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Swath-mapping ADEDAV survey by RV *L'Atalante* from Adelaide to Davao along the continental margin of western Australia, 1994: post-cruise and ADEDAV/TRANSNOR data processing report

by

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CONTENTS

FIGURES

Page

APPENDICES

ENCLOSURES

1. Index map for ADEDAV 1:100,000 bathymetric contour map and acoustic imagery sheets: Albany 1-5, Perth 1-9 and Argo 1-11; index map for TRANSNOR 1:100,000 bathymetric contour map sheets: Transnor 1-11.

2. Acoustic image with superimposed 100 m bathymetric contours of the continental slope off Carnarvon Terrace (Perth 7 1:100,000 map). Darker tones indicate areas of relatively higher acoustic backscatter (eg. canyon floors).

3. EM12D 20 m bathymetric contours of Taipan Canyon (Argo 5 1:100,000 map).

SUMMARY

In April 1994, a large volume of valuable swath-bathymetry, acoustic imagery and other geophysical data were collected on board the French oceanographic research ship *L'Atalante* during a transit survey (ADEDAV) between Adelaide and Davao via the west coast of Australia. The survey represented the first use of a wide-angle multibeam seafloor mapping system, in this case Simrad EM12D, to map and image large parts of the continental margin of western Australia and the North West Shelf.

Acquisition systems operated during the survey included hull-mounted Simrad multibeam echosounders EM12D (12 kHz, 162 beams, 150° maximum coverage, 20 km swath-width in deep water) and EM950 (95 kHz high resolution, 2x60 beams, 70°-150° coverage). Also run were a Bodenseewerk KSS-30 gravity meter, proton magnetometer and 3.5 kHz high resolution seismic profiler.

The survey length was 5400 km in the Australian EEZ. Swath-bathymetry and acoustic imagery (EM12D and/or EM950) data were collected along the entire 5400 km route. Included in this was 2050 line-km of deep-water (1-5.6 km depth) EM12D acquisition along the continental margin east of Albany, off Perth-Carnarvon and along the North West Shelf. The total area of continental slope swath-mapped by EM12D was 30,000 km^2. Gravity data were acquired along the entire transit route, and 3300 km of magnetic data were recorded off Western Australia.

The ADEDAV deep-water EM12D bathymetry and back-scatter data were processed in Noumea in June 1994 using proprietary IFREMER software. Bathymetry contour maps with 20 m contours and acoustic imagery were produced for 25 1:100,000 scale map sheets (Albany 1-5, Perth 1-9 and Argo 1-11). In addition, EM12D bathymetry data acquired in October 1993 over the Norfolk Ridge were also processed and mapped at the same contour interval and scale for 11 map sheets (Transnor 1-11). All bathymetry maps were produced at 1:250,000 scale and 50 m contour interval, as well. Together with special displays of selected sheets, 100 different maps were generated. Copies of these are available from AGSO.

Remarkable lineated patterns were observed in EM950 acoustic imagery of the continental shelf in the Great Australian Bight. The acoustic lineations, spaced at ~50-900 m, are not associated with major seafloor relief. They are probably due to variations in sediment grain size (sorting) produced by storm surges.

EM12D bathymetry and acoustic imagery of the continental slope east of Albany, off Perth-Carnarvon and off the North West Shelf show spectacular seafloor relief, commonly more than 1 km, due to margin structure and canyon incision. Pronounced NW and SW structural trends are seen on the slope east of Albany. These are consistent with margin formation by SE-directed rifting. Taipan Canyon, a major geomorphological feature adjacent to Rowley Terrace, was mapped in detail for the first time. The canyon walls at its mouth rise 2 km above the flat, mid Jurassic Argo Abyssal Plain. E-W fault scarps on the southern flank of the Timor Trough are believed to be due to down-faulting (?with sinistral dip-slip) of the Australian plate just south of the Australia-Eurasia plate boundary.

INTRODUCTION

On 29 March 1994, the French oceanographic research vessel *L'Atalante* arrived in Port Adelaide after completing a very successsful 6-week seafloor swath-mapping and geophysical survey (TASMANTE) by the Australian Geological Survey Organisation (AGSO) of the South Tasman Rise and west Tasmanian continental margin (Exon et al., 1994). The ship is owned by national French research institute IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer) and operated by GENAVIR (Brest). It is equipped with a technologically-advanced and powerful seafloor mapping tool, the Simrad EM12D multibeam echosounder.

The next major port call for the ship was to be Davao in the Philippines for the start of the next scheduled scientific program (MODEC). The transit route was to be via the coast of western Australia. This presented an opportunity to collect valuable swath and other geophysical data over the Australian continental margin while en route to Davao. IFREMER agreed to an AGSO proposal initiated by Neville Exon to conduct the data acquisition.

The transit survey, named ADEDAV, began on 3 April 1994 and finished in Davao 17 days later (Figures 1 and 2). EM12D data were collected along deep-water sectors of the route: east of Albany (Figure 3), off Perth-Carnarvon (Figure 4) and along the edge of the North West Shelf (Figure 5).

Both systems development work and data acquisition were conducted during the transit. The main priority of IFREMER during the transit was to ensure that a newly-installed, high-resolution Simrad EM950 swath-mapping system was fully operational for a submarine cable route survey scheduled for mid-1994 in the East/South China Sea area. IFREMER's chief systems engineer, Jean-Paul Allenou, was the cruise leader. Peter Hill, the only Australian participant, represented AGSO to ensure that the transit survey resulted in maximum benefit to AGSO's ongoing Continental Margins Program. Ship's crew, technicians, engineers and scientists (Appendix 1) numbered 39 on departure from Port Adelaide; 5 engineers and technicians left the ship at Albany after most of the trials on the EM950 had been completed and the system was operating satisfactorily.

IFREMER software to process and plot swath-data collected on *L'Atalante* had been installed at Service des Méthodes Administratives et de l'Informatique (SMAI) in Noumea, New Caledonia, in early 1994. The processing facility at SMAI was a key part of ZoNéCo (Zone Économique de Nouvelle Calédonie), a new government program set up to map and manage New Caledonia's offshore region and its resources. *L'Atalante* mapped parts of New Caledonia's EEZ in 1993 and mid 1994. Arrangements were made to use the SMAI centre to process and map *L'Atalante* data collected in, and adjacent to, the Australian EEZ. In addition to processing and mapping ADEDAV EM12D swath-data, bathymetric data from a 1993 transit survey by *L'Atalante* along the Norfolk Ridge (TRANSNOR, Hill (1993)) were also processed and mapped.

ACQUISITION SYSTEMS ON *L'ATALANTE*

L'Atalante (Appendix 2) is a modern 85-metre multi-purpose research vessel. It was launched in 1990 and replaces the *Jean Charcot*. The laboratories onboard contain a massive array of scientific equipment and computer facilities for acquiring, processing, storing and displaying a wide range of geoscientific and oceanographic data. The ship has the capability of launching and operating manned submersibles, such as *Nautile*, in water depths up to 6000 m. *L'Atalante* was specifically built for high-technology seafloor mapping, and carries the EM12D with hull-mounted transducers. The scientific and navigation equipment used on the ADEDAV survey are detailed in Appendix 3.

EM12D

The EM12D (Pohner and Hammerstad, 1991) consists of two EM12 13 kHz multibeam echosounders (one on each side of the ship), each generating 81 stabilised beams. The transducer arrays of each individual system are mounted on the hull in a cross-shaped configuration with one array for transmission (longitudinal relative to the ship) and one array for reception (transverse). The transmission transducers are 4.8 m long and the reception transducers 2.4 m long. The two sets of arrays are tilted 40° to each side from the horizontal. As presently configured on *L'Atalante*, there are 3 common central beams, and thus 159 points across-track on the seafloor are sampled with each ping.

The beam spacing of the EM12D can be set either to being equiangular or equidistant in horizontal spacing. The latter mode is most commonly employed since it provides regular sampling of the seafloor. Five sector pulses are transmitted from each set of transducers sequentially without delay. Ambiguities in reception due to sector overlap are eliminated since the sectors have different frequencies spread in a 1 kHz band around 13 kHz (12.66, 13 and 13.33 kHz). Unless manually overridden, the EM12D automatically selects the optimum angular coverage sector according to depth, bottom conditions, and the number of beams with valid bottom detections. In deep mode, the widest sector of 150° is usually operative in water depths to several kilometres. The swath width is 7.4 times water depth (in shallow to moderately deep water). Typical cross-track coverage from about 2500 m depth to full ocean depth is about 20 km.

The transmission sector is electonically stabilised both for roll (±15°) and pitch (±10°). The reception beams are roll-stabilised. The transmission beam width is 1.8° and the receive beam width is 3.5° (inner beams) to 5.0° (outermost beams) athwartship (Figure 3). The relatively large alongship receive beam-width of 20° eliminates the need for pitch correction.

In deep (water) mode, the received signal is sampled with a range resolution of 2.4 m. Detection of the bottom return in each beam to estimate travel time is carried out by analysing both the amplitude and phase of the return signals. Best results are usually obtained by using amplitude detection for the inner beams and phase detection for the outer beams, which strike the seafloor at grazing incidence and produce a return that is more smeared in time.

Amplitude data collected are used to produce acoustic imagery or backscatter images of the seafloor that are akin to sidescan sonar images created by systems such as SeaMARC II and

GLORIA. The EM12D acoustic imagery is geometrically corrected and is also amplitude corrected for slope of the seabed. On-board facilities allow the production of high quality maps of acoustic imagery superimposed on detailed bathymetry contours.

A hull-mounted sound velocity sensor provides near-surface data to control beam direction. In addition, sea temperature profiles are measured up to several times per day to depths of about 2000 m using expendable probes (Sippican XBTs with 0.2°C accuracy). Standard global salinity tables (Levitus/Carter) are used to convert the temperature data to sound velocity data. The sound velocity profiles are used to fully correct for refraction of the beams in the water column, and therefore enable accurate determinations of both depth and horizontal cross-track distance.

In deep water, the ping rate is typically 15 seconds. Survey speed is generally 10-11 knots (19-20 km/hr). This means that under normal conditions, bathymetric data are collected over a grid roughly 100 m x 100 m along a strip of seafloor up to 20 km wide at a rate of about 400 km²/hour. Deep-water bathymetric data processed on board are usually displayed at 20 m or 25 m contour intervals.

EM950

The Simrad EM950 (Alleman et al., 1993) is a 95 kHz high-resolution multibeam swath mapper that is similar in operation to the EM12D. With range limited by lower transmission power and higher frequency, it is designed to operate in relatively shallow water of less than ~400 m depth. The system is effectively 120-beam, with its 60 receive beams interlaced on alternate pings. In standard survey mode, the EM950 has an angular coverage of up to 150° (same as for the EM12D), resulting in a swath-width of 7.4 times water depth.

The EM950 transducers were installed by divers on *L'Atalante*'s hull during the Port Adelaide port call.

CRUISE NARRATIVE

L'Atalante sailed from Port Adelaide on schedule at 3.00 pm on Sunday 3 April, and headed west to the Great Australian Bight in fine weather with slight-moderate seas and moderate swell. The newly-installed, high-resolution Simrad EM950 swath-mapper was switched on; gravity data were collected.

Underway tests on the EM950 commenced as the ship steamed at 12 knots to the first test area "Zone A" (Figure 2). This area is located on the continental shelf at 33° 10.9' S 131° 19.4' E. The seafloor here is fairly flat at ~110 m depth.

Zone A was reached at about midnight on 4 April. After further preliminary calibrations of beam orientation, the EM950 was test run over a cross-shaped, grid pattern about 5 km across (Figure 6). Test speed was mainly 6 knots, but some lines were run at 12 knots. It soon became apparent that there was a problem. The cross-track bathymetry showed pronounced curvature, typical of incorrect velocity profile data having been entered into the system. A number of Sippican XBTs were deployed, and the data from these were double-

checked by sending a CTD through the water column to the bottom via the hydrographic winch. The data were found to be consistent. It was then discovered that a PROM with an inappropriate program had been inserted in the EM950. After this was replaced by the Simrad technician, the EM950 appeared to function well.

The ship then transited to the next test area, "Zone B" (Figure 2), located at 32° 30.0' S 129° 00.8' E, where the seafloor was flat and relatively shallow (52-56 m depth). A test grid of lines, similar to the pattern completed at Zone A, was run at this location (Figure 7). The tests appeared to be successful.

The next step in the EM950 trials was to run a set of test lines across a relatively steep part of the upper continental slope farther to the west, at "Zone C" south of the Archipelago of the Recherche (Figure 2). The performance of the EM950 and EM12D would be compared here.

