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CRUISE REPORT

Ship Name: VEMA

Cruise No: V33-03

Departure: 1/20/76 from Fremantle
Date Port

Arrival: 2/19/76 at Melbourne
Date Port

Days at Sea: 30 Days Foreign Port: 3
No. of days in arrival port

Area of Operation: Great Australian Bight North of 38°S from

Cape Leeuwin to King Island

Program Description:

See Attached Report

Participants: (All L-DGO unless otherwise specified)

Ivars Bitte - OBS
George Conrad - Camera
David Holland - E. T.
Van Paisley-Smith - Gravity
Bud Rock - Nav.
Howard Stagg - BMR observer
Dennis Quick - E. T.
John Mutter - BMR observer

Manik Talwani - Co Chief
Robert Houtz - Co chief
John Powell - Airgun
Michael Sundvik - Core
Bruce Herman - T Grad

All inquiries regarding cruise should be made to the chief scientist.

VEMA 33-03 CRUISE REPORT

Magnetic Lineations - Magnetic lineations 18 through 22 just south of the Great Australian Bight are well defined between about 125°E and 138°E . An exception applies to the eastern end of anomaly 22 which we discuss later. One of the objectives of this leg was to trace the westward continuation of anomalies 20, 21 and 22 to the region of the Diamantina Fracture Zone. We have been able to do so. Anomaly 22 is traced to 121°E , and anomalies 21 and 20 to 122°E and 122.5°E . Further westward continuation can now probably be done with the help of data acquired previously. The westward tracing of the anomalies has some interesting implications. Anomaly 22, the oldest anomaly associated with the early Tertiary sea floor spreading, coincides now with the northern limit of the Diamantina Fracture Zone. This suggests that this fracture zone is entirely over the ocean floor of Tertiary age and may simply represent sea floor of rugged relief generated at the inception of sea floor spreading. The distance between anomaly 19 and 22 south of the Bight at, say 129°E , is about 125 miles. At 123°E , just east of the Diamantina Fracture Zone, it is about 80 miles. Thus to the west the anomalies are "scrunched" together and represent slow spreading on the northern limb of the ridge. The high relief on the Diamantina Fracture Zone may correlate with the slow spreading rate.

Between two BMR tracks at $131^{\circ}75'$ and $131^{\circ}45'$, two north-south tracks were made between 36°S and 37°E to investigate the eastern termination of anomaly 22. Complete track charts of our cruise appear in Figs. 1a, 1b,

and 1c. It was established that it certainly does not continue east at a constant distance from anomaly 21. The area that it "would have" continued to was investigated seismically and, as discussed later, shown to be typical "quiet zone" crust. There is a possibility that anomaly 22 continues eastwards but that it is very close to and appears to form a part of anomaly 21.

A single line was run to establish the continuity of anomalies 21 and 20 east of 135°E . Though amplitudes are small it appears that 21 runs up to at least 136°E , while 20 probably continues beyond 137.5° and would appear to terminate against the major fracture zone at 138.5°E .

Just north of anomaly 22 there exists, near 127°E in the magnetic quiet zone, and E-W lineation well defined by two BMR lines and L-DGO profile C. By running a NW-SE line about 30 miles east of C we were able to show that this lineation has nearly died out by that distance and it would seem unlikely that this is a lineated anomaly of spreading sea floor origin.

Eastward Continuation of the Diamantina Fracture Zone - By making a number of traverses we were able to establish that the Diamantina Fracture Zone continues eastwards, progressively more deeply buried at least up to 129°E . We were not able to judge its continuation further east because we were unable to penetrate the sediment cover which increases markedly south of the Ceduna Plateau.

By establishing that the northern limit of the topographically expressed Diamantina Fracture Zone coincides with anomaly 22 which dates the Tertiary opening of the sea floor, and by establishing that the Diamantina Fracture Zone continues eastwards under sedimentary cover, a simple explanation for the Diamantina Fracture Zone can be given. It represents the rugged relief which would appear to accompany the initiation of sea floor spreading. Whether this is a general phenomena for all oceans is difficult to determine because the early opening crust in most oceans is generally buried under a thick impenetrable cover of sediments.

