels we observed would have belonged to that very wet phase as well. We also noted vast areas of dune fields, having perhaps developed from the deflation of sand from the margins of the large channels, possibly during subsequent dry phases.

One entire afternoon was spent trying to pierce the sandy cover that forms a mantle on the sea floor. We experimented with different barrel types, different speeds of lowering the corer down to the sea floor, with or without using a core catcher, and the result was that we were unable to recover a core. The conclusion is that a vibro-corer is perhaps the only suitable coring method to recover material from the sea floor in the Lacepede Shelf. The other decision we then made was to head to a different area and complete the unfinished work in the canyons area.

10 MARCH 2006

Overnight, we first attempted to dredge the sea floor along the 100m contour where we had observed, a few days earlier, saw-tooth rock formations, in order to determine the nature of the lithologies and their age. Only 2 small fragments of limestone were recovered and have been kept for analysis back in Canberra.

We started dredging down the eastern Sprigg Canyon from 300 to 760m in the hope of recovering corals and live organisms. Unfortunately, all we obtained was soft sediment, no rocks and no live organisms. Nevertheless, we noted that the material recovered became finer with depth as expected, but our conclusion is that the Lacepede Shelf is a very unproductive area, and it is on the shelf edge, at the shelf break, that bryozoans mainly are proliferating, possibly due to the high nutrient availability. It is those organisms that become fragmented and supply carbonates to the upper part of the canyons and that are eventually transported to greater depths, some through turbiditic flows, and the rest through natural down slope transport. This explains why the 2 AUSCAN cores (MD2607 and 2611) that we obtained 3 years ago display high sedimentation rates, perhaps some of the highest registered in the Australian region.

After that, we proceeded to the deeper parts of the Sprigg Canyon to fill the gaps in the data with the eventual purpose of obtaining a core at great depth in order to determine the extent of turbiditic flows down to the abyssal plain and the frequency of those events. During the late evening and early in the morning of the 11th we attempted coring at depth greater than 5,000m and our efforts (mostly long waiting time while lowering and bringing back the corer to the surface) proved fruitless. On both occasions, we got less than 1m of sediment in our core barrel [first core ~80cm and the second ~14cm). The core catcher in the first core contained a coarse sand with sponge spicules, rounded quartz grains, benthic foraminifers and also a piece of wood (~ 1 cm in diameter). This sediment

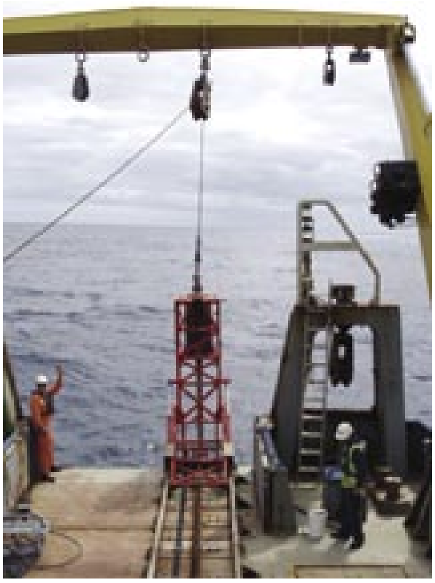

Figure 4: Photograph showing the corer in the process of being returned to the rear deck. On left is the boatswain Tony Hearn and on right is Nigel Craddy of ANU.

is reminiscent of the sandy fraction of a turbiditic sequence. The second core had much, much finer material and was pinkish-grey in colour. Additional observation in the laboratory will inform us on the nature on the material recovered.

We also observed that the sea floor at those depths is still very rugged and the sub-bottom profiler clearly indicates that the sedimentary sequences are flooded as well as faulted; this is perhaps not a surprise for the beginning of the abyssal plain.