Zone C was reached in the morning of Thursday 7 April. The weather was good with moderate seas on a moderate swell. At midday, test lines (Figure 8) were begun along a transect across the slope to water depths of at least 1200 m. The aim was to check the response of the EM950 to changing water depth and the function of the auto sector control. The EM950 proved to be okay to 470 m depth. The final test in this area involved the running of a 5 x 10 km, NE-SW oriented grid of closely spaced lines. Water depths over the grid, centred at 34° 26.5' S 123° 58' E, were in the range 80-340 m. EDBS (equidistant horizontal beam spacing) mode was compared with 1°BS. No major difference in data quality was found.

Early next morning (8 April), with the main phase of the EM950 calibration/testing completed, the ship headed to Albany. The magnetometer was deployed and magnetics recording began at 7.20 am. On this transit from the test area to Albany, EM12D data were collected along an E-W line over the mid and lower slope of the continental shelf (Figures 2 and 3). There was a 2½-hour break in EM12D acquisition on this line to allow an archive of the system software for J-P. Calvez.

L'Atalante arrived in Albany Harbour at 7.00 am on Saturday 9 April. Four French technicians/engineers and the Norwegian Simrad engineer (Appendix 1) were disembarked by launch, and by 8.00 am the ship was heading back out to sea. Weather was stormy and overcast with rough seas on a large swell.

Spikes in the EM950 data, seen as 'potatoes' in the Benson plots, were traced to the ADCP, which operates at 75 and 300 kHz. The ADCP was turned off to avoid the noise problem.

After rounding the southwest tip of WA, an EM12D line was run along the lower and mid slope of the continental margin west and northwest of Perth (Figures 2 and 4). The magnetometer was redeployed and recording by 7.10 am on 10 April. A T5 deep-water Sippican XBT (XBT No. 14) was deployed at 5.38 pm and successfully recorded to 2000 m depth (Figure 9).

It was hoped to run a line along the ESE margin of the Cuvier Abyssal Plain. However, it again become necessary to do further testing of the EM950 in shallow water, so a shorter

route close inshore was run. This would allow extra time for deep-water EM12D survey work planned along the Argo Abyssal Plain / Scott Plateau margin. Tropical cyclone 'Vivienne', which had been hovering over the planned route off NW Australia for the past week, moved west and so was not expected to jeopardise survey progress. Off the mid west coast (Carnarvon-Exmouth) ship's speed was ~11.6 knots; seas were moderate with a 15-20 knot easterly wind.

The survey continued to proceed very successfully. Full coverage with the EM12D and/or EM950 swath-mapping, magnetics and gravity was obtained all the way from the Exmouth area to the Timor Trough (Figures 2 and 5). The 3.5 kHz record coverage was patchy because of continued testing and software modifications.

The ship being a little ahead of schedule on the transit, several hours were available for deviations to survey the lower continental slope adjacent to the eastern Argo Abyssal Plain (NE Exmouth Plateau - Rowley Terrace - Scott Plateau). This included mapping the Taipan Canyon (Figure 5).

The survey finished southwest of Timor at 10 pm on Friday 15 April at the outer limit of the Australian Fishing Zone (Figure 5).

L'Atalante then continued north to Davao by the most direct shipping route through the Savu, Banda and Molucca Seas (Figure 1). The ship arrived in Davao at 8.00 am on Wednesday 20 April.

GEOSCIENTIFIC DATA COLLECTED

The survey length (in Australian waters) was approximately 5400 km. Details of events and start/stop times in the data acquisition are provided in the operators' log, Appendix 4.

Data collected included:-

Swath-bathymetry and acoustic imagery (EM12D and/or EM950)	5400 km
Gravity	5400 km
Magnetics	3300 km

3.5 kHz strip-chart records are available for about 30% of the survey. Extensive testing and software development of a digital 3.5 kHz acquisition system meant significant data loss was unavoidable. Nevertheless, the development work on the CHEOPS digital system by Pascal Viollette resulted in major improvements to the 3.5 kHz acquisition. These improvements include, (i) heave compensation, (ii) recorder speed linked to ship's speed giving scale constant in distance rather than time, and (iii) better time/depth scaling lines and improved annotation options.

The most valuable data set for AGSO's CMP (Continental Margins Program) are the deep-water (1-5.5 km depth) EM12D data. About 2050 line-km of such data were collected along the margin (east of Albany, off Perth-Carnarvon, and in the Rowley Terrace / Scott Plateau area; Figure 2). The area mapped amounts to about 30,000 km^2.

The EM950 was operated on those parts of the transit route that crossed the continental shelf (water depth less than ~ 0.5 km). This included the sections Adelaide to Zone C (SE of Esperance), Albany to SW of Perth, and Carnarvon to NW of Port Hedland.

The KSS-30 gravity meter was calibrated by ties to onshore gravity stations at Port Adelaide at the start of the transit and at Davao shortly after the cruise ended. The Port Adelaide tie results are provided and discussed in Exon et al. (1994, p. 54-55). The Davao tie data supplied by J-P. Allenou are:

Tie 122, 22 April 1994: Absolute gravity 978100.06 mGal Meter reading -2511.94 mGal
Tie 123, 7 May 1994: Absolute gravity 978095.3 mGal Meter reading -2508.8 mGal.

While the ship was moored at the wharf at Davao, the KSS-30 showed short period fluctuations of several mGals, with total variation as much as 10 mGal. Similar meter instability was first identified at the end of the TASMANTE cruise (Exon et al., 1994).

Total field magnetic data were collected from Zone C to Albany, and from SW of Perth to the Timor Trough (end of survey).

PROCESSING AND MAPPING OF THE EM12D SWATH DATA

Because the cruise was a transit leg with system trials being the priority, there was limited opportunity to process the EM12D/EM950 digital data on board ship specifically for scientific mapping purposes. The bathymetric data for Taipan Canyon were processed and displayed on board as a special request. However, these data represent only a very small subset of the data collected. The real-time bathymetric contour plots for the deep-water EM12D data were generally of fair to good quality, but the limited hardcopy acoustic imagery produced on board was of poor quality. Post-processing and display of the data was required to effectively present and utilise the considerable amount of information in the new data sets.

The shipboard ADEDAV digital swath data were processed in June 1994 by the author at SMAI in Noumea, using newly installed IFREMER software. The software included the TRISMUS (bathymetry) and IMAGEM (acoustic imagery) packages. Hardware available comprised a Sun Sparc10 workstation, Océ G9865 400-dpi thermal plotter (B&W) and Océ G5242-CAD A3 300-dpi colour plotter.

A diagram of the acquisition and processing sequence for *L'Atalante* swath-mapping and geophysical/oceanographic digital data is presented in Figure 10. The processing steps shown for the swath data are those devised for processing the ADEDAV and TRANSNOR (Norfolk Ridge) data. The bathymetric gridding and contouring was based on a 100 m grid size.

Bathymetry contour maps with 20 m contours and acoustic imagery were produced for 25 1:100,000 scale map sheets (Albany 1-5, Perth 1-9 and Argo 1-11). In addition, EM12D

bathymetry data acquired in October 1993 over the Norfolk Ridge were also processed and mapped at the same contour interval and scale for 11 map sheets (Transnor 1-11). Enclosure 1 is a location and index map of the sheets. All bathymetry maps were also produced at 1:250,000 scale and 50 m contour interval. Because the seafloor structure seen in the Argo 5 (Taipan Canyon), and Argo 10 and 11 (Timor Trough area) sheets were of particular interest and because the data quality was high, bathymetry contour maps of these sheets were also produced at 10 m contour interval (1:100,000 scale).

PRELIMINARY RESULTS

On the shelf of the Great Australian Bight, just east of Zone A (at about 33° 32' S 131° 54' E) prominent linear patterns were observed in the EM950 acoustic images. The seafloor lineations had a typical spacing of 50-150 m and NW-SE trend. The seafloor was fairly flat at 104 m depth; seafloor relief was ~0.5 m. The bands may represent variations in sediment type or grain size within a field of low-amplitude sediment waves possibly produced by storm surges.

The EM950 sonar imagery displayed similar lineated patterns at Zone B (Figure 11) and Zone C (Figure 12). The seafloor at Zone B, located mid-shelf, was almost flat. Water depth over a slightly undulating seafloor was 52-56 m. The distinct NW-SE trending acoustic lineations have a wavelength of mainly 50-80 m. There was no obvious correlation of bathymetry and acoustic pattern. At Zone C (shelf edge southeast of Esperance), the acoustic lineations were more widely spaced (~300-900 m) and oriented WSW-ENE. Again, there was no significant expression of the lineations in the bathymetry (mapped at 2m contour interval).

The deep-water EM12D data both off Perth and east of Albany are spectacular, showing strongly developed relief due to margin structure and canyon incision. Some of the canyons, such as the Perth Canyon, are more than 1 km deep. The canyon walls on the continental slope east of Albany show pronounced NW and SW structural trends, consistent with NW-SE rifting leading to margin formation. The continental slope off the Carnarvon Terrace is extensively and deeply incised by canyons (Figure 13). The canyon floors appear relatively dark in the acoustic imagery (Enclosure 2), suggesting exposed bedrock or coarse lag deposits.

The survey data acquired off the continental margin adjacent to the Argo Abyssal Plain (Rowley Sub-basin - Scott Plateau area) are of excellent quality and show the spectacular structure along the margin in great detail. The marginal slopes are rugged and show significant erosion and canyon incision.

Taipan Canyon (Figure 5), located on the NW Shelf margin adjacent to Rowley Terrace, is a major geomorphological feature with several kilometres relief. It was mapped in detail for the first time during the ADEDAV survey. The Argo 5 bathymetric map (Enclosure 3), which shows this feature, illustrates the detail and coverage possible with new-generation swath-mapping techniques, such as that employed by the EM12D. The canyon walls are formed by a series of steep scarps and some large terraces. The walls are 2 km high at its mouth. Here the canyon floor flattens and opens out to meet the Argo Abyssal Plain at 5600 m depth. The spectacular topography and structural detail is well portrayed in the 3-D net

relief presentation (Figure 14), based on a 100 m grid spacing that coincides roughly with the bathymetric data point distribution.

Towards the end of the survey, over the southern flank of the Timor Trough, the real-time bathymetry data (and subsequently the processed data) were plotted at 10 m contour interval. The contours and 3-D displays of this area (part of Argo 10 and 11 sheets - Figure 15) show canyon incision and well-defined E-W oriented fault-scarps, probably produced by down-faulting of the Australian plate as it approaches the Java (Sunda) Trench - Timor Trough plate boundary. Though the surface faulting appears largely extensional (normal faults), some ?sinistral dip-slip may be present due to a component of shear between the Australian and Eurasian plates.

ACKNOWLEDGEMENTS

Cruise leader, Jean-Paul Allenou, supported AGSO participation and made the data collected off Australia available. He is thanked for his help and excellent co-operation in allowing deviations and general flexibility in the transit survey route, so that areas of structural importance on the Australian margin could be mapped with the on-board systems.

The Captain, Jean Claude Gourmelon, officers and crew of *L'Atalante* were a pleasure to work with and their significant contribution in the operational aspects of the scientific program is gratefully acknowledged. The ship's scientific and electronic technicians worked conscientiously and tirelessly to ensure that data acquisition was of the highest possible standard. The author was very grateful for the extra effort put in to provide him with plots and data sets at the end of the cruise.

The author very much appreciated the hospitality and technical support provided by SMAI and IFREMER officers while in Noumea processing and mapping the swath data. Special thanks go to Emmanuel Bouniot (SMAI) and Michel Gauthier (IFREMER).

Neville Exon of AGSO reviewed the draft report.