Seismic Refraction Crustal Structure - About 25 long range Aquatronics sonobuoys and about 20 short range SSQ41 radio buoys were used for seismic refraction experiments. The long range buoys were used in conjunction with the Aquatronics low frequency modules. The SSQ41 buoys were used with an Aquatronics high frequency antenna and the Watkins Johnson receiver. The buoys were used in four different modes.

1. Air gun as sound source and recorded on the profiler. Reflection profiling carried on simultaneously.
2. Same as above, but profiler extended with 2 lb explosives shot at 20 sec - 1 min interval.
3. Long range buoys shot with explosives (2 lb - 67 lb) and recorded on SIE Dresser Camera. No reflection profiles.

4. Long range buoys shot initially with air gun and recorded on profiles and then with explosives (7 lb - 67 lb) and recorded on SIE Dresser Camera.

The last mode proved the most useful because it provides detailed sub-bottom reflection curves that enable one to obtain interval velocities from the profile and then refractions from the higher charges.

One simple modification in the deployment Aquatronics buoy which we made towards the end of the leg significantly quietened down the hydrophone. It therefore increased signal to noise ratio considerably and is highly recommended for future use. Essentially, the sack containing the lead weight is detached from its normal position just above the hydrophone and is instead attached about 120' from the sonobuoy. In the bag containing the hydrophone some paraffin wax is added so that the two together are nearly neutrally buoyant (tested by putting in a bucket of sea water). When the buoy is deployed in this fashion the lead weight hangs below the buoy and the hydrophone, because it is in a neutrally buoyant situation, is decoupled to a considerable extent from the motions of the buoy.

The stations at which refraction arrivals were obtained are shown in Figs. 1a, 1b, and 1c.

In the following discussion we will generally distinguish between stations south of anomaly 22 which lie on oceanic crust, and those north of anomaly 22 which lie in the magnetic quiet zone. In the western part of the area we will consider the northern limit of the Diamantina Fracture Zone as

representing anomaly 22 for the purpose of making the above distinction.

We have only a few good stations south of anomaly 22 and refractions from the main ocean layer (Layer 3) were surprisingly hard to come by. Nevertheless, we consider stations 22, 16 and 8 typically oceanic with a normal mantle with velocity 8+ km/sec and a layer with velocity of 6.7 to 7.0 km/sec. The average thickness of the crust is 5.7 km, excluding water and sediment layers.

The stations in the magnetic quiet zone appear to be characterized by:

- (i) larger crustal thicknesses. The average crustal thickness, exclusive of sediments and the water layer, is greater than 7.7 km.
- (ii) Greater variability in the crustal thickness. Excluding water and sediment layer, the crustal thickness varies from 5-7 km to more than 12 km.
- (iii) Greater variability in the velocity of the main crustal layer. The velocities range from 5.4 km/sec to above 7 km/sec. Variability in velocity and crustal thickness may not be entirely random as shown in Fig. 2, where there seems to be a consistent trend in crustal velocity between longitudes 125 and 130E. Stations in the west, that is north of the Diamantina Fracture Zone, tend to have high velocities - greater than 7 km/sec. Stations near the Ceduna Plateau, and one station to the east at 139.5°, have very low velocities - about 6 km/sec. A number of the other stations however have crustal velocities of about 6.7 km/sec which is, of course, typical of the oceanic Layer 3.

(iv) The sections contain a thick layer of high velocity (3.8 km/sec) sediment. From the seismic data above, it is difficult to decide whether the crust in the magnetic quiet zone is of continental or oceanic origin. Certainly the stations with low crustal velocities and large crustal thicknesses would appear to represent continental crust. On the other hand, stations at which the crustal velocity is 6.7 km/sec could be said to represent thick depressed oceanic crust unless some mechanism of oceanization can be postulated which can raise the velocity of the continental crust and thin it at the same time.

