VOYAGE SUMMARY SS05/2003

Title
Basin tectonics and salt structure delineation in the Browse-Bonaparte Compartments, Timor Sea

Itinerary
Departed Darwin 1000 hrs, Wednesday 11 June, 2003
Arrived Darwin 1000 hrs, Saturday 21 June, 2003

Principal Investigator
Associate Professor Antony White (Chief Scientist)
School of Chemistry, Physics & Earth Sciences,
Flinders University,
G.P.O. Box 2100,
ADELAIDE 5001 Australia
Tel. (08) 8201 2020 (Australia)
Fax. (08) 8201 2676 (Australia)
Email: antony.white@flinders.edu.au

Scientific Objectives
The sedimentary basins beneath the Timor Sea have very high hydrocarbon potential that have already become major exploration areas. Basic structural information on sedimentary basins and salt structures that are potential hydrocarbon traps has been obtained by conventional seismic methods. These methods are good at locating the top of salt structures but have poor sensitivity to lower salt structures due to reverberation and losses of acoustic energy. Magnetotelluric (MT) methods, in which natural electromagnetic variations signals are measured at the seabed, have recently been found to be highly successful in similar marginal seas at locating not only the top but also the bottom of the salt diapirs and the depth to basement, imaging them in terms of electrical conductivity.

This experiment represents a pilot study in which up to twenty separate MT deployments were made, each deployment for a 1-2 day period. The MT instruments were deployed in transects with site spacing of 2-3 km along a previous seismic line near the Tern well in Bonaparte Gulf where there are salt diapiric structures. It is anticipated that an electrical conductivity model structure for the study area will be developed that complements and enhances geological understanding of the salt structures. In particular, the model will address the age and depth extent of the structures and their relationship with sedimentary structures.

Voyage Objectives

The voyage objectives were to obtain the magnetotelluric (MT) data required for the project by deploying to the seabed a number of recording OBEMs (Ocean Bottom Electrometer/Magnetometers) along transects aligned with Geoscience Australia's seismic line 100/003 in the Bonaparte Gulf. These instruments free-fall to the sea floor and record magnetic and electric field fluctuations until they are acoustically commanded to re-surface. The instruments weigh approximately 250kg, and deployment and recovery was by light crane over the side of the vessel. Such procedures with these instruments have been used many times previously on R.V. Franklin.

Initially, 4 long period instruments were deployed along the line about 85 km (50 n.m.) apart, and these will form a baseline to provide the regional structure for the short period instrument study. They were deployed at the start of the voyage and recovered at the end before returning to Darwin. The short period instruments were deployed in a closely spaced grid (approx spacing 2-3 km) in the vicinity of Tern well and only recorded for periods of approximately 24 to 36 hours. They were continuously recovered and redeployed during the voyage to give maximum possible spatial coverage. Site location, spacing and recording length was varied depending on results obtained during the experiment.

During periods when all instruments are recording on the sea floor, an array of Self Potential electrodes and a magnetometer were towed at 4 knots across faults and other structures seen on the seismic interpretation. This investigated whether SP signals are associated with the structures. The deployment/recovery and towing schedule was repeated to maximise the number of sites occupied by the short period instruments (probable number of sites is 16 to 20).

Voyage Track

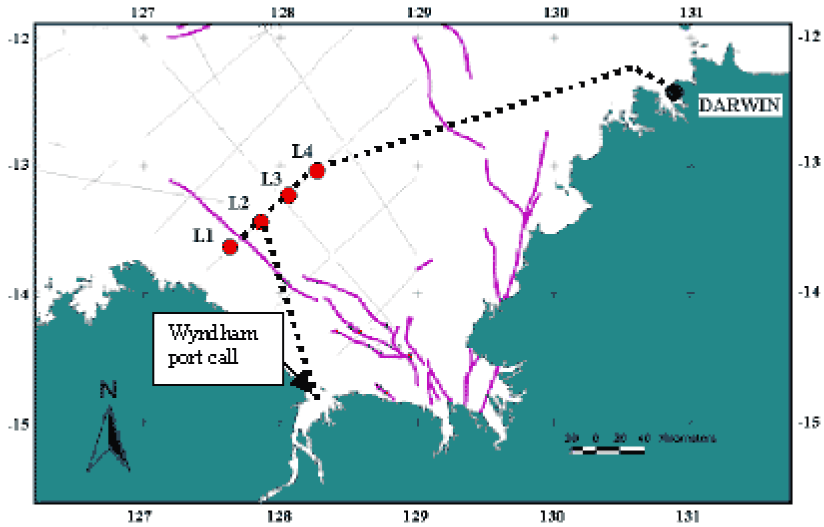

Figure 1. Seafloor instruments were left at L1-4 during the experiment. Others were deployed and recovered from positions between L2 and L3 during the voyage (as shown in later figures).

