PRELIMINARY REPORT OF THE TH95 GEOLOGICAL AND GEOPHYSICAL SURVEY RESULTS IN THE ROSS SEA AND DUMONT D'URVILLE SEA

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Abstract: Geophysical and geological surveys of the TH95 cruise on the R/V HAKUREI-MARU, in the abyssal basin and the continental rise area of Dumont d'Urville Sea (DDS) offshore of Adélie and Wilkes Land, and Victoria Land Basin (VLB) in the western part of the Ross Sea continental shelf, were carried out in the 1995–96 austral summer season.

The deformed very thick sedimentary sequences, which are interpreted to have been deposited in the pre-rift and rifting stage, are revealed under thick post-break-up pelagic sedimentary sequences in DDS. There are several basement highs of (1) the igneous basement, including ultra-mafic rocks, which was uplifted in associated with the fracture zone, (2) the uplifted oceanic basement which is deformed by the normal fault, (3) the structural high with anomalous basement, which is interpreted as a piece of micro-continent, in DDS. These phenomena suggest the wide area of DDS is underlain by the characteristic intermediate type of crust between oceanic and continental.

Even the deep structure of most of the Ross Sea continental shelf is not clear by the strong sea bottom multiples, more than 7 km of thick sedimentary sequences in VLB is confirmed with MCS and OBS survey. The sequences are deformed by the extensional normal faults along the western margin and the Terror Rift.

Geological samples which were recovered in the VLB gave important evidence of the late Ross Ice Shelf advance and retreat history.

key words: Wilkes Land margin, Dumont d'Urville Sea, Victoria Land Basin, marine geological and geophysical surveys, sedimentary sequences

1. Introduction

The Technology Research Center, Japan National Oil Corporation has been conducting marine geophysical and geological surveys of the Antarctic continental margins with the R/V HAKUREI-MARU since 1980. Some of the results of previous cruises have been already published (KIMURA, 1982; OKUDA *et al.*, 1983; SATO *et al.*, 1984; TSUMURAYA *et al.*, 1985; MIZUKOSHI *et al.*, 1986; SAKI *et al.*, 1987; YAMAGUCHI *et al.*, 1988; SHIMIZU *et al.*, 1989; ISHIHARA *et al.*, 1996).

This paper reports the preliminary survey results in Dumont d'Urville Sea (DDS) and Victoria Land Basin (VLB) in the western Ross Sea, which were surveyed during TH95 early and latter legs, respectively.

The TH95 survey cruise was planned to survey mainly the western part of the Ross

Sea continental shelf after the survey cruises of the central (TH91) and the eastern (TH92) parts of the sea. But the early leg of the cruise was devoted to the survey of Dumont d'Urville Sea after cruises TH82, 83, 90, 91, 92 and 93 because it was necessary to wait for the Ross Sea pack ice to open.

The tectonic setting of the TH95 survey area in DDS is shown in Fig. 1. It lies in the junction area between the western normally spread seafloor area which is represented by the magnetic lineations which are parallel to the shelf margin, and the eastern fracture zone-short spreading center area which is characterized by the long offset of spreading centers. The boundary of two areas is the George V fracture zone. There is only one DSDP drill hole at site 269 in the survey area. It reached the Oligocene or older marine hemipelagic sequence at 300 m below the sea floor. The deepest sampled horizon is in the middle of the seismically recognized sedimentary sequences. Magnetic lineations in the western normally spread area are interpreted as 34 to 18 anomalies which show that very slow seafloor spreading between Antarctica and Australia started in the late Cretaceous (about 100 Ma, CANDE and MUTTER, 1982). After this slow spreading, it converted to the present Southeastern Indian Ridge spreading which is represented by the 13 and younger anomalies at about 40 Ma. Magnetic anomaly variation is not clear in the junction area in DDS and the feature is recognized as a part of broad
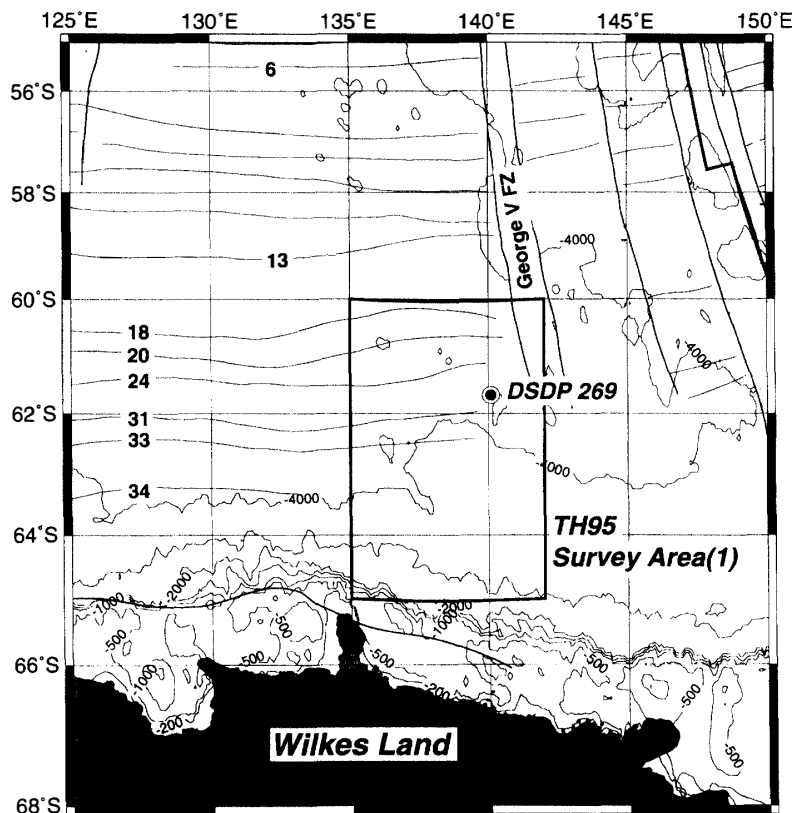

Fig. 1. Tectonic setting and topography of the TH95 survey area of Dumont d'Urville Sea (DDS) off Adélie Land and Wilkes Land. Topographic contours, magnetic lineations and fracture zones are drawn by GMT (WESSEL and SMITH, 1991) using ETOPO5 bathymetric data and boundary files in NOAA NGDC Global Relief CD-ROM.

magnetic quiet zone along the continental margin (Cande and Mutter, 1982). Tanahashi et al. (1987) reported a possible piece of continental fragment which has thick sedimentary sequences to represent the rifting stage in this area.

VLB is situated between the Coulman High and Transantarctic Mountains in the western part of the Ross Sea continental shelf as shown in Figs. 2a and 2b. It is believed to be formed as a rift basin which developed in two stages during the late Mesozoic(?) and Cenozoic (Cooper et al., 1987). A widely distributed distinct erosional unconformity between these two stage rift structures is well recognized as RSU6 (Anderson and Bartek,
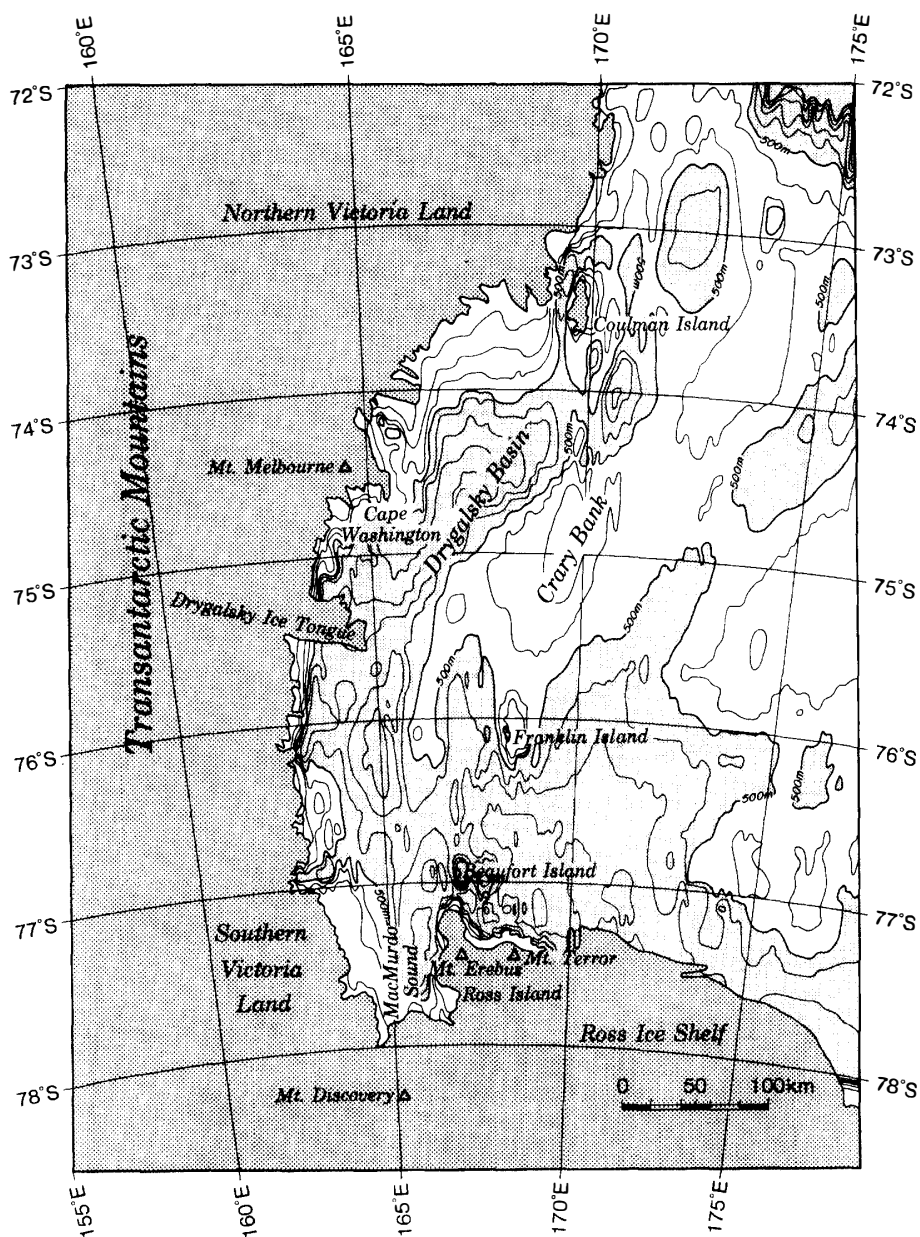

