# VI. CONTINUOUS SEISMIC REFLECTION PROFILING SURVEY

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## Introduction

A continuous seismic reflection profiling survey was carried out along the ship's tracks shown in Figs. I–4 and I–5. The ship's speed was 8, 10 or 12 knots during the survey. The sound source was a BOLT PAR 1900B Air Gun with 120 cubic-inches firing chamber. Its firing interval was every 12 seconds in an operating pressure of 1,300–1,500 p.s.i. (91–105 kg/cm$^2$). Seismic signals were detected by a Teledyne Hydrostreamer with 50 crystal hydrophone elements towed 150 meters behind the ship. The signal was processed through a Teledyne Model Au-220 amplifier system with filters passing generally 25–160 Hz and fed into a Raytheon Universal Graphic Recorder Model 196B employing a 4 seconds sweep rate.

From the obtained profiling records (Fig. VI–9), we have tried to divide stratigraphically the substrate layers according to the characteristics of acoustic pattern of the formations (Figs. VI–1 and VI–2), and to show the horizontal or regional changes of such layers especially in terms of their thicknesses (Figs. VI–3, VI–4, VI–5, VI–6, VI–7, VI–8, and Table VI–1).

In describing the features of the acoustic stratigraphy, it is convenient to deal with them respectively in the three characteristic topographic areas, namely, the Magellan Trough area, the Basin area, and the Magellan Rise area. In the Basin area and the Magellan Trough area, sedimentary formations overlying the acoustic basement are acoustically divided into two layers, Unit I and Unit II.* However, on the Magellan Rise area, the sedimentary formations overlying the acoustic basement are thicker and divisible acoustically into four layers, tentatively called as A, B, C, and D layers.

## The Basin area

In the Basin area, the sedimentary formations on the acoustic basement are acoustically divided into two layers. We call the lower one the Unit II layer and the upper one the Unit I layer respectively. The typical seismic reflection records and the interpreted sections of them are shown in Fig. VI–1. The Unit I layer is either an acoustically transparent layer or a highly stratified layer. The thickness of the acoustically transparent layer varies from 10 m to 200 m, having a tendency to become thicker from the northern area to the southern area. On the other hand, the highly stratified layer has uniform thickness, though its distribution is restricted to the western and the southeastern areas. The Unit II layer is an acoustically semi-opaque layer whose thickness is 40 m to 250 m. The acoustic basement is characterized by a strong reflector with the irregular surface.

*As the name of the acoustical stratigraphic divisions in this GH77–1 cruise area, we principally use the system proposed in the report of the foregoing GH76–1 cruise (TAMAKI, 1977).

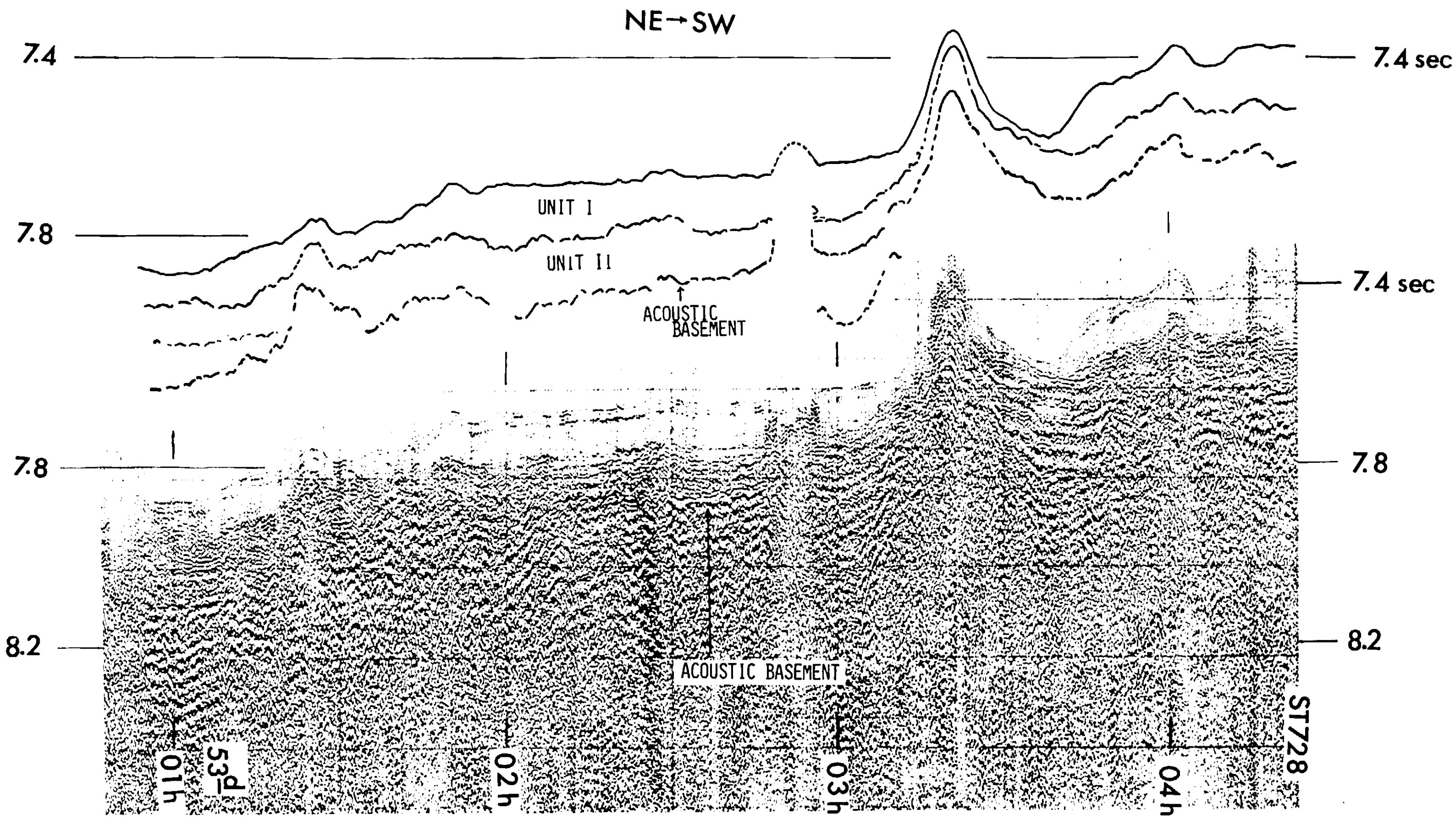
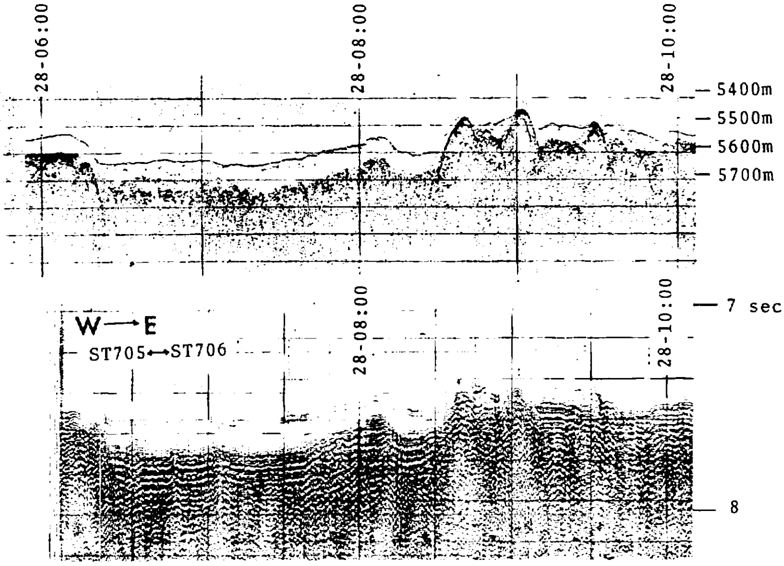
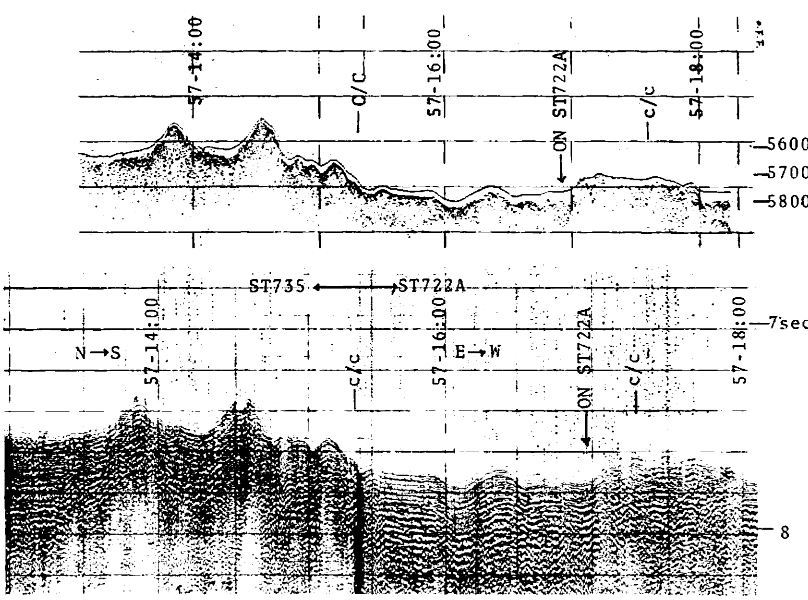



Fig. VI–1 An example of the typical seismic profile and its interpreted section in the Basin area. The depth is shown in seconds of two-way acoustic travel time. The Unit I layer is composed of acoustically transparent layer.

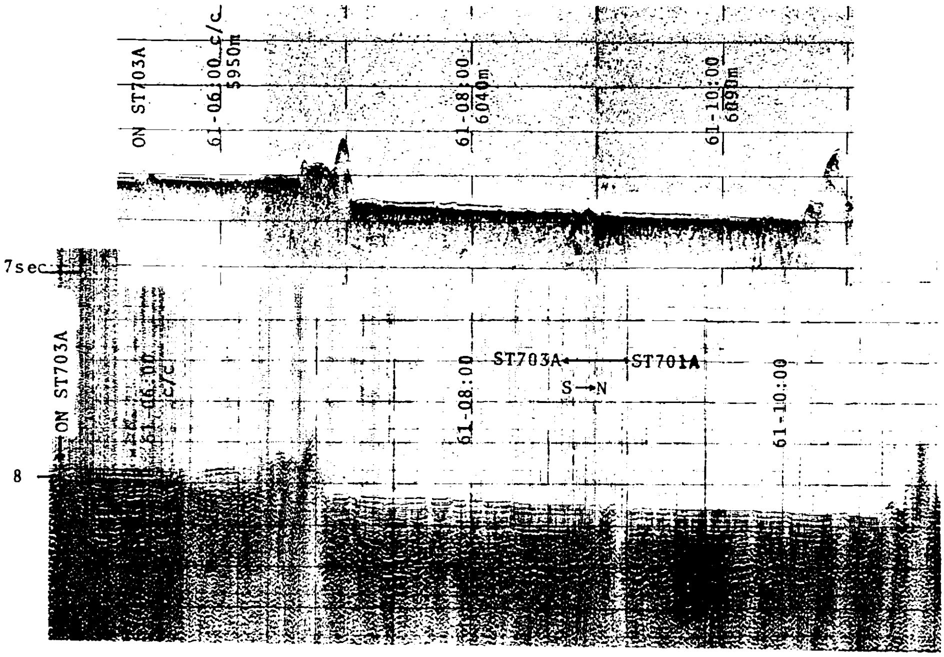
Fig. VI-2(a, b, c and d) 3.5 kHz PDR records and seismic reflection records showing two different acoustic patterns of the Unit I layer. The upper one in each set shows 3.5 kHz PDR record and the lower one shows seismic reflection record. a and b; Records of Type A consisting only of the acoustically transparent layer. c and d; Records of the Type C composed of the acoustically highly stratified layer overlain by thin transparent layer.




(a)

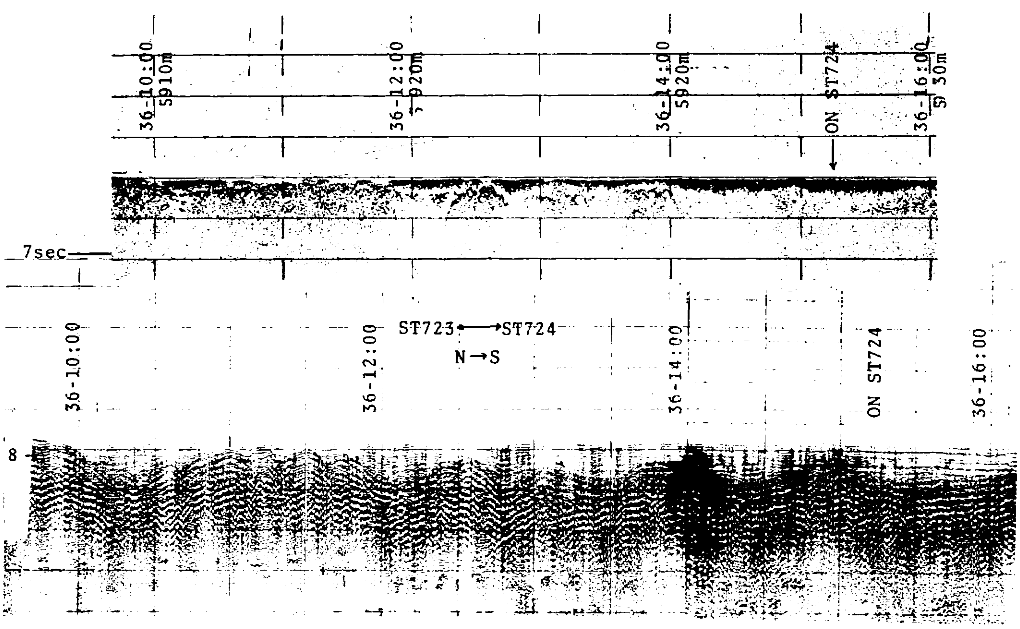



(b)



ON ST703A
61-06:00 c/c
5950m
61-08:00
6040m
61-10:00
6090m
7sec
ON ST703A
61-06:00
c/c
61-08:00
ST703A←→ST701A
S→N
61-10:00
8


(c)



36-10:00
5910m
36-12:00
36-14:00
5920m
ON ST724
36-16:00
7sec
36-10:00
ST723→ST724
N→S
36-12:00
36-14:00
ON ST724
36-16:00
8


(d)

*The Unit I layer*

The Unit I layer is divided into two types from the difference in their acoustic pattern, namely, the acoustically almost transparent layer, Type A, and the highly stratified layer, Type C.