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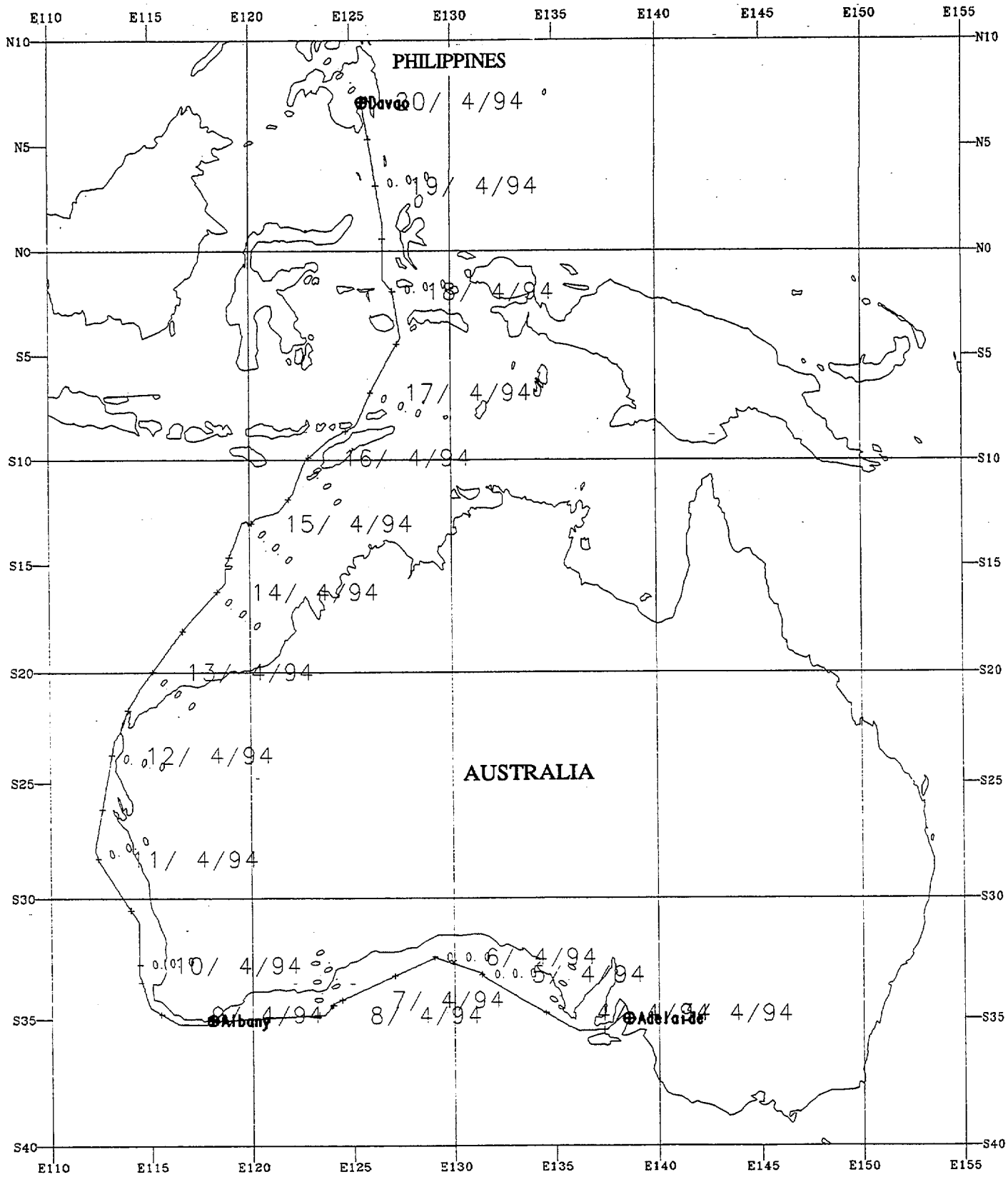


FIGURE 1. *L'Atalante* time-annotated track map, ADEDAV transit survey from Adelaide to Davao (Philippines). Crosses every 12 hours UT.

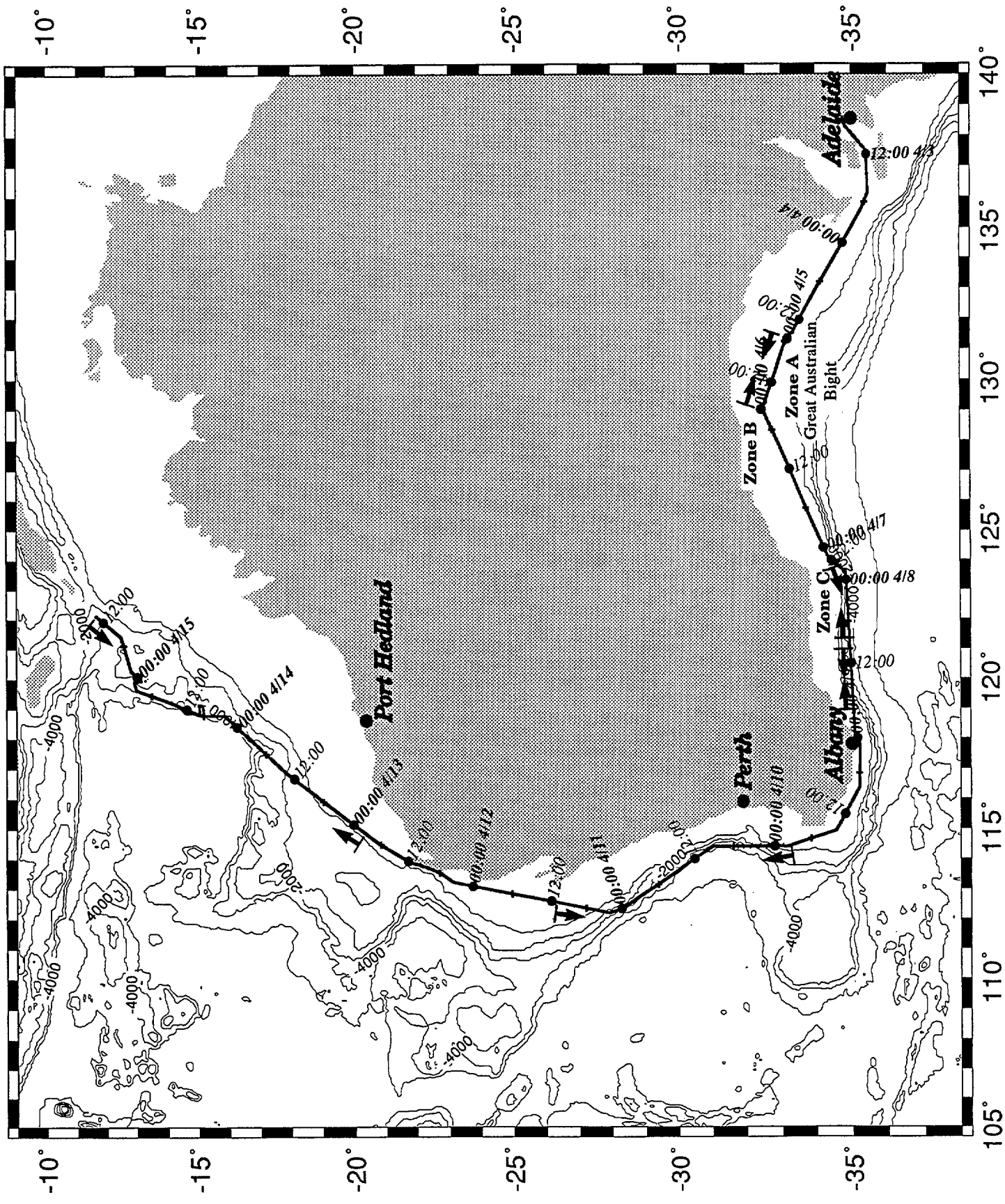


FIGURE 2. ADEDAV survey location in Australian waters. Bathymetry contours at 1000 m interval based on ETOPO5 data set. Arrows indicate EM12D coverage.

FIGURE 3. Detail of ADEDAV survey location in deep water of the Great Australian Bight east of Albany. Bathymetry contours at 200 m interval based on ETOPO5 data set.

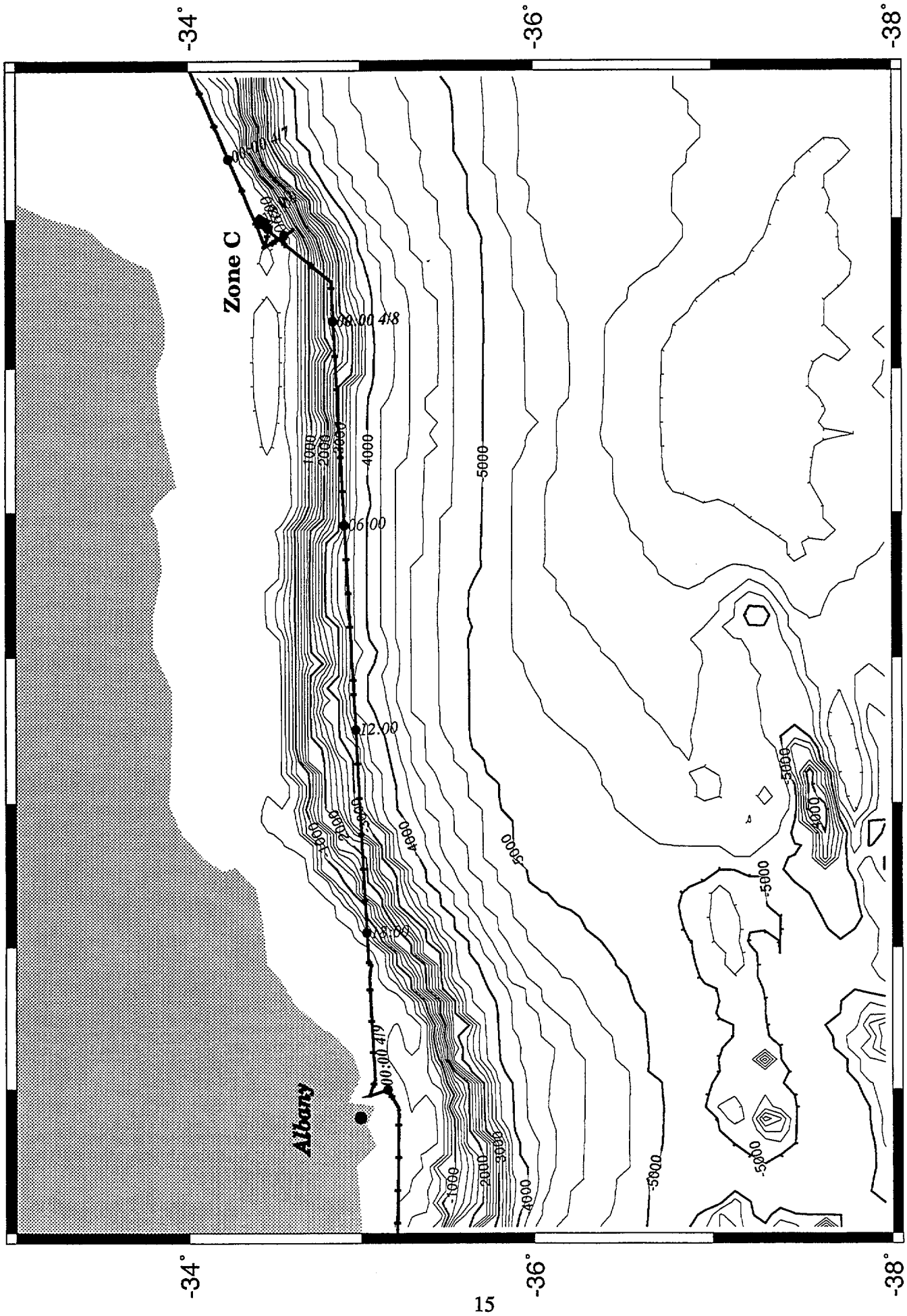


FIGURE 4. Detail of ADEDAV survey location along the continental margin west and northwest of Perth. Bathymetry contours at 200 m interval based on ETOPO5 data set.