Fig. 2a.   Topographic map of TH95 survey area of Victoria Land Basin (VLB), western
         Ross Sea continental shelf: contours are drawn by GMT using ETOPO5 data
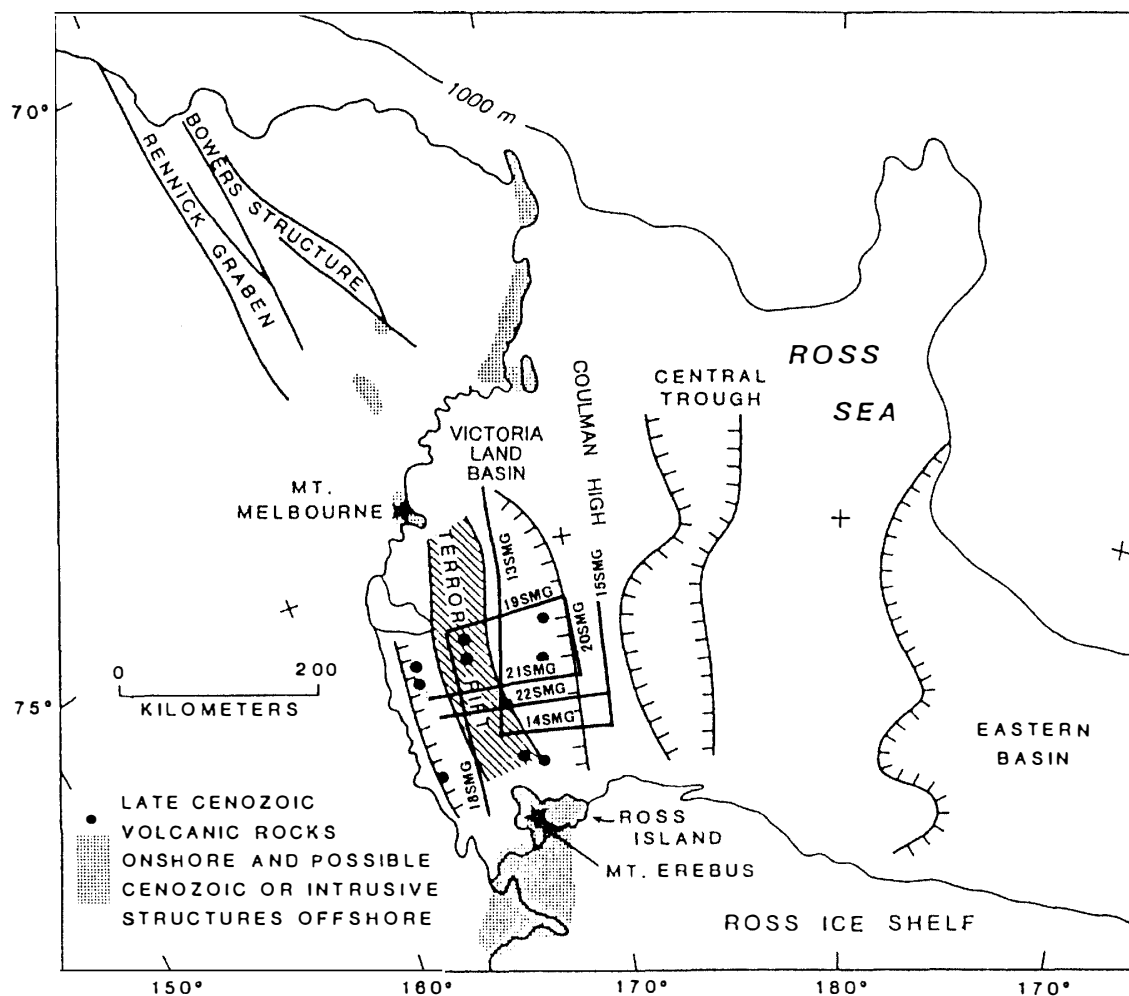   file in NOAA NGDC Global Relief CD-ROM.

*Fig. 2b.   Tectonic setting of the TH95 survey area of VLB.   Sedimentary basin distribution in Ross Sea by
Cooper et al. (1987).   Terror Rift in VLB consists of western Discovery Graben and eastern Lee
Arch.*

1992; Brancolini *et al.*, 1995). RSU6 is interpreted as the boundary between the Early
Oligocene RSS-1 and Late Oligocene to Early Miocene RSS-2 (Brancolini *et al.*, 1995).
The Terror Rift, which represents a major structure during a younger rifting stage, is
developed in the central part of VLB along the axis of VLB, from Cape Washington to
Ross Island. It consists of the eastern Lee Arch and western Discovery Graben (Cooper
et al., 1991). Although the banks and troughs in the northeastern part of the study area
show a NE to SW trend, the structural trend of the VLB rifts is nearly N-S. This sug-
gests that the major topography is controlled by the erosion and deposition which are
related to glaciation.

2.   Outline of Survey Methods

The marine geological and geophysical survey of the TH95 cruise was carried out
from December 26, 1995 to January 11, 1996 in Dumont d'Urville Sea and from January

18 to February 23, 1996 in Victoria Land Basin .

The volume of data and samples which were acquired during TH95 cruise is listed in Table 1. A summary of TH95 survey methods with specifications of equipment and operating conditions is given in Table 2.

The seismic source was towed along two cables equipped with two GI guns each.

Table 1.   Summary of the TH95 cruise.

Survey period	53 days
Seismic reflection survey	1977.7 km
Seismic refraction survey	6 sites
Magnetic and gravity survey	13441 km
Dredge	2 sites
Gravity coring	6 sites
Heat flow measurement	4 sites

Table 2.   Summary of survey equipment and operating conditions.

Survey	Instrument (specification) and operating conditions
Multichannel seismic reflection (MCS)	Source: 4 × SSI GI-guns 　　　(105 cu-in. generator + 105 cu-in. injector in DDS) 　　　(45 cu-in. generator + 105 cu-in. injector in VLB) 　　　air pressure is 2000 psi (13.8×10^6 Pa) Receiver: Alliant Technology 24 bit digital streamer cable 　　　(12.5 m × 8 ch/100m/section × 21 sections = 168 ch 　　　2100 m in total in DDS) 　　　(12.5 m × 8 ch/100m/section × 24 sections = 192 ch 　　　2400 m in total in VLB) Recorder: Alliant Technology AESOP seismic recorder Sampling interval: 4 ms Record length: 12 s Shot interval and　*ca* 50 m, 22 s with 4.4 knot in DDS 　　ship speed:　*ca* 25 m, 14 s 3.5 knot in VLB CMP coverage:　2100% in DDS 　　　　　　　　2400% in VLB
Seismic refraction	Source:　　　4 × GI guns (concurrent with MCS) Receiver:　　DTC6030 digital Ocean Bottom Seismometer 　　　　　　(3 geophones with a hydrophone)
Gravity	Lacoste & Romberg SL-2 gravimeter
Magnetics	Geometrics G-811G proton gradiometer during MCS Geometrics G-866 proton magnetometer during other than MCS Tera Teknika three component shipboard magnetometer
Bathymetry	12 kHz PDR system (Raytheon CESPIII with PTR and LSR 1811)
Subbottom profiling	3.5 kHz SBP system (Raytheon CESPIII with PTR and EPC)
Bottom sampling	Gravity corer and chain back dredge
Heat flow measurement	Nichiyu Giken GS-type, 5 channels Thermal conductivity meter: Kyoto Denshi QTM-D3

The GI gun chambers were set for "harmonic mode, 105+105 cubic inches" in DDS (13.8 l in total) and "true GI mode, 45+105 cubic inches" in VLB (9.8 l), targeting deep penetration over the deep sea and finer resolution over the shallow shelf, respectively.

A new 24 bit digital streamer cable and recording system, which was used for the first time in this project, showed a higher S/N ratio and increased stacking effect with the increases number of channels than the previous system (24 ch in TH82, TH90 and 48 ch in TH91 and TH92). Unfortunately the recording system malfunctioned occasionally because of a control software problem.

All the reflection and refraction seismic data were thoroughly processed by JAPEX/ GeoScience Inc. after the cruise. All the reflection seismic data of VLB were processed by the "reducing multipled reflection method" to reduce extremely strong sea bottom multiple reflections in the continental shelf area. Conventional filtered CMP stacked and multiple reduced CMP stacked data were used as the standard data set for the interpretation of DDS and VLB, respectively. Besides, all of the profiling data were used for the time migration and further depth conversion processing. The dip moveout (DMO) process, a kind of pre-stack migration to reduce stacking noise from high angle reflectors, was applied to selected parts of profiles which include steeply dipping phenomena. Even the shot intervals were not identical during the survey. The plotting scale are unified in this report with a vertical exaggeration of 5.33.

3.   Geological Sampling and Heat Flow Measurements

A summary of sampling sites and samples and heat flow measurement results is

Table 3.   Summary of bottom samplings and heat flow measurements.

Site	Lat. (S)	Lon. (E)	Depth (m)	Recovery	Description	T.C.	H.F.
D 1601	61°49'37"	140°32'42"	4040	25 kg	manganese nodule,		
	61°49'13"	140°34'42"	3491		granite, gneiss, diorite,		
					calcareous ooze		
GC1601	61°49'29"	140°35'42"	3451	0.00 m	hit by gravel?		
D1602	62°18'55"	140°56'24"	3748	150 kg	granite, gneiss, slate,		
	62°18'59"	10°54'42"	3466		manganese nodule & crust,		
					calcareous ooze		
GC1602	62°16'40"	140°50'06"	3692	3.70 m	calcareous sand-silt,		
					siliceous silt-clay	2.5596	
GC1603	67°49'17"	178°17'00"	3326	4.30 m	silt clay ~ calcareous		
					sand silt	2.3294	8.47
GC1604	74°32'55"	168°00'06"	922	2.54 m	siliceous ooze, soft clay,		
					silt-sand ~ sand-silt		
GC1604H	74°32'55"	168 00'06"	922			2.9536	179.75
GC1605	76°00'03"	167°34'30"	595	1.07 m	diatom, clay, sand-silt		
GC1605H	76°00'03"	167°34'30"	595			3.1094	149.88
GC1606	76°46'14"	166°52'36"	751	2.96 m	siliceous clay, clay, sand-silt		
GC1606H	76°46'14"	166°52'36"	751			2.6166	115.19

Recovery: Recovered core length and dredge sample weight, T.C.: Thermal conductivity (1 0^{-3} cal/cm s°C), H.F.: Heat flow (mW/m^2).

given in Table 3. Sampling sites in DDS and VLB are shown in Figs. 3a and 3b, respectively. NISHIMURA et al. (1996) and TOKUHASHI et al. (1996) described the gravity cores which were collected until TH92 in the Ross Sea. NISHIMURA et al. (1997) reported the sedimentary sequences, composed of glacial-marine, transitional glacial marine and basal tills in descending order, and the AMS ^{14}C age of VLB cores, GC1604, 1605 and 1606, which were recovered during TH95. They estimated that the three core sites were under the grounded ice sheet during 23530 and 37460 y.B.P. and the ice sheet retreated before 21140 y.B.P. at the GC1604 site.