*Type A* The typical profiling records of Type A transparent layer of the Unit I are shown in Fig. VI–2 (a and b). Type A layer conformably overlies the Unit II, and is distributed widely throughout the survey area. However, the thickness or development of the transparent layer, being within 10 m to 200 m and 52 m on the average, varies slightly

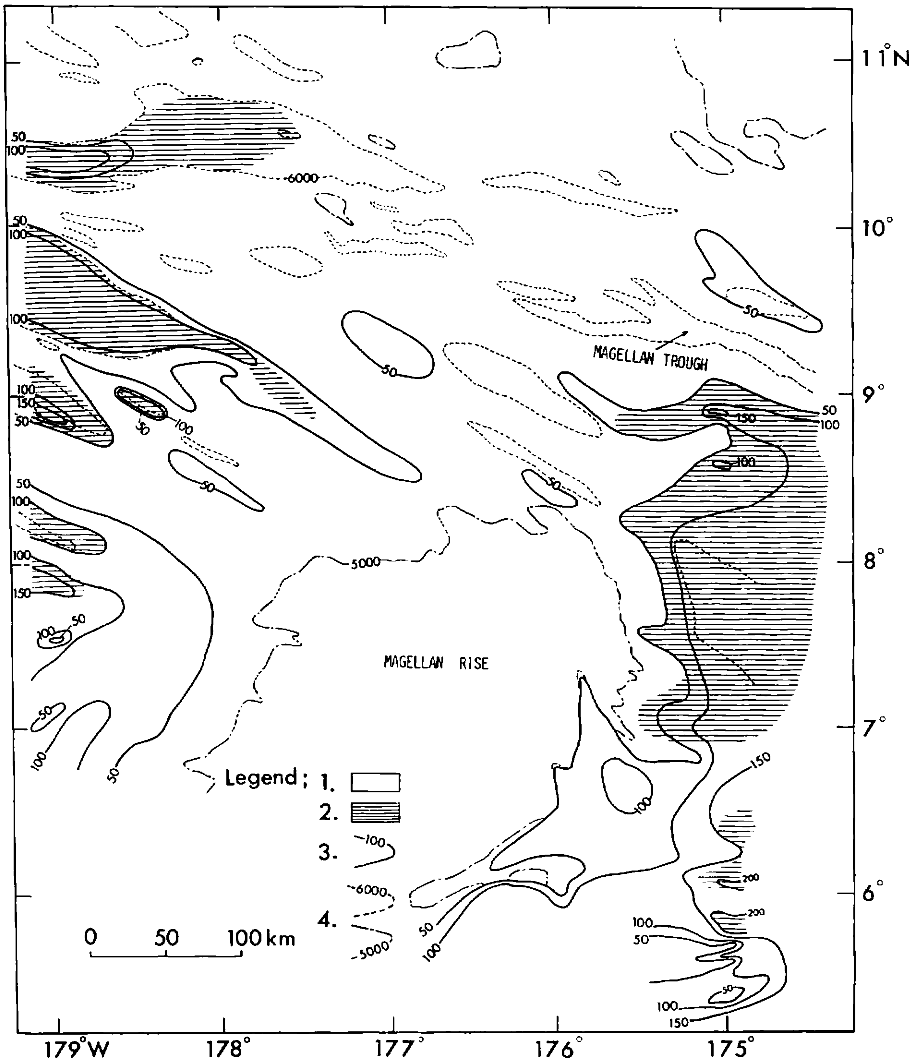



Fig. VI–3 Contour map of the thickness of Unit I layer and distribution of Type A and Type C. A sound velocity of 1.5 km/sec was applied in conversion of the thickness from travel time scale into meters. Legend, 1; Type A, 2; Type C, 3; Contour of the thickness of Unit I layer (in meter), and 4; Contour of water depth (in meter).

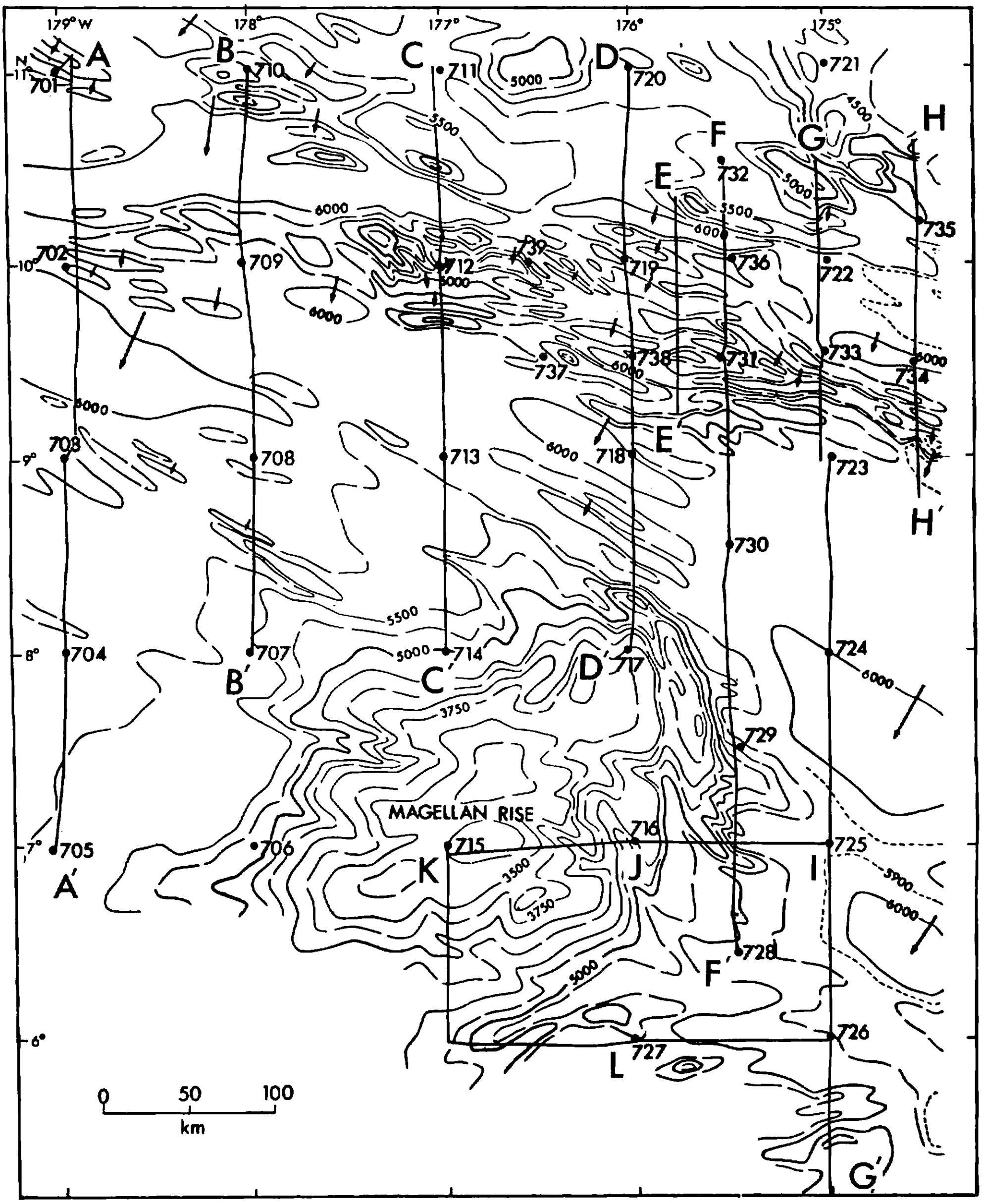
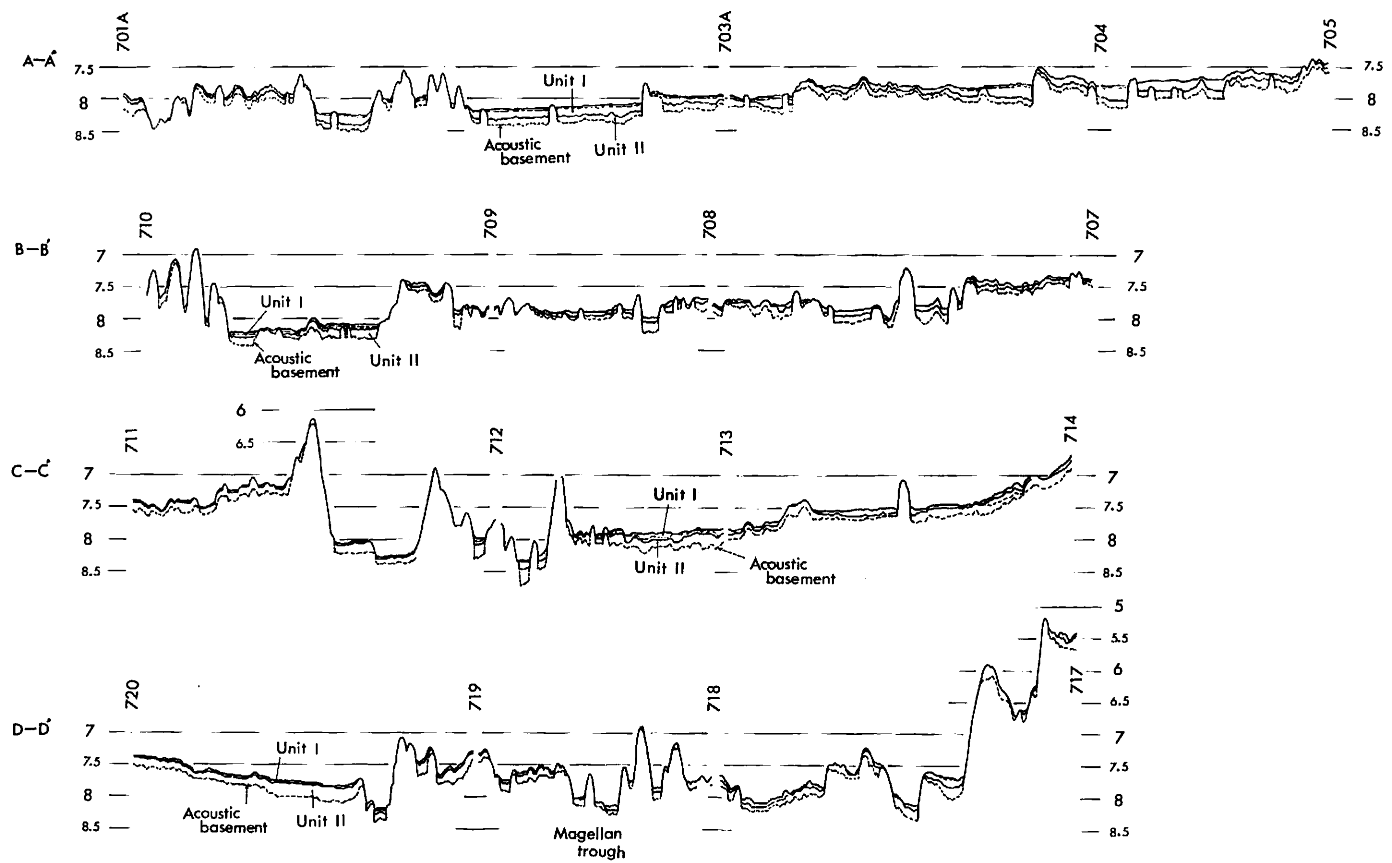
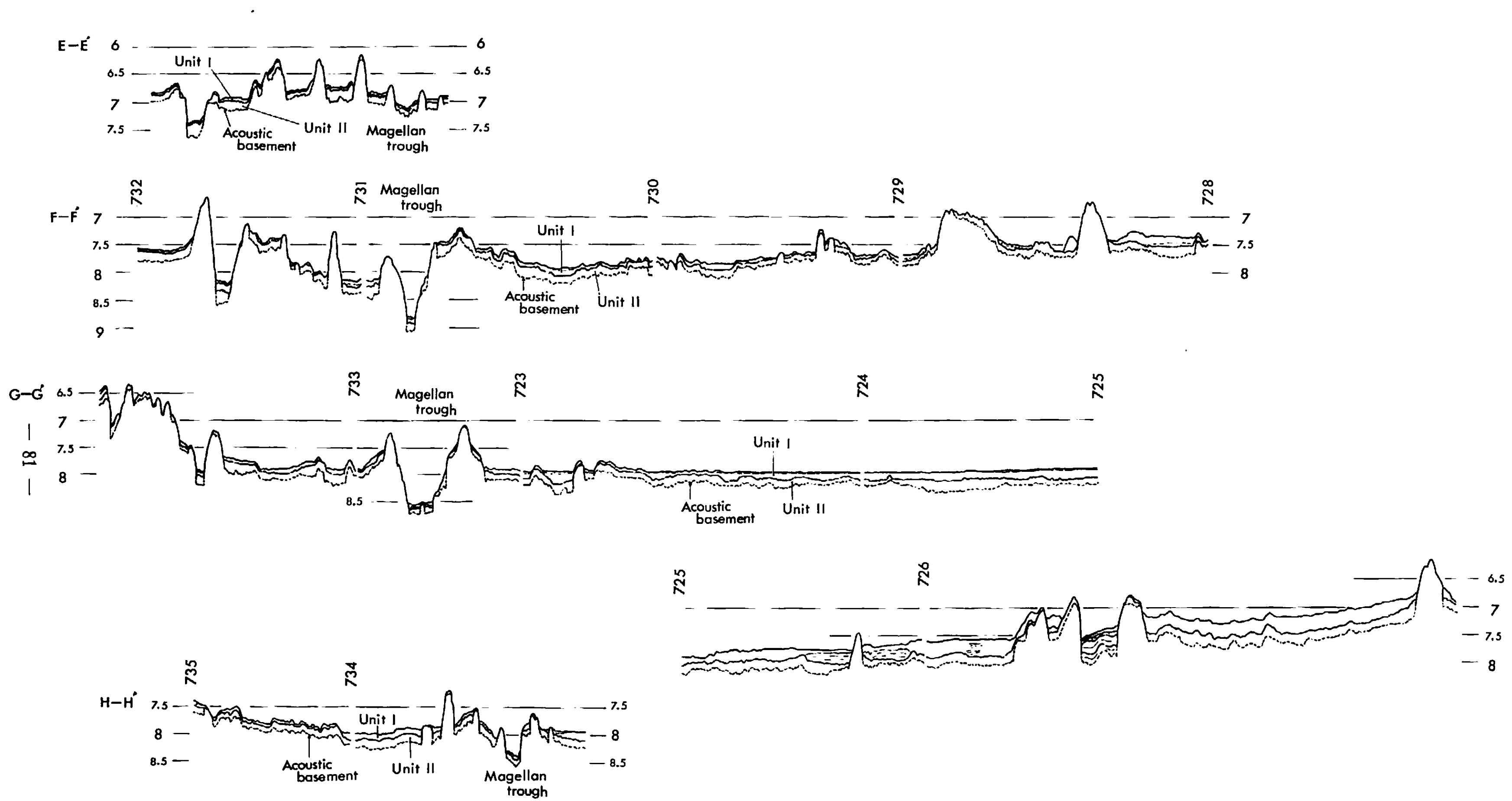



