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REPORT ON STUDIES OF SEISMIC PROFILE OF THE ZAIRE DEEP-SEA FAN
- ATLANTIC OCEAN

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1. SUMMARY

One high resolution seismic reflection recording, collected during a cruise on board 'Tyro' in 1980 by NIOZ in the Zaire deep-sea fan was studied by the author. The purpose of the work is to find out the bathymetry, topographic features, and various reflectors along with stratigraphic units. The profile falls in the area off west African coast between about Long. $7^{\circ} 30'$ to $11^{\circ} 15'E$ and Lat. $4^{\circ} 30'$ and $6^{\circ} 45'S$. Channels, fossil channels and levees are easily recognisable in the profile. On the continental slope, salt diapiric structures are present. At shallower depth (about 1200 m), the area is cut by a submarine canyon of about 900 m deep. The maximum and minimum water depth revealed from the profile is 3840 m and 810 m respectively. The depth of the water increases toward western direction i.e. away from the African coast.

2. INTRODUCTION

The Zaire, or Congo deep-sea fan, which is one of the world's largest fans, lies in the Angola basin, the deepest depression of the eastern South Atlantic Ocean. This is a restricted basin bounded by the Walvis Ridge to the south, the Mid Atlantic Ridge to the west, and Guinea Ridge to the north (Fig. 1). The fan extends westward from a canyon at the foot of the continental slope at about 3000 m water depth. The fan is built up by a wide system of channels and levees (van Weering et al., 1984), fed through a 300 km long canyon of which the upper 30 km is incised in the river mouth. The continental shelf is about 100 km wide. The Zaire River which

is the second largest river in the world with an average discharge of $1.45 \times 10^{12} \text{ m}^3$ per year has a drainage basin of $3.7 \times 10^6 \text{ km}^2$ (Peters, 1978). This river is the main carrier of terrigenous sediments to the eastern South Atlantic Ocean, together with the river Niger. The sediments of the fan are still observed at 5600 m depth, more than 1000 km away from the African coast (Jansen et al., 1984a). The relatively rapid sedimentation of the deep-sea fan may provide a higher resolution of the various regional and ocean-wide marine signals as well as terrigenous signals. Four sediment types, reflecting different depositional mechanisms, are recognised (van Weering et al., 1984) in cores from the deep-sea fan: 1) fine grained turbidite mud, 2) pelagic and hemipelagic biogenic muds, 3) homogeneous uniform muds, and 4) debris flow deposits.

As a research programme, two expeditions were undertaken by Netherlands Institute for Sea Research in 1978 and 1980 on board the RV "Tyro", to study the sediment transport processes and sedimentation pattern of the Zaire deep-sea fan. During the cruise many high resolutions seismic reflection profiles were recorded, using an array of five airguns (40-200 HZ).

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3. PREVIOUS STUDIES

The maximum age of the Zaire deep-sea fan is determined by the initial opening of the South Atlantic, where the oldest oceanic crust, identified near South Africa, is of Early Cretaceous age, or 130 million years old (Larson and Ladd, 1973; Rabinowitz 1976; Rabinowitz and LaBreque, 1979). Middle Aptian salt accumulations resulted in extensive zones of diapiric structures along the continental margins of Angola, Zaire, Congo, and Gabon in the east, and Brazil in the west.

Studies of multichannel seismic reflection profilings reveal the presence of following seismic reflectors in the fan (Jansen, 1984):

- Middle Miocene
- Late Eocene-Oligocene
- Maastrichtian-Early Palaeocene
- Cenomanian
- Aptian-Albian
- top basalt

Ocean-wide intervals with common hiatuses are well-known to occur in the Cenomanian, at the Cretaceous-Tertiary boundary, in the Late Eocene-Oligocene and in the Late Miocene periods (Moore et al., 1978). The latter three intervals are visible as regression levels at the Congo-Gabon shelf (Jansen et al., 1984b). The greatest interval of deposition (40% of the total)

dates to the Albian (Early Cretaceous; Jansen, 1984), the first period after the opening of the ocean. The greatest part, or 70%, of sediments in the Zaire fan area were already supplied before the Tertiary boundary, i.e. 66 million years ago.

4. PRESENT STUDIES AND DISCUSSIONS

I studied one of the seismic reflection profiles (Tyro 1980; 11/10-9.30 h to 14/10-8.35 h; Fig. 2) to determine the depth and to find out different reflectors along with stratigraphic units and features. While carrying out the survey, the speed of the ship was restricted to 7 knots. This profile falls in the area between about Long. 7° 30' to 11° 15'E and Lat. 4° 30' and 6° 45' S.