Heat flow measurement results in the Ross Sea are plotted on the map with previous cruise results (Fig. 4). The data in VLB is higher than at other sites in the Ross Sea area, and are interpreted as the effect of present volcanic activity along the Terror Rift.
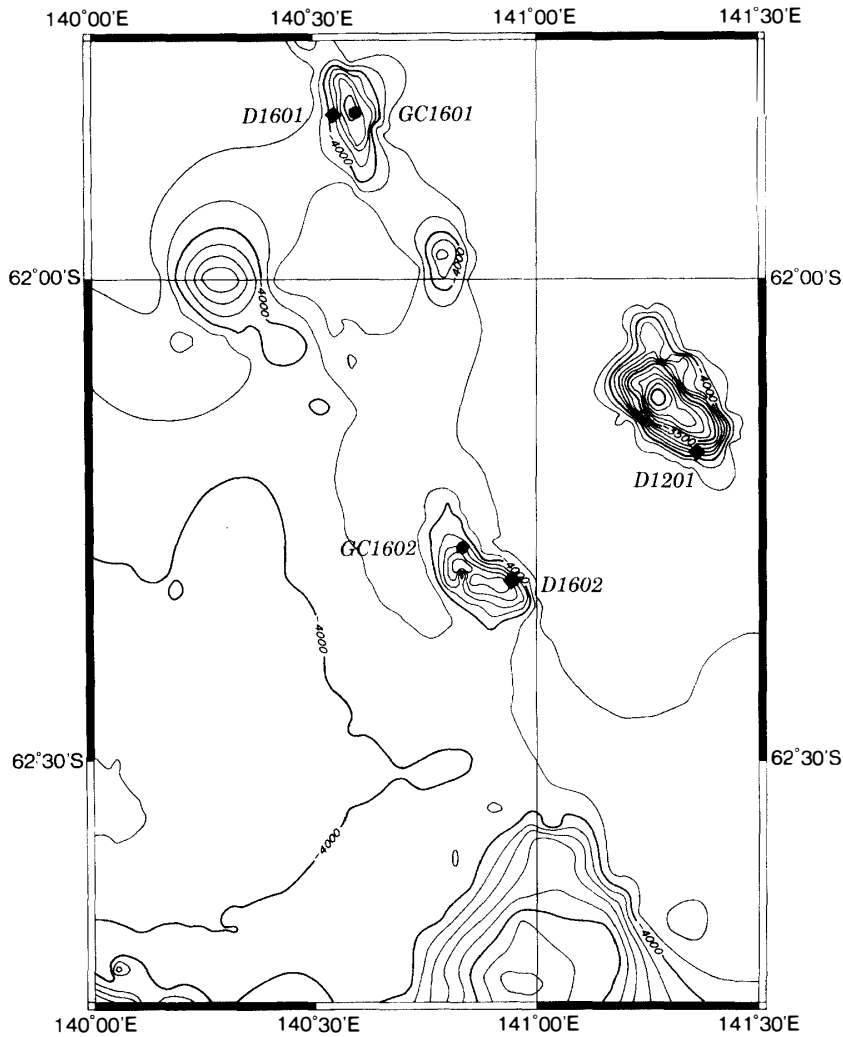
Fig. 3a.   Sampling sites of the TH95 cruise in DDS. D: dredge, GC: gravity core. D1201 is
           peridotite sampled site during TH91.
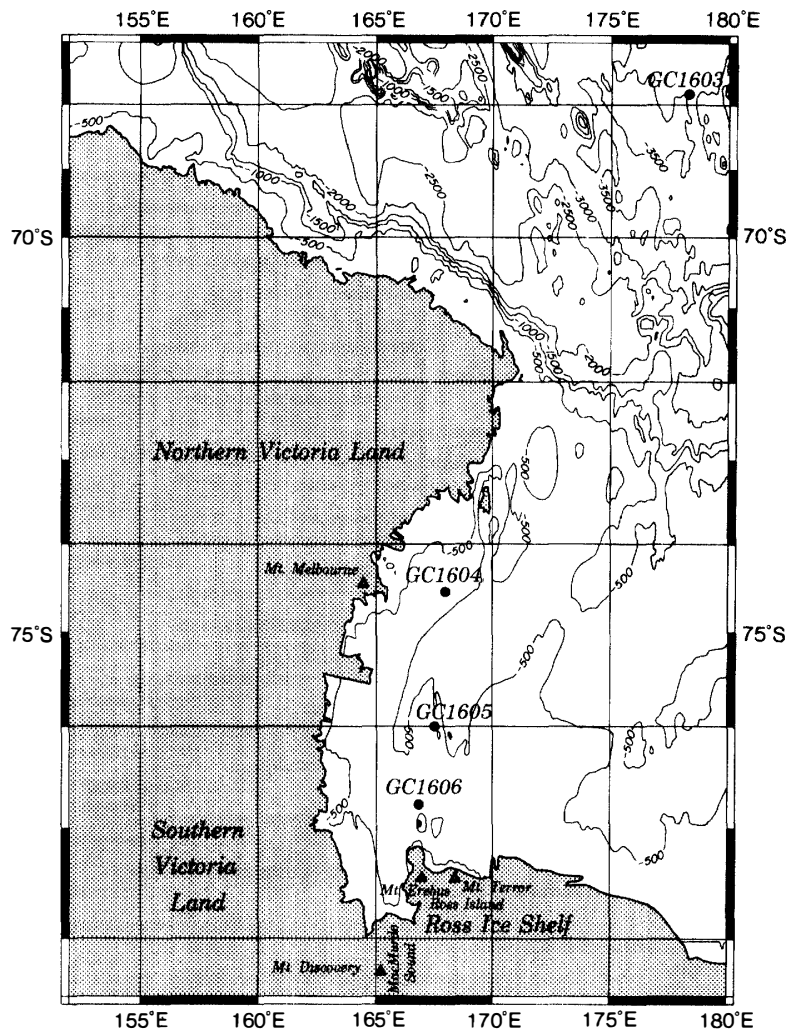
Fig. 3b. Sampling sites of the TH95 cruise in VLB. GC: gravity core.

4. Gravity and Magnetic Surveys

Gravity anomaly data which were obtained in DDS and VLB during TH95 cruise are plotted in Figs. 5a and 5b, respectively. Figure 6 shows the compiled gravity map of TH95 and previous cruise and satellite altimetry data over the TH95 survey area in DDS. Free air anomaly grid data by SANDWELL and SMITH (1992) using satellite altimetry are used to fill the surface survey data gap. The figure shows the broad gravity low over the knoll along 63°S and its vicinity (Fig. 8a). The knoll itself corresponds well to the local E-W gravity high. The seismic data which were obtained over the broad gravity low area shows thick deformed sedimentary sequences under the less deformed well stratified pelagic sedimentary sequences. These facts strongly suggest that there is a fragment of continental crust which was deformed with continental rifting and filled by syn-rift sediments. The local E-W gravity high which is observed at the knoll is interpreted as the intrusion of higher density material which caused the uplift of the knoll.

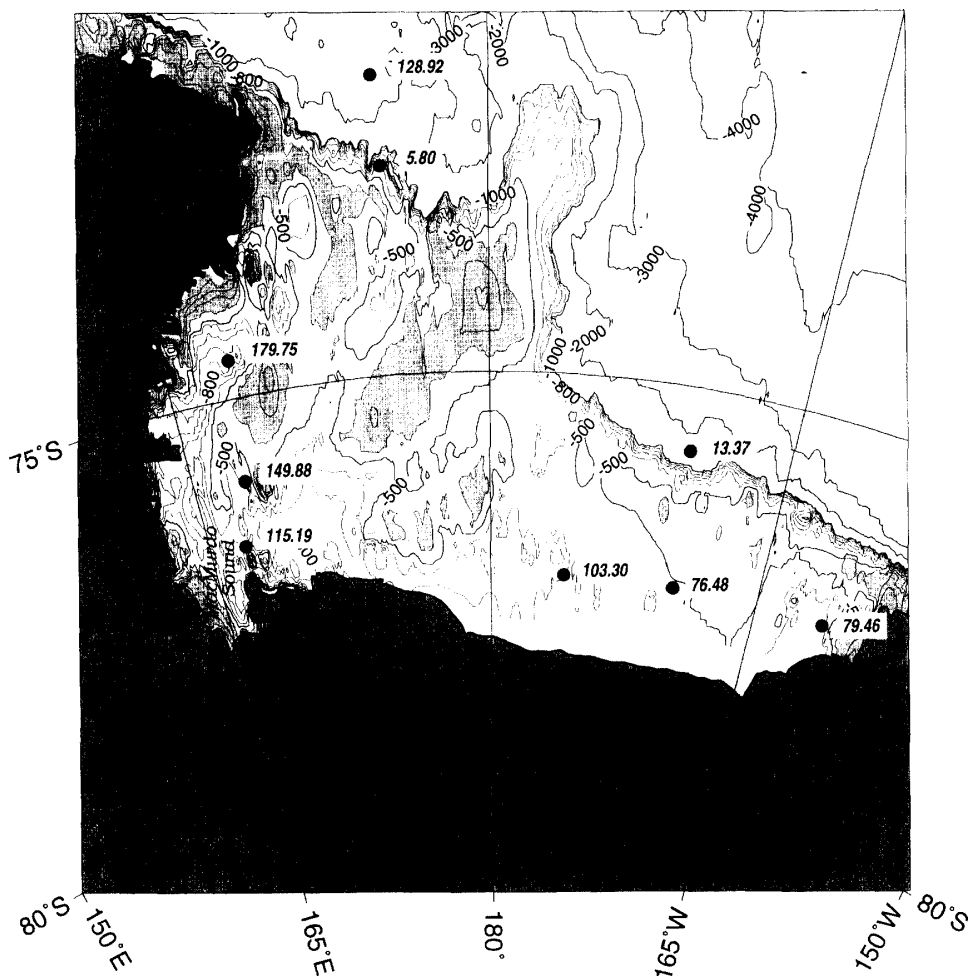Gravity anomaly data in VLB on Fig. 5b show the high anomalies on the eastern

Fig. 4. Heat flow value in Ross Sea observed during TH cruises. Unit is mW/m².

end of E-W survey lines corresponding to the Coulman High. The wide low anomaly between 170°E and 164°E corresponds to VLB. There are two wide highs along about 166°E and 169°E and broad gentle low between them in VLB. There is a local high in the broad gentle low along 22SMG, north of Beaufort Island (Fig. 2a). It probably corresponds to the volcanic intrusion along the Terror Rift as Beaufort Island. The negative anomaly decreases from south to north along 18SMG. It probably corresponds to the magnitude of the VLB along its axis.