Fig. VI–4 Ship's track for the interpreted sections of Fig. VI–5 and Fig. VI–8. Solid lines show ship's tracks and solid circles with station numbers show positions of the on-site observation.

Fig. VI-5(a and b) Interpreted sections of seismic reflection records along the north-south ship's tracks from A-A′ to H-H′ in Fig. VI-4. The depth is presented in seconds of two-way acoustic travel time. Numbers marked above some points of the interpreted sections show the station numbers of on-site observations.

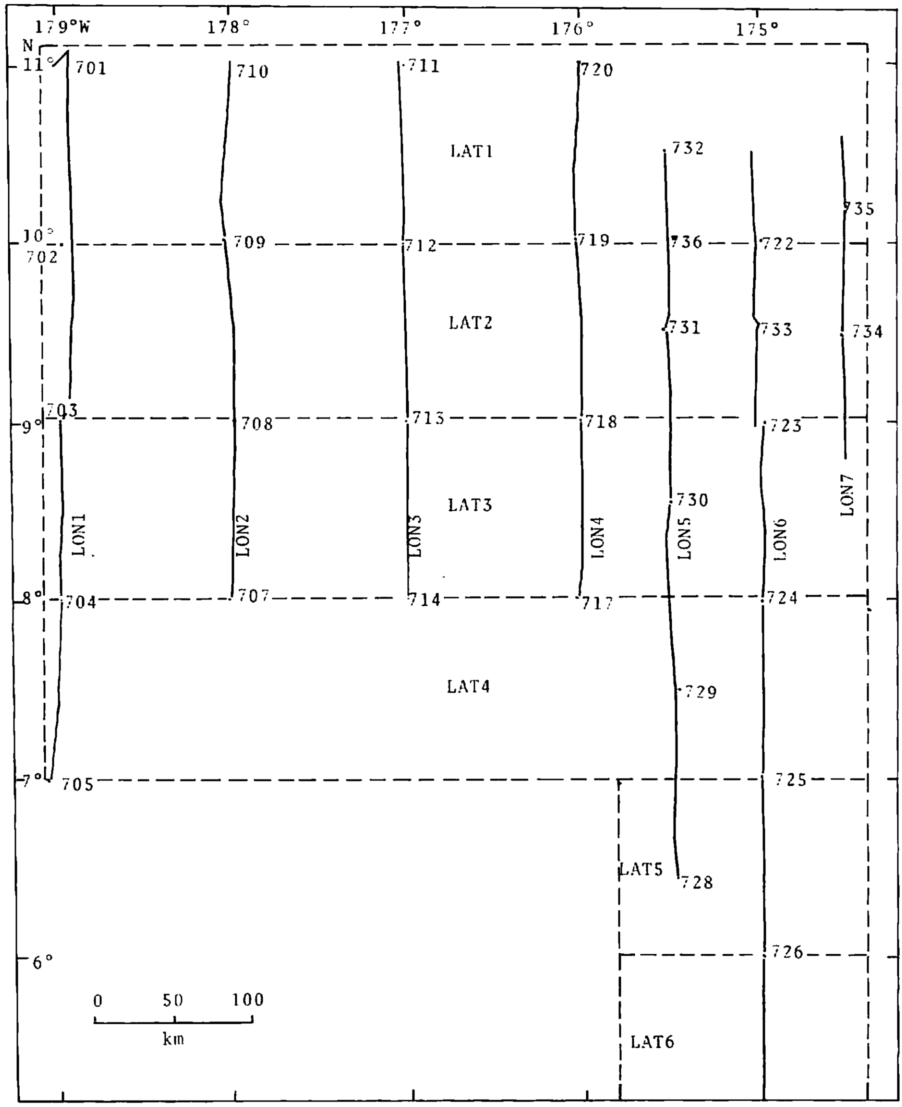



(a)



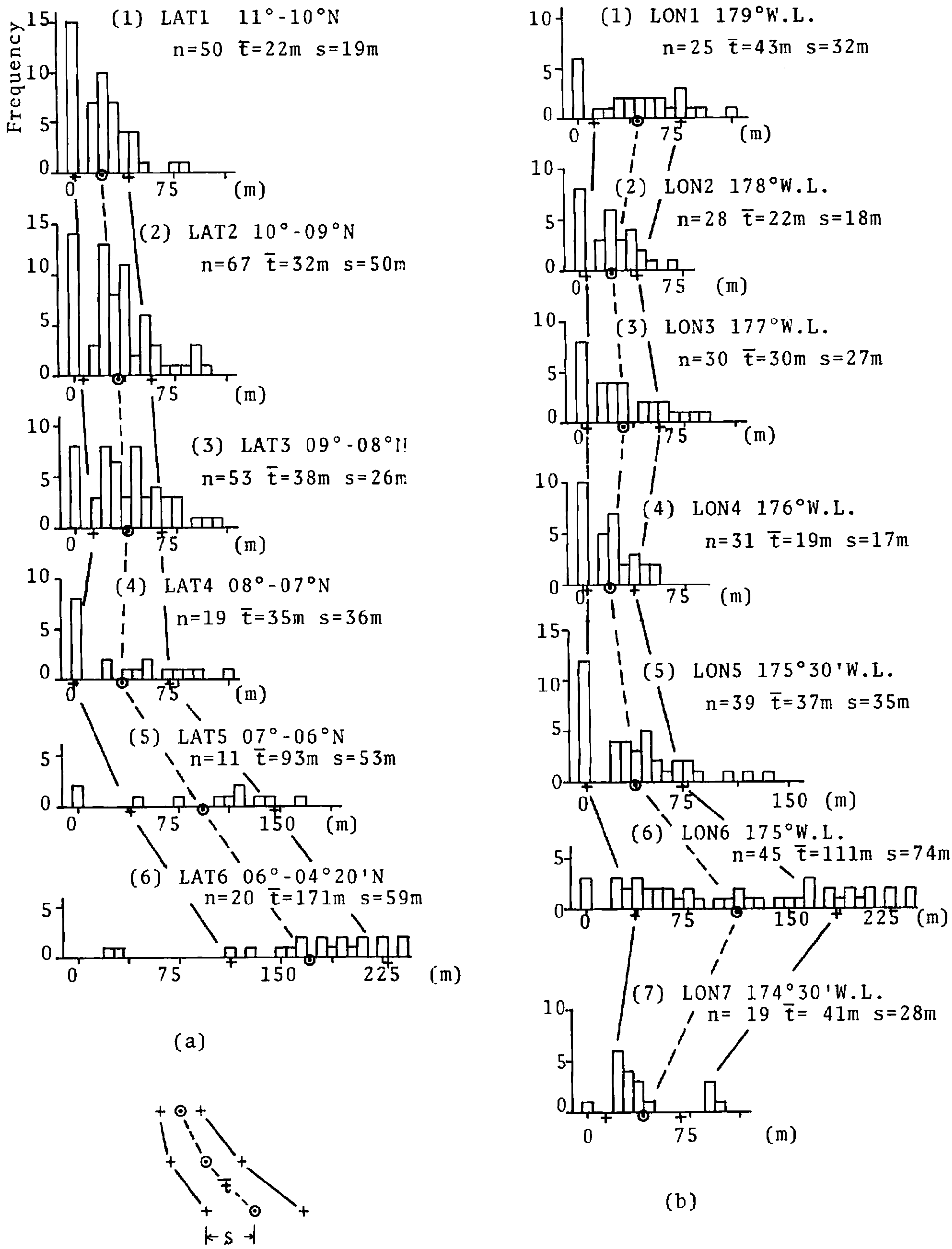
E–E'
6
6.5
7
7.5
Unit I
Unit II
Acoustic basement
Magellan trough
F–F'
732
731
730
729
728
8
8.5
9
G–G'
733
723
724
725
726
H–H'
735
734


(b)



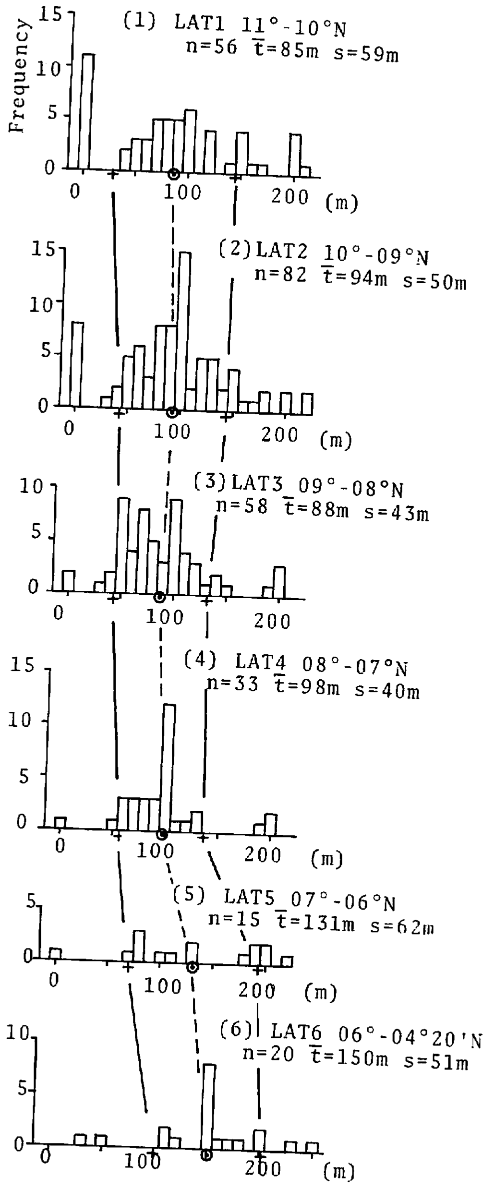

(A)

Fig. VI-6(A and B) Variation of the thickness of Unit I transparent layer and Unit II layer along the direction of the north-south and east-west, shown by means of histograms. A: Solid lines show the north-south tracks of seismic reflection survey. The thickness of Unit I and Unit II layers was measured at each one point of ten equally divided intervals between two neighboring stations of on-site observation. A sound velocity of 1.5 km/sec was applied for the Unit I layer and 2.0 km/sec for the Unit II layer to convert the travel time thickness into the thickness in meters. LAT1 to LAT6 represent each compartment section between the neighboring broken lines and LON1 to LON7 represent each one between the two neighboring solid lines. The histograms are prepared by the thickness data of the layer along each solid line or in each compartment section. B–a; Histograms showing the north-south variation of the thickness of Unit I layer. B–b; Histograms showing the east-west variation of the thickness of Unit I layer. B–c; Histograms showing the north-south variation of the thickness of Unit II layer. B–d; Histograms showing the east-west variation of the thickness of Unit II layer. Letter n is the number of thickness data, $\bar{t}$ is the mean value, and s is the standard deviation.