A histogram of crustal thicknesses north and south of anomaly 22 appears in Fig. 3. Crustal columns from the present work are shown in Fig. 4.

In any event, there seems to be little doubt that anomaly 22 is close to a major crustal boundary. The crustal structure changes across the boundary and judging from the thickness of high velocity sediments, the crust in the area underlying the magnetic quiet zone is considerably older than the Tertiary sea floor to the south. If the topographic high at 22 has acted as a dam, the greater thickness in the quiet zone is not necessarily an indication of greater age.

Of special note perhaps are sonobuoy stations 13 and 37 run over the isostatic gravity high at the foot of the slope very near the northern boundary of the magnetic quiet zone. Station 13 yielded a shallow 7.5 km/sec layer but 37 had a thick low velocity crustal layer.

OBS Experiment - An OBS experiment was designed in which two OBS's were deployed about 20 miles apart, the second OBS being roughly east of the first OBS, and an Aquatronic long range sonobuoy was deployed 20 miles further east of the second OBS. Charges were set off along a line which started from the Aquatronic buoy and ran 20 miles west of the first OBS - a total distance of 60 miles. 35 lb charges were shot at 15 minute intervals and in between 15 lb charges were fired at 5 minutes.

The deployment and recovery of the OBS went off without any hitch. On OBS 1 the horizontal seismometer did not work on the bottom, although it did on the deck before and after. The time code could not be read during playback, apparently because of 60 cycle problems. The hydrophones did not show any signal. When, on OBS 2, the shot was far away from the instrument the horizontal seismometer showed a signal much earlier than the vertical signal. For a proper evaluation of the OBS's, records will have to be played back at the lab.

Heat Flow - A difference between the heat flow through the old ocean basins and that of stable continental platforms has been frequently observed, although it is usually only a few tenths of a cal/cm^2 (HFU). In a sufficiently well sampled area, differences of this magnitude should be observable on a scale suitable for determining the boundary between the oceanic and continental crust. 22 heat flow measurements from this cruise are suitably distributed for such a determination.

Over magnetic anomaly 22 and to the south of it, the heat flow is about .8 - 1.0 HFU, with a few higher values that probably reflect localized effects in the Diamantina Fracture Zone. This ties in very well with the subnormal heat flow measured by Anderson and Hayes on V33-02. The usual heat flow in basins being about 1.1 to 1.3.

North of anomaly 22, seismic refraction work discussed elsewhere in this report indicate a very thick crust. The heat flow values obtained over this vary widely, from .22 to 4.02 HFU. This does not compare favorably with the heat flow associated with stable continental areas. However, it is believed that much of this variability is due to a combination of the measurements being shallow and fluctuating bottom water temperatures.

The sediment on the lower continental rise is exceedingly hard and this makes it nearly impossible to obtain good penetration with the corer. As a result of the measurements with deep penetration, the bottom four probes would establish a linear gradient significantly more shallow than that of the upper two probes. The deeper gradient intersects the surface at .1 - .2°C, while the shallow gradient extrapolates generally to less than .03°C. It would thus appear that at some earlier time, the bottom water was significantly warmer than it is now.

A peculiar bottom water gradient was also found in this area. At about 2500 fm., the gradient is positive. This is not generally the case in other areas receiving Antarctic bottom water. Because this gradient is steep, as are the negative gradients observed elsewhere in this area, small changes in the depth of the isotherms will cause large changes in the temperature of the bottom water, and thus alter the near surface (<3 m) thermal gradient. Until the history of the water column in this area is understood, it will be difficult to interpret shallow heat flow measurements with confidence. The inverted true temperature gradient in the water column is most likely the cause of the variability in the measurements north of anomaly 22.