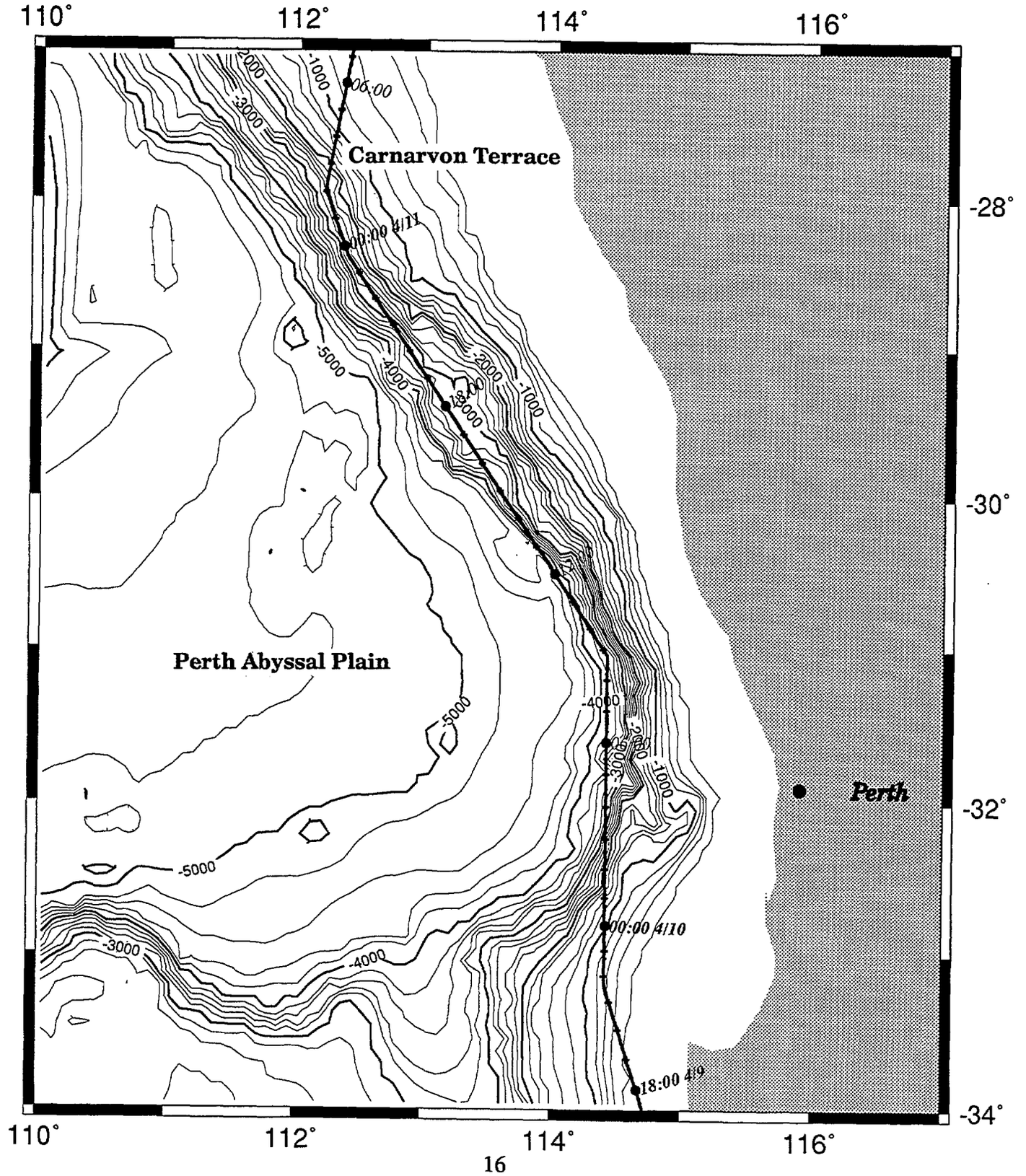
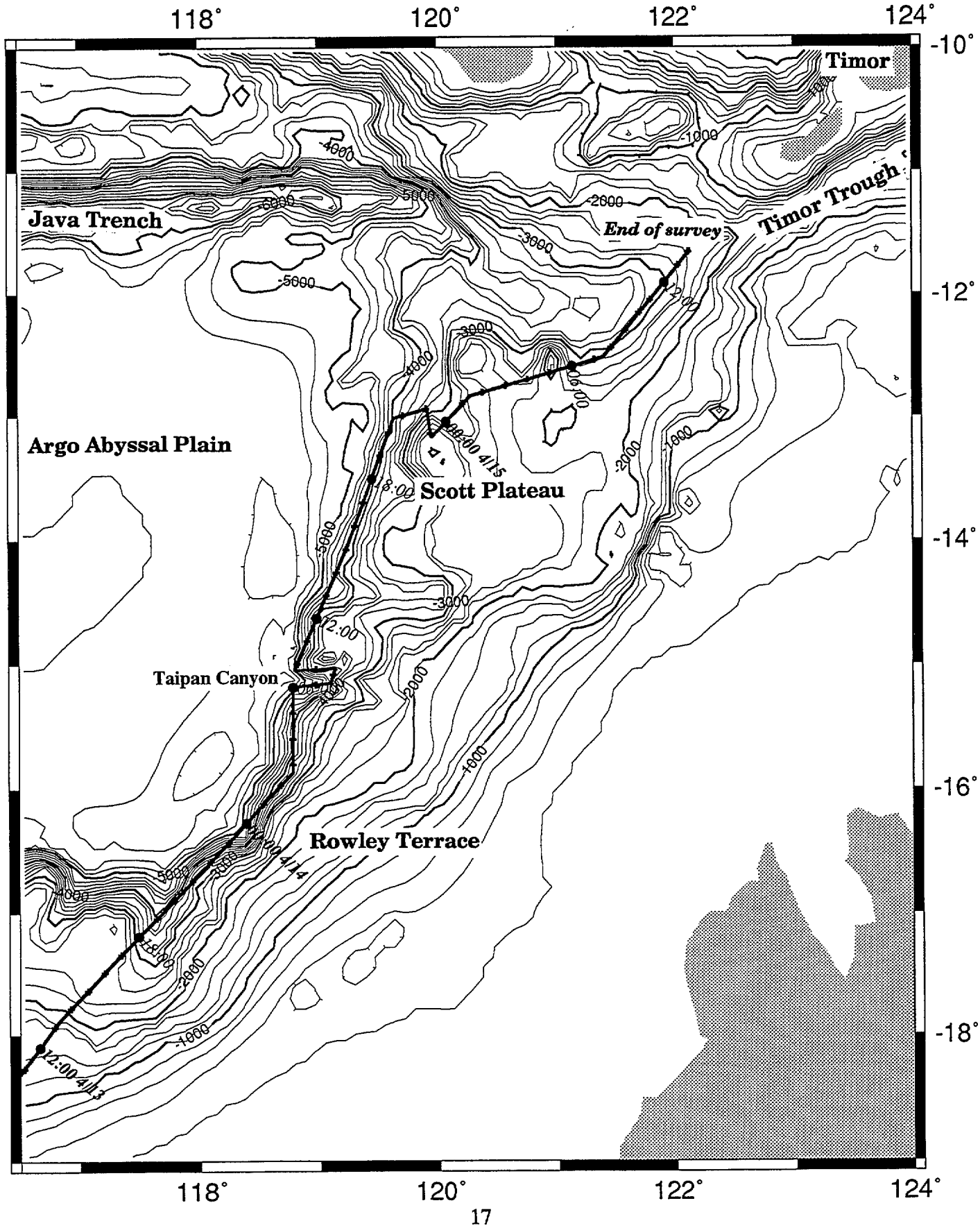


FIGURE 5 Detail of ADEDAV survey location along the continental margin of northwest Australia (Rowley Terrace / Scott Plateau / Timor Trough). Bathymetry contours at 200 m interval based on ETOPO5 data set.



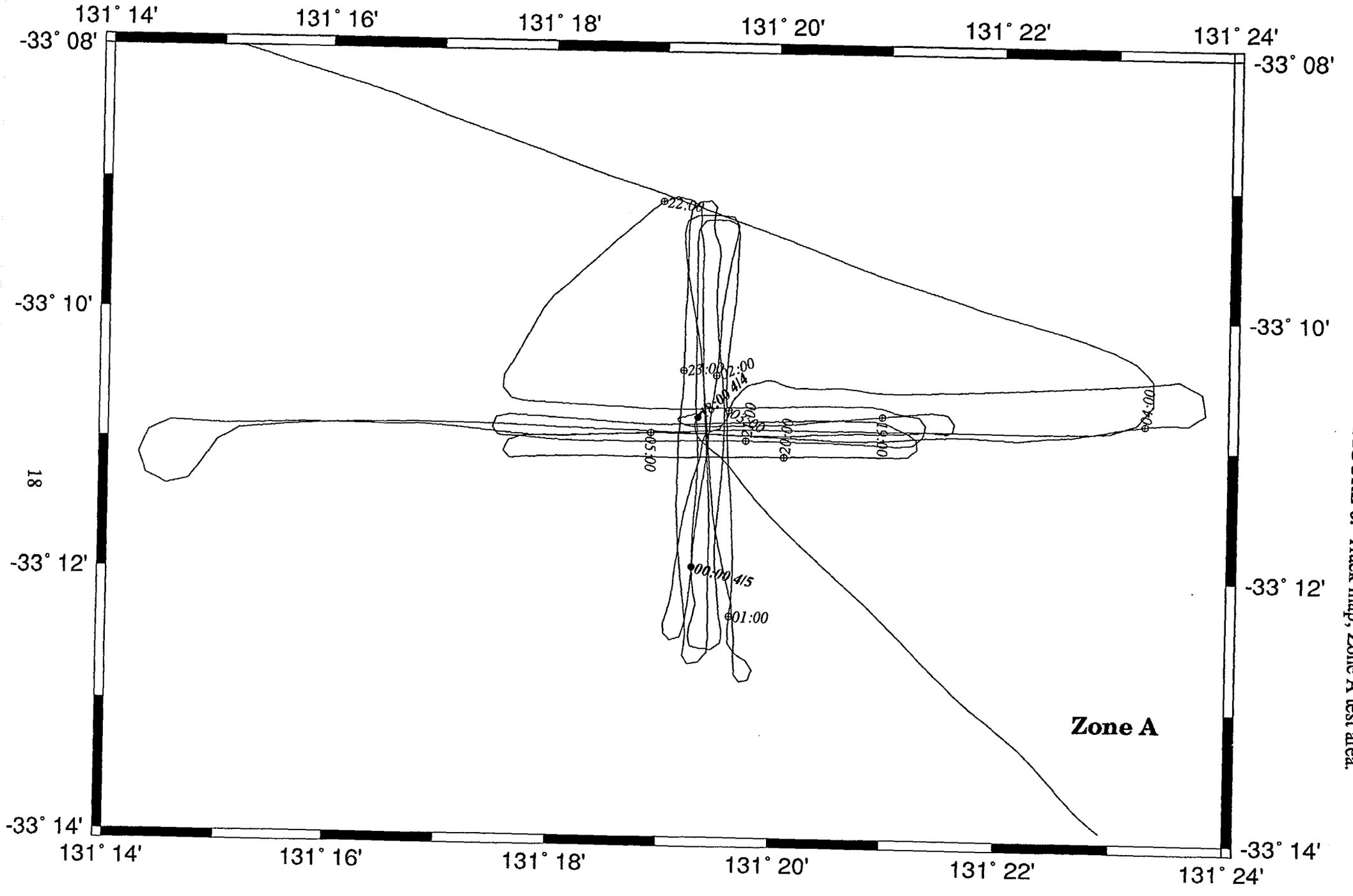


FIGURE 6. Track map, Zone A test area.

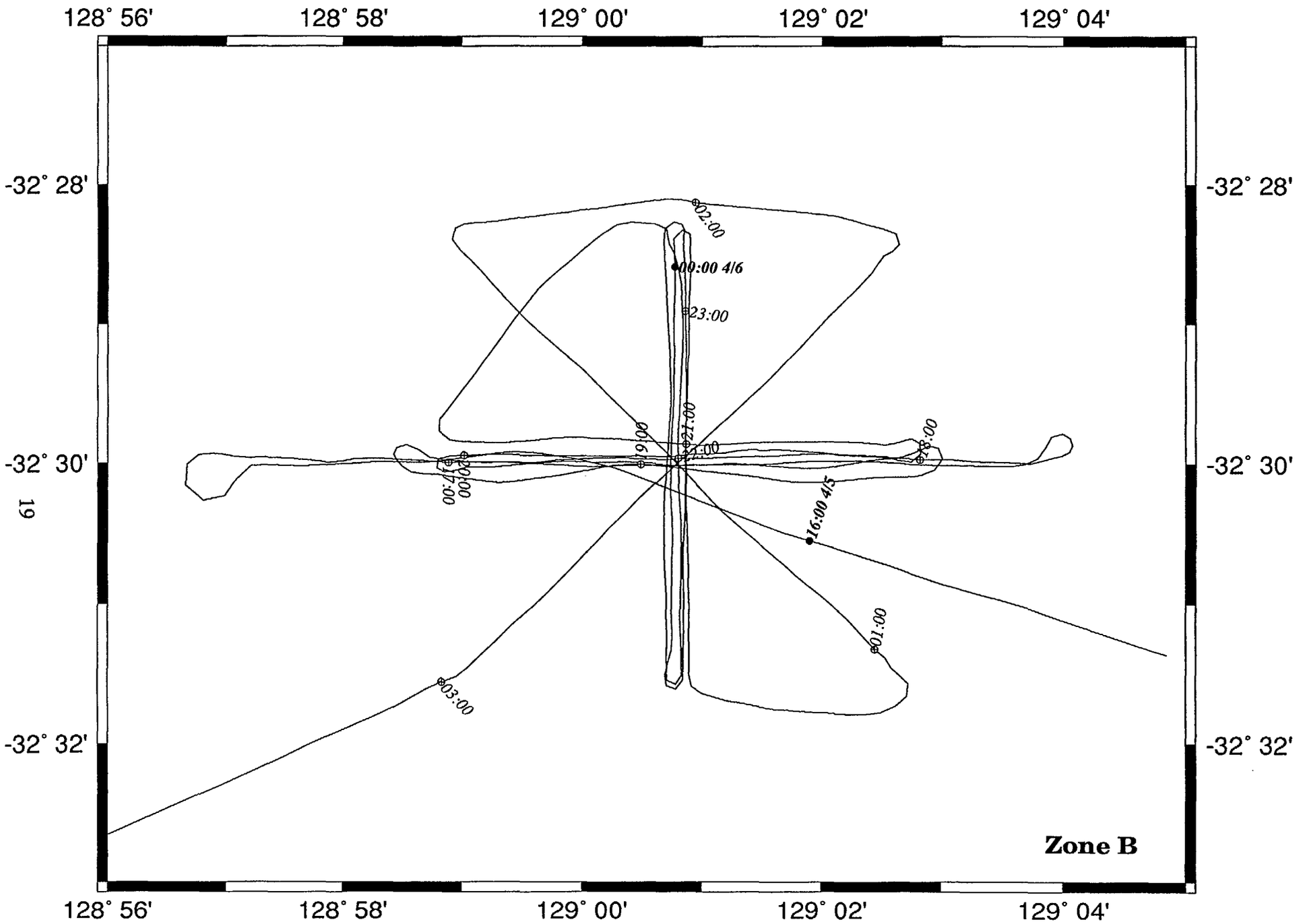


FIGURE 7. Track map, Zone B test area.