Magnetic anomaly data which were obtained during the TH95 cruise in DDS and VLB are plotted on Figs. 7a and 7b, respectively. In DDS, distinct E-W anomaly along the N-S survey lines north of 60–61°S between 136–139°E are interpreted as the magnetism during oceanic crust accretion along the E-W spreading system between Australia and Antarctica. They are correlated with anomalies (21 to 34) during the late Cretaceous and Paleogene (Fig. 1). There are three positive anomalies along E-W survey lines between 137° and 139.5°E. They are correlated with basement highs which are observed on seismic profile 6SMG (see Fig. 8a). In contrast, no distinct magnetic anomalies are observed on the eastern part of the profile on which are two exposed and some buried basement highs. Ultramafic rocks were recovered from one of those seamounts
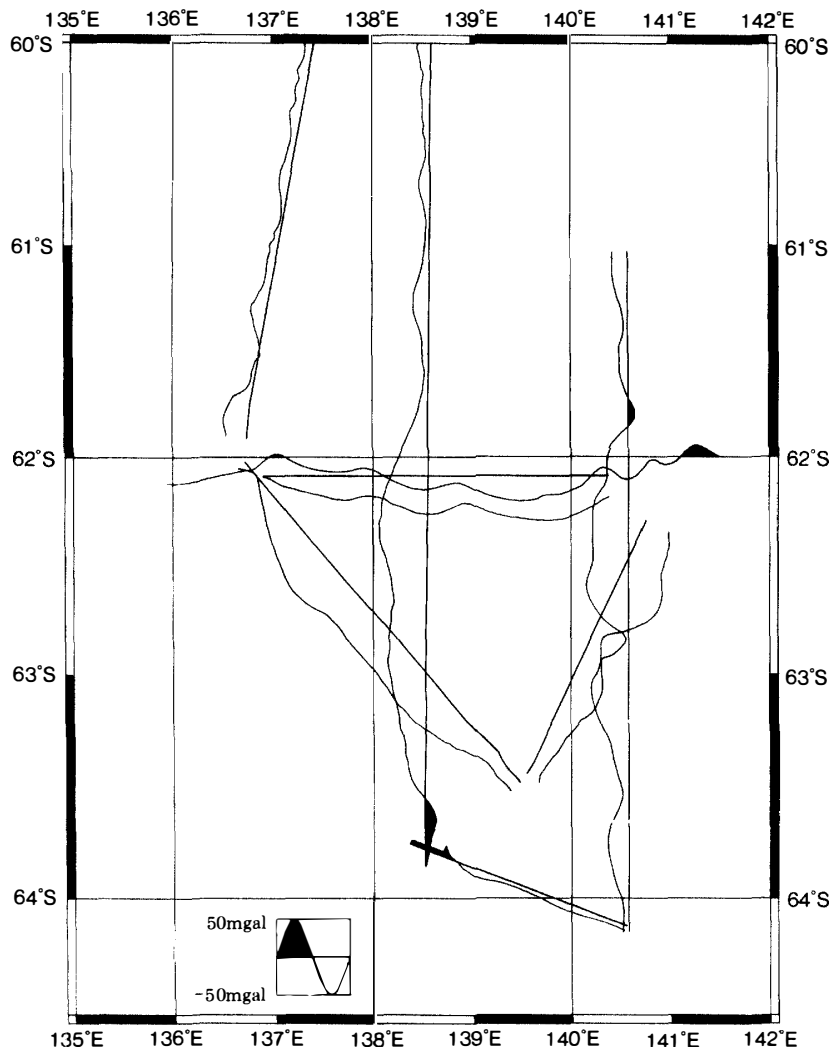
Fig. 5a.   Free-air gravity anomaly profiles along ship's track during TH95 cruise in DDS.

during TH91 and TH92 (Fig. 3a; YUASA *et al.*, 1995). It is interpreted to be exposed along the George V fracture zone.

Magnetic anomaly data in VLB in Fig. 7b show the broad magnetic low running NNW-SSE between Mt. Terror and Cape Washington. It may be correlated with the Terror Rift. There are several local magnetic anomalies which are correlated with the basement highs on the seismic profiles in the VLB area. They are interpreted as volcanic intrusions within the Terror Rift and its vicinity.

5. Preliminary Interpretation of Seismic Survey Results

Seismic survey lines of DDS and VLB are shown in Figs. 8a and 8b, respectively. A refraction seismic survey using Ocean Bottom Seismometer (OBS) was carried out at two and four stations in DDS and VLB, respectively. The seismic signal was detected with three component geophones and hydrophone sensors, and digitally recorded on
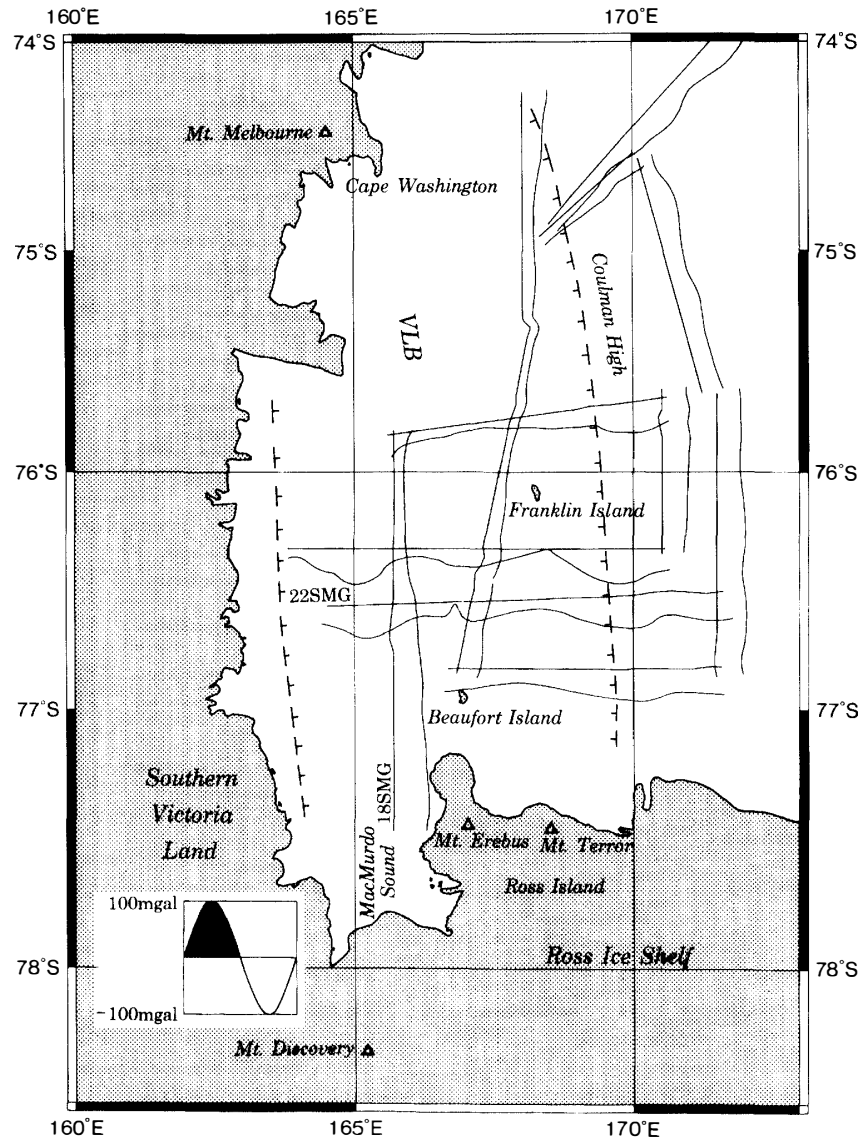
Fig. 5b.   Free-air gravity anomaly profiles along ship's track during TH95 cruise in VLB.

Magneto-optical disk. Even the two OBSs in VLB did not record properly; data quality of other OBSs was fairly good (as in Fig. 9) to resolve the structure given in Table 4. The thickness and depth are described as the two way travel time in seconds and km on the time section and depth section, respectively.