Results

The main objectives of the voyage were completed successfully. The four long period OBEM's (which recorded electric and magnetic field fluctuations at the seafloor, sampling every 10 seconds) were deployed at the start of the experiment and recovered at the end of the voyage. The instrument at site L3 failed to record electric field data, otherwise all instruments performed well.

Site	Instru-ment	Lat	Long	Depth	CDP	Data	Start	End
L4	Ernie	12º 56.56'	128º 21.38'	97	2900	E and B	13 June	18 June
L3	Fuzzy	13º 09.69'	128º 07.40'	92	2200	B only	13 June	18 June
L2	Igor	13º 23.07'	127º 53.62'	88	1500	E and B	13 June	18 June
L1	Dodo	13º 36.23'	127º 40.01'	97	800	E and B	13 June	18 June
RR	Sandfly	12º 26.01'	130º 52.62'	0		B only	11 June	21 June

Table 1. Instrument locations and data acquisition for the long-period OBEMs and land magnetometer (RR, near Darwin). In the data column, B indicates magnetic field, E indicates electric field. The CDP column represents the seismic shot point notation used by Geoscience Australia along their previously acquired seismic reflection line.

Four sets of deployments and recoveries of the high frequency OBEM's (sampling at 20 Hz) were made. Unfortunately the instrument initially deployed at site HF2 was lost, leaving 3 instruments with which to complete the survey. We believe the lost instrument was caught and dragged by a prawn trawler shortly after deployment (see voyage narrative). Two sites had to be re-occupied owing to this loss and a malfunctioning electrode in another instrument. In the final analysis 11 high frequency sites were occupied successfully and good data obtained from all of them. Including the long period instruments, 17 deployments were made and 16 instruments recoveries made.

Site	Instru-ment	Lat	Long	Depth	CDP	Data	Start	End
H1	HFM1	13º 21.22'	127º 55.60'	86	1600	E and B	13 June	15 June
H7	HFM4	13º 20.33'	128º 56.61'	85	1650	E and B	15 June	17 June
H2	HFM2	13º 19.38'	127º 57.55'	83	1700	LOST		
H2A	HFM3	13º 19.22'	127º 57.18'	86	1700	E and B	17 June	19 June
H8	HFM1	13º 18.45'	127º 58.56'	86	1750	E and B	17 June	19 June
H3	HFM3	13º 17.50'	127º 59.52'	84	1800	E and B	13 June	15 June
H9	HFM3	13º 16.56'	128º 00.44'	86	1850	E and B	19 June	20 June
H4	HFM4	13º 15.58'	128º 01.45'	82	1900	E and B	13 June	15 June
H4A	HFM4	13º 15.55'	128º 01.52'	86	1900	E and B	17 June	19 June
H10	HFM1	13º 14.62'	128º 02.43'	88	1950	E and B	19 June	20 June
H5	HFM1	13º 13.62'	128º 03.56'	89	2000	E and B	15 June	17 June
H11	HFM4	13º 12.63'	128º 04.43'	92	2050	E and B	19 June	20 June
H6	HFM3	13º 11.70'	128º 05.55'	93	2000	E and B	15 June	17 June

Table 2. High frequency MT instrument locations, and data acquisition. Site H4 recorded only one component of electric field due to a bad electrode. The site was repeated with H4A.

Data obtained showed strong 'oceanographic' signals, that is, tidal motion and high frequency wave induced signals. Both of these are due to conductive sea water moving through the Earth's magnetic field and inducing electrical 'eddy currents'. Filtering and otherwise separating such signals from the ionospherically induced signals that we wish to analyse may prove to be a significant problem. Data from the towing of the magnetometer and SP array was not extensive owing to repeated equipment failure in the heavy sea state. Heavier duty towing gear will have to be developed if such surveys are to be undertaken in future.