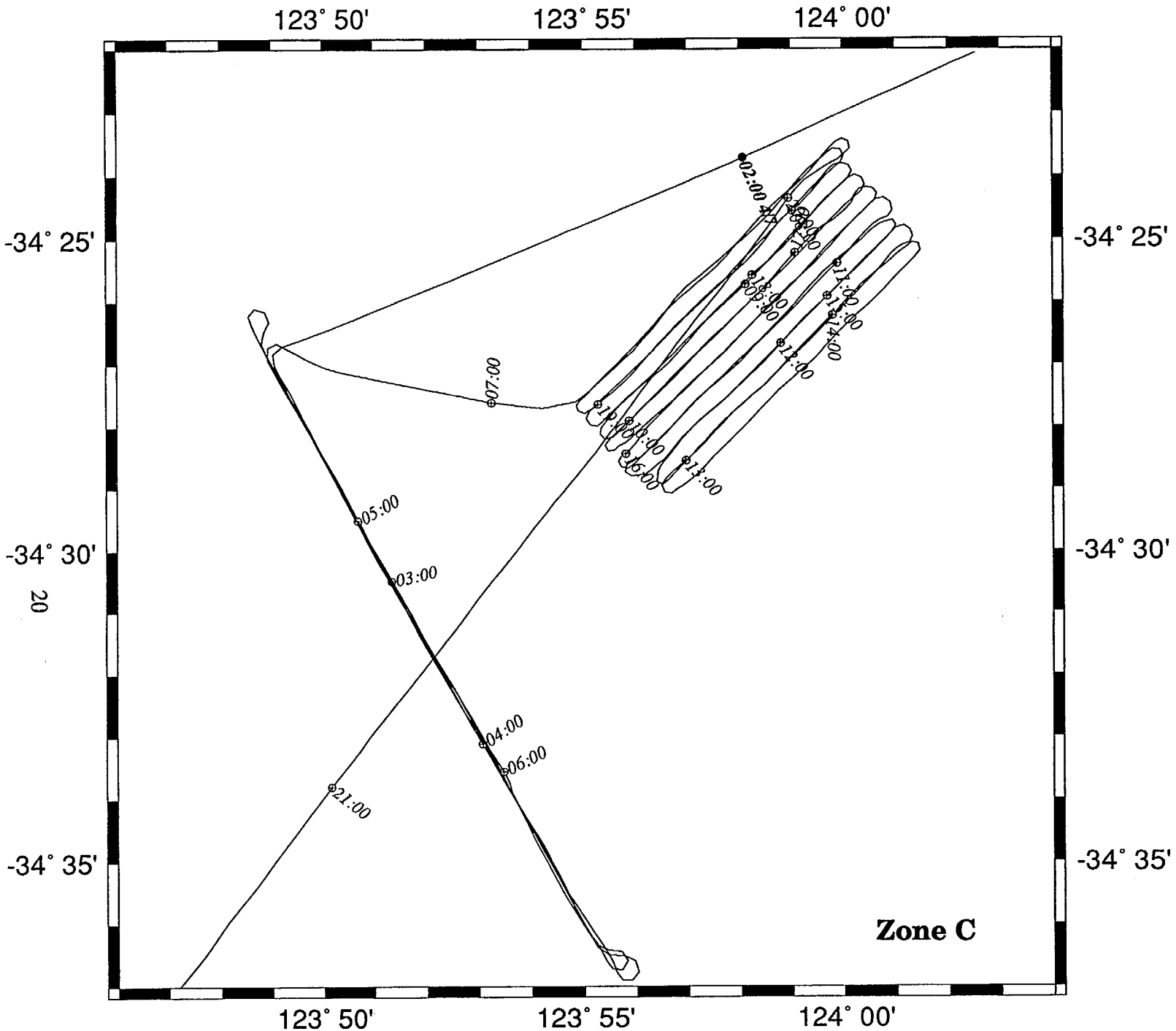
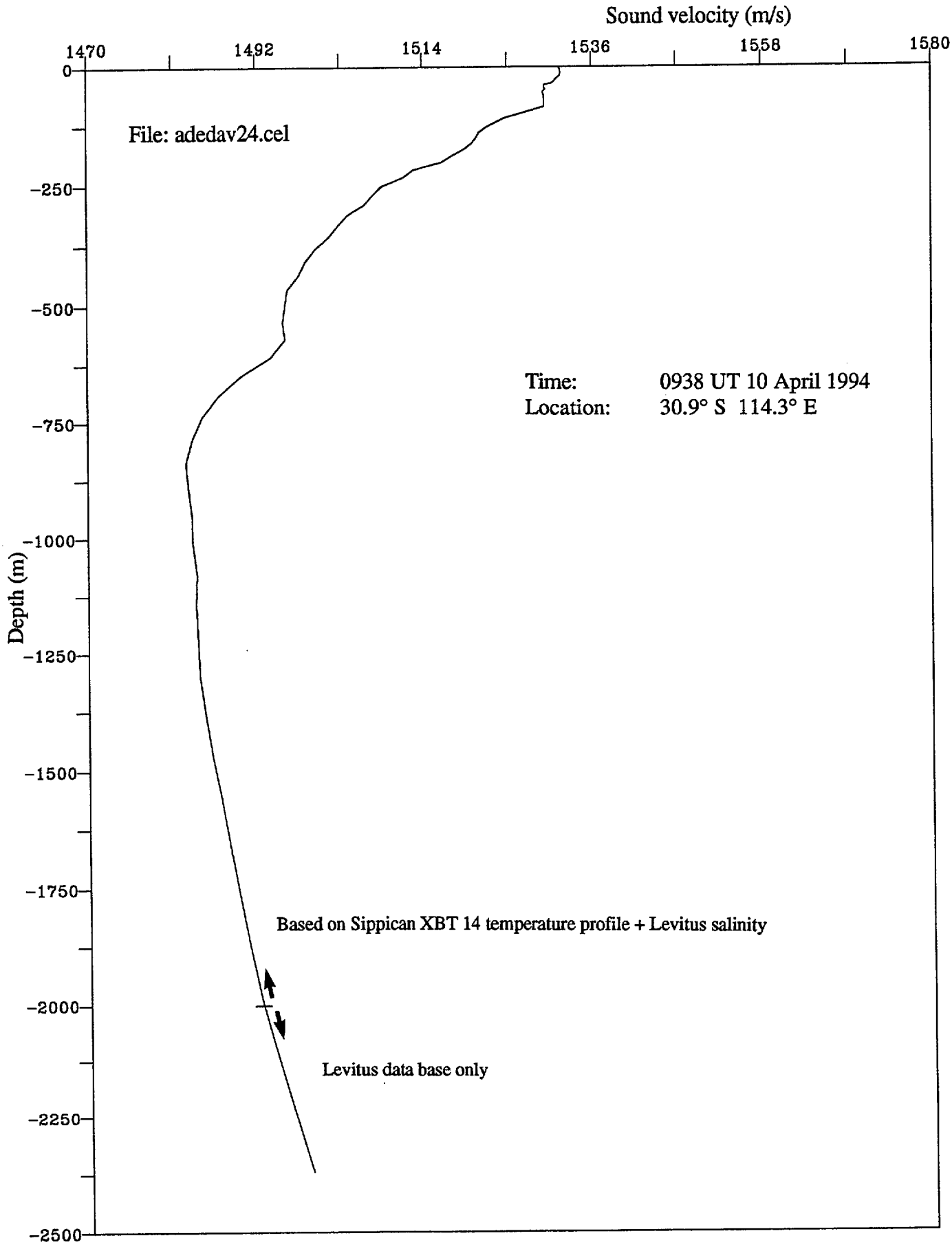


FIGURE 8. Track map, Zone C test area.

FIGURE 9. Sound velocity profile off Perth based on Sippican XBT 14.



Shipboard Data Acquisition Systems

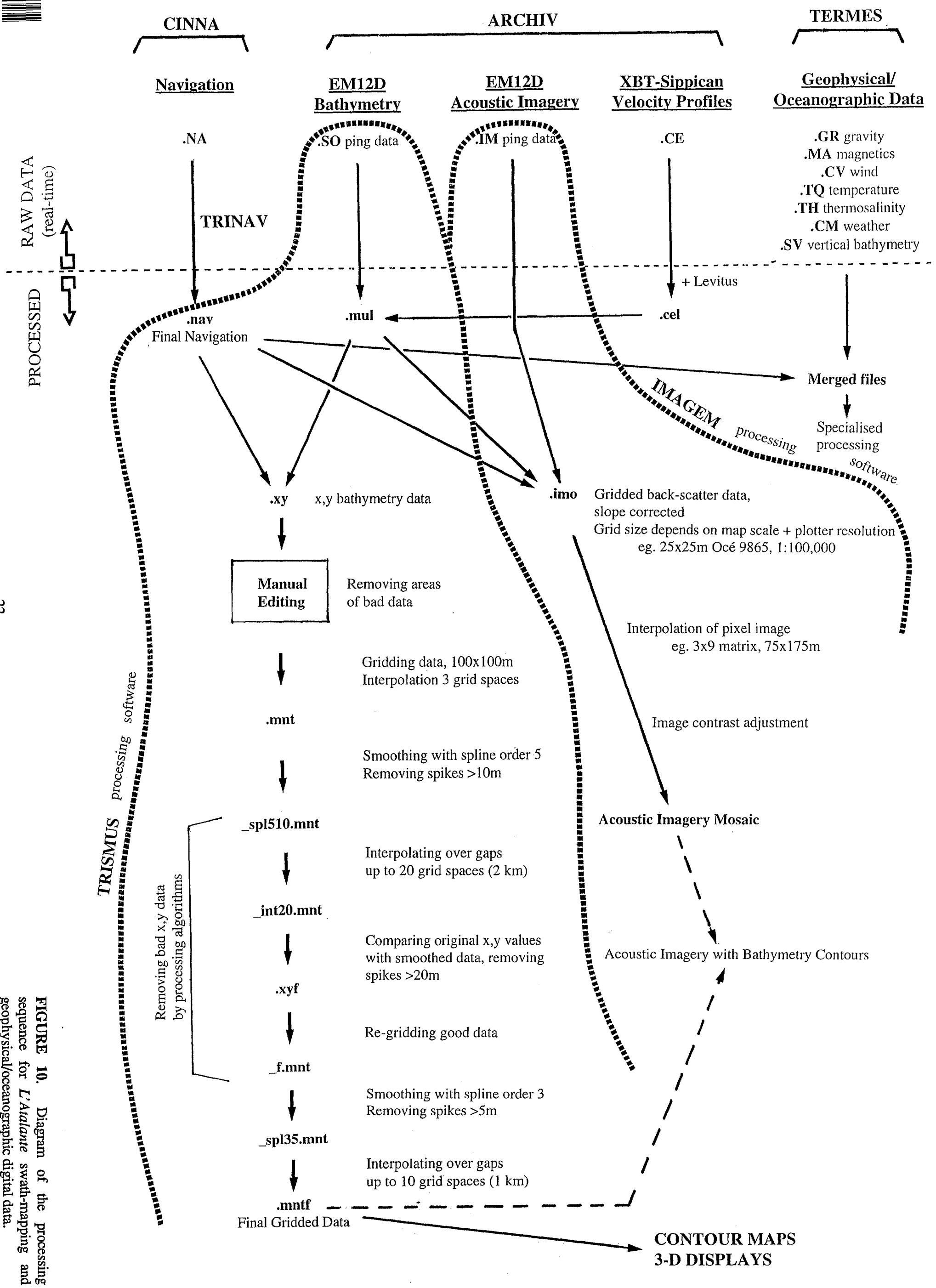


FIGURE 10. Diagram of the processing sequence for *L'Atalante* swath-mapping and geophysical/oceanographic digital data.