5.1. Dumont d'Urville Sea area (DDS)

Four major unconformities, WL1, WL2, WL3 and WL4 in descending order, have been recognized on IFP, USGS and JNOC MCS profiles in the Wilkes Land margin including DDS (TANAHASHI et al., 1994). Although there is very little geological age evidence, they are interpreted, mainly from the regional tectonics and comparison with the Australian margin, as the possible Late Miocene glacial erosion, possible Eocene gla-
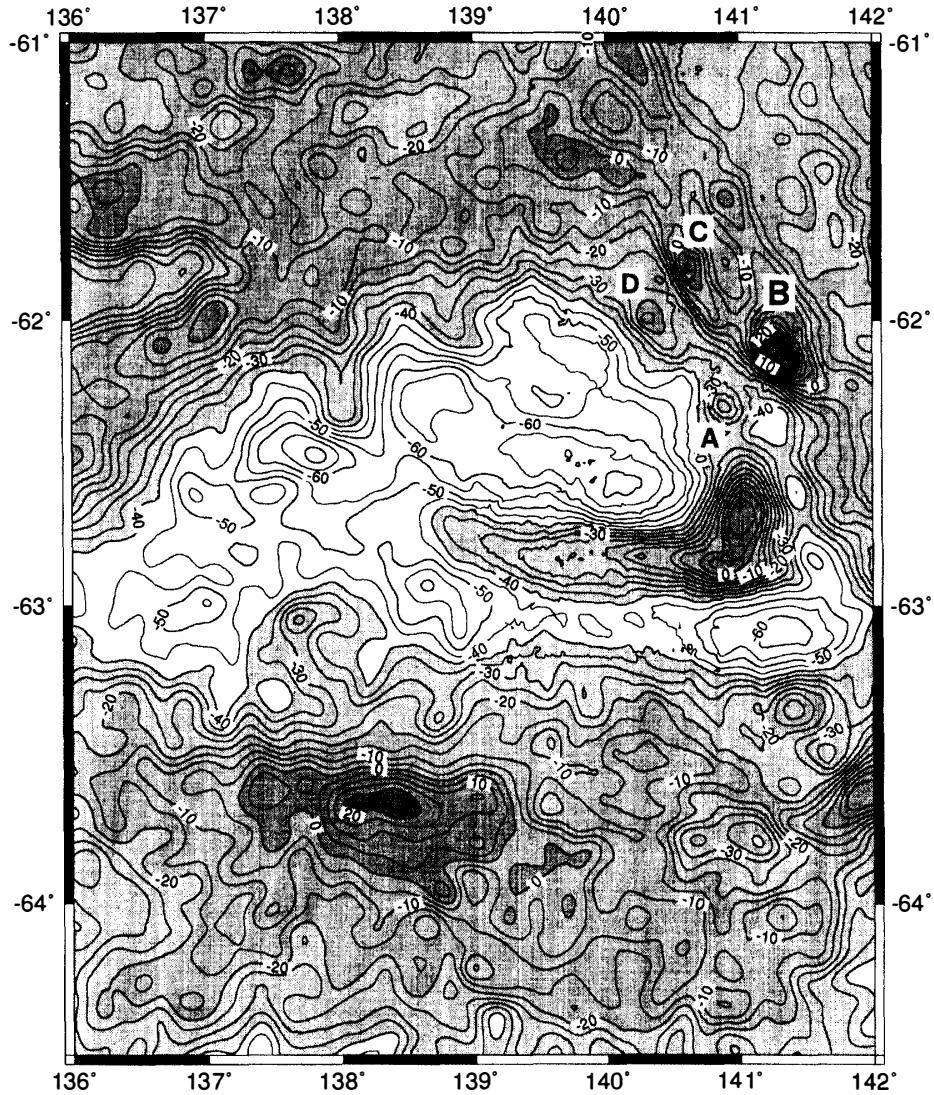
Fig. 6. Free-air gravity anomaly contours drawn with the data from JNOC TH82, 83, 90, 91, 92, 93 and 95 cruises and satellite altimetry data by SANDWELL and SMITH (1992).

cial-onset, early Late Cretaceous break-up and Jurassic(?) rift-onset unconformities in descending order (Table 5). DSDP site 269 provided the stratigraphic data from Oligocene to Holocene, but didn't reach the basement.

Four of seismic profiling lines were carried out during TH95 in the lower continental rise and the deep ocean basin in DDS. Every profile shows an upper unit which comprises horizontally well stratified marine sequences and lower unit which consists of both possible volcanic basement without regular internal structure and some older sedimentary sequences.

The relationship between these two units is clear on line 3SMG (Fig. 10). The upper unit consists of 1.5 s (2 km) thick sequences which show evenly flat-lying reflectors. The uppermost part of the unit shows the variable layer thickness between 0.1–0.4 s. It is almost eroded at the channel between sp 300–900 of 3SMG. The base of this
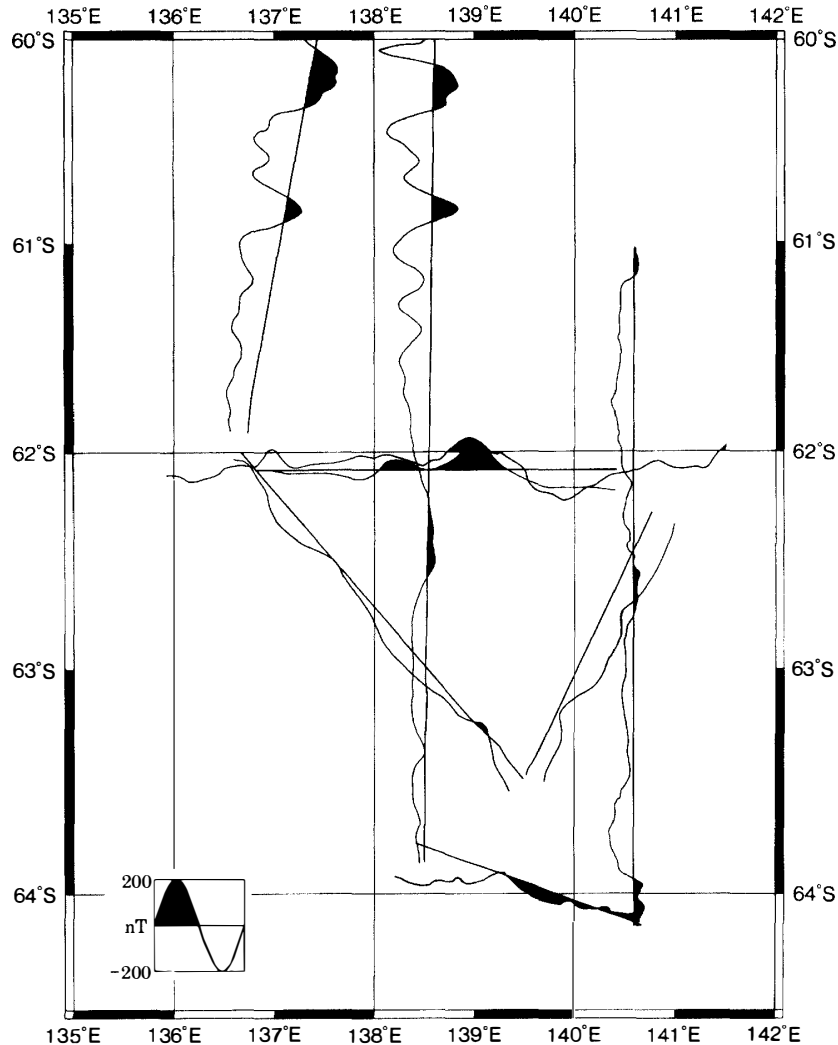
Fig. 7a.   Magnetic anomaly profiles along ship's track during TH95 cruise in DDS.

uppermost part is correlated with possibly Late Miocene WL1 of Tanahashi et al. (1994).

There is a strong reflection parallel to the sea floor and about 1–1.5 km deep below the sea floor (Fig. 10). It is correlated to the distinct unconformity, with onlapping by the upper part of the upper unit south of the knoll on 4-1SMG (Fig. 11). This unconformity is correlated to the very widely recognized unconformities, WL2 of Tanahashi et al. (1994) and unconformity-T by Eittreim and Smith (1987). WL2 is interpreted as a gla- cial-onset unconformity by the initial advancement to the continental shelf in about the Eocene age by Tanahashi et al. (1994). Although WL2 is not deformed so much, the knoll shows an upward warping deformation of WL2 along 4-1SMG. This suggests some sort of structural movement during the post-breakup tectonic regime.

The upper unit overlies the deformed lower unit with clear erosional unconformity even within a narrow area (3SMG, sp 1050–1300, Fig. 10). The lower unit is comprised of sub-units which are interpreted as (1) well stratified sedimentary sequence, (2) less stratified nearly massive sedimentary and volcanic sequence, and (3) massive volcanic
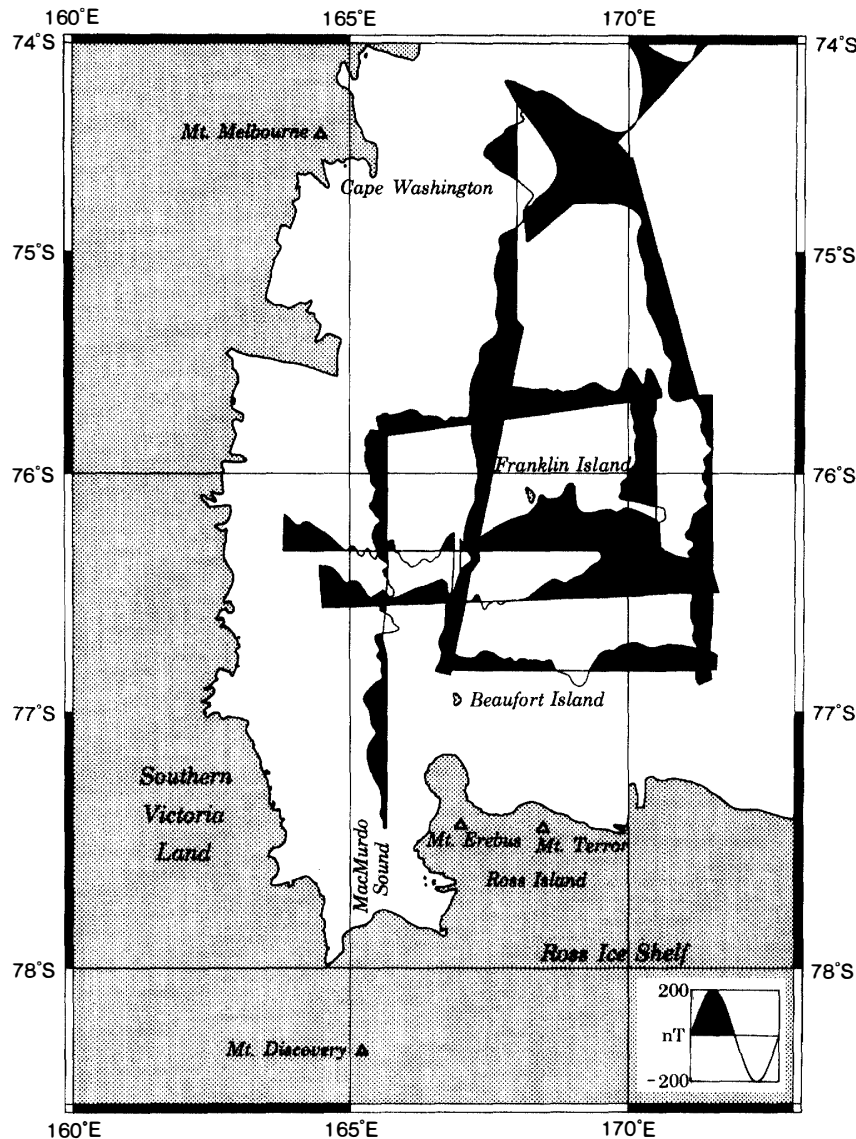
Fig. 7b.   Magnetic anomaly profiles along ship's track during TH95 cruise in VLB.

or igneous basement without regular internal structure. The unconformity between the upper stratified and lower unit is tentatively correlated with WL3 of TANAHASHI *et al.* (1994) .