I. EQUIPMENT

A. Seismic

1. Profiler/Eel/Air gun

All these systems are operational, but we are short of spares. The delay and time-writing module for profiler B is defective. This means that profiler A only can be delayed reliably, and that the date/time group does not appear on B. New modules are on order, but there are long delays because a shipment has been misplaced.

Only one eel is operational. A second set of hydrophones has been strung. The only Bayol aboard is in a third inoperative eel, which will have to be drained into a new eel to be usable. The towing cable of the inoperative eel has a 6K short and cannot be used. Additional Bayol and a towing cable are on order.

2. Aquatronics Eel and Signal Processor

The Aquatronics eel was tested thoroughly on the leg into Melbourne and it was found to be performing well. The Signal Processing Unit is in very bad shape (had chips, shorted components, and loose wires), and will have to be returned for overhaul.

3. SIE/Dresser System

This unit performed reliably. Time-lines are usually unstable when a new roll of paper is started. A new uphole amplifier is on order. Our jury-rigged amplifier is adequate, but could fail. This amplifier is required to drive the shot instant galvanometer, so that no shot-instant can be recorded without it. We found the 10-60 Hz pass-band from the PDR receiver gave the best shot instant and surface-bounce returns.

4. Aquatronics Sonobuoy/Receiver

The long-range sonobuoys and the receiver work very well. The connectors to both antenna systems were checked over in Fremantle. One short-range receiver module is inoperative and the other is difficult to tune and puts out a poor signal. Both HF (short-range) modules will be returned for replacement. Long-range sonobuoys may average nearly 35 sec of range.

5. Military Sonobuoy/Receiver System

This system working well. Receiver no. 2 is much less effective than no. 1 and the former should eventually be replaced. The Aquatronics

antenna now in use is apparently as effective as the original antenna because the SSQ sonobuoys have been recorded frequently to 18 sec range and more.

Oscillograms and other information concerning four defective sonobuoys have been sent to the manufacturer. This information will be assessed by the manufacturer before providing us with replacement sonobuoys.

B. Computer

Two computer engineers - one between Esperance and Esperance and the other between Esperance and Melbourne finally got one computer going. It worked well for several days and was running in Melbourne. Both engineers claimed that ruggedized interconnecting cables were the source of a lot of problems and they suggested that regular cables might be better. The computer engineers report is given separately.

C. Sat Nav

Mast group was changed in Esperance II. The old unit did not pick up low elevation satellites and the audio signals were weak. It is being sent to L-DGO for repair.

D. Gravity

Bitte installed the gyro heater amplifiers in Esperance and corrected some misconnections. Gravity worked fine. Occasionally, long slow swells gave rise to large cross coupling and raggedy looking records.

E. Magnetometer

Worked fine - no problems.