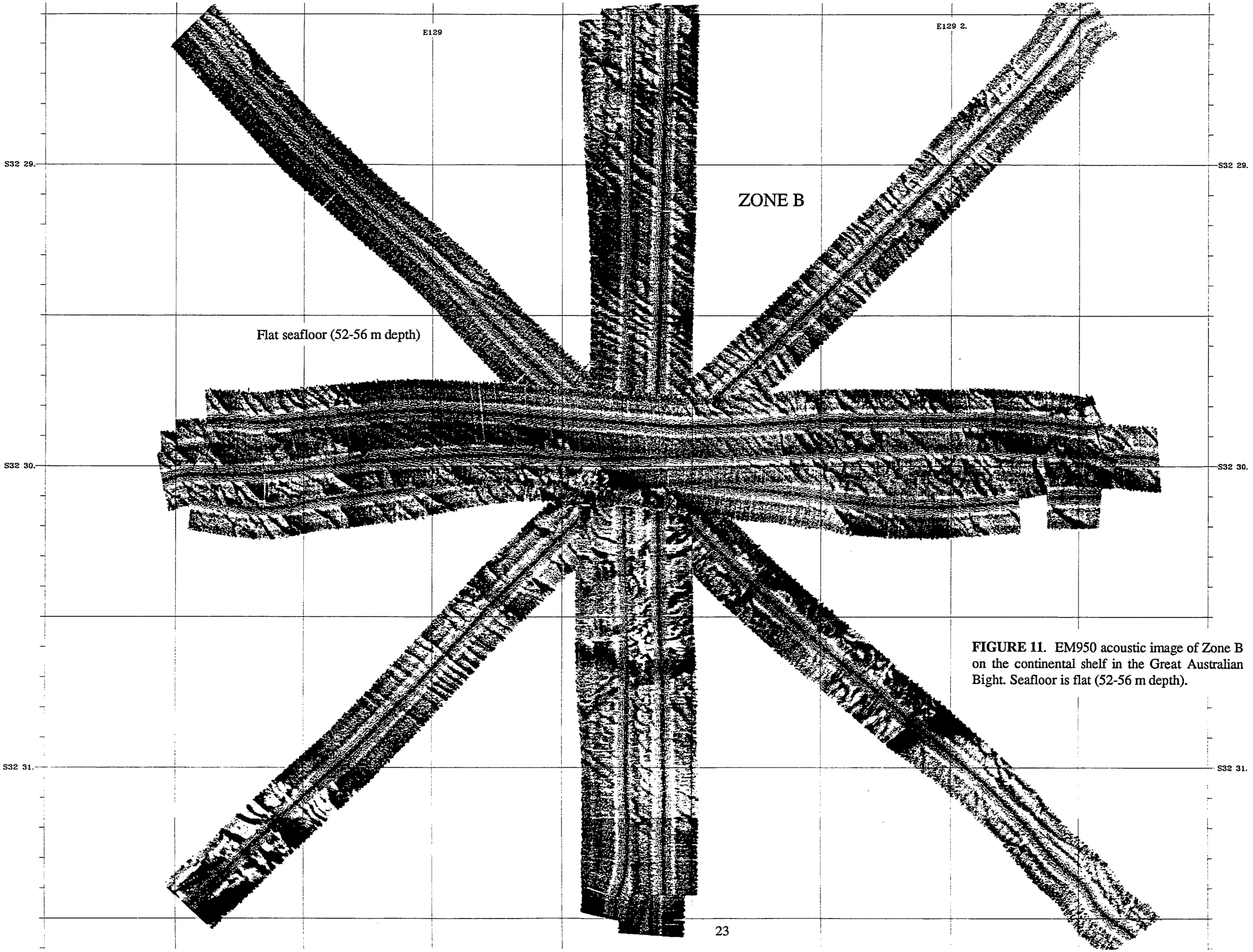


FIGURE 11. EM950 acoustic image of Zone B on the continental shelf in the Great Australian Bight. Seafloor is flat (52-56 m depth).

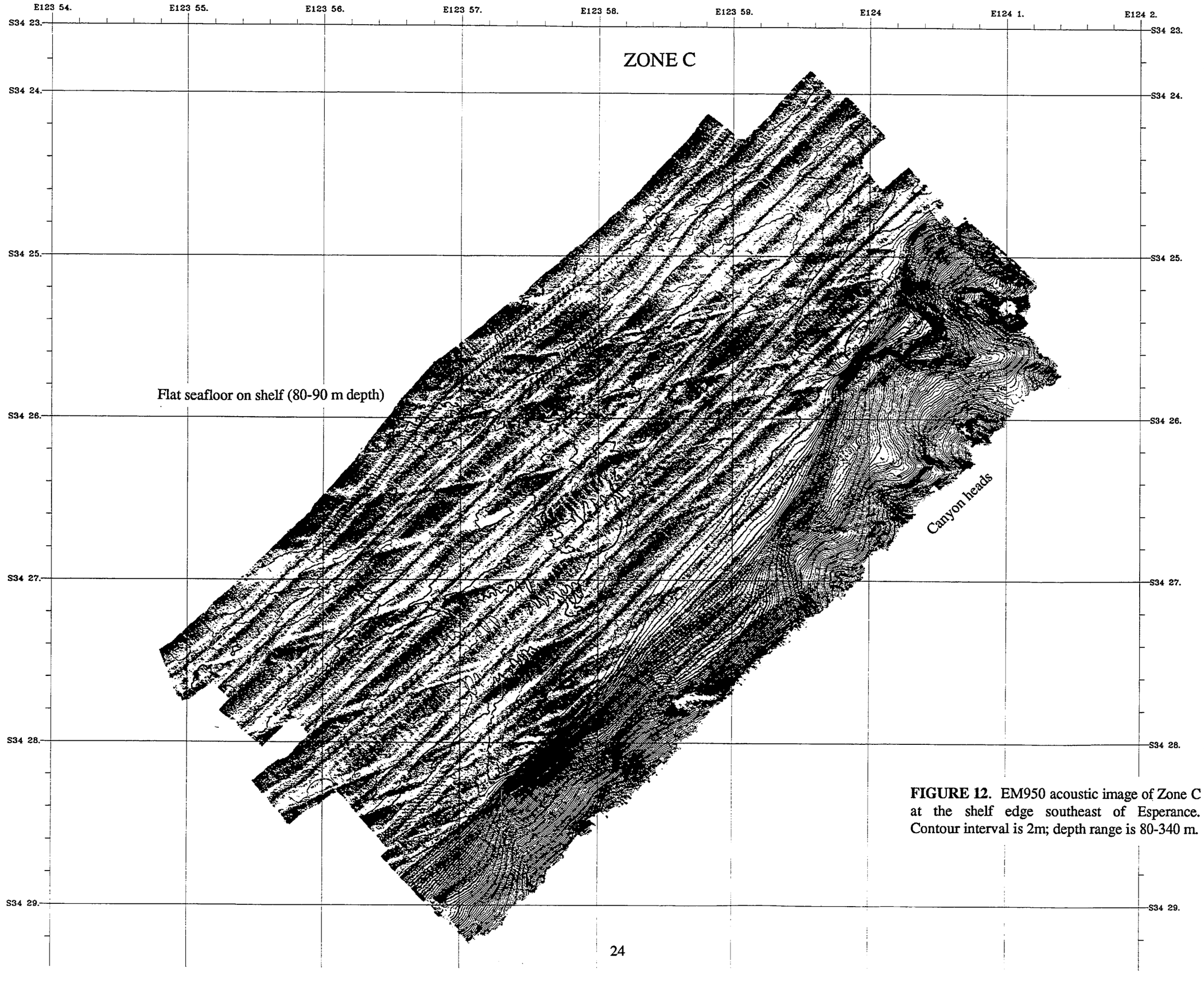


FIGURE 12. EM950 acoustic image of Zone C at the shelf edge southeast of Esperance. Contour interval is 2m; depth range is 80-340 m.

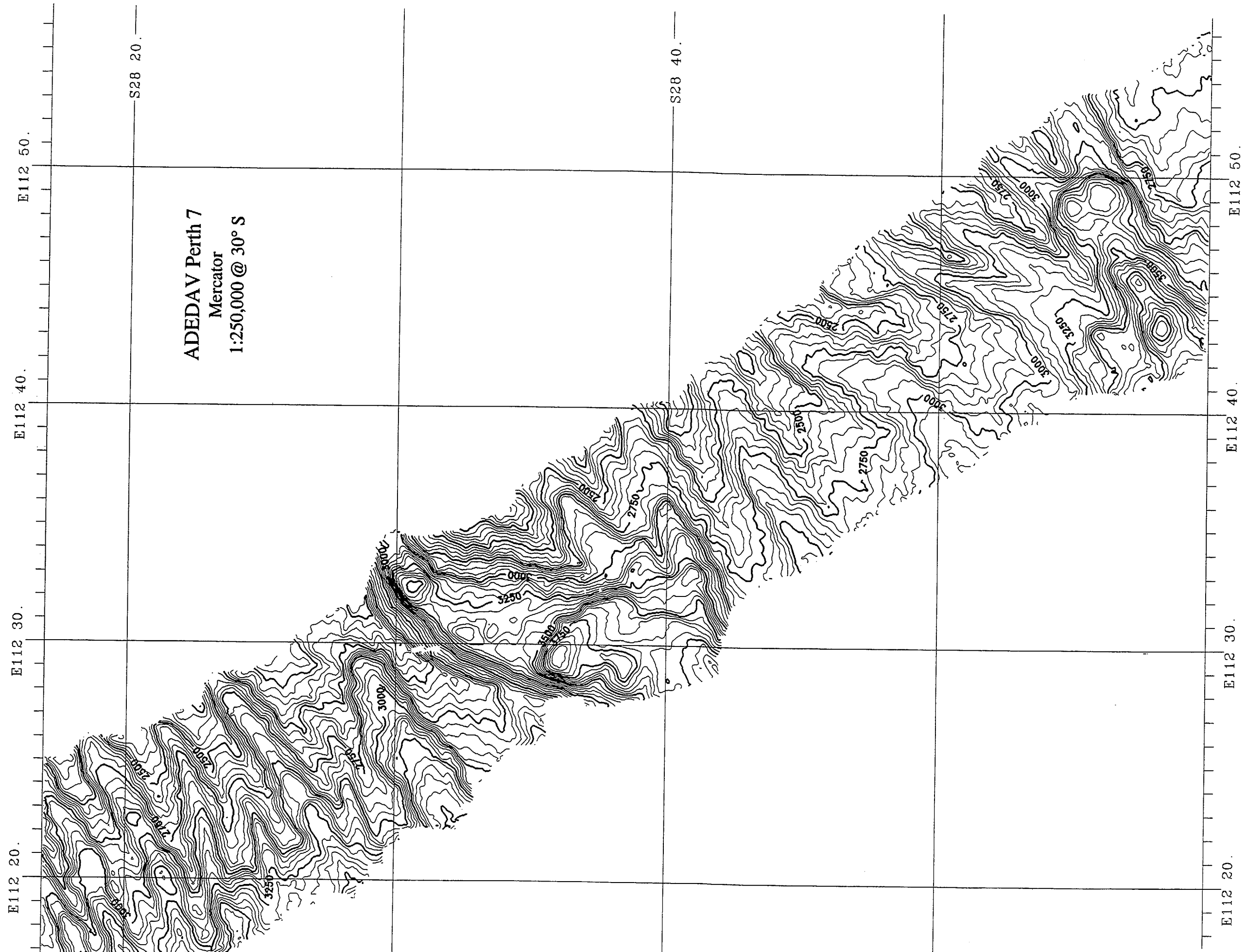


FIGURE 13. EM12D 50 m bathymetric contours of the continental slope off Carnarvon Terrace (Perth 7 1:250,000 map).

