National Facility Research Vessel

RV FRANKLIN

VOYAGE DOCUMENTS

RV SOUTHERN SURVEYOR

CSIRO AUSTRALIA

CSIRO MARINE AND ATMOSPHERIC RESEARCH

Voyage Plans and Summaries

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Franklin Voyage Summary No. FR04/99

Title

Extension of cool-water carbonate facies into deeper water in Australia's tropical North-West Shelf area: oceanographic, sedimentological, paleontological and geochemical history.

Itinerary

Sailed Darwin 0850 hrs, Monday, 21st June, 1999
Docked Dampier 0700 hrs, Tuesday, 13th July, 1999

Principal Investigators

Dr Yvonne Bone (Chief Scientist)
University of Adelaide, Adelaide, SA

Dr Noel P. James,
Dept. of Geological Sciences,
Queens University, Canada

Dr Lindsay Collins
Curtin University, Perth, WA

Dr T. Kurtis Kyser
Dept. of Geological Sciences,
Queens University, Kingston, Canada

Scientific Objectives

The specific objectives of this research cruise were:

(1) To investigate/map the distribution of facies with cool-water attributes in the north-west shelf area, and compare the pattern with measured

oceanographic parameters.

(2) To take bottom sediment and biota samples to (a) accurately determine the hydrodynamics of sediment production, accumulation and history and (b) to determine the density and distribution of living benthic invertebrates and compare them to the recently dead and relict specimens in the sediment samples.

(3) To ground-truth the sea-floor by colour photography, with the added advantage of thereby enabling ready comparisons of living vs. dead biota.

(4) To collect bottom water samples for analysis (onboard and onshore), to measure salinity, temperature profiles (CTD), pH, nutrients and currents (ADCP) to determine the influence of each parameter on the seafloor and its biotic cover.

(5) To assess the potential of the area for the concentration of such mining targets as diamonds, heavy minerals and other industrial minerals, in paleostrandlines and paleochannels related to seafloor morphology. This aspect would involve bottom sediment sampling of sites selected on the basis of precision depth profiling and prior geomorphic assessment (by geomorphologist E. Campbell) of adjacent onshore environments that show source potential.

(6) To shed light on the route of some taxa into the southern hemisphere, e.g. the point of origin of the vagrant bryozoans is contentious, i.e. the older literature suggests they evolved in the northern hemisphere, where they are now mainly extinct, and were relatively late arrivals here, where they now flourish, whereas the work of Conroy, from the samples collected on FR01/96 suggests they may have originated from a southern circumpolar source. This aspect will involve detailed taxonomy and also dating of relict material.

(7) To determine the shallow seismic profiles along selected transects in order to determine the Tertiary and younger stratigraphy of the area.

This is the seventh cruise, by these scientists, investigating such parameters along Australia's southern and western margins.

Ancillary Objectives

The transit area traversed across the Yampi Shelf in an area of fundamental interest to AGSO Petroleum and Marine Division. This was a known site of hydrocarbon seepage. Thus, it was opportune to add the investigation of this site as an additional piggy-back project.

The goal was to investigate the biota in the immediate vicinity of the seeps, to sample the sediments accumulating, to measure the physical and chemical

parameters of the seawater and to run seismic across the sites. This work was organised by Kriton Glen and Steve Thomas, with assistance by the remainder of the scientific crew.

Results

Sea-floor sediment and biota samples were obtained from 134 sites, ranging from nearshore (depths of ~30 m) to downslope depths of 1000 m. These were obtained by:-

epibenthic sled	111	samples
pipe (Bleys Dredge)	11	samples
Smith-McIntyre grab	2	samples

Water samples were obtained from 77 of the sediment sampling sites. These were obtained by CTD.

These samples were to have been augmented by the deployment of the underwater camera, but upon unpacking the boxes, it was discovered that the camera had been removed (the week of departure, by one of Bone's PhD students, to use in the field!).

The real-time underwater video system was successfully deployed at 13 sites.

Flow-through fluorometry recordings were made at regular intervals.

Bathymetric depth profiling was continuously recorded, along with surface temperature and surface salinity recordings. Bottom water temperature and bottom salinity data were recorded at all the CTD station

The ADCP was run continuously throughout the cruise.

Narrative

Un-anticipated loss of time through bad weather occurred three times and necessitated changing planned cruise tracks in the early stages. However, the time savings resulting from the inability to deploy the still camera eventually put us ahead of schedule, so that we were able to re-design the cruise track and extend it further south than had been originally intended. This allowed us to link up with our 06/96 cruise from Fremantle to Pt Maud, and thus complete our coverage of the southern and western margins of Australia, from Portland in Victoria to Broome in Western Australia.

Follow-up work will undoubtedly provide much new information and allow increased reliability in our interpretations of the characteristics of these southern and western margins of Australia.

Specific topic summaries are:

Sedimentology

A total of 134 sediment stations were occupied, using an epibenthic sled or pipe dredge, accompanied by CTD sampling at 77 of these sites. 13 video sites were selected from associated sites. Samples were obtained in depths of 30 to 1050 metres. Bathymetric profiles were run on all traverses.