The well stratified sedimentary sequence of the lower unit is well deformed and makes thick (>4 km) basin fill deposits. It is developed typically on profile 4-1SMG (sp 1200–1500) in the north of a knoll (Fig. 11), and is interpreted as the pre-break-up syn-rift sedimentary sequence. It is characteristic that the such thick syn-rift sequence is developed in these deep water as 3.5 to 4 km. Thick syn-rift sediments probably cause the low gravity anomaly shown in Figs. 5a and 6.

A less stratified nearly massive sedimentary and volcanic sequence is recognized on 4-1SMG (sp 1500–2000, Fig. 11). These sequences are interpreted as deformed syn-rift sequences.
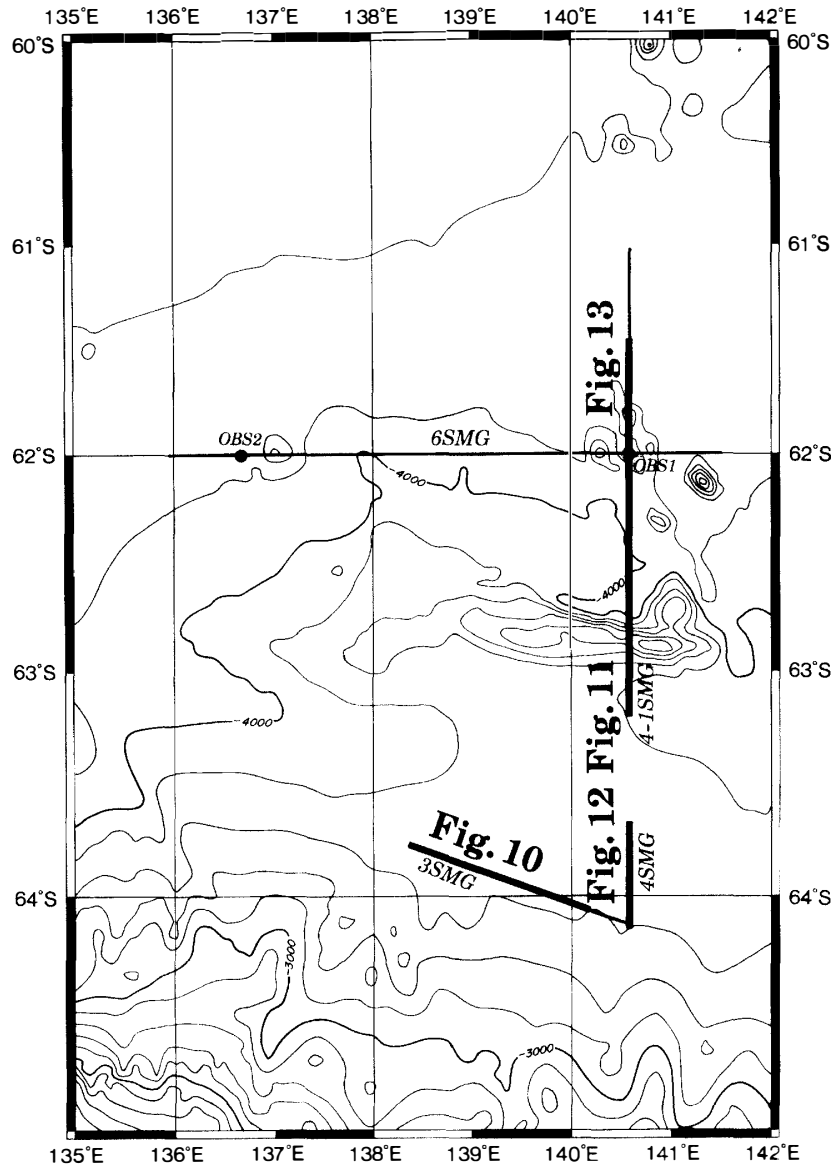
*Fig. 8a. Multichannel seismic reflection survey lines during TH95 cruise in DDS.
Solid circles show OBS sites.*

A possible volcanic basement without regular internal structure is well recognized
at the basement high as 4SMG sp 100–400 (Fig. 12). Pieces of basement are cropped
out on the sea floor or shallow sub-bottom on 4-1SMG and 6SMG. The knoll on 4-
1SMG sp 2930–3200 (Fig. 13) shows no local magnetic anomaly. This suggests that the
basement is a non-basaltic, *i.e.* metamorphosed continental fragment or igneous base-
ment.

5.2. Victoria Land Basin (VLB) area in Ross Sea

VLB is a north-south trending deep graben which developed between Transantarctic
mountains in the west and Coulman high in the east (Figs. 2a and 2b). The Terror Rift,
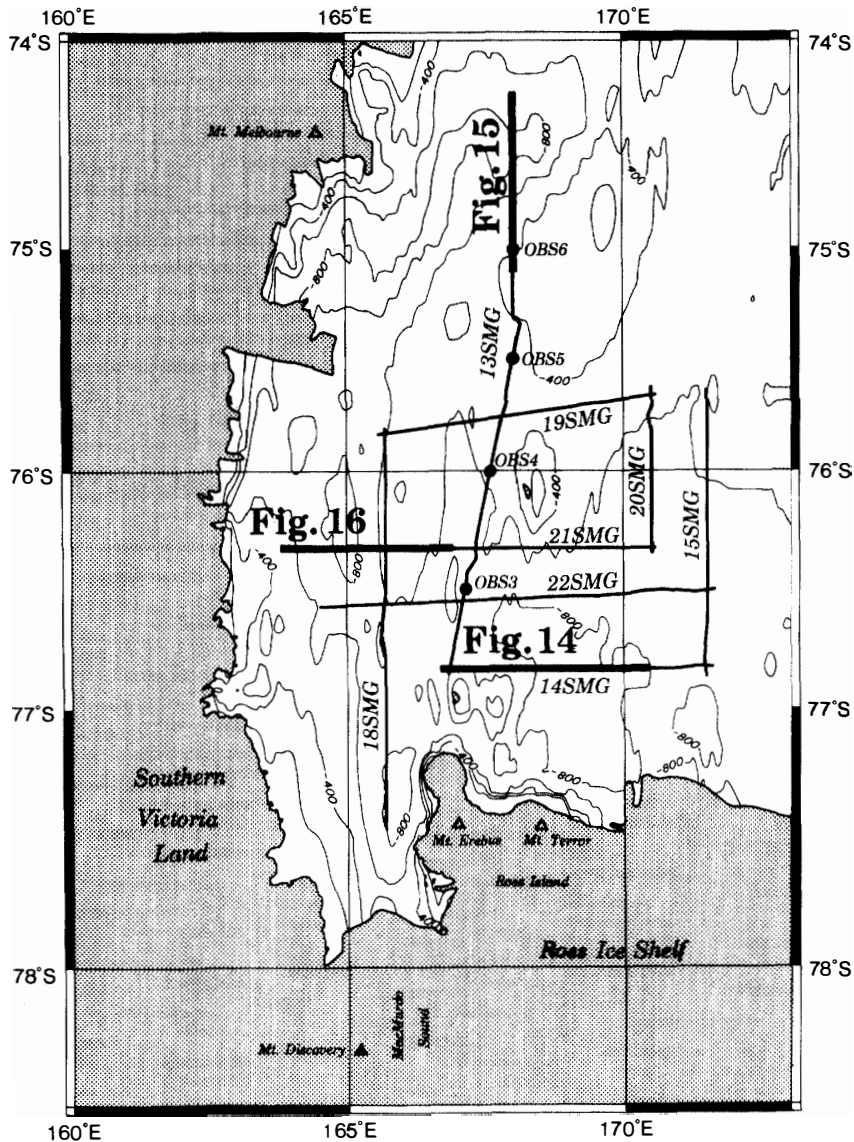
Fig. 8b.   Multichannel seismic reflection survey lines during TH95 cruise in VLB. Solid
           circles show OBS sites.

which consists of western Discovery Graben and eastern Lee Arch, lies along the axis of
VLB from Ross Island to Cape Washington. VLB is believed to have developed in the
Late Jurassic to Late Cretaceous as a rift basin, then after being filled by sediments
during the Late Cretaceous and Paleogene, it was reactivated in the Paleogene to Ho-
locene tectonic movement which is represented by the Terror Rift (COOPER et al., 1991).

     The topographic low develops from McMurdo Sound to the northeastern direction
and the trend is diagonal to the VLB trend (Fig. 2a). This is interpreted to mean that the
topographic low is controlled by glacial erosion during the ice sheet advancement pe-
riod.

     The Coulman High is well observed on the eastern part of the profile 14SMG (Fig.
14). There is an unconformity about 0.5–2.0 km below the sea floor in the Coulman
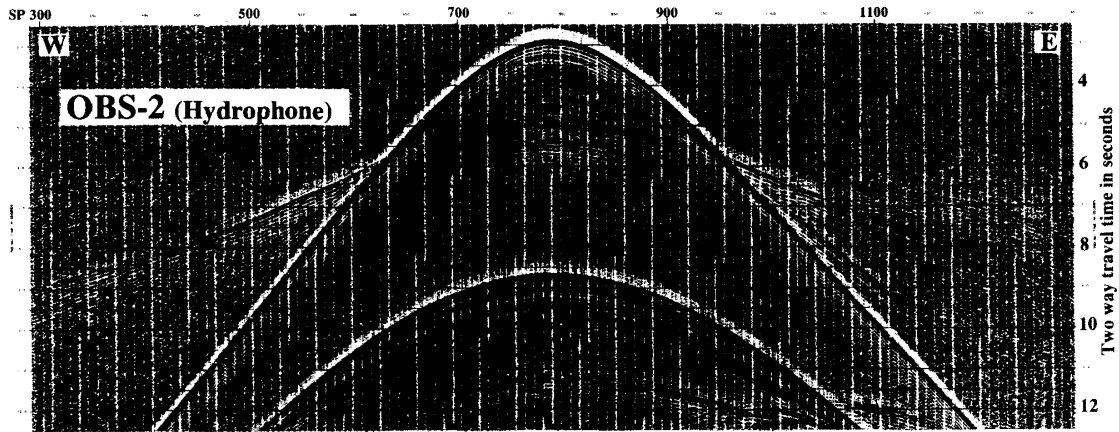
Fig. 9.   Example profile of OBS record (TH95 OBS-2 on 6SMG, Hydrophone record).