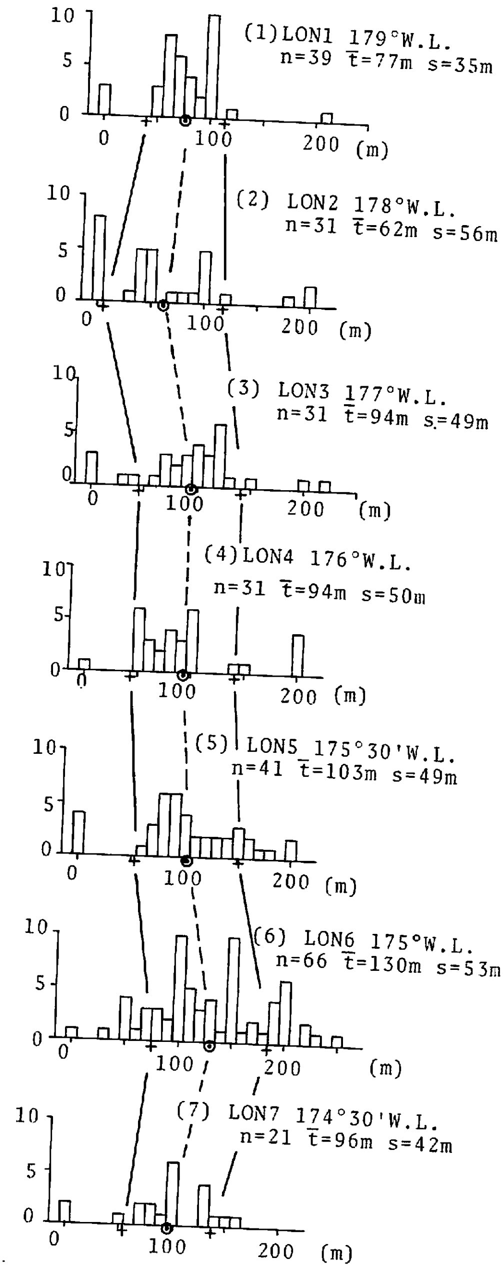


Frequency
(1) LAT1 11°-10°N
n=50 t̄=22m s=19m
(2) LAT2 10°-09°N
n=67 t̄=32m s=50m
(3) LAT3 09°-08°N
n=53 t̄=38m s=26m
(4) LAT4 08°-07°N
n=19 t̄=35m s=36m
(5) LAT5 07°-06°N
n=11 t̄=93m s=53m
(6) LAT6 06°-04°20'N
n=20 t̄=171m s=59m
(m)
(a)
(1) LON1 179°W.L.
n=25 t̄=43m s=32m
(2) LON2 178°W.L.
n=28 t̄=22m s=18m
(3) LON3 177°W.L.
n=30 t̄=30m s=27m
(4) LON4 176°W.L.
n=31 t̄=19m s=17m
(5) LON5 175°30'W.L.
n=39 t̄=37m s=35m
(6) LON6 175°W.L.
n=45 t̄=111m s=74m
(7) LON7 174°30'W.L.
n= 19 t̄= 41m s=28m
(b)
t̄
s


(B-a, b)


Frequency
(1) LAT1 11°-10°N
n=56 t̄=85m s=59m
(2)LAT2 10°-09°N
n=82 t̄=94m s=50m
(3)LAT3 09°-08°N
n=58 t̄=88m s=43m
(4) LAT4 08°-07°N
n=33 t̄=98m s=40m
(5) LAT5 07°-06°N
n=15 t̄=131m s=62m
(6) LAT6 06°-04°20'N
n=20 t̄=150m s=51m
0
100
200
(m)

(c)


(1)LON1 179°W.L.
n=39 t̄=77m s=35m
(2) LON2 178°W.L.
n=31 t̄=62m s=56m
(3) LON3 177°W.L.
n=31 t̄=94m s=49m
(4)LON4 176°W.L.
n=31 t̄=94m s=50m
(5) LON5 175°30'W.L.
n=41 t̄=103m s=49m
(6) LON6 175°W.L.
n=66 t̄=130m s=53m
(7) LON7 174°30'W.L.
n=21 t̄=96m s=42m
0
100
200
(m)

(d)

**(B-c, d)**

with the structural characters of the underlying Unit II. There is a tendency that the transparent layer is thicker in the region where the surface of the Unit II is smooth or more depressed, while it is thinner in the region with undulating surface of Unit II.

The contour map of the thickness distribution of the Unit I including that of Type A layer (Fig. VI-3) and the interpreted profiles (Fig. VI-5) show the general tendency of the variation in the thickness of the Type A layer in the whole surveyed area. From these figures, it is evident that the thickness of Type A, though increases to more than 50 m in the western and eastern areas of the Magellan Rise, generally does not vary along the east–west direction, but remarkably varies along the north–south direction. This tendency is more clearly shown in the histograms of the variation of thickness of Type A layer along north–south direction (Fig. VI–6B-a) and along east–west direction (Fig. VI–6B-b). These indicate that the variation of the mean value of the thickness is characterized by the random fluctuation ranging from 19 m to 111 m along the east–west direction, and by the systematic thickening towards south along the north–south direction.

On the other hand, in detail on the seismic reflection records the thickness of the transparent layer varies rather abruptly (Fig. VI–5 and Fig. VI–9). For example, around 20 km south of St. 704 in the southwestern part of the surveyed area, the thickness of the transparent layer increases abruptly from 60 m to 100 m. In the vicinity of St. 725 in the southeastern area, it abruptly increases from 60 m to 150 m. Besides, in the northern area, the thickness of the transparent layer is thinner than 50 m except some localized areas.

*Type C* Type C is depicted as an acoustically highly stratified layer on the seismic reflection records, but it is shown as an opaque layer on the records of the 3.5 kHz PDR (Subbottom profiler). Usually, the highly stratified layer is covered with the thin transparent layer of the thickness of 20–30 m (Fig. VI–2c and d). The Type C layer unconformably overlies the Unit II layer, and constitutes a very smooth sea floor regardless of irregularity of underlying surface of the Unit II layer. Type C is distributed only in the western and southeastern areas. Both areas have the different topographical environments with regard to the depositional features of Type C. In the western area, Type C is distributed only in troughs having a trend of WNW–ESE and a width of 20 km to 60 km. Type C layer gradually thins out from the west to the east, and disappears in the vicinity of 177°30′W. In the eastern area, the distribution of Type C is localized in the east of the Magellan Trough, delineating a half-elliptic shape. Its distributional area is about 33,000 $km^2$ according to our estimations together with the results of GH76–1 (TAMAKI, 1977). As the average thickness of the Unit I layer is about 100 m in this region, the volume of Type C is estimated at the value of 3,300 $km^3$.

*The Unit II layer*

The Unit II layer is an acoustically semi-opaque layer. Its acoustic inner structure is not uniform, but varies a little in places of the surveyed area. Generally speaking, its acoustic inner structure seems to be made up of densely layered reflectors showing minor folding, though if the thickness of Unit II layer becomes thinner the inner structure becomes not clear.

The thickness of Unit II layer ranges from 0.04 to 0.25 seconds in two-way acoustic travel time, and it is 0.095 seconds on the average. According to the drilling results from the DSDP Site 165 to Site 170 (WINTERER, EWING *et al.*, 1973), the interval sound velocity of the layer which corresponds to the Unit II layer is about 2.0 km/sec on the average. Basing on the data, the true thickness of the Unit II layer is calculated as 40 m to 250 m in the range and 95 m on the average. The variation of the thickness of Unit II layer in the direction of the east–west or the north–south is shown in Fig.VI–6B-c and d by means of histogram. These show that mean value of the thickness hardly varies along the direction of the north–south between 11°N to 8°N, but gradually thickens towards further south, and that, however, it does not systematically vary along the direction of the east–west, but rather randomly varies in the range of 60 m to 130 m.

*The acoustic basement*

We defined the distinct reflector below the Unit II layer as the acoustic basement. Depth from the sea floor to the acoustic basement is about 425 m at the maximum and 150 m on the average. Although acoustic basement generally abounds with the undulation, it has a smooth surface at some places. The topography of the sea floor is principally controlled by the structures of the acoustic basement except the region covered by the Type C of Unit I layer.

**The Magellan Trough**

The topography and structure of western extension of the trough called the GH76–1 Trough tentatively in MIZUNO *et al.* (1977) and formally renamed as the Magellan Trough (See Chap. III, in this report) were studied with particular attention in the GH77–1 cruise. The Magellan Trough trending in WNW is traceable westwards up to around 176°W, where it loses its topographic features as a clear trough. Northern and southern rims of the trough are bordered by the ridges made up of acoustic basement. With regard to the topographical size, the southern ridge is larger than the northern ridge, showing the relative height from the bottom of the trough to the crest of the southern ridge as 1,100 m to 1,200 m at the maximum.

The thickness of transparent layer within the trough is 10 m to 30 m, being thinner than that of the surrounding basin. The transparent layer lies on the semi-opaque layer whose acoustic nature is almost the same as the Unit II layer in the Basin area. TAMAKI (1977) inferred that the top of the semi-opaque layer within the trough might be volcanic siltstone instead of chert. Normal faults are observed on the slopes of both sides of the two ridges, especially well developing on the southern ridge (Fig. VI–7).

**The Magellan Rise**

The Magellan Rise with relatively flat top at the depth of about 3,200 m occupies almost a quarter of GH77–1 surveyed area at its central southern part. Fig. VI–8 shows the interpreted profile sections traversing the Magellan Rise. The acoustic stratigraphy on the Magellan Rise is distinguished into A, B, C, and D layers tentatively called in descending order. The correlation of these layers to the drilling data of DSDP Site 167 is shown in Table VI–1. According to the DSDP data, the total thickness of sedimentary formations above the acoustic basement at the Magellan Rise is about 1 km. Some eroded features are observed at the outer edge of the plateau, and these eroded parts lack the layers A, B, or C (Fig. VI–8c).

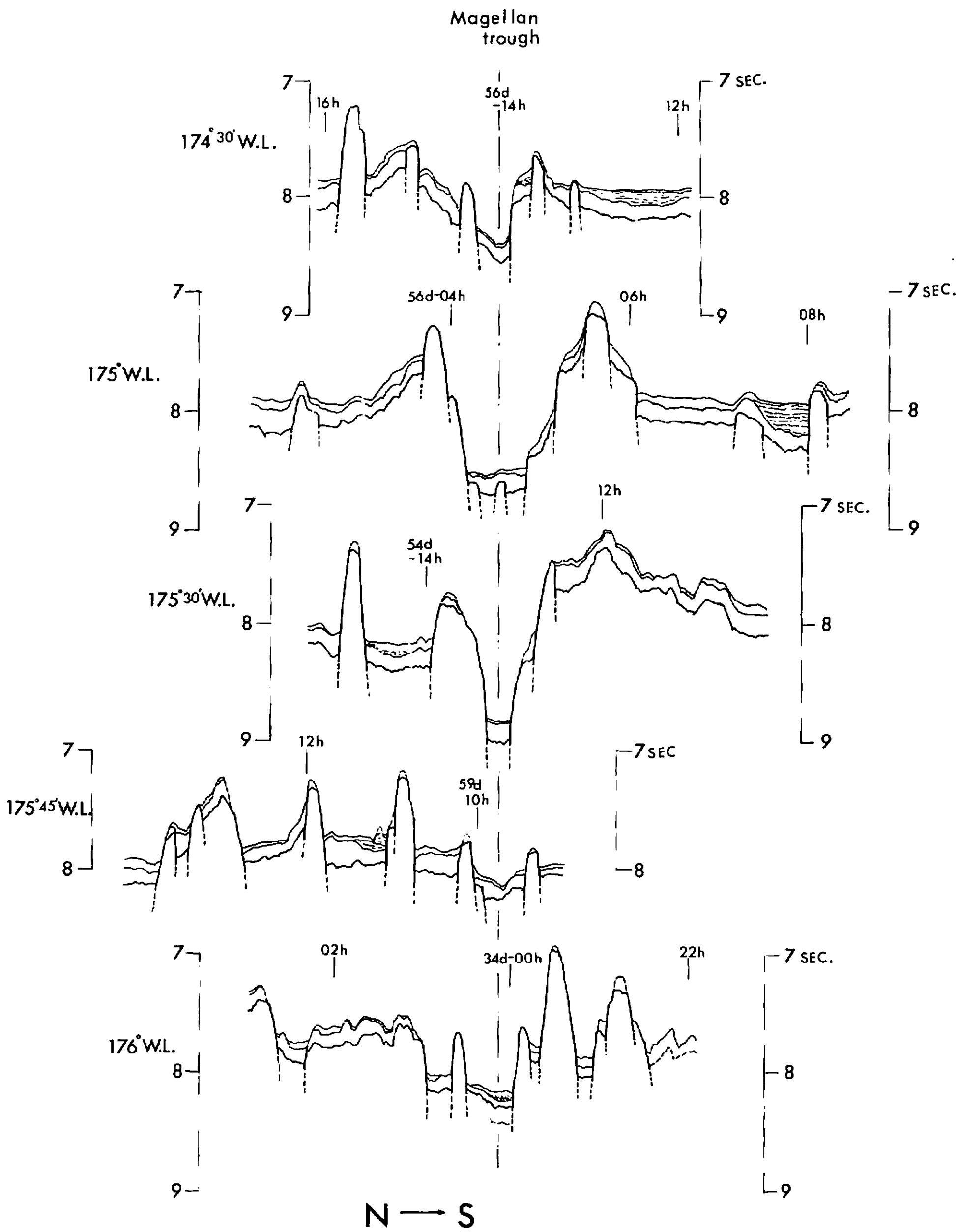
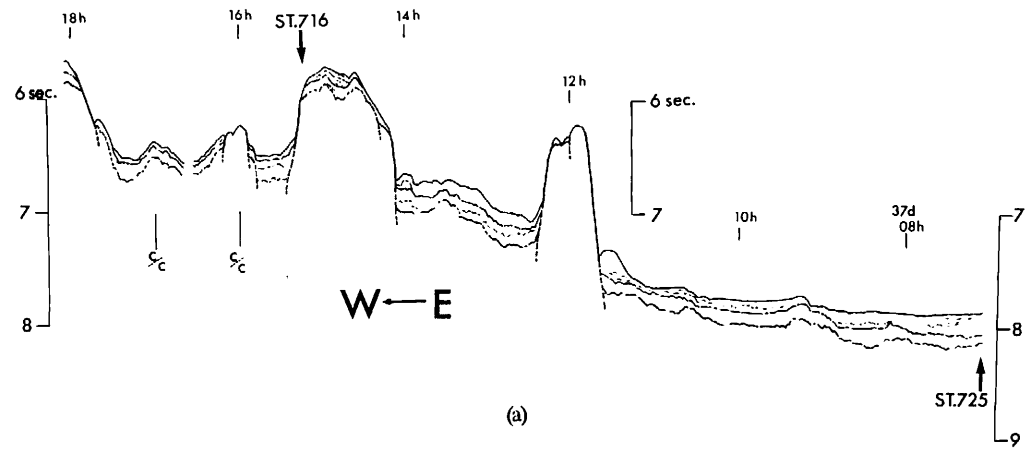
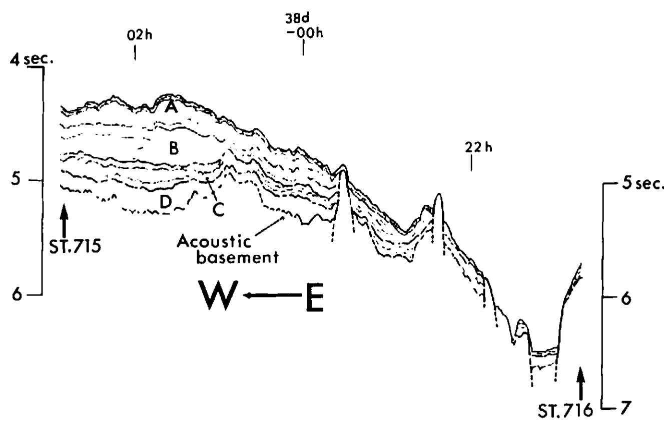