11 MARCH 2006

The early morning hours of the day were spent swath mapping several parts of the Sprigg Canyon in order to close up on some of the missing data; this meant quite a bit of zig-zagging, but we now have a good, high resolution cover of this amazing canyon, and we will be producing a final map for display as an important outcome/achievement of our voyage. After that we headed westward once more to make a final W-E transect above the Murray and Sprigg Canyons in order to delineate one of the courses of the Murray. This, we did not find, as the sea floor, as we discovered earlier, is much winnowed by strong bottom currents. These currents must efficiently bring any sediment down to the edge of the shelf before it is transported down slope and in the process becomes finer with depth. We have demonstrated this with our sled dredging a few days earlier.

On our W-E transect towards Robe we crossed the largest set of river channels that must have been some 40m deep at times, with the lowest level in the channel being lower than 130m, thus having ‘ferried’ water below the lowest possible glacial sea level, ignoring any possible tectonic movement. It is possible that this depression registered a record of more than one discharge of the River Murray across different time periods, perhaps from different glacial/interglacial periods. We also witnessed many characteristic karstic features on the sea floor around 60m water depth, with little or no sediment cover over the limestone basement.

We are now heading towards the inner shelf parallel to the coastline from Robe down to Portland.

12 MARCH 2006

We have followed the coastline for a long period of time and have not gone over any evidence of buried channels. We then veered south and followed the course of an unnamed canyon offshore Bridgeport. Once again, we discovered narrow meanders within the upper part of the canyon, indicating that it has been active in recent times. Once we reached the canyon half way down its length, we travelled outside it and took a long core in very soft, fine pelagic muds. We retrieved a 5.78m core which our German student will work on if she finds a suitable scholarship to return to Australia.

After this successful operation, we travelled back up another adjacent canyon to the shelf before heading towards the Glenelg River region where there are 4 unstudied canyons. The purpose is to map at least one or two of them and also determine their antiquity and define whether they are likely candidates for an ancient course of the Murray as postulated by Mike Sandbridge and Malcolm Wallace.