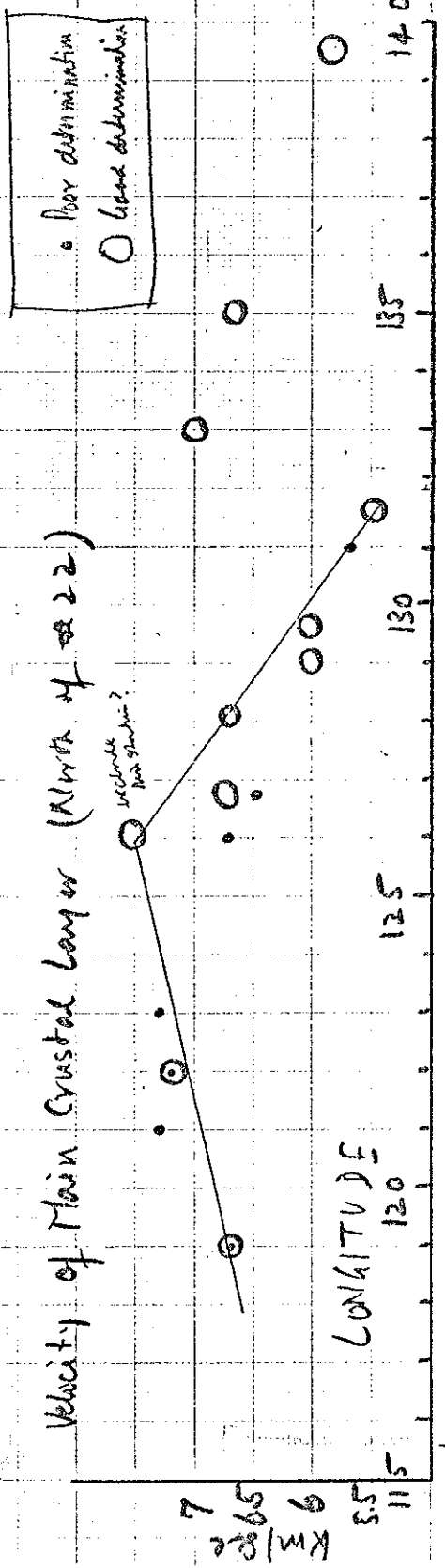
F. Coring

Hard sediment north of anomaly 22 coupled with large drift rates caused many bent pipes. Kohler is taking care of ordering core pipes. Oil tea from winch was observed. New seal will be installed in Melbourne. Otherwise coring operation worked fine.

G. Camera-Nephelometer

Not used.

Velocity of Main Crustal Layer (North of #22)



velocity not shown?