Fig. VI–7 Interpreted sections of seismic reflection records along the ship's tracks crossing the Magellan Trough. The depth is represented in seconds of two-way acoustic travel time.

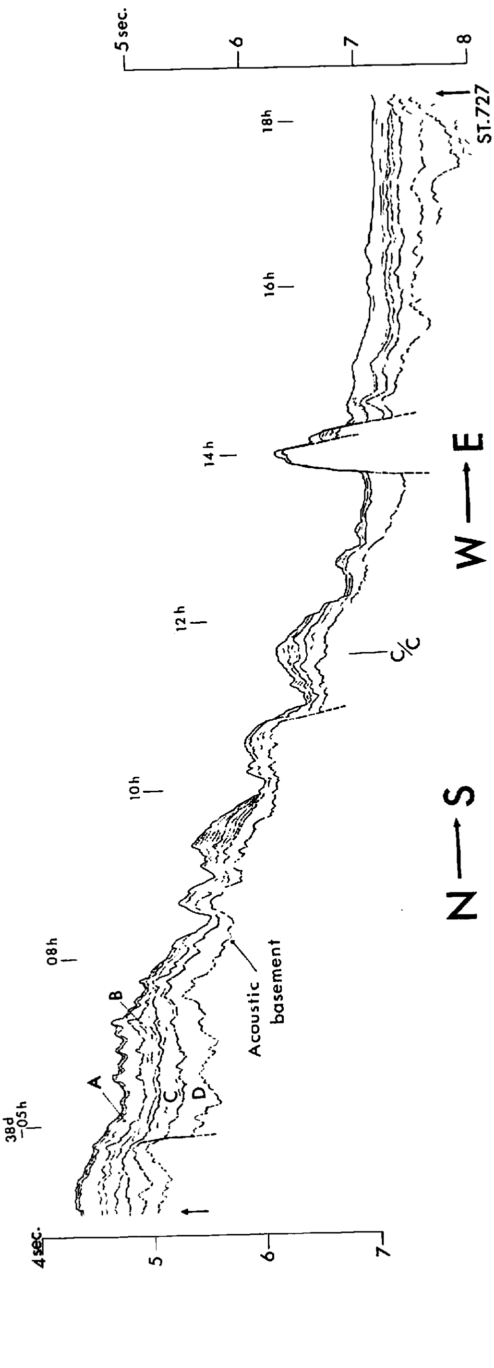
Fig. VI–8(a, b, and c) Interpreted sections of seismic reflection records along the ship's tracks traversing the Magellan Rise. The depth is presented in seconds of two-way acoustic travel time.




(a)



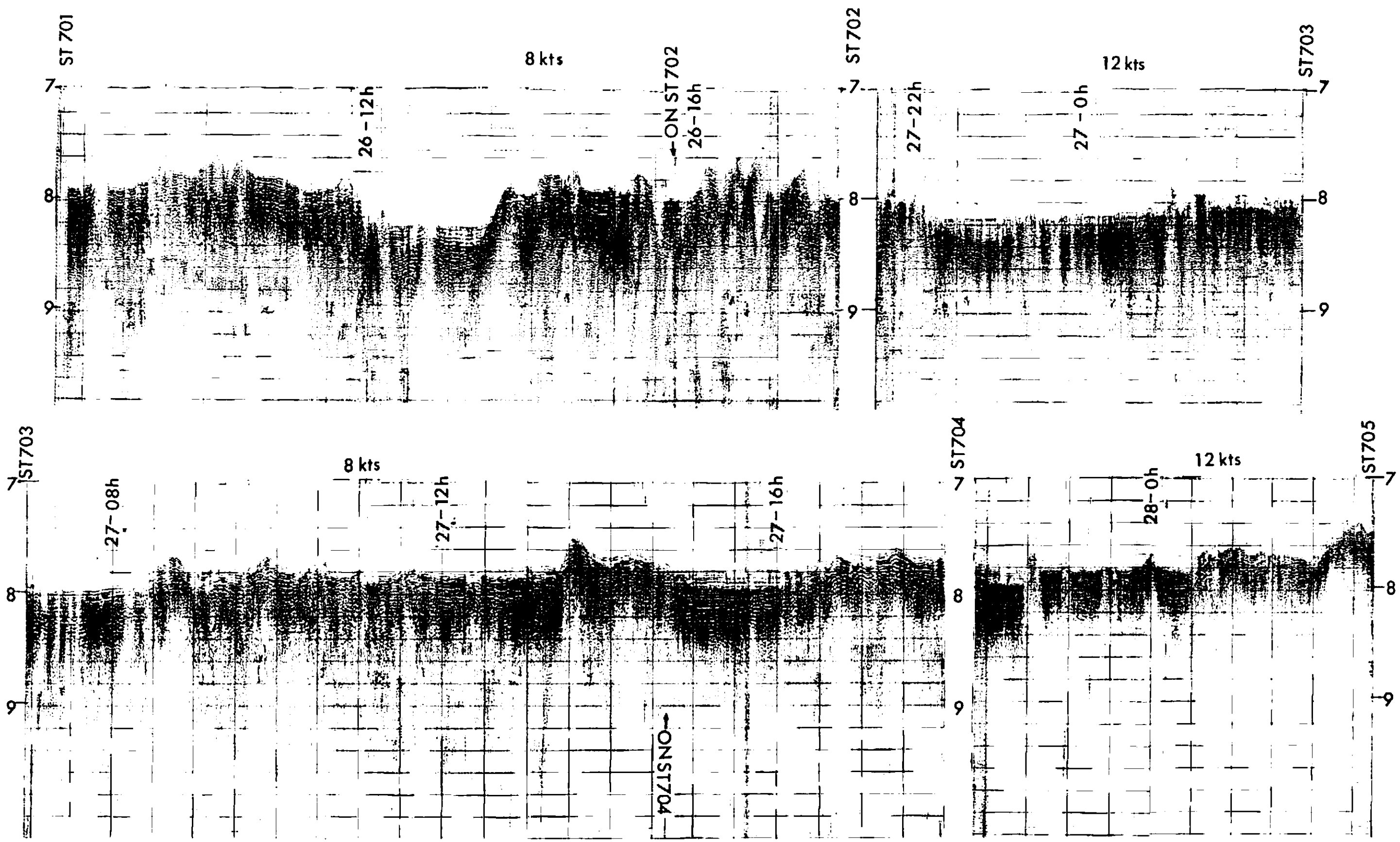

(b)



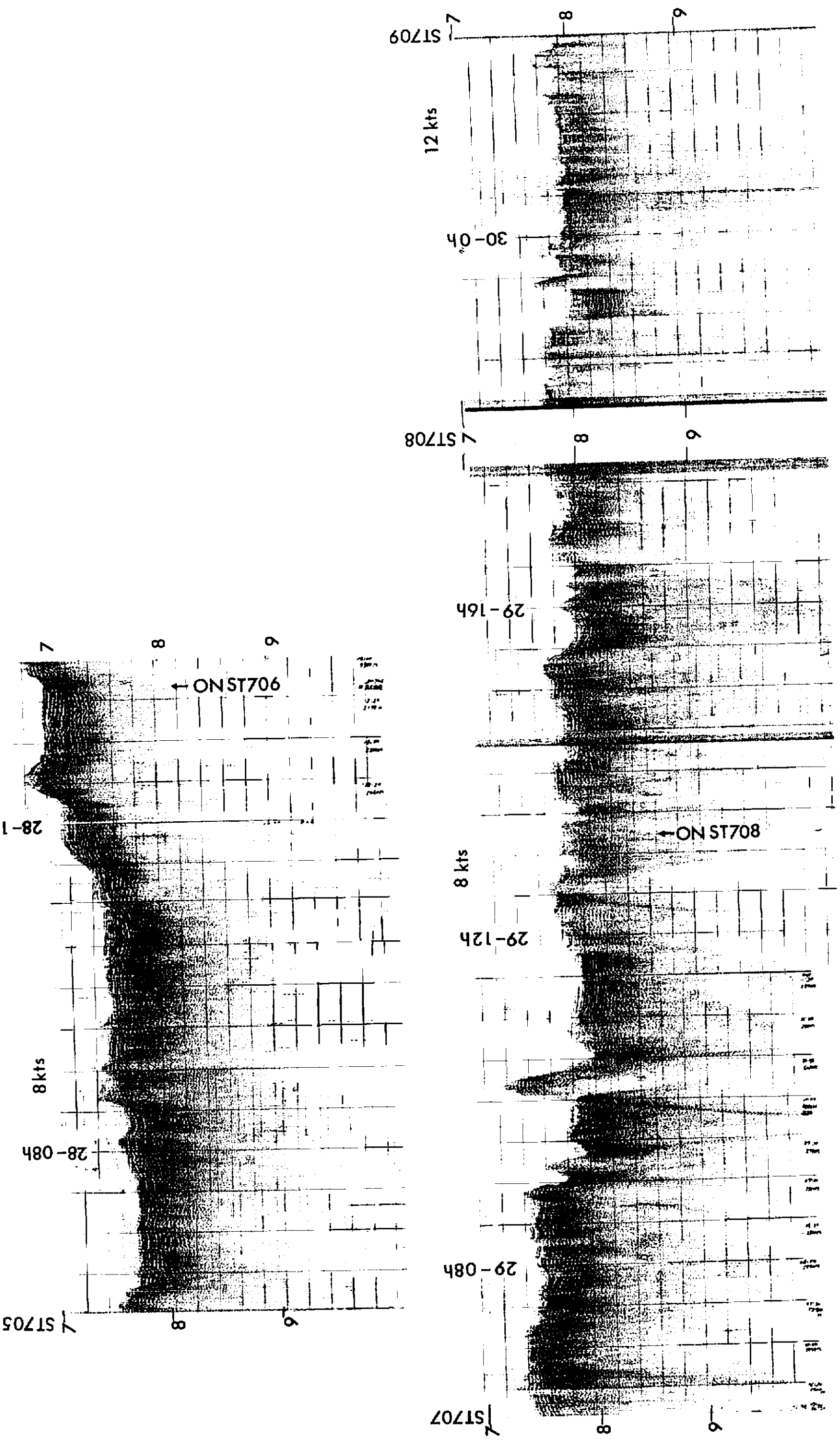
4 sec.
5
6
7
5 sec.
6
7
8
38d 05h
08h
10h
12h
14h
16h
18h
A
B
C
D
Acoustic basement
C/C
ST.727
N → S
W → E


(c)