Voyage Narrative

We initially steamed from Darwin for fifteen hours to the start of our survey line and deployed our long-period OBEM (Ocean Bottom Electrometer Magnetometer) instruments at sites L1, L2, L3 and L4, with an inter-site spacing of 35 km.

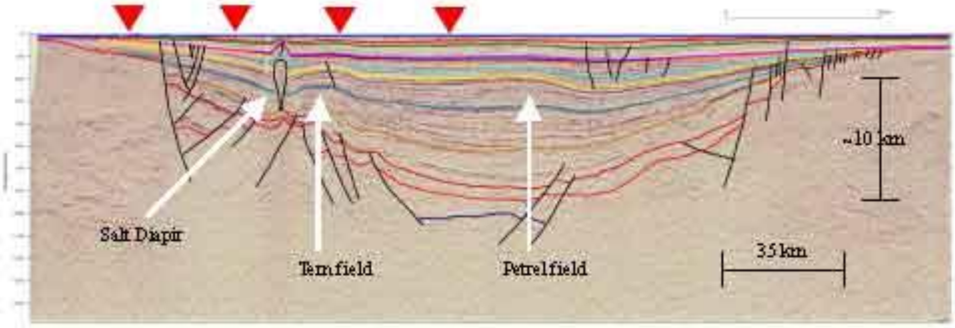

Figure 2. Location of the four long-period OBEM sites (L1-L4, left to right, red triangles) on the interpreted seismic line 100/3. Inter-site spacing is 35 km.

Figure 3. An OBEM about to be deployed (left). A ballast weight causes it to sink to the bottom where it remains until the weight is acoustically released and the instrument floats back up to the surface for recovery (right). A magnetometer and other electronics (including acoustics) are housed in glass spheres (inside the yellow protective container); electrodes the end of each of the white pipes allow measurement of the electric field gradient in two orthogonal horizontal directions.

In checking location of the instruments using the Flinders University acoustic units, it was found that contact was very limited due to the narrow beam of the hull-mounted transducer. Subsequent to the deployment of the long-period instruments, Jeff Cordell (Voyage Manager) installed one of our acoustic transducers on the moon pool trolley. This improved our acoustic communications enormously although there were subsequent problems with cable strumming and chafing in the moon pool during long transits in a high sea state. We would recommend that in future individual projects be permitted to routinely install instruments on a dedicated platform in the moon pool.

Subsequently we proceeded to the focus area, namely the salt diapir structure and adjacent Tern field and deployed four high-frequency OBEMs at sites H1, H2, H3 and H4 with an inter-site spacing of 5 km (see Figure 3 and Table 2). All initial deployments were completed by midnight Thursday 12th June. It was noticeable during these deployments that there were a significant number of prawn trawlers in the vicinity, several of which came very close to our survey line. Radio contact was made to advise nearby fishing vessels of instrument locations.