Table 4.   Velocity structure resolved from Ocean Bottom Seismometer observation during
TH95 cruise. V: Velocity (m/s), T: Thickness (m), Layer 1 is seawater.

Site No.	OBS-1		OBS-2		OBS-4		OBS-6	
Line No.	6SMG		6SMG		13SMG		13SMG	
Location	62°00.00'S		62°00.06'S		76°00.02'S		75°00.00'S	
	140°35.00'E		136°40.14'E		167°34.40'E		168°00.00'E	
Area	DDS		DDS		VLB		VLB	
Layer	V	T	V	T	V	T	V	T
1	1491	4308	1491	4335	1491	594	1491	376
2	1867	244	2151	554	1818	386	1833	394
3	2177	668	2708	717	2031	78	2377	91
4	2411	580	3000	517	2609	720	2688	431
5	3797	836	3849	689	3592	697	2917	694
6	4844		4595	1108	4085	1540	4052	1933
7			5000	2164	5133		5248	
8			6594					

Table 5.   Sedimentary sequences and unconformities in offshore Wilkes Land margin
(modified from TANAHASHI et al., 1994).

| Type of sequence		Age	Unconformity and sequence
			Sequence A1
	deep-marine sequences		Sequence A2
		Late Miocene?	WL1-Unconformity
			(glacial erosion unconformity)
Post breakup sequences			Sequence B1
			Sequence B2
	shallow-marine sequences		Sequence B3
		Eocene?	WL2-Unconformity
			(glacial-onset unconformity)
			Sequence C1
		Late Cretaceous?	WL3-Unconformity
			(breakup unconformity)
Syn-rift sequence			Sequence D
		Jurassic?	WL4-Unconformity
			(rift-onset unconformity)
Pre-rift sequence			Sequence E
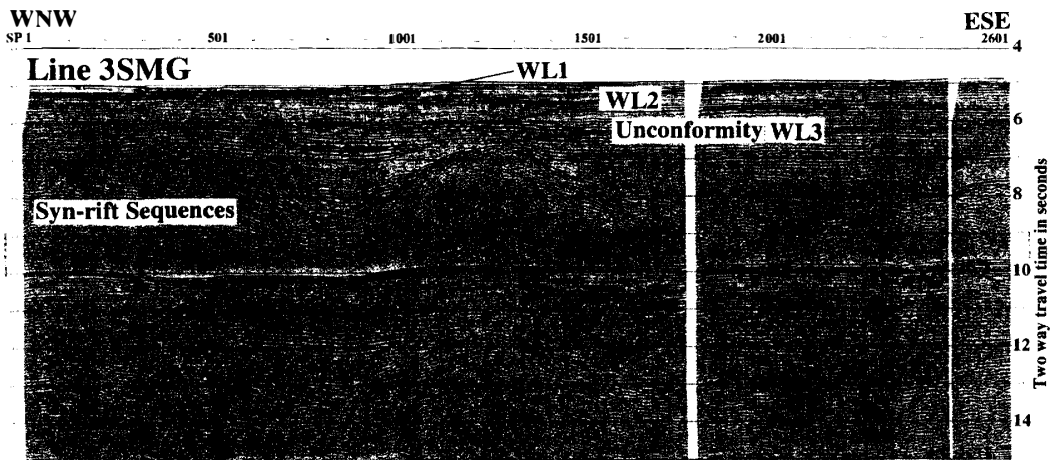
Fig. 10. Seismic profile 3SMG. Unconformity between upper flat undeformed and lower deformed sequences is probably correlated with WL3. Thick possible syn-rift sequences are developed.
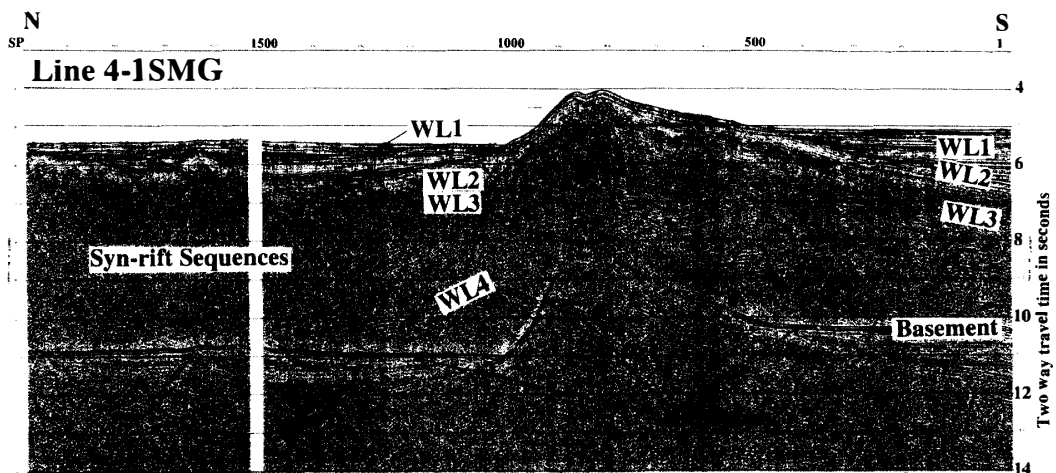

Fig. 11. Seismic profile 4-1SMG over the knoll at 63°S. Thick possible syn-rift sequences are developed under and north of the knoll.

High area. The unconformity shows erosional feature of the lower basement which is a severely deformed sedimentary unit. The unconformity, itself, shows moderately deformed roughness. Some normal faults associated with this deformation dislocate the whole sedimentary section of the upper unit. This shows that the extensional deformation over Coulman High was active until the Quaternary.

The basement is interpreted as the pre-Jurassic Beacon Group or its equivalent sedimentary units (COOPER et al., 1991). The unconformity is inclined to the west and vague in deep and becomes an acoustic basement in VLB (Fig. 14). It is not clear in the central part of VLB because the deformation and volcanic intrusion in shallower parts mask deeper reflections. The depth of the unconformity is about 6 s (about 9 km below seafloor) in the central part of VLB along 13 and 18SMG.
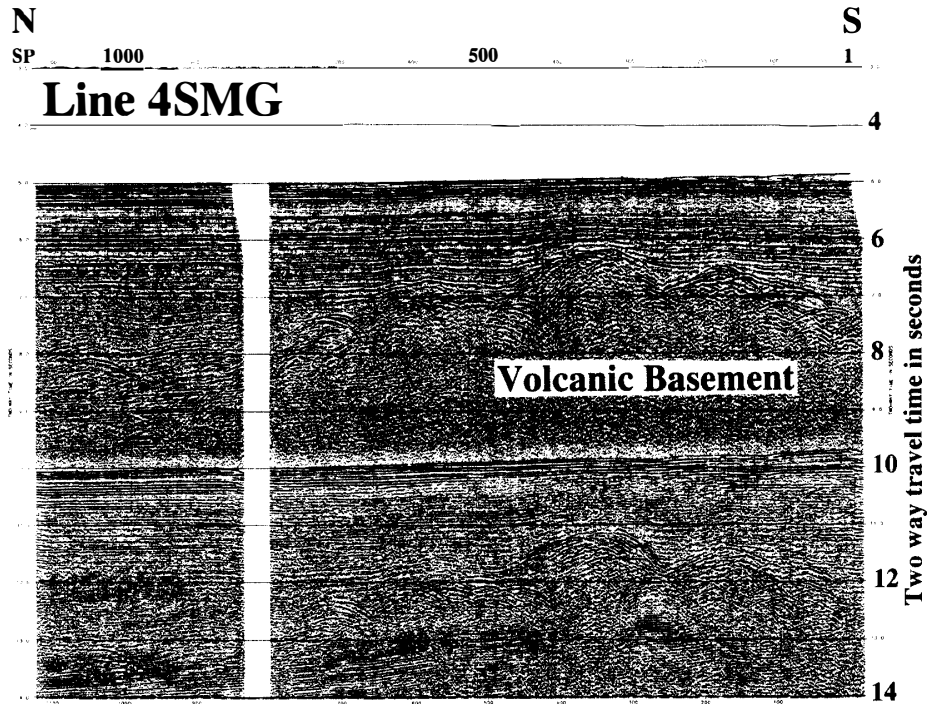
Fig. 12.   Seismic profile 4SMG.   Volcanic basement is well developed at the center of the continental rise basin.
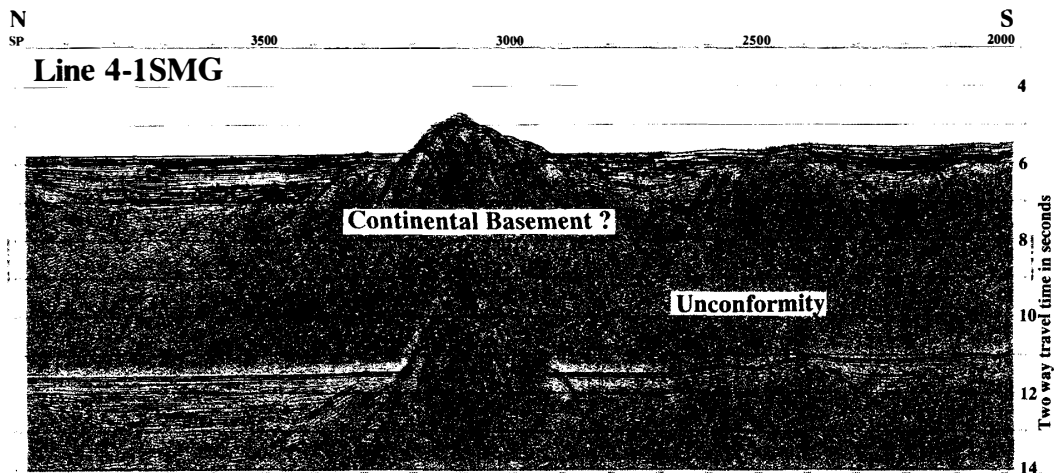