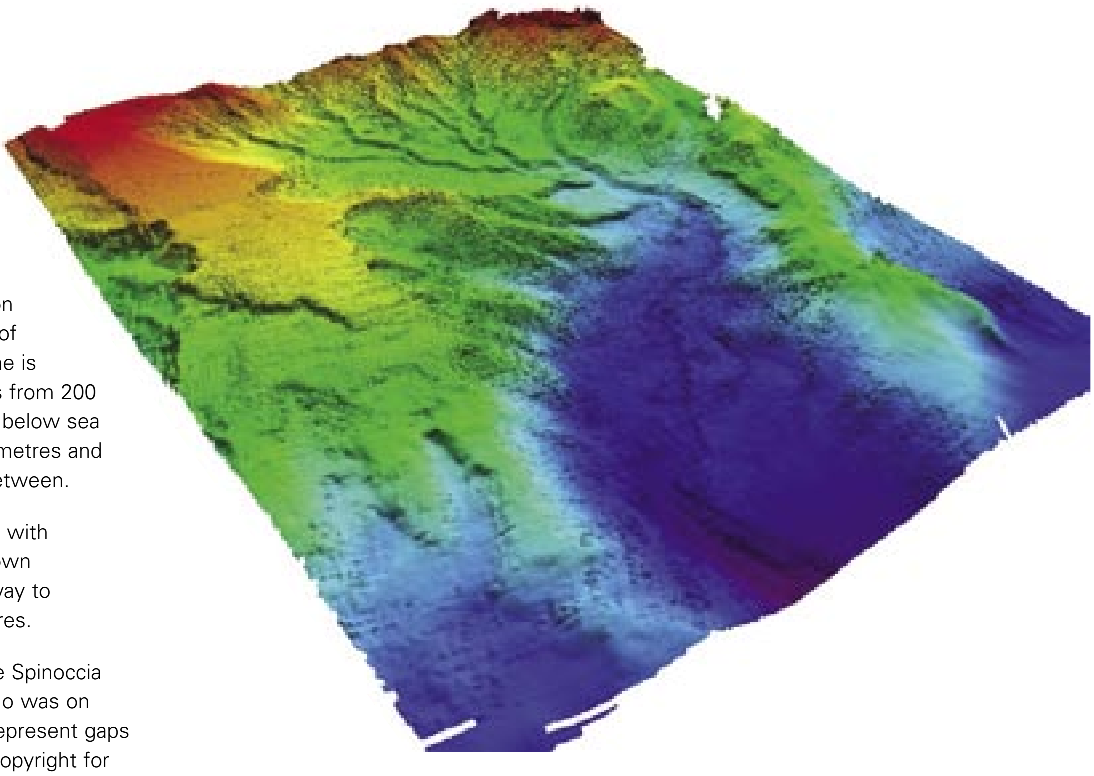

Figure 5: Sprigg Canyon: three dimensional view of the Sprigg Canyon southeast of Kangaroo Island. Obvious are the undersea meanders that feed the canyon in the bottom right hand side of the canyon. The colour scheme is such that red indicates depths from 200 metres down to 1000 metres below sea level, blue greater than 4000 metres and green and yellow depths in between.

Imagine dense flows of water with muds and sands cascading down those channels and this is a way to engender those erosion features.

Map generated by Mr Michele Spinoccia from Geoscience Australia who was on board the vessel. The white represent gaps in the mapping. There is no copyright for this picture. The picture may appear grainy but this is limited by the data gathered by the swath mapping equipment on the ship.

The overall topography is reminiscent of what we know in the Blue Mountains, but the relief under the sea is more than 4 times bigger. We believe that the canyons are often visited by whales and fish due to the constant upwelling of cold, nutrient-rich waters from the abyss.

After reaching the most western canyon of the Glenelg Complex, we headed down its course and, half-way down, decided to exit the course of the canyon westwards and to take a long gravity core. We attempted to obtain a 7m-long core by using an extension on the core barrel and retrieved, very successfully, a 6.17m long core which appears to contain pelagic mud as shown by the material stuck to the outside of the core barrel. This proved to be our longest core taken during this voyage.

After that we headed north to the shallow shelf by travelling along the canyon adjacent to the one we mapped before, and then followed the coastline in search of ancient buried channels. This would take us more than 12 hours of travelling time.

13 MARCH and 14 MARCH 2006

During the night the ship travelled along the shelf offshore the Glenelg River and eventually picked up an old channel south east of the mouth of the Glenelg River which Chris von der Borch interpreted as being quite ancient because some of the features even show signs of deformation. This could be an ancestral course of the Murray as postulated by M. Wallace and colleagues. It is interesting to note that our second survey line located at shallower depths along the shelf offshore the Glenelg River did not pick up the ancestral river course. It is possible that any evidence may have been eroded away, as suggested by C. von der Borch.

After that we started to head towards Tasmania with one last task to perform: one more core offshore the Otways and the Warrnambool region in order to find a suitable marine record that could be correlated with many of the lacustrine records of Western Victoria. Basically our tasks are to take a long core at approximately 1,000m water depth and continue surveying the sea floor until we reach Hobart. This we achieved by obtaining a 5.55m long core, with some evidence of decomposing organic matter near the bottom due to the high smell of H_2S we encountered.

After that successful core, our voyage ended on a high note, but this was soon curtailed by the rough seas we passed though during the night and the entire following day.

15 MARCH 2006

We had a safe arrival in Hobart and I am grateful to all who made this voyage a very successful one. I wish to express my thanks, on behalf of all the people involved in our group, for the great and very professional support we received before and during the voyage. This was a very enjoyable experience that returned with superb data that are going to keep us busy for quite a while and provide much material for PhD students. The voyage also offered ample opportunity for our students to gain much valuable experience at sea. Thank you all.