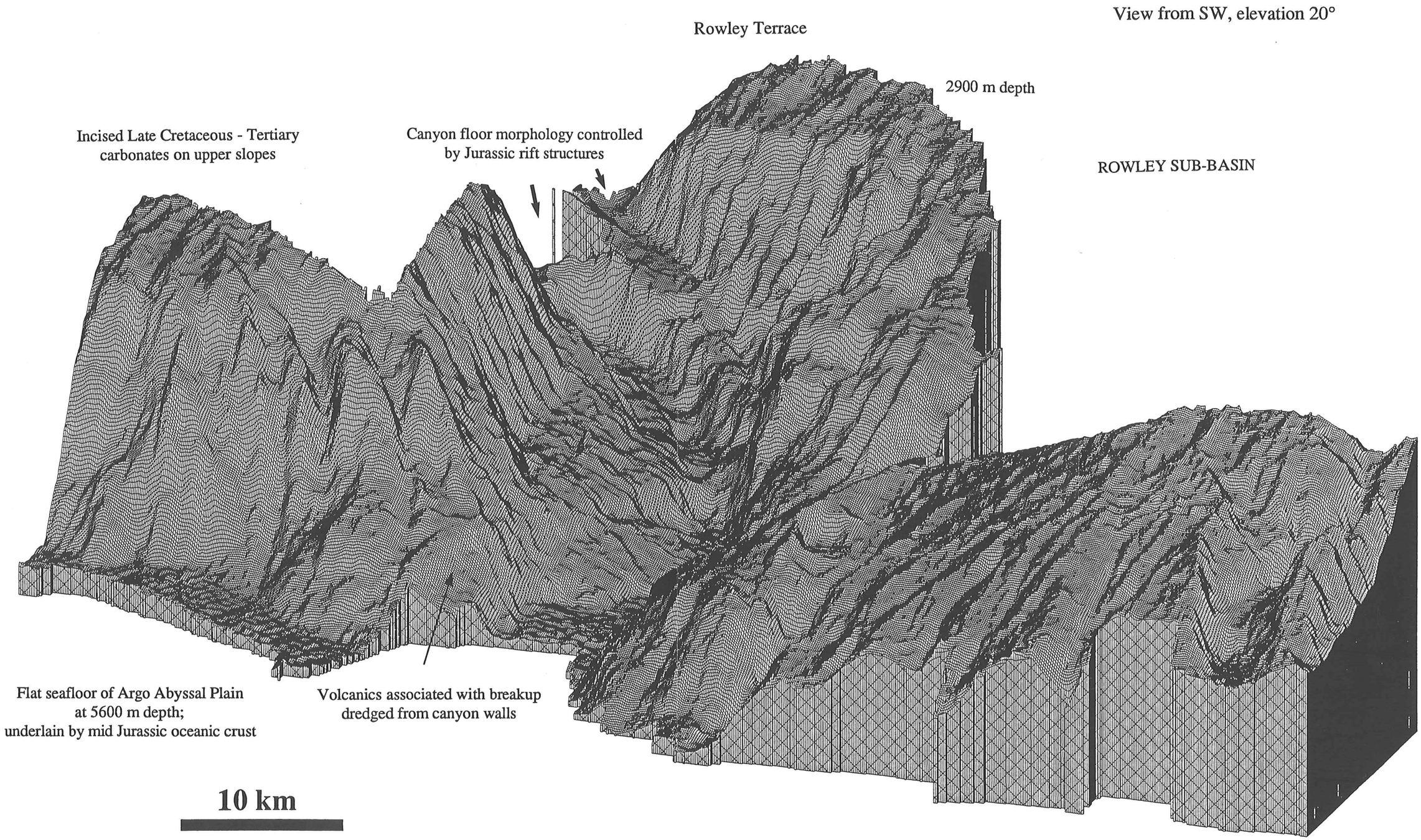
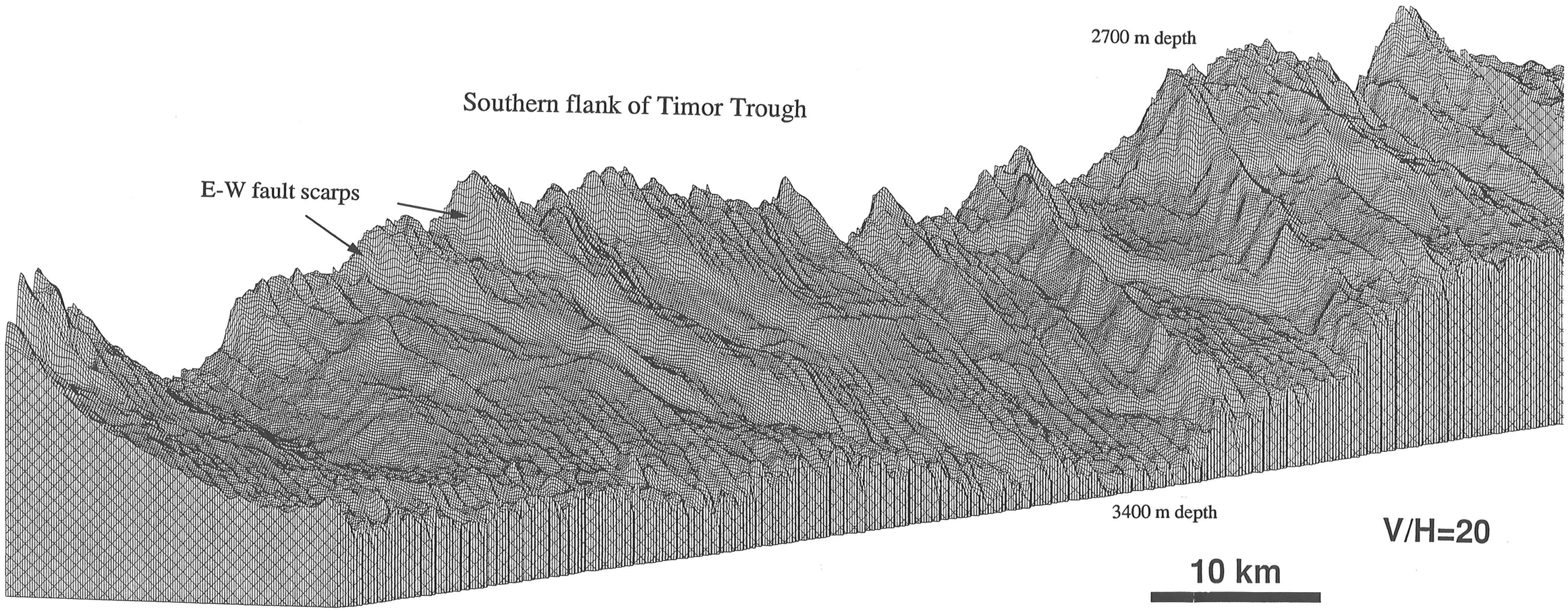


FIGURE 14. Three-dimensional bathymetric image of Taipan Canyon (Argo 5 map sheet).

View from NNW, elevation 10°



Swath-mapped area shown lies between 12° 32'S and 11° 55'S

FIGURE 15. Three-dimensional bathymetric image of the southern flank of the Timor Trough (part of Argo 10 and 11 map sheets).

APPENDIX 1
Shipboard Personnel

Ship's Crew (GENAVIR)

GOURMELON	Jean Claude	Master
LEMOINE	Mathieu	Chief Mate
LE PAPE	Philippe	Mate
MOIMEAUX	Phillipe	Mate
ABAUT	Robert	Radio Officer
LE QUELLEC	Alain	Chief Engineer
GUILLEMET	Philippe	Second Engineer
TROUDART	Luc	Engine Officer
LOSSOUARN	Hubert	Electronician
HALL	Guy*	Electronician
BRENAUT	Michel	Electronician
LE SCAON	Philippe*	Electronician
LE GOASDUFF	Jean Yves	Boatswain
TUATAANE	Kelekolio	Second Boatswain
MILLINER	Guy	Able Seaman
COROLLEUR	Francois	Able Seaman
LE BIHAN	Thierry	Able Seaman
TUAL	Denis	Able Seaman
NEMOADJOU	Victor	Seaman
ROGER	Marcel	Chief Greaser
PLOUHINEC	Philippe	Electrician
SARAULLO	Eric	Greaser
QUEDEC	Olivier	Wiper
GUILLOU	Jean Pierre	Chief Cook
SEITE	Jean Jacques	Chief Steward
BERTHELE	Jacques	Second Steward
SCARPETTA	Jean Francois	Second Cook
PERSOGLIA	Michel	Steward
TUUGAHALA	Mikaele	Steward

Scientists / Technical Experts

French

ALLENOU	Jean Paul	Cruise leader & chief systems engineer, IFREMER
CALVEZ	Jean Pierre*	Engineer (information systems), STERIA SBS
EDY	Christian	Engineer (software), IFREMER

LE BRIS	Joël	Technician, GENAVIR
LE CAP	Jean Michel*	Technician, THOMPSON
LOUSSOUARN	Claude	Technician, GENAVIR
ROUAT	Louis	Engineer, GENAVIR
VIOLLETTE	Pascal	Engineer, GENAVIR
Australian		
HILL	Peter	Geophysicist, AGSO
Norwegian		
UHLEN	Helge*	SIMRAD engineer

* Left the ship at Albany (total of 5 engineers and technicians)

APPENDIX 2
Information on *L'Atalante*

Length overall	84.60 m
Beam overall	15.85 m
Draught (zero trim)	5.05 m
Gross tonnage	2355 tons
Net tonnage	435 tons
Cruising speed	13 knots
Maximum speed	14.5 knots
Endurance at 12 knots	60 days
Port of registry	Brest, France

Propulsion:

Diesel-electric, twin screw

- 3 diesel alternators, each 1570 kVA
- 2 main electric engines DC, each 1000 kW
- 1 directional retractable bow thruster, 370 kW DC

Deck Equipment:

22 ton rotating stern A-frame

12 ton deep-sea winch (2 x 8000 m storage capacity)

Accommodation:

Total complement of 59 in single/double berth cabins

Officers and crew, 17-30

Scientists and technicians, 25-29

Operating company:

GENAVIR

APPENDIX 3
Scientific and Navigation Equipment

Swath-mapping

SIMRAD Dual EM12 13 kHz multibeam bathymetric / acoustic imagery system
SIMRAD EM950 95 kHz high-resolution multibeam bathymetric / acoustic imagery system

Geophysical

Raytheon 3.5 kHz echo-sounder / high resolution sediment profiler, 2 kW power (typical penetration ~50 m), with experimental IFREMER digital processing system CHEOPS

BODENSEEWERK KSS-30 gravity meter (accuracy ~1 mGal)

BARRINGER M-244 magnetometer (~1 nT accuracy), sensor towed 270 m astern

Navigation

SERCEL NR103 differential GPS receiver - primary navigator GPS1 (operated in non-differential mode, giving position accuracy of ~100 m)

CM015 GPS Navigator (MLR Electronique) - secondary navigator GPS2

Standby receivers: Transit MAGNAVOX MX 1107 and Loran-C MLR LRX22P

Vessel heading: 2 BROWN SGB 1000 gyrocompasses

Relative fore-and-aft & athwartship speeds: THOMPSON SINTRA Doppler log & electromagnetic ALMA log

DATAWELL Hippy 120 pitch, roll and heave sensor

Oceanography

RD Instruments acoustic doppler current profiler VM-ADCP, 75 kHz (nominal depth range 560 m) and 300 kHZ (nominal depth range 160 m)

SIPPICAN expendable bathythermographs (XBTs), 2000 m depth range @ 6 knots (to 700 m depth @ 10 knots)

SIS CTD+1000 thermosalinometer (fitted in tank supplied with continuous flow of seawater; can be cabled to 1000 m depth to obtain temperature/salinity profile)

APPENDIX 4
Operators' Log
(Translated from the French and edited)

Times are in GMT (UT).

OPU= Operator Unit
BDU= Bottom Detector Unit
QAU= Quality Assurance Unit
SIU= Sonar Imaging Unit
DON= Laser disk 6Gb (ARCHIV)
SDIV= Video display control
TSE= Temperature and sound velocity equipment
CINNA= Navigation data acquisition system
TERMES= Geophysical / oceanographic data acquisition system
ARCHIV= Swath-mapping (bathymetry and acoustic imagery) data acquisition system
XBT sounding T5= to 2000 m @ up to 6 knots ship's speed, T7= to 760 m @ up to 15 knots, T10= to 200 m @ up to 15 knots.

Sunday 03 April:
05h30: Departed from Adelaide.
06h00: Start of acquisition on TERMES.
06h30: TSE turned on.
13h47: Sippican XBT measurement Adedav01.exp (2 attempts required); Adedav01.cel entered in the OPU.
16h30: Fault in CINNA; the various displays were very slow to update. Reboot required.
17h15: CINNA; was not following the profile: restarted the navigation trace.
20h15: Sippican successful: Adedav02.cel into the OPU.