Major findings were:

- zoozanthellate corals are only common in a few locations, e.g. the Ningaloo Reef area and just north of Dampier:

- sea-grass is almost non-existent and algae are rare:

- living rhodolith pavements are found in shallow sites immediately sea-wards of the Ningaloo Reef:

- dead bryozoans are abundant and ubiquitous, living ones are common:

- a wide, sandy ramp is characterised by a number of specifically-different biotic assemblages, which seem to be controlled by physical parameters, e.g. sea-floor nick points (see Seismic Section), current direction, substrate type, outcropping basement, et al.

- a sandy to muddy transition and then back to a slightly coarser silt down the ramp.

The information collected is an important addition to the knowledge of the Australian continental margin sedimentation and history.

Living Bryozoa

Bryozoans are an important but not major skeletal component on this ramp on the North-West shelf of Australia. Surprisingly, the sediments from over half the stations sampled contained dead bryozoans (78 out of 134). Thirty six of these samples contained abundant dead bryozoans. Similarly, 61 of the stations contained living material in the sediment obtained, and of these, 25 sites had abundant living material. Samples ranged from low to very high diversity. High diversity samples usually contain bryozoans of many different growth forms. Most of the sites contain numerous dead vagrants in quantities not seen along the southern margin. *Adeona* sp. is not as common here as it is on the southern margin, and does not appear as abraded fragments until Site 084 (19¡24' - 116¡53') The first living *Adeona* specimen was found at Site 094 (20¡40' 116¡13'). The most widespread bryozoan type along the southern

margin, namely the articulated zooidal form, is rare.

The depth at which the bryozoans were found ranged from 15 - 374m. Deeper samples contain fewer robust bryozoans but have common delicate cyclostomes, particularly *Idmidronea* spp.

A detailed analysis of the habitats and distributions of the living species will aid in the understanding of this ecosystem as a whole, especially when they are compared with the southern margin findings. Similarly, an analysis of the distribution of the dead material will add to our understanding of climate change and also the consequences of continental drift even over the geologically short term.

In view of the abundance of the bryozoans, it was consequently not surprising to also find brachiopods present. Nine stations returned sediment with living brachiopods, and 12 had dead brachiopods. The living brachiopods were abundant at one site: the dead at three sites.

In addition, information about these Bryozoa will provide valuable insights for paleoenvironmental analysis of carbonate rocks from related settings throughout the Cenozoic of Australia.

Water Sampling

Water samples from the deepest portions of all of the 77 CTD casts were collected for stable isotope analysis, nutrient contents, dissolved oxygen, and trace metal contents. In addition, 15 sites were sampled more extensively to augment the temperature and salinity data from the CTD, which were used to characterise distinct water masses.

Data from the CTD in conjunction with the nutrient contents measured on board clearly indicate that there are distinct water masses in the area covered by the transects. Although these data represent those waters present during this season, CTD and nutrient data collected from previous cruises will be compared with our extensive set to trace the seasonal extents of the various masses we identified. Among the more pronounced water masses that we will further characterise with stable isotope and trace metal analysis are:

--High salinity and temperature waters originating against the coast,

--Low salinity, relatively high temperature waters above bottom waters that contain a component of the Leeuwin Current water

Those waters that reside on the inshore area have salinities, temperatures, and nutrient contents that appear to correlate with distinct assemblages of biota. Consequently, there is a direct connection between water character and the biota present, which is very sparse.

Seismic and Side Scan Profiling

Three seismic and side scan traverses were conducted, along sediment sample and PDR traverses, as follows:

1. Rowley Shoals traverse, line G-H, 100 km long, depth 30-300m, inner to mid ramp;

2. Forrestier Islands traverse, line Q-R, 80-250 m, 50 km, mid-ramp profile;

3. Rankin Bank traverse, 25 km; outer shelf/upper continental slope profile.

The major findings were as follows:

1. A widespread submarine ridge system, developed in depths of 30-90 m, was imaged seismically, on side scan, and with PDR. Where sampled the ridges consist of ooid grainstone. The genesis of the ridge system, which has a number of different ridge morphologies and is uppermost in a less than 5m thick seismic package, will be determined by follow-up studies of lithology, diagenesis and age.

2. A 12 m thick seismic package with similar ridge morphology to, but underlying that in (1) above was also mapped seismically. This older system may have a similar genesis to its younger counterpart.

3. Up to 4 regional seismic reflectors in the top 100 ms of section were mapped in a cross-shelf traverse. Two of these reflectors have downlapping terminations to seaward in a mid-ramp position, and two are developed as regional surfaces. One of these reflectors appears to intersect the depositional surface which was repeatedly recovered from benthic samples in depths of 200-220 m.

4. The 120 m shoreline, where traversed, showed no seismic evidence of early transgressive depostion, and appears to be largely an erosional feature. Shoreline and embayment sediments sampled from this depth are likely to be thin Holocene deposits overlying an unconformity surface.