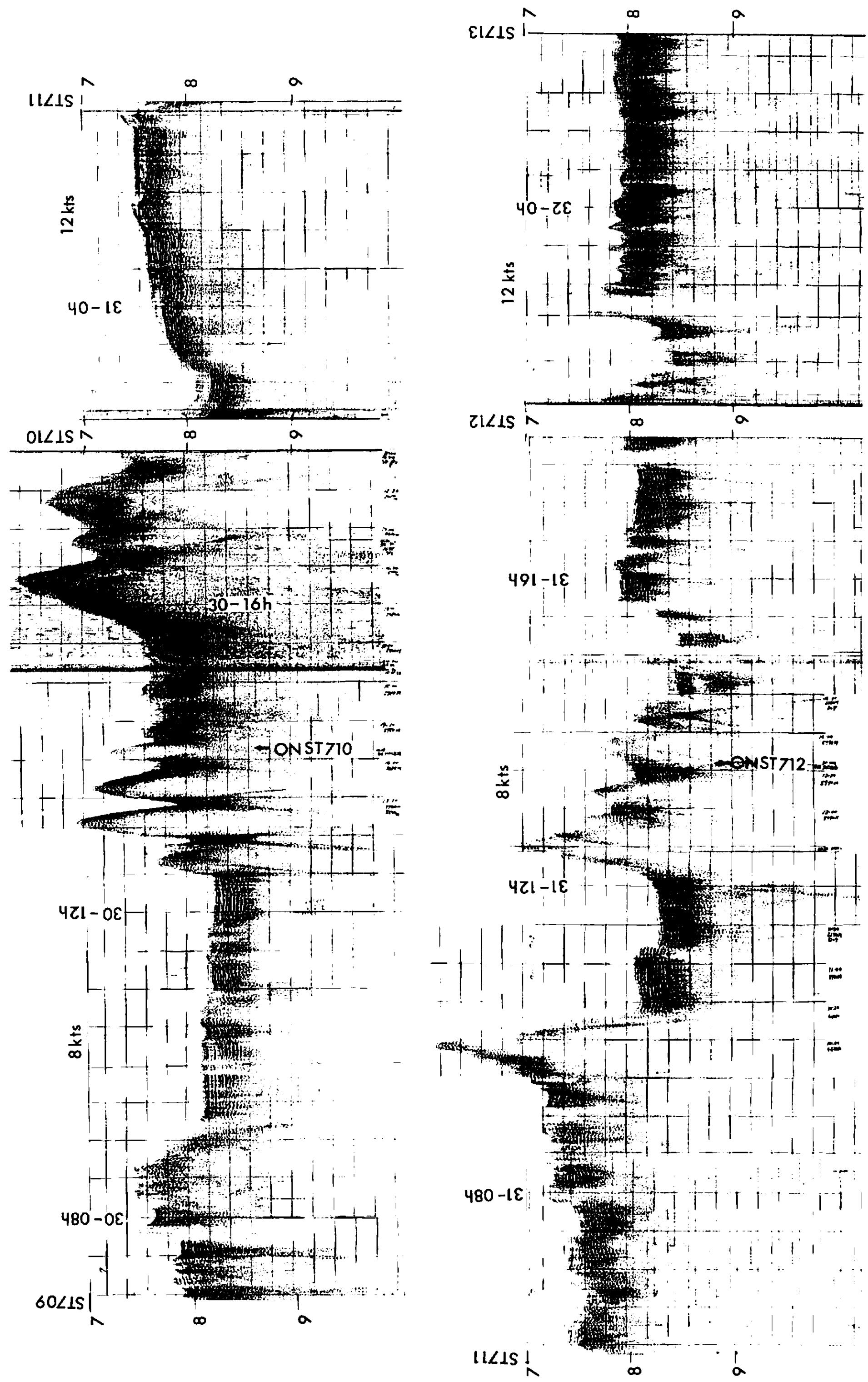
Fig. VI–9(1–12) All seismic reflection records in GH77–1 surveyed area. Vertical exaggerations are 1:23 (at 8 knots), 1:33 (at 10 knots), and 1:40 (at 12 knots).



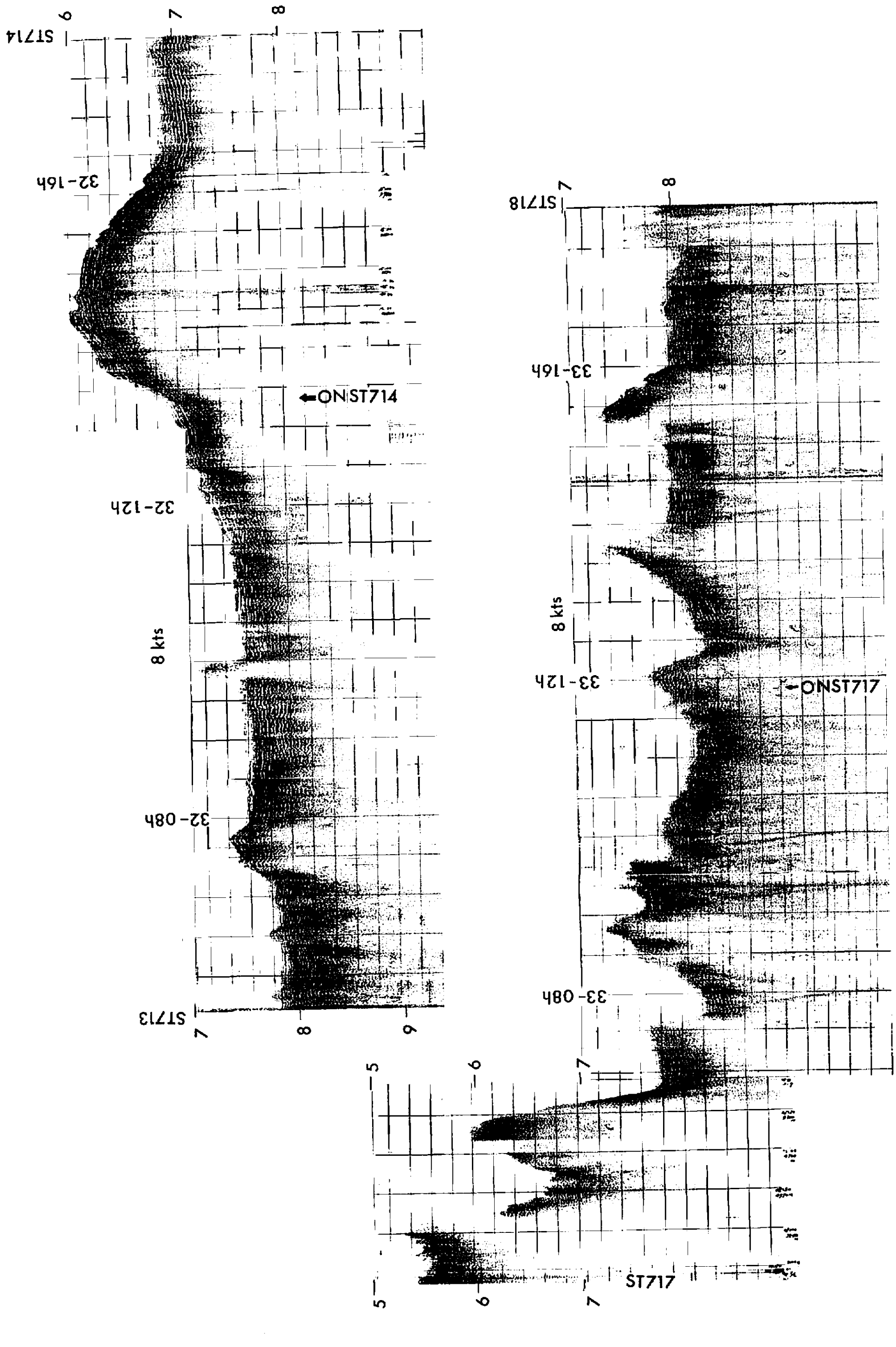

(1)


ST705
28-08h
8kts
28-12h
ON ST706
ST707
29-08h
29-12h
8 kts
ON ST708
29-16h
ST708
30-0h
12 kts
ST709

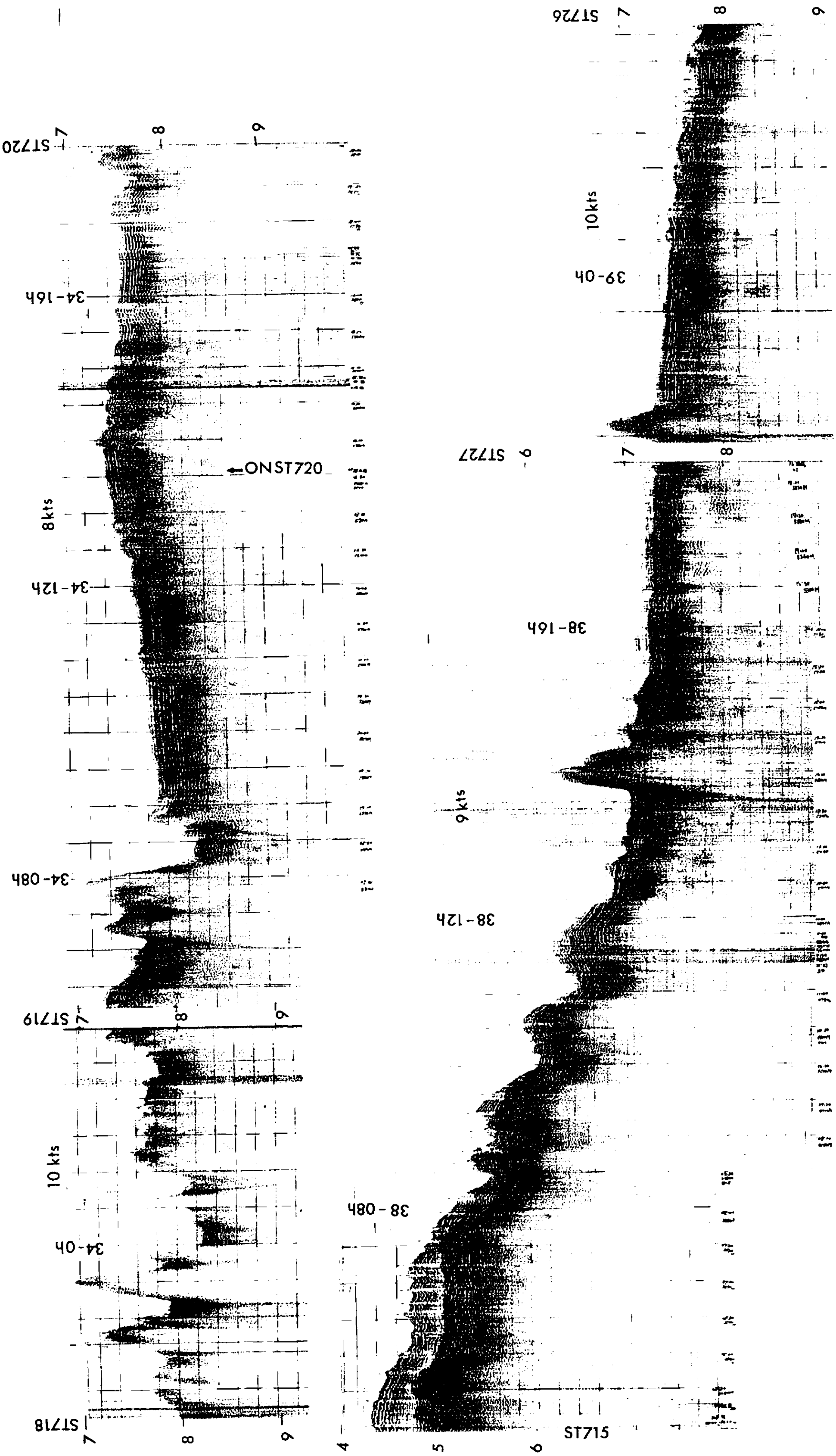
(2)


ST711
12 kts
31-0h
ST710
30-16h
ON ST710
30-12h
8 kts
30-08h
ST709
ST713
32-0h
12 kts
ST712
31-16h
ON ST712
8 kts
31-12h
31-08h
ST711
7
8
9