Figure 6: Group photograph of the scientific staff of voyage SS02/2006

Front left to right, standing, John Rogers, Dan Wilkins, Doreen Roßler, Sarah Tynan, Nigel Craddy, Peter Hill, Chris von der Borch, Michele Spinoccia (Swath Mapper from Geoscience Australia), Don McKenzie (Voyage Manager), and in front Stephen Eggins and Patrick De Deckker. Missing are Bernadette Heaney and Lindsay MacDonald (both from CSIRO).

Summary

During voyage SS02/2006, using the sub-bottom profiler, we successfully located several ancient courses of the River Murray, but also determined the position of 2 extensive lacustrine deposits on the Lacepede Shelf. Despite many attempts at coring the sea floor using a gravity corer, we failed to penetrate a sandy layer that is overlapping the 'ancient lakes' deposits. One site is located offshore the Murray mouth at a depth of about 40m below the sea surface, and the other occurs in the central part of the Shelf at approximately 60m below the sea surface.

The latter deposit, based on its depth and extent (being approximately 30km across), is considered to have been formed during the last, extremely wet climatic phase experienced in Australia when climatic conditions were such that the River Murray and its tributaries moved large amounts of water, at such a rate, that the major rivers in SE Australia where shifting sand in contrast with today's situation where only silt and clay can be transported. Although the well-known Willandra lakes, such as Lake Mungo, were filled at the time of the wet period, only a good chronology of events were obtained. Interest on the Mungo sites have always been considered to be of great archaeological importance, because of the presence of human remains found there, but so far little is known about climatic conditions and the sequence of events that led to human occupation in SE Australia because no pollens are preserved at Lake Mungo and associated lakes, and also because sedimentological features have been altered by pedogenic phenomena. Thus, the recovery of lake sediments located on the Lacepede Shelf could provide much information on past climatic events for a period of time that lasted possibly 20,000 years when sea level was lower than 60m.

Personnel

Scientific Participants

Patrick De Deckker	Chief scientist	ANU
Chris von der Borch	Principal Investigator/ sedimentologist	ANU
Peter Hill	Principal Investigator/Geophysicist	ANU
Stephen Eggins	Principal Investigator/Geochemist	ANU
Sarah Tynan	PhD student (palaecologist)	ANU
Doreen Roessler	PhD student (sedimentologist)	ANU
John Rogers	PhD student (micropalaentologist)	ANU
Daniel Wilkins	PhD student (chronologist)	ANU
Nigel Craddy	Coring operation manager	
Michele Spinoccia	Geophysicist/Swath Mapping	GA
Don McKenzie	MNF Voyage manager	CMAR
Mark Rayner	MNF Hydrochemistry support	CMAR
Bernadette Heaney	MNF Computing support	CMAR
Lindsay MacDonald	MNF Electronics support	CMAR

ANU – Australian National University, GA – Geoscience Australia,
CMAR – CSIRO Marine and Atmospheric Research

Marine Crew

Ian Taylor	Master
Samantha Durnian	First Mate
Rob Ferries	Second Mate
Roger Thomas	Chief Engineer
Robert Cave	First Engineer
Seamus Elder	Second Engineer
Tony Hearne	Boatswain
Tony Van Rooy	Integrated Rating
Russell Williams	Integrated Rating
Mark Jaques	Integrated Rating
John Howard	Integrated Rating
Bianca Napper	Chief Steward
Alan Session	Chief Cook
Jason Phillips	Second Cook

Patrick De Deckker is extremely grateful to Don McKenzie for all his help and advice provided before and during the voyage. Don was always available before the voyage for advice and help and he rendered the task easier with respect to all the logistics involved in voyage preparation.

The voyage proved to be a great success with the superb and very professional work of the entire crew. This proved an excellent experience for the scientific team, knowing that safety was continuously maintained through pertinent monitoring. The good humour and pleasant nature of all members of the crew gave a great environment to work in.

The Southern Surveyor, despite its age, is a very suitable working platform for the type of work we performed. The high performance of the swath mapping equipment and sub-bottom profiler proved ideal assets for the type of investigations we carried out.

Patrick De Deckker