(a) Bathymetry.-On the basis of course direction of the cruise, the profile has been divided into seven lines (Fig. 2) marked by date and time of the cruise as follows:

Line	Date & Time	Course Direction
AB	11/10-9.33 h to 12/10- 8.30h	149° to 154°
BC	12/10-9.00 h to 12/10-10.27h	272°
CD	12/10-10.27 h to 12/10-24.00h	285° to 297°
DE	12/10-24.00 h to 13/10- 1.10h	31°
EF	13/10- 1.00 h to 13/10- 8.30h	90°
FG	13/10-10.30 h to 14/10- 1.00h	90° to 100°
GH	14/10- 1.00 h to 14/10- 8.35h	21° to 27°

The water depth of the sea bottom along the lines has been measured on the basis of two way travel time i. e.

$$\text{Depth} = \frac{\text{Two way travel time(s)} \times \text{compressional-wave velocity in water (1500m/s)}}{2}$$

To find out topographical features on the sea floor, water depth was plotted for each line (Fig. 3). The maximum and minimum water depth are about 3840 m (line DE) and 810 m (line GA) respectively. It is noticed that the water depth increases toward western direction i.e. away from African coast. The channels, levees, canyon and salt diapirs are clearly identified from these figures.

The lines AB and CD show the presence of a few shallower channels and line EF has few deeper channels. The levees, showing a more or less smooth bathymetric pattern, are prominent on line CD. On line FG i.e. in the inner continental margin, the sea bottom sediments were raised locally due to buried salt diapir beneath the sediments. These raised features are marked by gradual decrease of water depth followed by gradual increase of water depth. Line GH shows a cross section of a submarine canyon on the continental slope. The bathymetric data give the apparent depth of this canyon section as about 900 m.

(b) Seismic units.-Three major reflectors were identified in the profile. A correlation of these reflectors with multichannel seismic profiles studied by Jansen (1984) at the location (Fig. 4: reflectors A,B,C,) indicates that the

geological boundary of these reflectors may be M. Miocene (A), L. Eocene-Oligocene(B), 3)Maastrichtian-E. Palaeocene (C). At this location the total thickness of the sediments above the C reflector is about 0.7 km. Here the uppermost seismic unit may represent turbidites which probably continue into the lower unit toward southeastern direction. The average compressional wave velocities may be summarised as follows (Jansen, 1984):

Unit 1: 1.65 km/s

----- M. Miocene .

Unit 2: 1.8-1.9 km/s

----- L. Eocene-Oligocene

Unit 3: 2.0-2.1 km/s

----- Maastrichtian-E. Palaeocene

The studies of the profile reveal that there are channels (Fig. 6) and levees. There also exist fossil channels. Turbidites are mostly concentrated in the upper seismic unit. These general observations are made after correlating with the data of this area. The presence of fossil channels and levees are clear from Figs. 5 and 6. A general view of turbidites may be seen from Fig. 4. Figs 7 shows the typical salt diapiric structure which is common on the continental margin off Angola-Congo-Gabon. Actually diapiric domes consist of masses of low-density salt, mobilised after being deeply buried by sediments. They rise through overlying denser sediments. A substantial thickness variation in the overlying Tertiary and younger sediments is required to initiate growth of salt dome. It is seen on the profile that sediments above the diapiric

canyon is clearly identified from the profile (Fig. 8). This is a steep-walled valley with V-shaped cross section. At both flanks of the canyon, there exists evidence of submarine slumpings, which were marked by the lowest reflectors.