Crustal Thickness at Stations north of #22

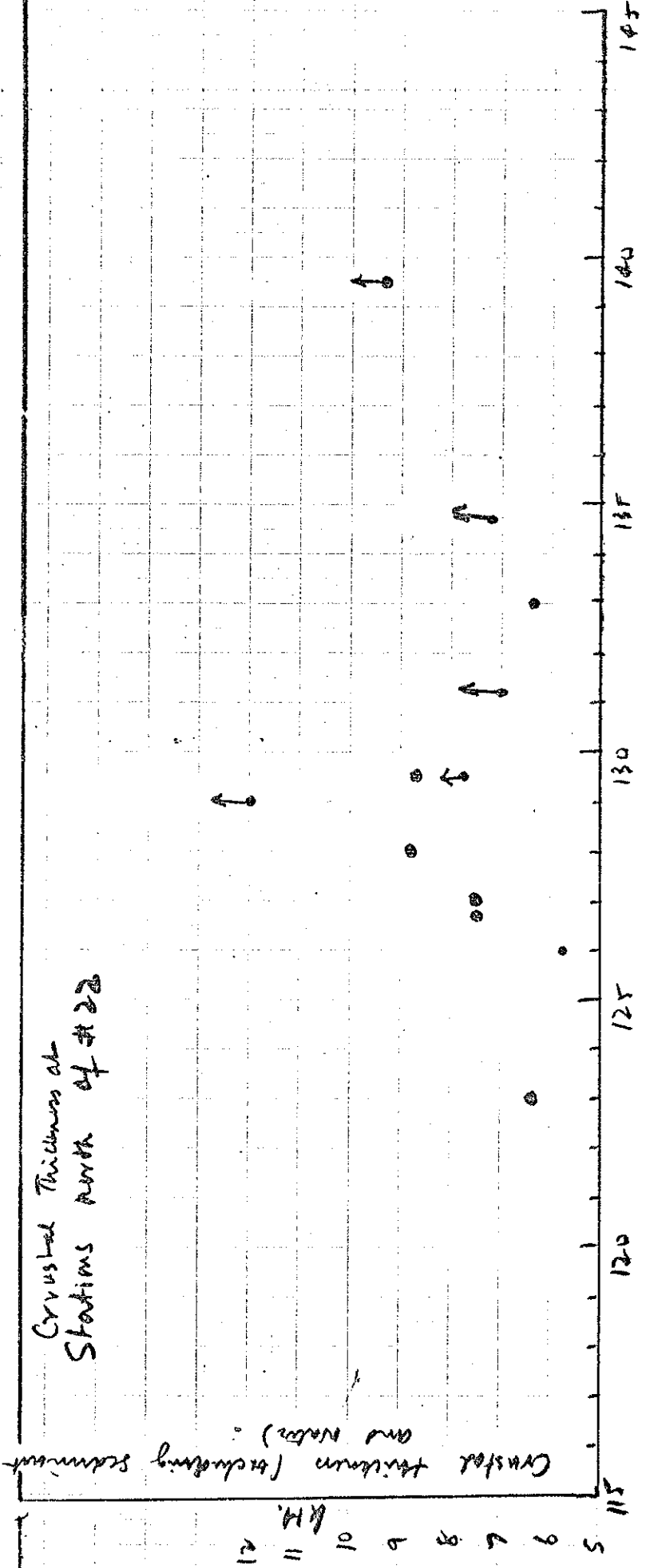


FIG. 2