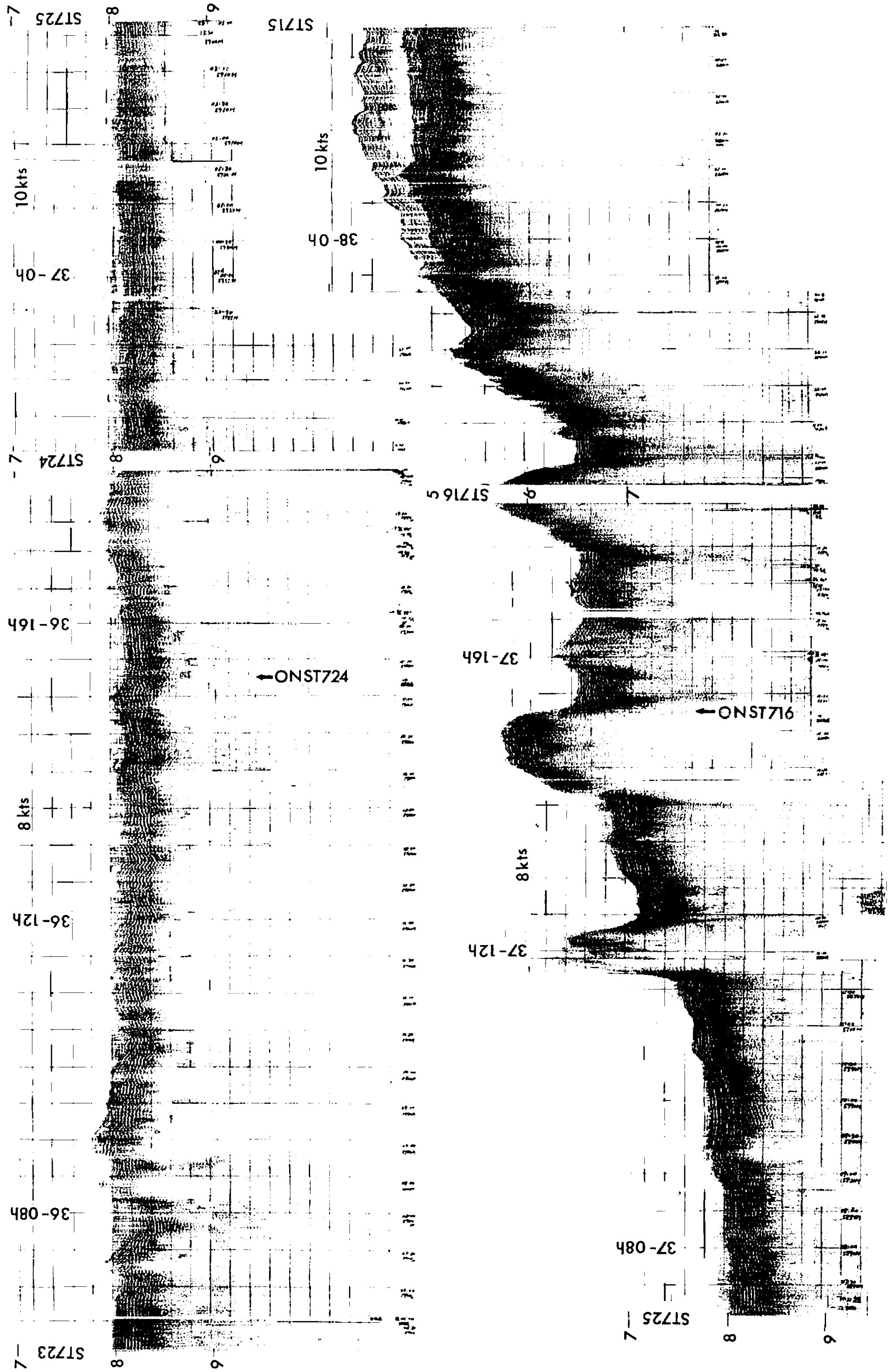
(3)


ST714
32-16h
ON ST714
32-12h
8 kts
32-08h
ST713
ST718
33-16h
33-12h
ON ST717
33-08h
ST717

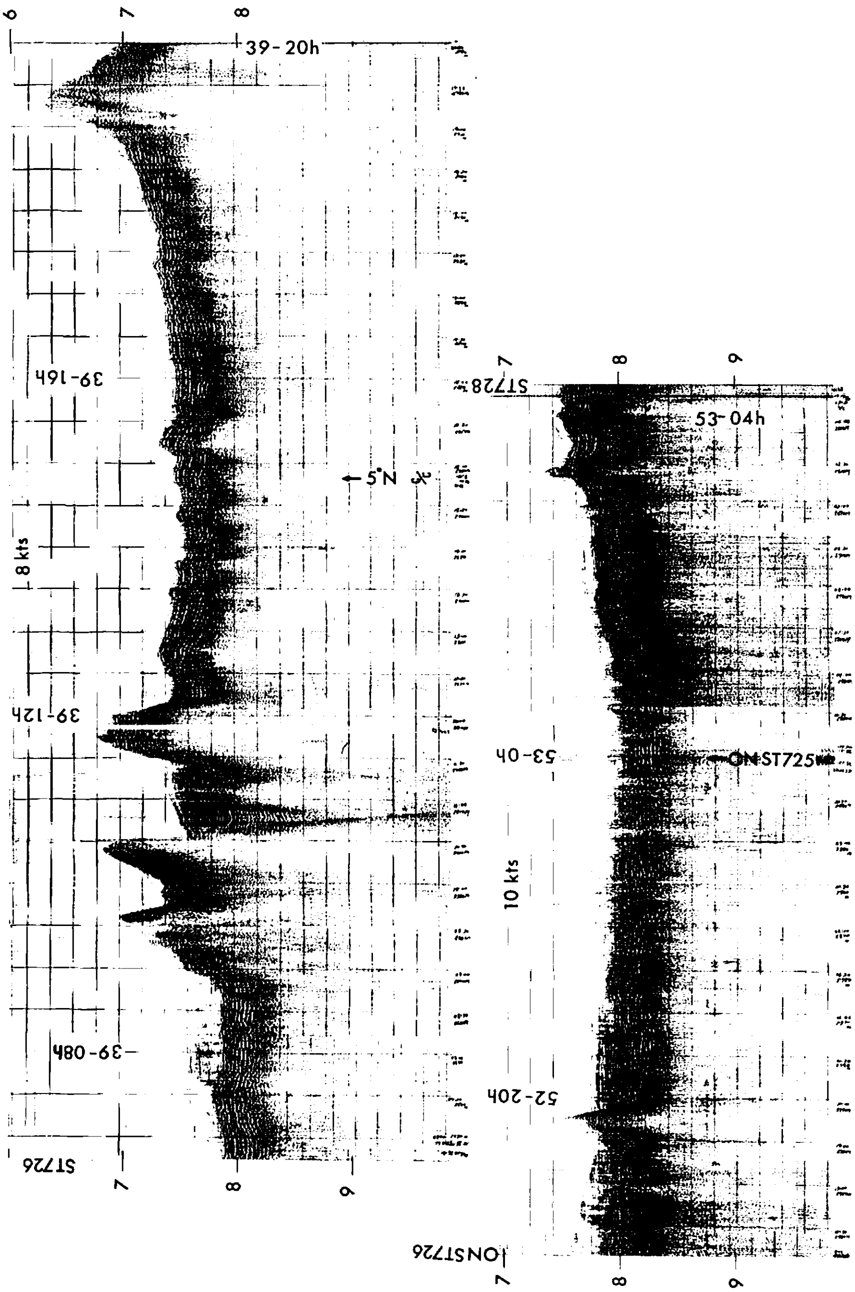
(4)


ST718
ST719
ST720
34-0h
34-08h
34-12h
34-16h
10 kts
8kts
ONST720
ST715
38-08h
38-12h
38-16h
9kts
ST727
39-0h
10kts
ST726

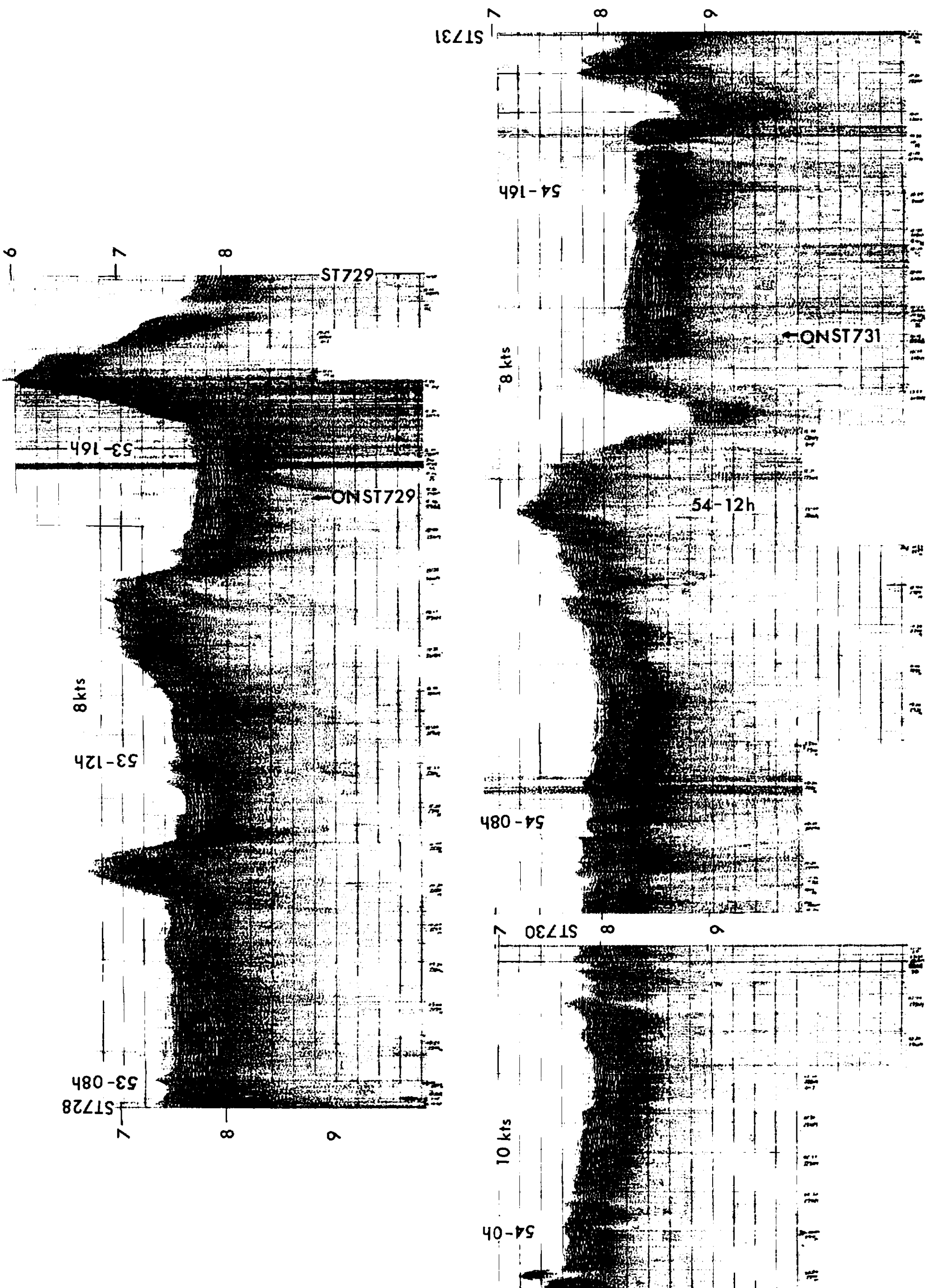
(5)


ST725
ST724
ST723
10kts
37-0h
36-16h
ONST724
8kts
36-12h
36-08h
ST715
38-0h
ST716
37-16h
ONST716
37-12h
37-08h
ST725

(9)

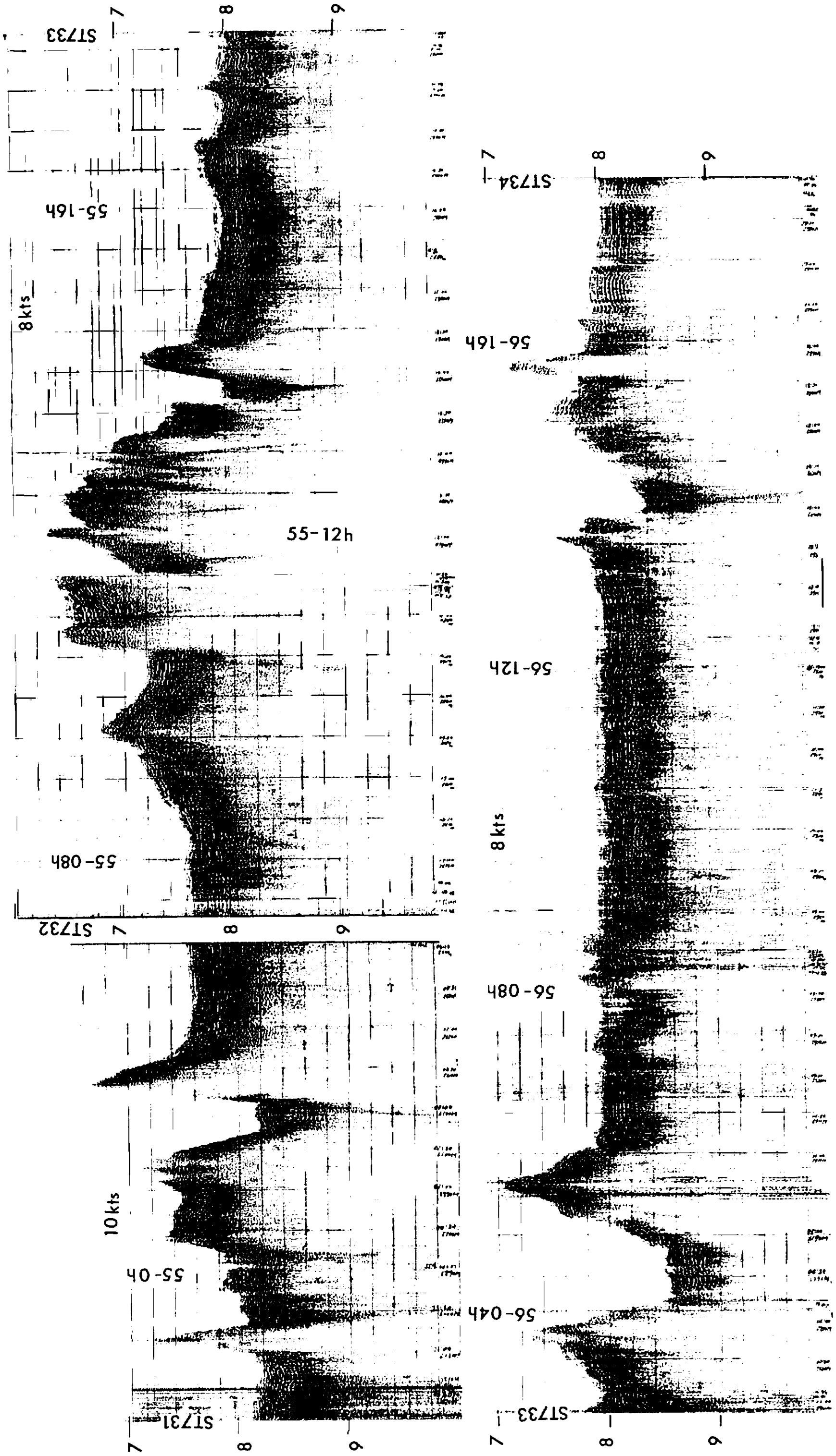

39-20h
39-16h
39-12h
39-08h
ST726
8 kts
5°N
ST728
53-04h
53-0h
ON ST725
10 kts
52-20h
ON ST726
6
7
8
9