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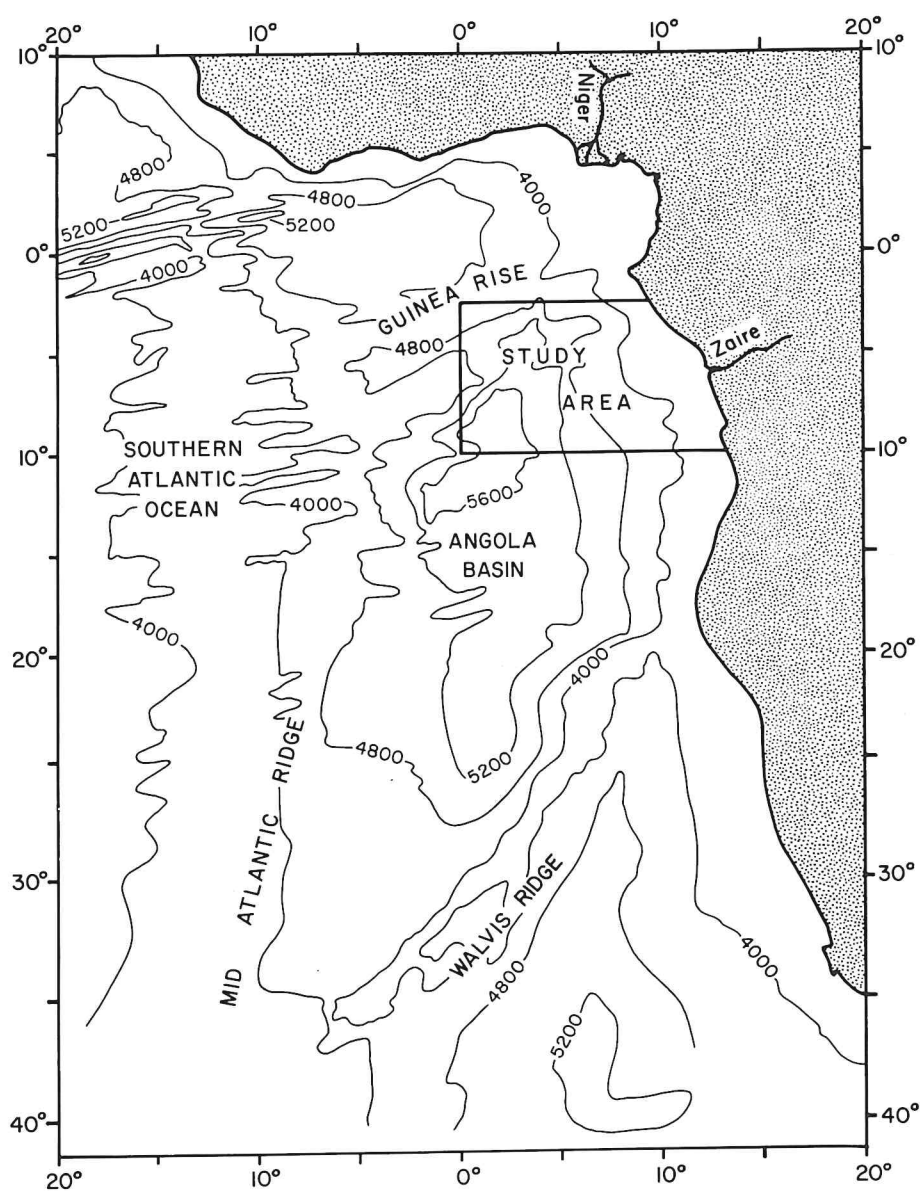


Fig. 1. Map showing the main topographical features of the Angola Basin, Atlantic Ocean.

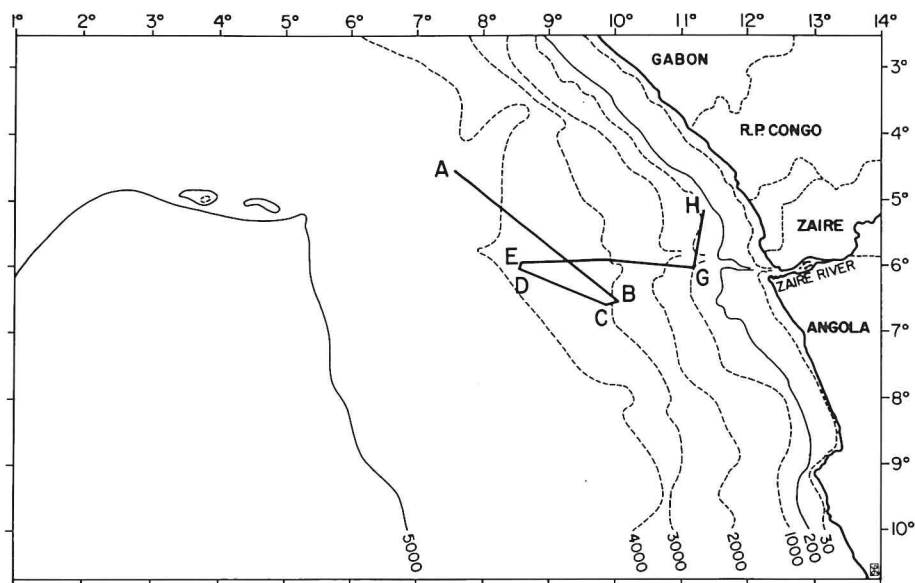


Fig. 2. Map showing cruise line of seismic survey, described in this report and recorded during the cruise on "Tyro" in 1980 in the Zaire deep-sea fan.