Monday 04 April:
15h00: Clocks set back half hour at midnight (now 00h00= 9 am local)
14h39: Sippican sounding T10 completed; Adedav04.cel into the OPU.
15h00: Start of EM950 roll calibration measurements.
16h20: Calibrations finished.
MOTION SENSOR MENU:
ROLL OFFSET= 0.47 deg entered into the OPU. Not good.
Set out on course 315 deg. to find a new calibration area.
16h43: Started running the EM12D as well as the EM950.
ARCHIV acquiring data from both sounders.
16h52: New settings entered into the SDIV for bathymetry (0 to - 200 m).

EM12 TRANSDUCER MENU:
EM12 DEPTH = 4.50 m.
EM12 ALONGSHIP OFFSET=+28.80 m.
EM12 ATHWART OFFSET=0.00 m.

EM1000 TRANSDUCER MENU:
EM1000 DEPTH = 5.98 m.
EM1000 ALONGSHIP OFFSET=16.83 m.
EM1000 ATHWARTH OFFSET= -0.22 m.

18h00: Stopped the EM12D. Ended acquisition on ARCHIV.
18h10: Sippican successful: Adedav05.cel entered into the OPU.

ZONE A:

19h12: Start of profile No 1.
Changed the time on ARCHIV by -1.27 minutes.
19h37: End of profile / start of turn.
19h43: Start of profile No 2.
20h07: End of profile / start of turn.
20h14: Start of profile No 3.
20h38: End of profile / start of turn.
20h46: Start of profile No 4.
21h10: End of profile No 4.
21h15: Start of profile No 5.
21h44: End of profile No 5.
On the way to the start of the N/S profiles.
22h06: Start of profile No 6.
22h36: End of profile No 6.
22h42: Start of profile No 7.
23h10: End of profile No 7.
23h12: Start of profile No 8.
23h49: End of Profile No 8.
23h55: Start of Profile No 9.

Tuesday 05 April:

00h25: End of profile No 9.
00h30: Start of profile No 10.
01h01: End of profile No 10.
01h12: Start of profile No 11.
01h43: End of profile No 11.
01h49: Start of profile No 12.
02h19: End of profile No 12.
03h19: SIS-CTD probe into water using hydrographic winch (to 50 m depth)
03h25: Probe back on board.
04h05: Start of profile No 13.
04h30: End of profile No 13.
05h14: End of profile No 14 (finish of grid A)
05h35: Start of EM12D acquisition on ARCHIV (transit to grid B)
15h35: EM12D stopped; depth 55 m. Noticed a reception problem on one of the staves of the port STAVE display (partial or complete loss of one column, always the same one).
16h00: Profile for roll calibration (before heading to grid B).
17h00: New ROLL OFFSET:0.21 deg.

17h30: Successful Sippican measurement - Adedav06.cel into the OPU.

ZONE B:

18h00: Start of profile No 1.
18h35: End of profile.
18h48: Start of profile No 2.
19h18: End of profile.
19h30: Start of profile No 3.
20h00: End of profile.
20h05: Start of profile No 4.
20h38: End of profile.
20h44: Start of profile No 5.
21h16: End of profile No 5 (last of the E/W profiles).
21h43: Start of profile No 6.
22h16 End of profile No 6.
22h20 Start of profile No 7.
22h48 End of profile No 7.
22h55 Start of profile No 8.
23h37 End of profile No 8.
23h31 Start of profile No 9.

Wednesday 06 April:

03h52: Changed file on ARCHIV (Adedav091 registered).
14h52: Adedav08.cel into the OPU. No Sippican measurement made.
17h45: Successful Sippican: Adedav09.cel entered into the OPU.
19h42: Changed cassette (150 Mb) on TERMES, New file:Adedav033.
21h05: Sounder EM950 had stopped? Restarted.

Thursday 07 April:

02h41: Started profiling in Zone C.
AUTO mode on the EM950: EDBS150 with 80 m water depth at the start of the profile.

03h06: Sounding of 203 m on the EM12D. The EM950 lost the bottom. Plenty of central beams. Remaining in AUTO mode....the EM950 went to EDBS128.

03h44: Start of the second profile in Zone C.
04h47: Start of profile.
05h15: Sippican No 10(sounding T10) successful; entered Adedav10.cel into the OPU.
05h35: End of profile. Change of file on ARCHIV. Completion of Adedav134.
05h36: Start of file Adedav135.
05h46 Start of profile.
06h38: End of profile.

ZONE C:

07h09: Start of profile No 1.
07h42: End of profile.
07h54: Start of profile No 2.
08h33: End of profile.

08h38: Start of profile No 3.
09h17: End of profile.
09h25: Start of profile No 4.
10h00: End of profile.
10h06: Start of profile No 5.
10h40: Sippican successful: Adedav11.cel into the OPU.
10h46: End of profile.
10h50: Start of profile No 6.
11h31: End of profile.
11h40: Start of profile No 7.
12h18: End of profile.
12h24: Start of profile No 8.
13h03: End of profile.
13h07: Start of profile No 9.
13h44: End of profile.
13h48: Start of profile No 8 repeat (profile 8 run in opposite direction).
14h27: End of profile.
14h31: Start of profile No 7 repeat.
15h11: End of profile.
15h15: Start of profile No 6 repeat.
15h54: End of profile.
16h01: Start of profile No 5 repeat.
16h44: End of profile.
16h50: Start of profile No 4 repeat.
17h28: End of profile.
17h35: Start of profile No 3 repeat.
18h16: End of profile.
18h21: Start of profile No 2 repeat.
19h00: End of profile.
19h03: Changed TERMES file: Adedav058.
19h07: Start of profile No 1 repeat.
19h48: End of profile.
19h57: Changed cassette on TERMES.
21h00: Changed cassette on TERMES.
21h20: EM950 turned off at 500 m water depth.
.....Start of EM12D acquisition on ARCHIV.
22h19: TERMES data not being recorded on cassette; drive had not been activated.
.....Clocks were set back at midnight by 1 hour (now 00h00=8am local - kept the same for the rest of the survey).

Friday 08 April:

08h12: Acquisition on ARCHIV stopped to allow system software to be archived (for return to France at Albany port call).
10h35: Recommencement of acquisition on ARCHIV: Adedav139.
12h55: System crash on EM12D, probably caused by a sudden change in velocity profile.
13h30: EM12D okay.
13h35: Adedav12.cel into the OPU.
15h13: Adedav13.cel into the OPU.
18h55: Ended EM950 acquisition on ARCHIV.
19h00: Retrieved the magnetometer fish and ended magnetics acquisition on TERMES.

19h33: Stopped the EM12D.
Problem with CENTRALE de VENT (wind data acquisition) on TERMES: showing zero speed and direction intermittently.
23h55: *L'Atalante* left bay at Albany.

Saturday 09 April:

EM950 in operation.
01h20: TERMES stopped.
02h04: Restarted acquisition on TERMES
02h06: Stopped RDI current meter.
03h00: Continued on course with RDI on 75 kHz.
Note: the imagery is perturbated with the RDI current meter set on 75 kHz.
04h20: Set the RDI on 300 kHz.
04h30: Adedav15.cel into the OPU.
Imagery affected by the change.
07h00: Successful Sippican (T10): Adedav16.cel into the OPU.
09h27: Adedav17.cel into the OPU (.cel file is 100 line/350 m file because of shallow water).
Sound velocity sensor not operating.
13h00: EM950 set on SHALLOW mode. (RDI 75 and 300 kHz off).
14h00: Set the EM950 in EDBS150 mode.
14h35: Adedav18.cel into the OPU.
15h00: Set the EM950 to SHALLOW mode.
16h00: Set the EM950 to EDBS150 mode.
17h00: Set the EM950 to SHALLOW mode.
18h04: Set the EM950 to EDBS150 mode.
19h00: set the EM950 to SHALLOW mode.
20h10: Turned the EM12D on.
20h30: Stopped the EM950.
21h00: Sippican measurement good (T7): Adedav21.cel into the OPU.
23h00: Magnetometer deployed; started acquisition on TERMES.

Sunday 10 April:

04h09: Change of file on ARCHIV (Adedav143 registered).
04h12: Adedav23.cel into the OPU.
04h35: Temperature alarm on for transducer TRU Tribord(28 deg C, normally ~21 deg C).
Alarm switched off.
10h00: Successful Sippican (T5) : Adedav24.cel into the OPU.
13h40: Change of file on ARCHIV (Adedav144 registered).
16h27: Adedav25.cel into the OPU.
17h20: Sippican No 15 (sounding T7) completed: Adedav26.cel into the OPU.

Monday 11 April:

04h17: Adedav27.cel into the OPU.
04h40: Change of file on ARCHIV (Adedav145 registered).
05h43: SVP10 s/n:5013 put back into service.
06h30: Sippican No 16 (T7) completed; Adedav28.cel into the OPU.
09h18: To test SIU, version 1.7x entered on the BDUs: not good.
09h40: Trying version 1.6x on the BDUs as a test. Test okay.

10h05: Changed version of OPU program: 3.80 now in the OPU.
10H15: Again acquiring data on ARCHIV.
10h25: Started EM950. Start of acquisition on ARCHIV.
11h07: EM12D stopped
13h53: Completed Sippican No 17 (T7 to 120 m depth). Adedav29.cel into the OPU.
Values only to 350 m.
21h00: EM12D stopped.
21h50: EM12D back on.

Tuesday 12 April:
01h08: Changed cassette on TERMES.
09h18: Acquisition stopped on TERMES.
15h00: Adedav30.cel into the OPU.
18h02: Stopped the EM950 (at 515 m ??)
18h06: Adedav31.cel into the OPU.
18h30: Ran Sippican No 18 (T7). Adedav32.cel into the OPU.
21h10: Restarted the EM12D (250 m water depth).

Wednesday 13 April:
05h11: Adedav33.cel into the OPU.
06h40: Stopped the EM950.
06h54: Adedav34.cel into the OPU.

PROGRAM VERSIONS USED FOR THE SOUNDERS:

OPU: 3.80 BDU (EM12D): 1.6x BDU (EM950): 2.21 QAU : 3.34 SIU : 3.12

10h15: Sippican No 19 (T7) successful. Adedav35.cel into the OPU.
13h21: Start of profile.
18h01: Adedav36.cel into the OPU.
19h05: Relinked DON to ARCHIV.

Thursday 14 April:
05h40: Adedav37.cel into the OPU.
05h58: Start of turn.
06h02: Start of profile.
11h15: Reset port BDU.
14h54: Failure of port and starboard BDU.
16h38: Adedav38.cel into the OPU.
20h35: Course change.
21h00: Adedav39.cel into the OPU.

Friday 15 April:
01h26: Change of profile.
02h00: Adedav40.cel into the OPU.
07h20: Adedav41.cel into the OPU.
13h39: Magnetometer off.
13h55: End of profile and transit survey.

ADEDAV

TRANSNOR

Timor

Bonaparte Basin

Scott Plateau

Argo Abyssal Plain

Browse Basin

Broome

Exmouth Plateau

L'Atalante track

Port Hedland

Carnarvon Basin

Carnarvon

WESTERN

AUSTRALIA

Perth Basin

Perth

Albany

Bremer Basin

Noumea

New Caledonia

Norfolk Island

New Zealand

Adelaide

ENCLOSURE 1. Index map for ADEDAV 1:100,000 bathymetric contour map and acoustic imagery sheets: Albany 1-5, Perth 1-9 and Argo 1-11; index map for TRANSNOR 1:100,000 bathymetric contour map sheets: Transnor 1-11.

E112 10. E112 20. E112 30. E112 40. E112 50.

S28 20.

S28 30.

S28 40.

S28 50.

S29

E112 10. E112 20. E112 30. E112 40. E112 50.

ENCLOSURE 2. Acoustic image with superimposed 100 m bathymetric contours of the continental slope off Carnarvon Terrace (Perth 7 1:100,000 map). Darker tones indicate areas of relatively higher acoustic backscatter (eg. canyon floors).

E118 35. E118 40. E118 50. E119 E119 10. E119 16.

S14 49. S14 50. S15 S15 10. S15 20. S15 30. S15 32.

ENCLOSURE 3. EM12D 20 m bathymetric contours of Taipan Canyon (Argo 5 1:100,000 map).

ECH = 1/ 100000 a S15 0.00	*AGSO*
Projection : MERCATOR Ellipsoide : WGS-84	SMAI 23 Juin 1994 12h29m10s
Isobathes : 20 m. / Mait. : 100 m. Pas du MNT : 100.0 metres	Logiciel TRISMUS Propriete IFREMER
ADEDAV survey - Argo 5	