5. The Rankin Bank area profile of a steep continental margin with a mid shelf ridge system showed a widespread, 10 m think seismic package in depths of 80-240 m. This is presumed to represent the Quaternary section which probably thinly overlies the Tertiary at this location. A terrace developed at 225 m apparently predates the seismic package, which only partly infills the erosional relief of the terrace feature.

Within the limits set by equipment capabilities and weather conditions the seismic results are informative. Further data analysis will be assisted by reprocessing, and comparison of results with subsurface lithologic information

from site test cores and petroleum wells.

Follow-up Labatory work (brief outline)

(a) Bulk sediment samples: These will be cleaned and dried, and a qualitative analysis of the composition of the bulk sample and the coarse fraction from each sample will be made by Bone and James. They will produce a facies map, based on sediment composition. Selected samples will be dated, to enable sea-level history interpretation. This aspect will be under the leadership of Collins.

(b) Bryozoa: The living bryozoans have been separated abroard and will be further taxonomically identified by Bone. All living species collected on this cruise will be photographed for inclusion. Bone will continue comparative studies with other modern areas and she and R. Schmidt will compare these to the fossil bryozoans in onshore Tertiary basins. Bone will continue her geochemical studies.

(c) Brachiopods: Kyser, Bone and james will continue their geochemical studies, testing the brachiopod analysed results against those measured in their ambient sea-water. Living and relict brachiopods from the same site will be compared, as will different species from the same site.

(d) Corals: Similar studies will be done on the corals as those done on the brachiopods.

(e) Water Samples: Kyser will analyse samples for stable isotopes, age and selected trace elements. These results will be integrated with work on phytoplankton productivity, and then overall integration with studies on both sediments and biota.

(f) Seismic and Side-Scan Sonar: Collins and Thomas will continue "massaging" the material acquired.

(g) Other Biota:

(i) Whalebones et al.: Bone will endeavour to date these and identify the organisms from which the bones and teeth were derived.

(ii) Foraminifera: Dr Li Qianyu, Dept. of Geology and Geophysics, University of Adelaide, will be asked to analyse the distribution of the modern and relict specimens of both benthic and planktic species in all samples, and determine Holocene environments. there is scope for an Honours student to study the prolific large benthic forams and their symbionts.

(iii) Rhodoliths: There is scope for another Honours project on these, similar to the one done by Ryan (1998), who assessed the distribution of living and

dead rhodliths, their associations with other biota, their substrates, sea-floor temperature and salinity data and the factors that control their shape, density and size from the Great Australian Bight cruises.

(h) Mud: Dix will determine the physical components, including complete and fragments or elements of biota, within the silt to fine sand-size fraction.

Personnel

Scientific	
Yvonne Bone	University of Adelaide - Chief Scinetist
Noel James	Queens University, Ontario, Canada - sediments
Lindsay Collins	Curtin University - sediments, seismic
Kurt Kyser	Queens University, Ontario, Canada - hydrogeochemist
George Dix	Carleton University, Ontario, Canada - micro-sediments
Chris Rancourt	Queens University, Ontario, Canada - biota
Kriton Glen	AGSO, Canberra - hydrocarbon seeps
Steve Thomas	AGSO, Canberra - seismic operator
Bob Beattie	CSIRO - Cruise Manager
Erik Madsen	CSIRO - Electronics
Val Latham	CSIRO - Hydrochemist
Daniel Conwell	CSIRO - Electronics trainee
Crew	
Neil Cheshire	Master
Arthur Staron	Chief Officer
Paul Ware	2nd Officer
Gordon Gore	Chief Engineer Officer
David Jonker	1st Engineer Officer
Hugh McCormick	2nd Engineer Officer
Bill Hughes	Bosun
Simon Smeaton	I.R.
Travis Broadhurst	I.R.
Terry Ganim	I.R.
Phillip French	Greaser
Gene Innes	Chief Steward
Gary hall	Chief Cook

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Acknowledgements

The scientific party would like to acknowledge the professional expertise of Captain N. Cheshire, and all officers and crew of CSIRO RV *Franklin*, and thank them for their unstinting and friendly help at all times. This is the seventh cruise in this series wherein the *Franklin* has proven itself to be an excellent research vessel, well-suited to this type of geo- and bio- scientific work. The CSIRO personnel (Cruise Manager, Bob Beattie, and Electonics Specialist, Erik Madsen) were thoroughly competent and co-operative. Their continuous cheerfulness and skill in all situations enabled non-stop data-gathering. Special compliments must be given to the Chefs, Gary and Tom, for their excellent culinary delights throughout the voyage.

The Principal Investigators have all had considerable marine experience, with up to sex prior cruises aboard the *RV Franklin*, and so were able to maximise the scientific returns from this oppurtunity of time allotted to their work. Their research is funded by the Australian Research Council and the Natural Sciences and Engineering Research Council of Canada.

Dr Yvonne Bone
Chief Scientist
November, 1999

Updated: 31/01/03