Fig. 13.   Seismic profile 4-1SMG.   Possible metamorphosed continental fragment or igneous basement is exposed as the seamount on the floor. A deep unconformity is developed south of the seamount. The areas north of the seamount is interpreted as the Continent Ocean Boundary (COB) which is mapped in Fig. 17.
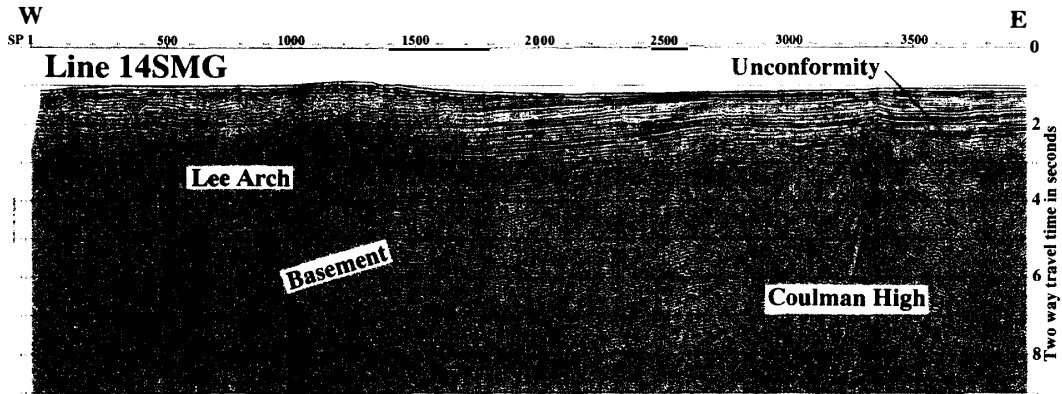
Fig. 14. Seismic profile 14SMG. An erosional unconformity is developed in the Coulman High area. The basement of the VLB is inclined to west and is hidden in deep by the deformation of upper sequences and possible volcanic intrusion at Lee Arch.
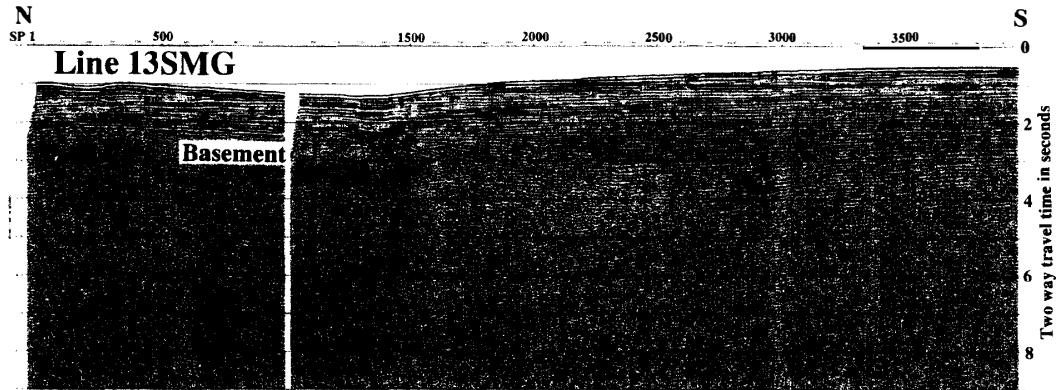

Fig. 15. Seismic profile 13SMG. Shallow basement in the northern part of VLB is well observed. The sequences which fill the VLB are mostly flat and the basement is not clear in the deep area in the southern part of this figure.
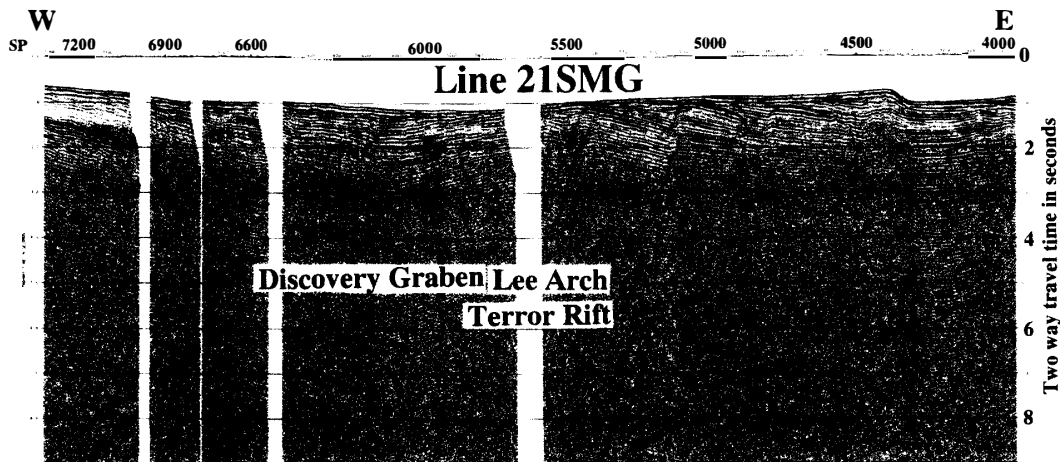

Fig. 16. Seismic profile 21SMG. Normal faults are well developed at the dome-like structure along Lee Arch in Terror Rift.

The sedimentary sequences which fill the VLB are usually parallel to each other and don't show the clear unconformity feature among them. The sequences decrease to about 1.5 km in the northern part of the basin (northern part of 13SMG, Fig. 15) while it increases to 7–8 km in the southern part of the basin (in the west of 14SMG, Fig. 14). The sequence is deformed upward and many normal faults developed in the neighbor of the Lee Arch (in the western part of 21SMG, Fig. 16).

6. Discussion

The presence of thick deformed sedimentary sequences under the less deformed well stratified marine sediments strongly suggests the development of the pre-rift and
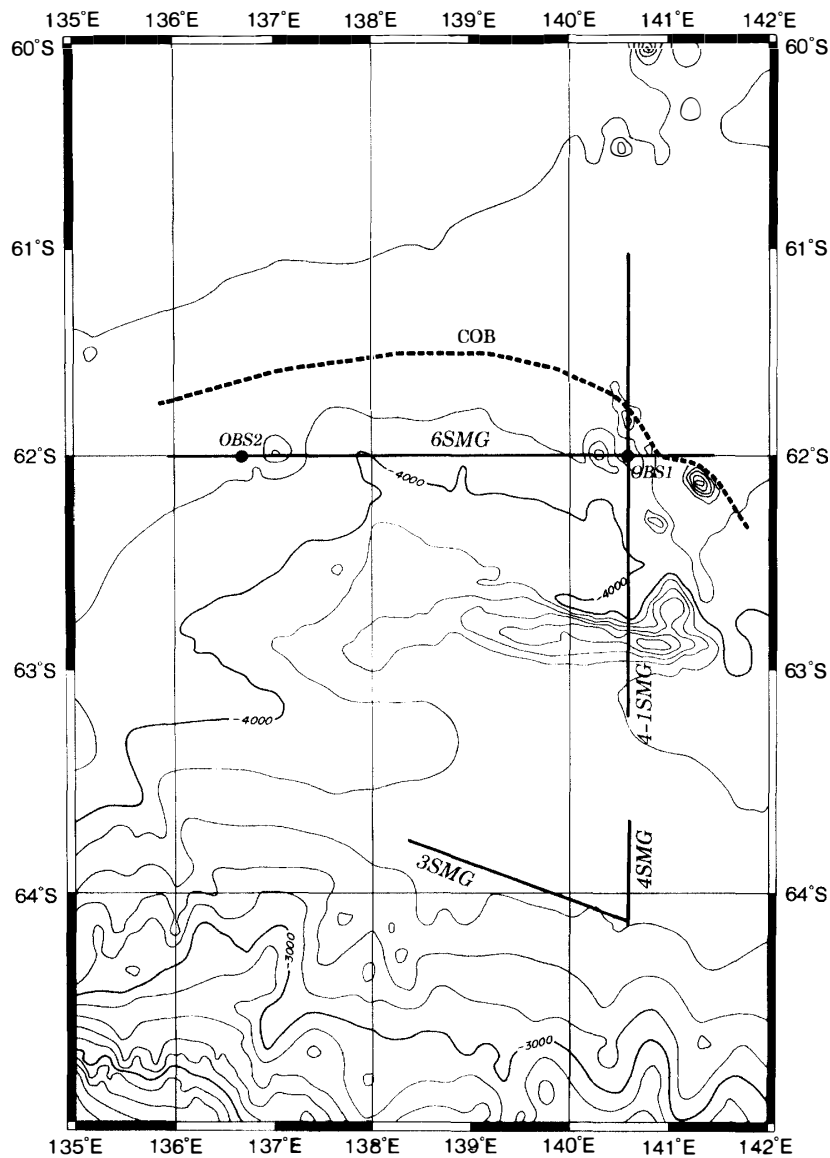

Fig. 17.   Distribution of continent-ocean boundary (COB) interpreted from seismic reflection data as shown in Fig. 13.

syn-rift sedimentary sequences within a continental fragment around 63°S, 140°E in the 3000 to 4200 m water depth area. This is supported by the extension of low gravity anomaly over the area and lack of magnetic anomaly lineations which is well observed in the western part of the survey area. The dimensions of the fragment are estimated from the low free air gravity anomaly area as about 150×150 km². The interpreted continent ocean boundary (COB) is plotted in Fig. 17. The area is described as an anomalous oceanic zone by WANNESSON et al. (1985). Although they interpreted the area developed over the oceanic crust with the magnetic anomaly identification of 30–31 and 34, this is not obvious because the anomaly pattern is very indistinct south of 61.5°S in this area. We interpreted this magnetic character change as a difference of basement crusts between north and south. This anomalous crust in such deep sea is not well documented at any other diverging continental margin. It is necessary to sample the deep seated formations to establish the tectonic history of the separation Antarctica and Australia.

Although the basement of VLB is not recognized well because of the strong multiple reflections, the extent of VLB is confirmed at least about 7–8 km in depth. It is deformed with extensional faults which cut the uppermost possible Quaternary formations in the western part and Terror Rift area of VLB and the Coulman High. Highly deformed VLB basement with sedimentary sequences is well observed in Coulman High area. The sampling of the these deformed basements is strongly expected to clarify the tectonic history of the western Ross Sea.

Acknowledgments

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