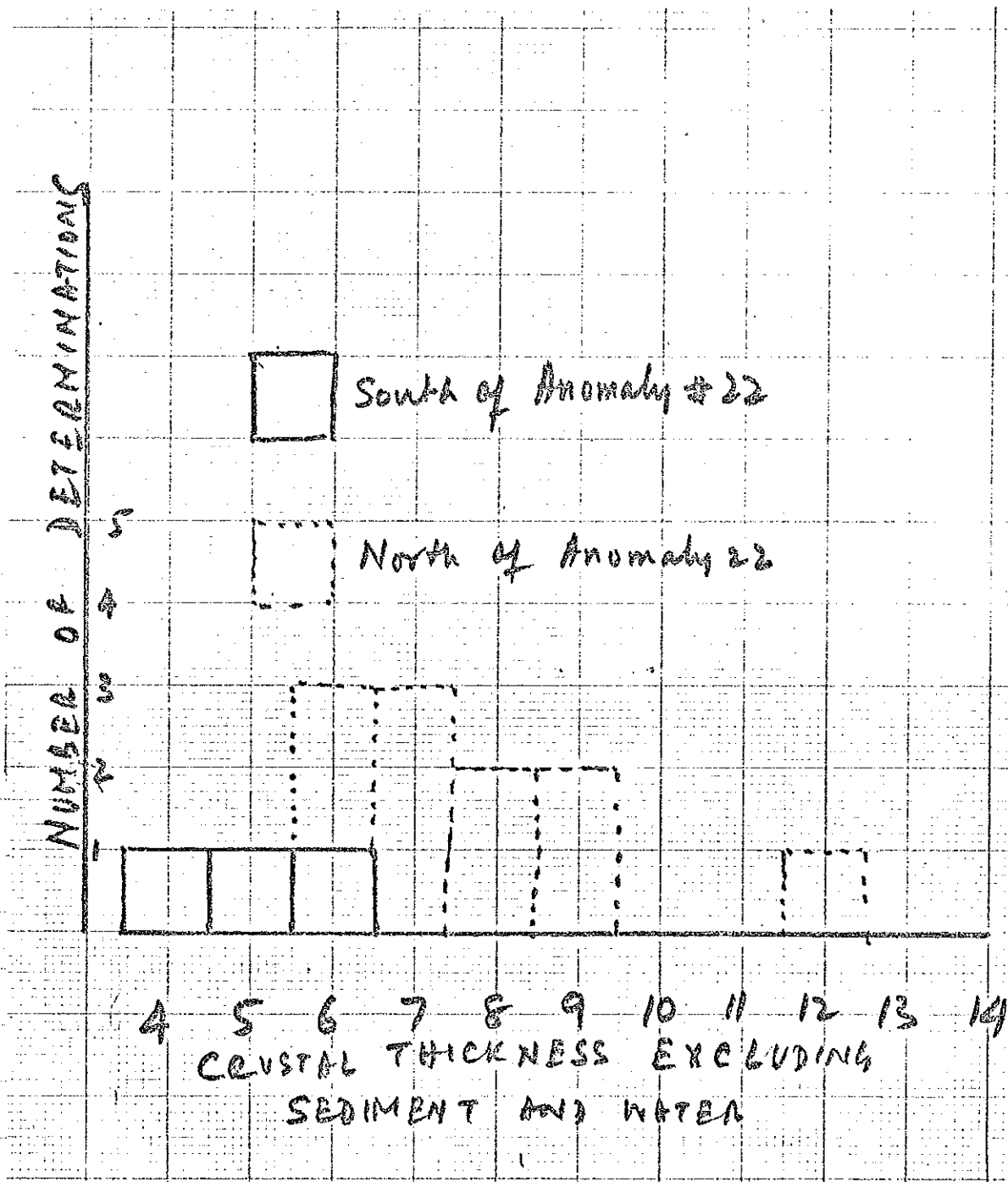
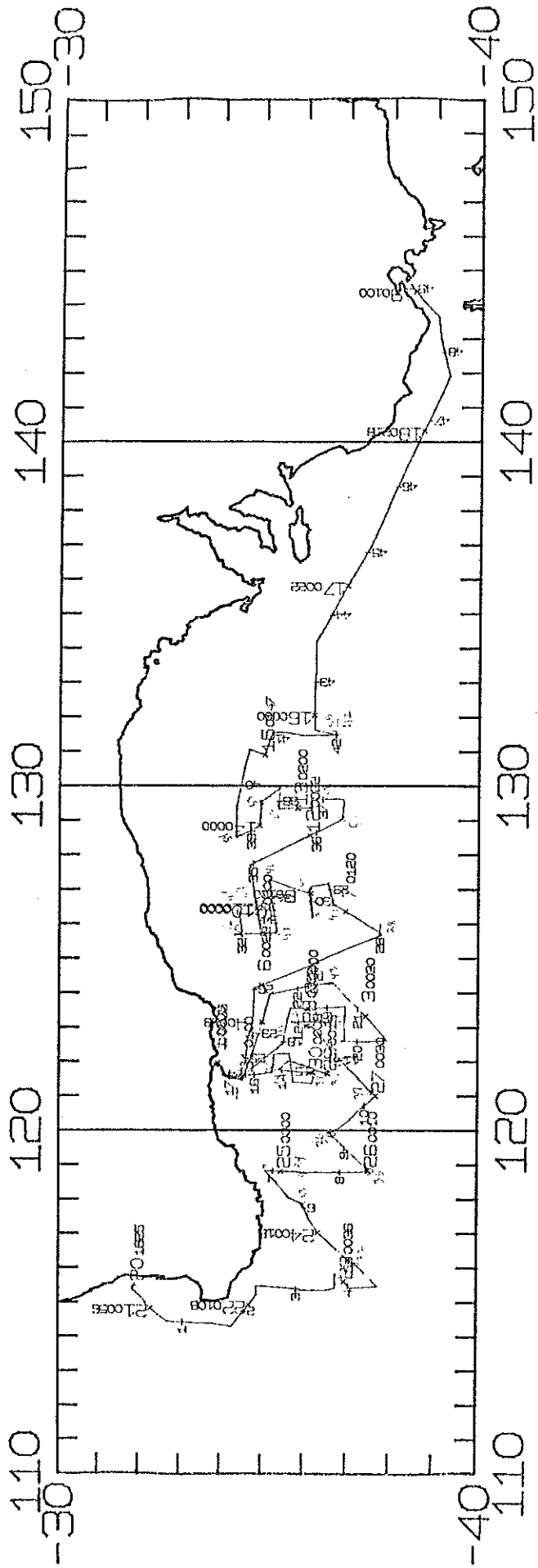


FIG. 3



V-3303 (FREMANTLE - MELBOURNE)