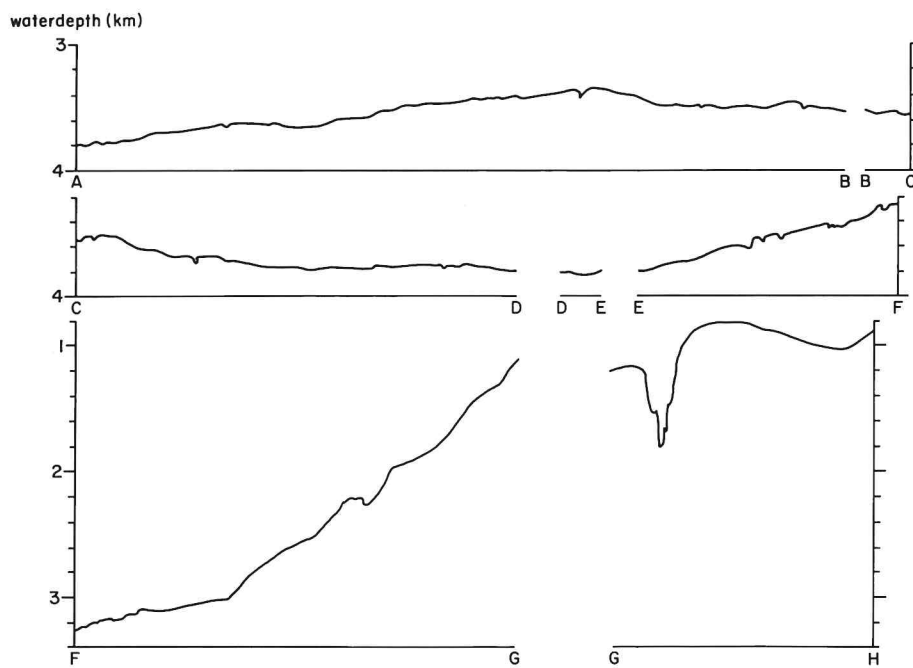


Fig. 3. Sea bottom topography along the cruise line of the seismic profile. For location see Fig. 2.

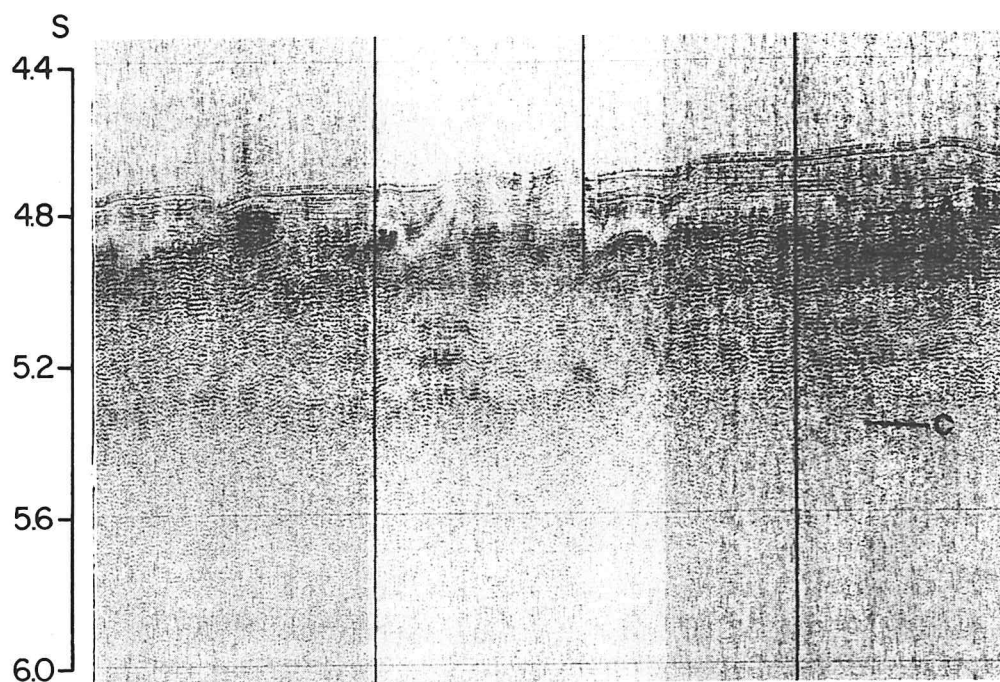


Fig. 4. Part of seismic reflection profile along cruise line AB (see Fig. 2). Two-way travel time in seconds.