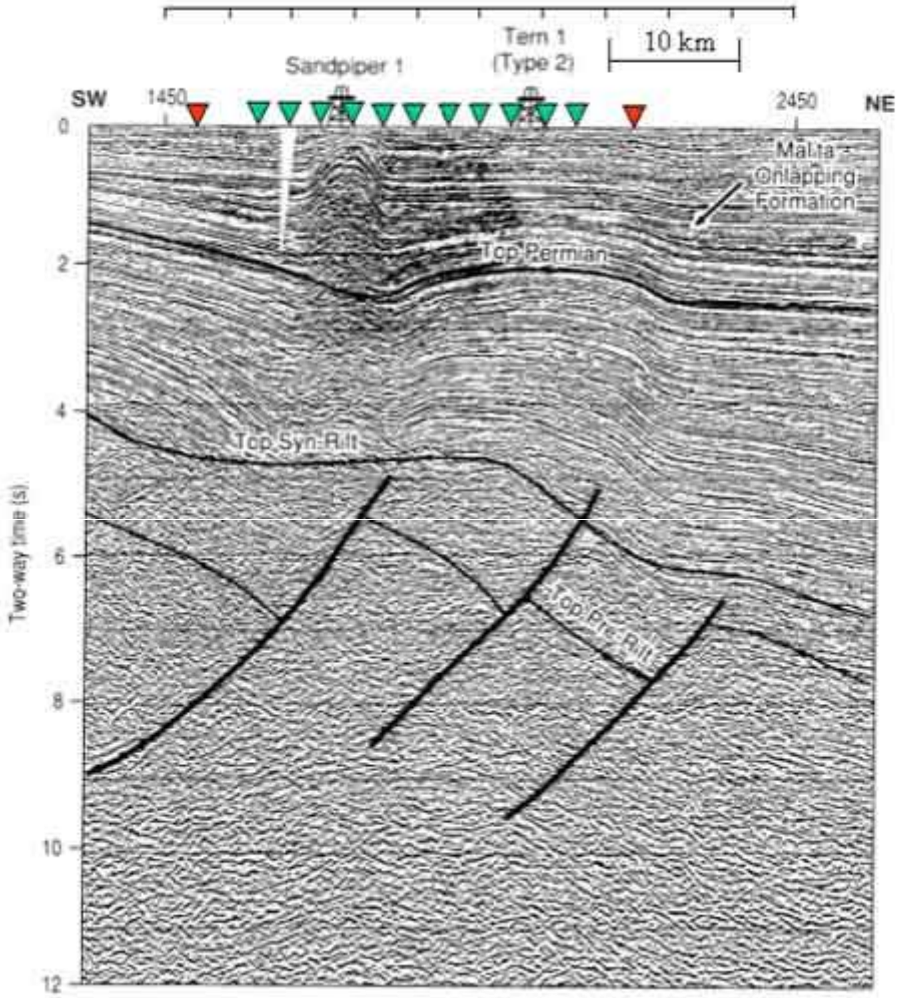

Figure 4. Location of the high-frequency OBEM sites (green triangles, H1-H11, see Table 2 for sequence) between two of the long-period OBEM sites (red triangles, L2 far left, L3 far right) superimposed on a section of the seismic data showing the salt dome and the Tern hydrocarbon field.

Because the plan was to redeploy high frequency OBEMs every 36 hours, we occupied the intervening period by towing a magnetometer and a SP (Self Potential) electrode array. Towing commenced at 0100 on Friday 13th June and was concluded at 0100 on Saturday 14th June after which we proceeded back to the high frequency OBEM deployment sites. Owing to high winds, gusting to 40 knots and high sea state, it was thought inadvisable to attempt to recover instruments and a day of ship time was lost.

In slightly more favourable conditions on Sunday 15th June, we recovered the high-frequency OBEM at site H1, but found there to be no acoustic response at site H2. After a brief search it was decided to proceed to sites H3 and H4 to recover those OBEMs in daylight. This was accomplished with no problems. Having refurbished the three instruments with new batteries and memory cards, we redeployed at sites H5, H6 and H7. After dark, we returned to site H2 and undertook a systematic search for the OBEM by conducting an expanding circle search around the site to a radius of about 2 km. Unfortunately, no response was obtained from the instrument.

In the morning of Monday 16th June we again commenced towing the magnetometer and SP array in very heavy seas. Unfortunately both instruments sustained cable damage after a few hours towing. While repairing the equipment, a request was made for a compassionate port stop at Wyndham to allow a CMR technician to disembark. Transit from the towed array site to the pilot at Wyndham was about nine hours, and the transfer was completed at 1 am on Tuesday 17th June and we returned to the survey line by about 10 am. Three of the scientific party (Dr Lilley, Mme Claire Menesguen and Mr Tjipto Prastowo, all from ANU) also took the opportunity to disembark owing to prolonged seasickness of Menesguen and Prastowo.

OBEMs at sites H5, H6 and H7 were released and recovered without problems, although some maintenance on the moon pool transducer cable had to be carried out first. These instruments were immediately redeployed at sites H2A, H8 and H4A. Site H2A was a substitute site for the lost instrument, about 300 m to the north west of the original drop point, and site H4A was a repeat station owing to no data collection in one of the electric field channels in the original deployment. The new deployments were completed by sunset on Tuesday 17th June.