(7)

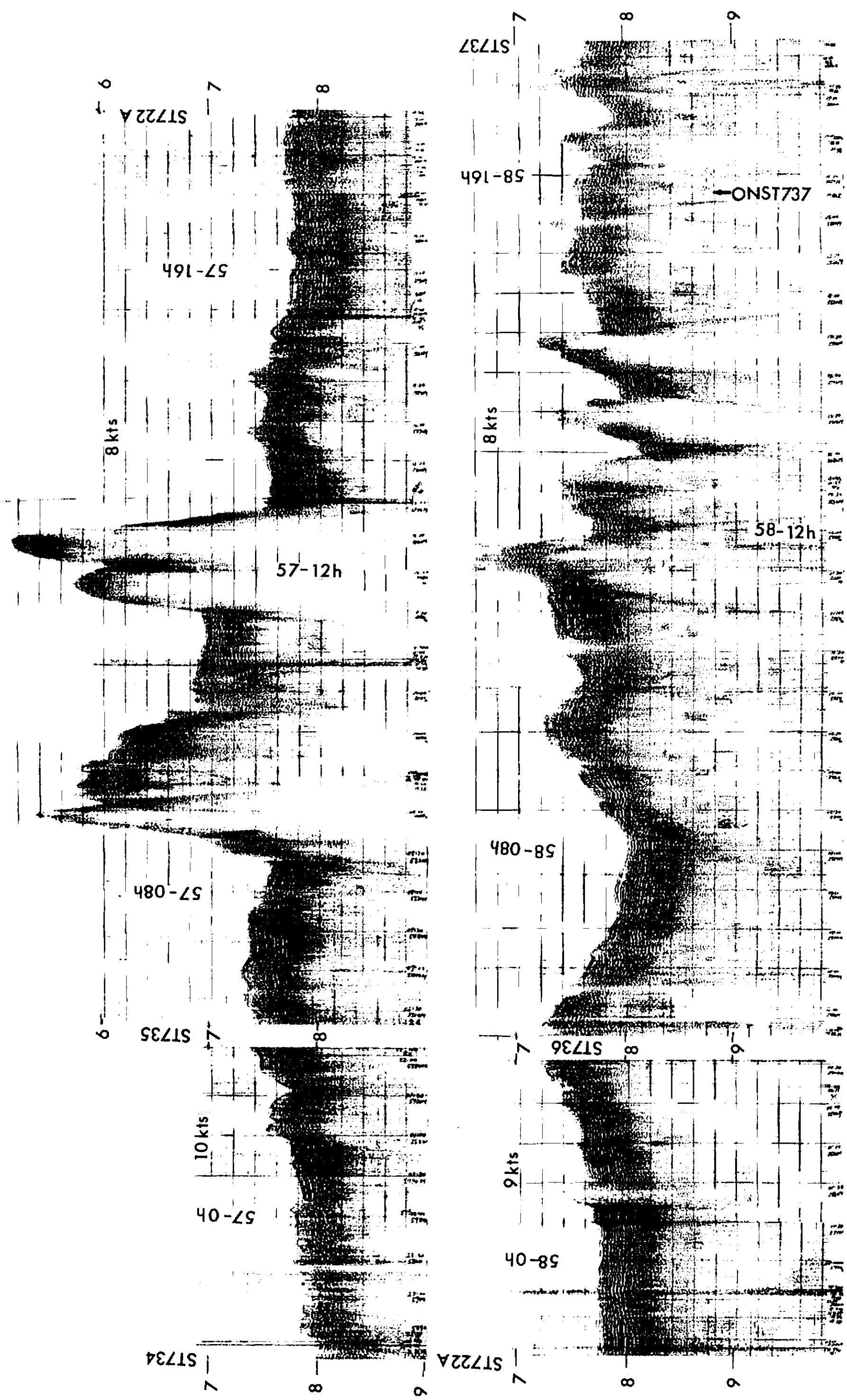


ST728
53-08h
53-12h
8kts
53-16h
ONST729
ST729
6
7
8
9
ST729
54-0h
10 kts
ST730
54-08h
54-12h
8 kts
ONST731
54-16h
ST731


(8)

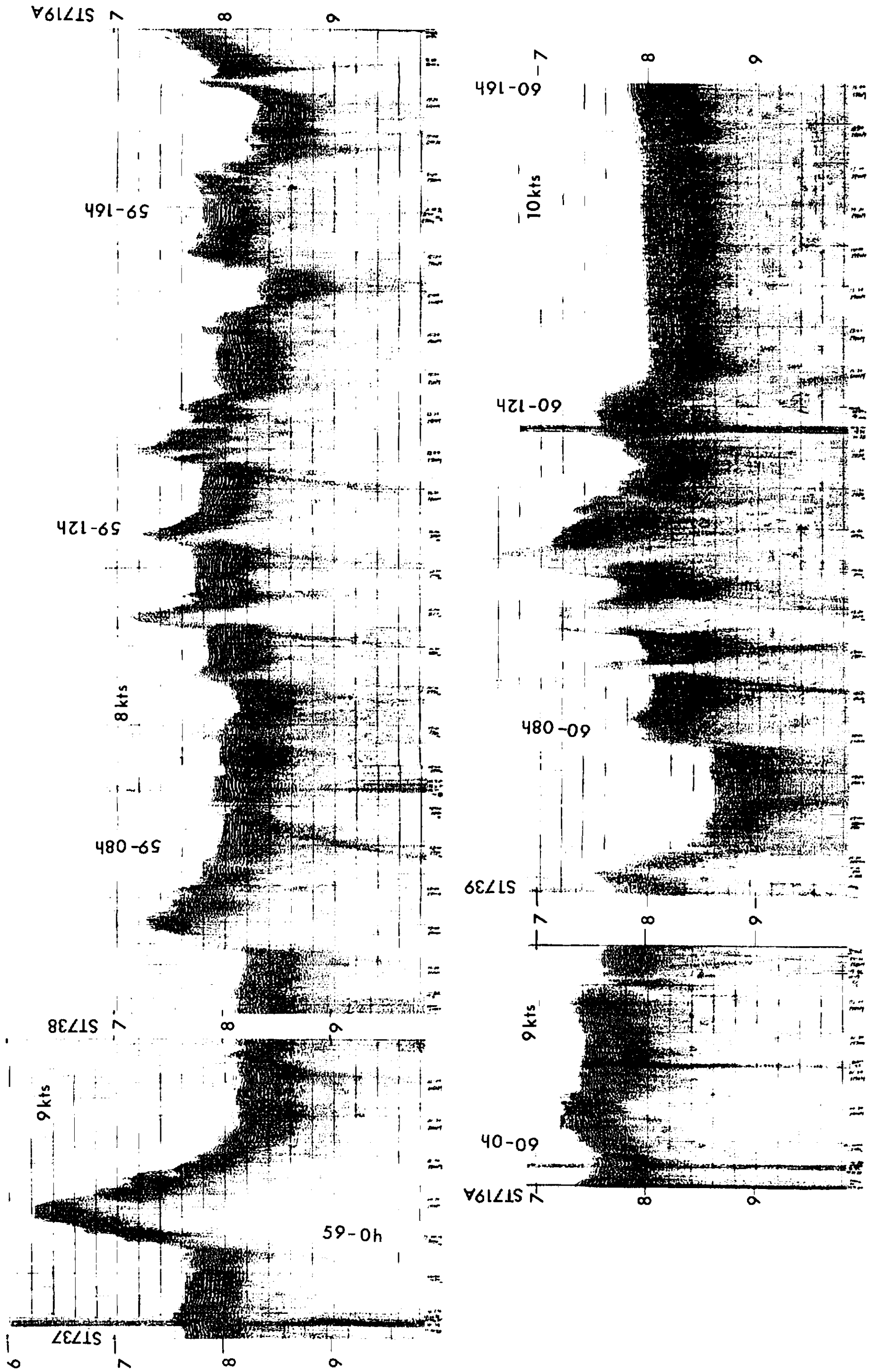

ST731
ST732
ST733
ST734
55-0h
10kts
55-08h
55-12h
55-16h
8kts
56-04h
56-08h
56-12h
56-16h
7
8
9

(9)

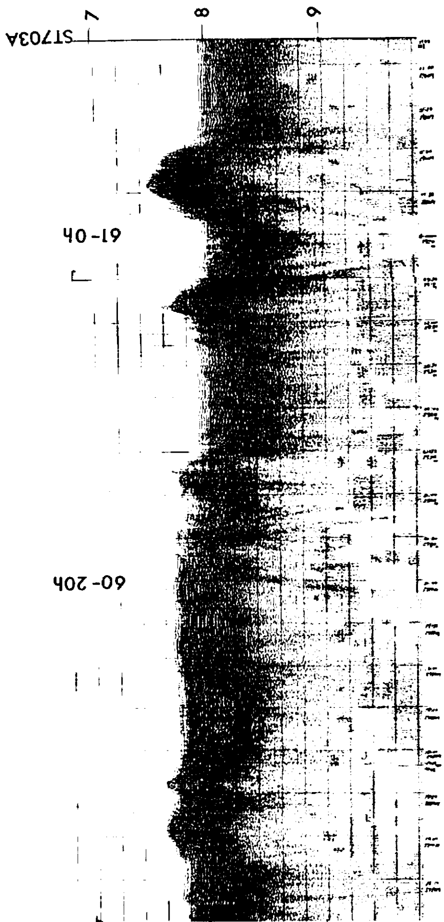


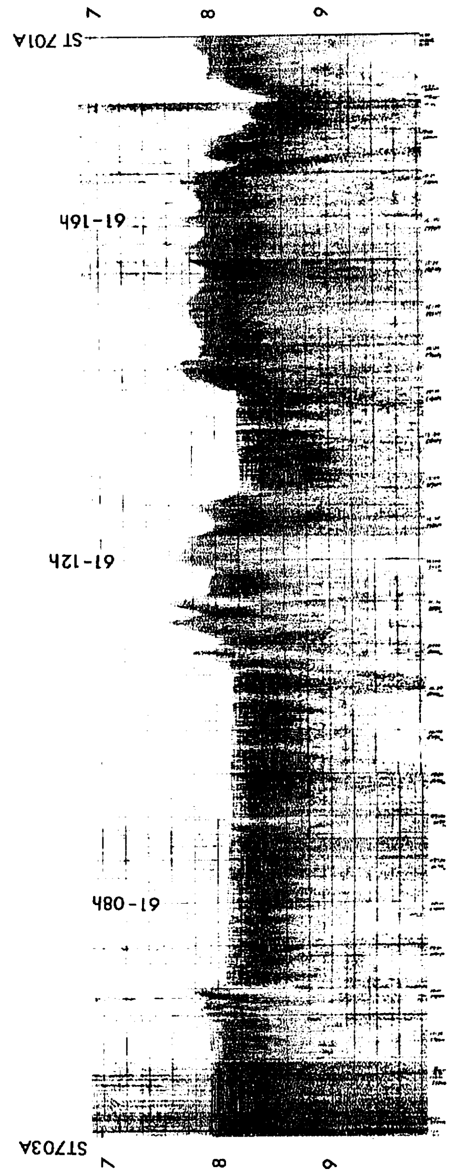
ST722A
57-16h
8kts
57-12h
57-08h
ST735
10kts
57-0h
ST734
ST737
58-16h
ONST737
8kts
58-12h
58-08h
ST736
9kts
58-0h
ST722A


(10)


ST737
9kts
59-0h
ST738
59-08h
8kts
59-12h
59-16h
ST719A
60-0h
9kts
ST739
60-08h
60-12h
10kts
60-16h

(11)


ST703A
7
8
9
61-0h
60-20h
60-16h


ST 701A
7
8
9
61-16h
61-12h
61-08h
ST703A

(12)

Table VI–1 Correlations of the acoustic stratigraphy at the Magellan Rise area according to the data of GH77–1 cruise to the lithological stratigraphy established by the drilling data of the DSDP Site 167.

| | Lithology | Thickness and average velocity | | Acoustic stratigraphy in GH77–1 cruise |
|---|---|---|---|---|
| **DSDP Site 167** | | (m) | (km/sec) | |
| Position | Quaternary-Miocene | 220 | 1.82 | A |
| Lat. 07°04.1′N | Nanno-foram ooze | | | |
| Lon. 176°49.5′W | Oligocene-Middle Eocene | 380 | 2.11 | B |
| Water depth | Nanno-foram ooze | | | |
| 3,176 m | and chalk | | | |
| | Middle Eocene-Late Cretaceous Cherty chalk | 227 | 2.38 | C |
| | Late Cretaceous (Santonian-Coniacian) to Earliest Cretaceous-Late Jurassic Cherty limestone | 345 | 3.26 | D |
| | Late Cretaceous or Latest Jurassic Basalt | | 3.86 | |

## References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