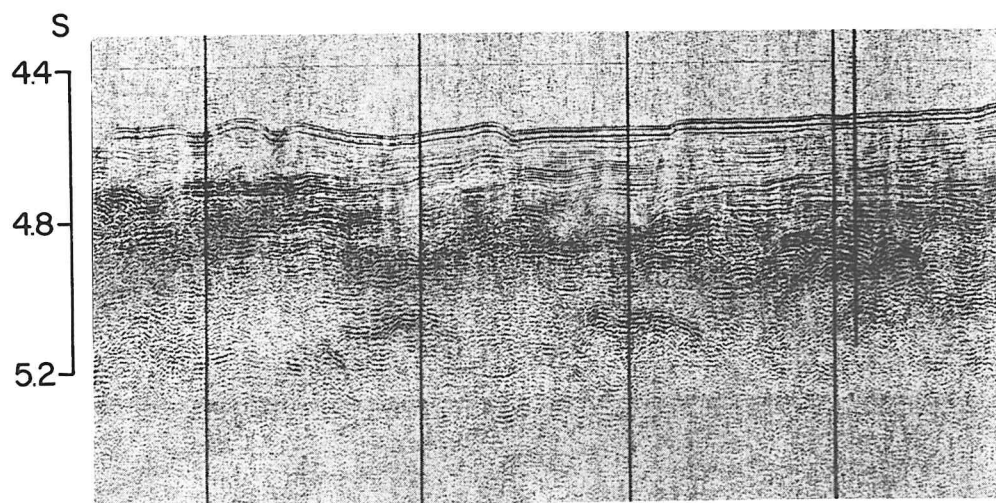


Fig. 5. Part of seismic reflection profile along cruise line AB (see Fig. 2). Two-way travel time in seconds.

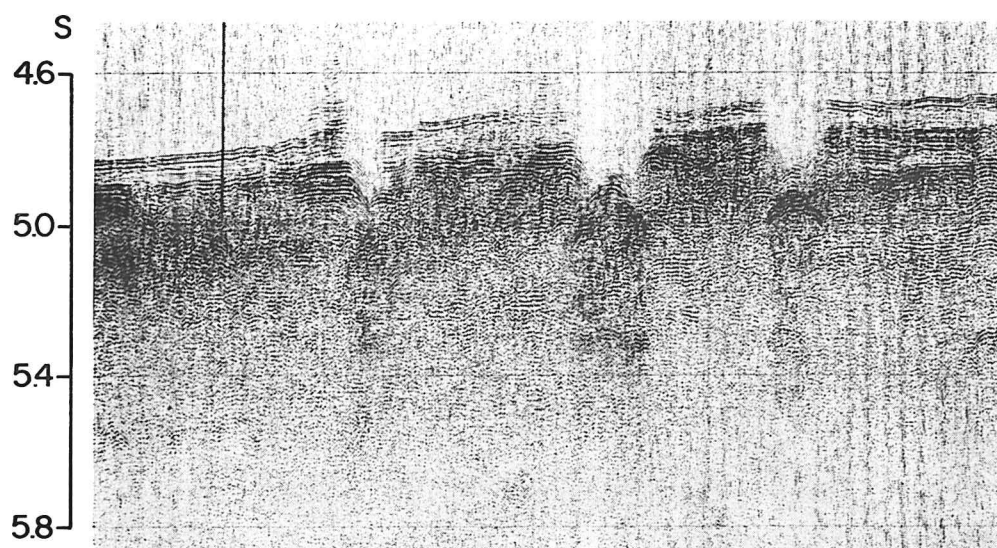


Fig. 6. Part of seismic reflection profile along cruise line EF (see Fig. 2). Two-way travel time in seconds.