After dark, we returned to sites H2 and H2A to attempt an echo sounder survey to see if we could recognise an instrument of 1 m height at the seabed. Despite several passes over the instrument at site H2A it was concluded that we could not reliably recognise the presence of an instrument at the seabed by this means. We then proceeded to site L1 to begin recovering the long-period OBEMs during daylight hours of Wednesday 18th June.

All four long period OBEMs were recovered without problems by mid-afternoon. A brief attempt at towing the SP array was made, but damage to the cable was too severe and the work was aborted. Instead, the ship continued slowly overnight to site H2A to be there by first light. On Thursday 19th June, we recovered all three high-frequency OBEMs at sites H2A, H8 and H4A, and redeployed these at sites H9, H10 and H11 by midday.

In the afternoon the plan was to send an acoustic release to the lost instrument at site H2 in the event that the transducer had been damaged. We also made plans to grapple for the instrument at its original drop point. However, in transit to the site, communication with the prawn trawler fleet to inform them of site locations for H9, H10 and H11 revealed that a trawler had probably dragged the instrument from the original site-location H2 for several miles downwind. We proceeded to execute an expanding fan-shaped search pattern to a distance of 3 mile, attempting to establish acoustic contact. By 5 pm it was clear than no contact was going to be made, and it was reluctantly deemed that the instrument had been lost.

From 6 pm, with a new cable, the towing of the SP instrument was resumed transverse to the survey line to a distance of 5 miles to the northwest and southeast along three traverses centred around H3. Towing was concluded at 1.30 am on Friday 20th June, and the ship proceeded slowly to site H9. Final recovery of the three instruments commenced at 11 am and was completed by 2.30 pm, after which we started the transit back to Darwin to arrive by 10 am on Saturday 21st June.
In summary, seventeen deployments and sixteen recoveries of OBEM instruments were made encompassing the scientific objectives of the voyage plan.

Summary
Overall, the scientific objectives were very largely met. One sea bottom instrument was lost, presumed dragged and damaged by a prawn trawler. All recovered instruments (16 of 17 deployments) recorded good electromagnetic data, predictably dominated by very strong signals induced by sea water motion (tides and waves).

The sea state was constantly high due to the continuing strong SE trade winds and the large tidal range in the relatively shallow water (depths 60-90m). Despite this the Southern Surveyor handled conditions well — better than would have been the case on RV Franklin — and we were able to deploy and recover the instruments with very little difficulty. Underway acoustics using the ship's hull transducer was difficult; this was rectified by attaching our own transducer to the moon pool trolley.

Scientific Personnel

Assoc. Prof. Antony White	Flinders University	Chief Scientist
Mr Wayne Peacock	Flinders University	Technician
Mr Goran Boren	Flinders University	Technician
Dr Graham Heinson	Adelaide University	Research Scientist
Ms Selina Donnelley	Adelaide University	Research student
Dr F.E.M. (Ted) Lilley	Australian National University	Research Scientist
Mr Tjipto Prastowo	Australian National University	Research student
Mme Claire Menesguen	Australian National University	Exchange Research student
Jeff Cordell	CSIRO Marine and Atmospheric Research	Voyage Manager, Electronics
Miroslaw Ryba	CSIRO Marine and Atmospheric Research	Computing
Mark Rayner	CSIRO Marine and Atmospheric Research	Hydrochemistry
Ken Suber	CSIRO Marine and Atmospheric Research	Radiometer

Ships' Crew

Ian Taylor	Master
Roger Pepper	Chief Officer
John Boyes	Second Officer
Evan Peters	Chief Engineer
Jim Hickie	First Engineer
Jim Gaffey	Second Engineer
Malcolm McDougall	Bosun
Graham McDougall	IR
Tony Harne	IR
Paul O'Neill	IR
Phillip Soley	Greaser
David Willcox	Chief Steward
Garry Phillips	Chief Cook
Ton Beerman	Second Cook

Acknowledgements
The Master, Ian Taylor and the bridge officers, Roger Pepper and John Boyes were very accommodating in terms of instrument deployment and recovery, and in executing search patterns for the lost instrument. Jeff Cordell (Voyage Manager) was extremely helpful, particularly in fixing our acoustic transducer to the moon pool trolley so that we had good acoustic communication with our equipment. The food on board was uniformly excellent.

Associate Professor Antony White
Chief Scientist