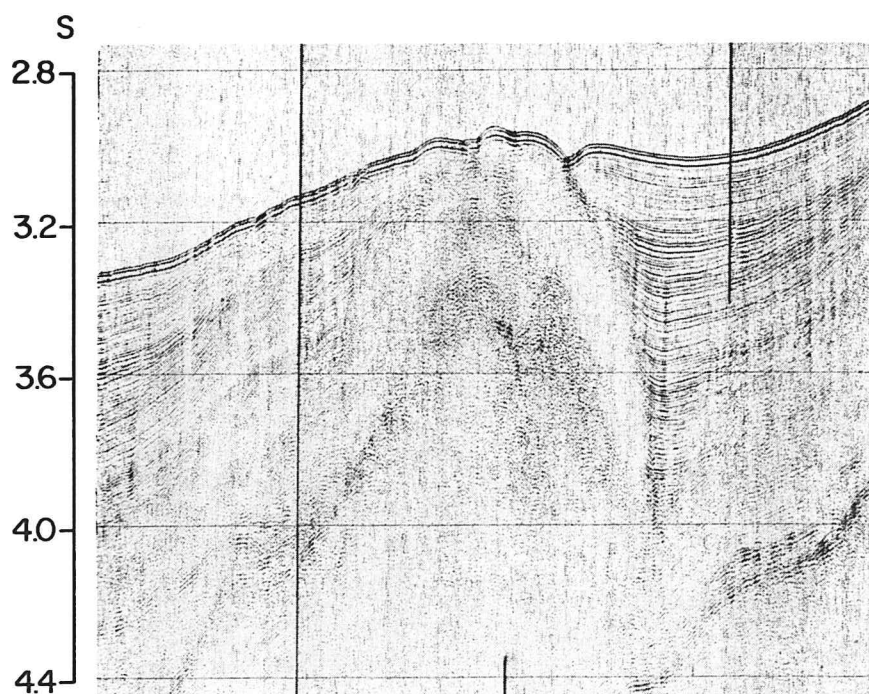


Fig. 7. Part of seismic reflection profile along cruise line FG (see Fig. 2). Two-way travel time in seconds.

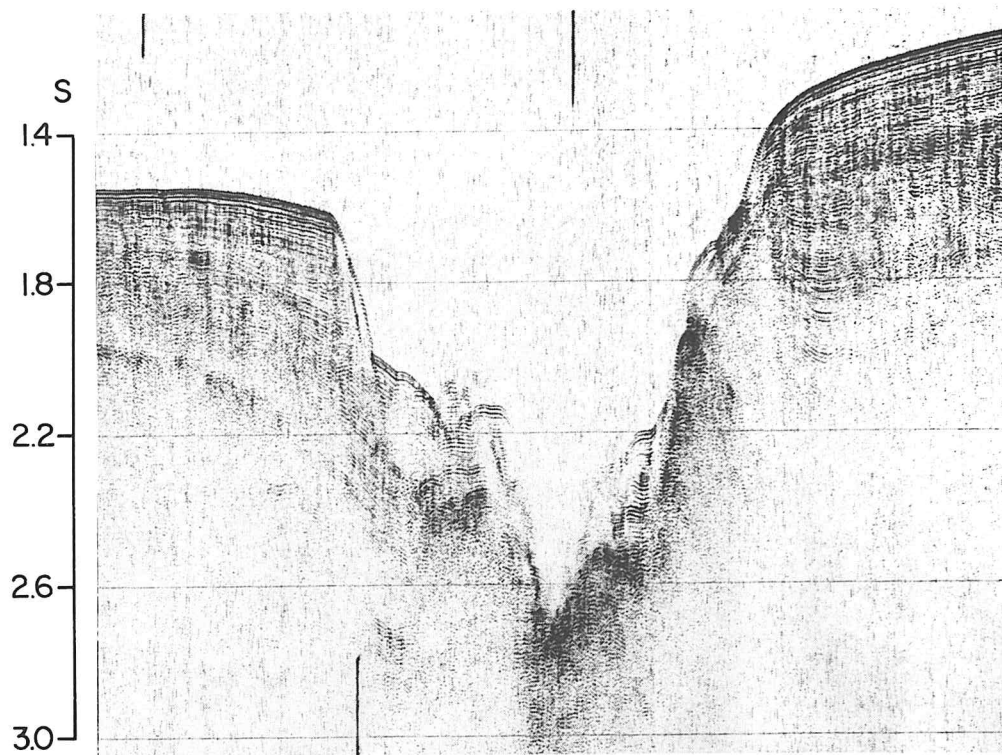


Fig. 8. Part of seismic reflection profile along cruise line GH (see Fig. 2). Two-way travel time in seconds.

