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PRELIMINARY RESULTS OF SEISMIC SURVEY IN THE CENTRAL BRANSFIELD STRAIT, ANTARCTIC PENINSULA

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Abstract: Multichannel seismic profiles in the central Bransfield Strait show structural variation mainly controlled by transform faults across the strait. Near King George Island, large displacement of the spreading axis, discontinuity and different style of the faults, intense deformation of the basement, and abrupt change in the morphology of the basin are indicative of the presence of a large fault zone. On the basis of the fault map, the central Bransfield Strait can be divided into three segments. Transform faults, including the large fault zone, form the boundaries of segments. The basinward-dipping reflectors concentrated in the central segment suggest that initial rifting activity was relatively strong in this region.

key words: the central Bransfield Strait, multichannel seismic survey, transform fault, basinward-dipping reflectors

1. Introduction

Bransfield Strait has been interpreted as being formed by interarc extension that separates the South Shetland Islands from the Antarctic Peninsula (BARKER, 1982; GAMBÔA and MALDONADO, 1990). The age of formation of Bransfield Strait is rather unclear. Recent volcanic activity, a well-defined spreading ridge along the axis of the Bransfield Strait and high-angle normal faults along the southeastern margin of the South Shetland Islands indicate that extension is continuing presently in Bransfield Strait (*e.g.* GONZÁLEZ-FERRÁN, 1985; JEFFERS and ANDERSON, 1990). The physiographic setting of the strait behind the South Shetland Trench, has led many scientists to believe that Bransfield Strait is a subduction-related backarc basin (*e.g.* BARKER, 1982; BARKER and DALZIEL, 1983; LARTER, 1991). However, since there is no direct evidence, such as seismicity, for continuing of subduction along the South Shetland Trench, the origin of the strait is still controversial (*e.g.* GONZÁLEZ-FERRÁN, 1985; TOKARSKI, 1987; KIM and JIN, 1994).

Bransfield Basin is segmented longitudinally into three subbasins, western, central, and eastern subbasins that show different structure styles in width and depth (JEFFERS and ANDERS, 1990). The western basin south and west of Livingston and Deception Islands is relatively shallow and irregularly shaped. The central basin over 2000 m deep is located along Robert, Nelson, and King George Islands. Bridgeman Island is the northeastern limit of the central basin. The eastern basin northeast of the Bridgeman Island is still deeper, in places exceeding 2500 m. This segmentation may

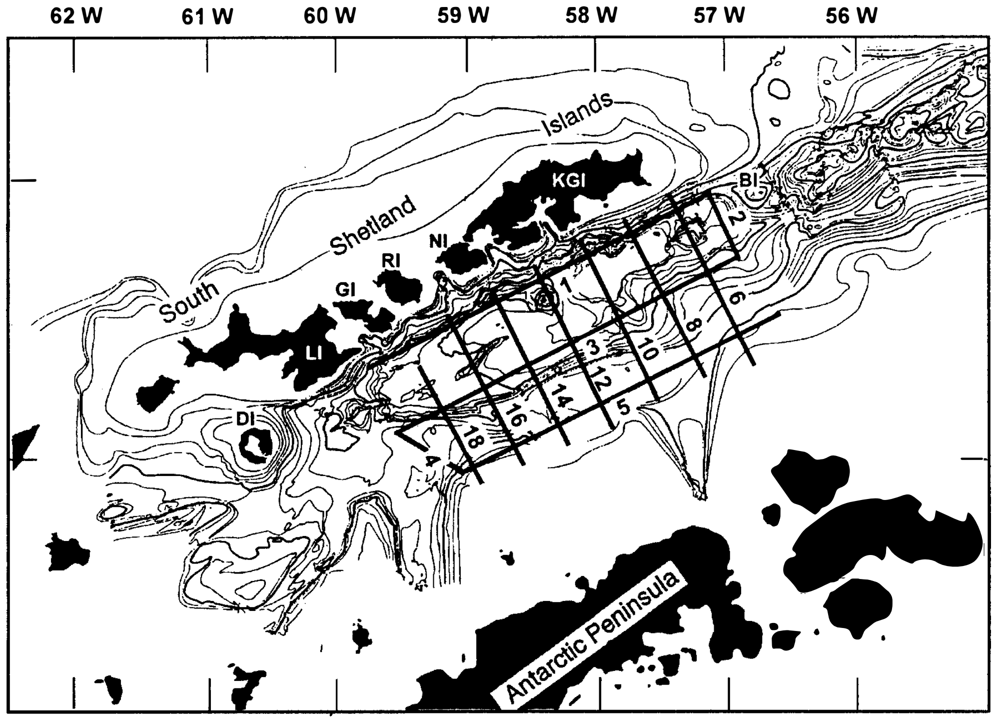

Fig. 1. Location of seismic lines with bathymetric map complied by KLEPEIS and LAWVER (1993). BI-Bridgeman Island, DI-Deception Island, GI-Greenwich Island, KGI-King George Island, LI-Livingston Island, NI-Nelson Island, RI-Robert Island.

be controlled tectonically and strongly influences on the sedimentary environment and lithofacies.

This study presents the preliminary results of a marine seismic survey in the central Bransfield Strait during the austral summer season of 1994/95. Approximately 1000 km of seismic data were collected (Fig. 1). Data were recorded using a 12-channel analog streamer at 6.25 m intervals. An airgun with a volume of 180 in^3 (3 *l*) was used as an acoustic source and the acquired seismic data were processed by conventional processing procedures.

2. Interpretation of Seismic Profiles

2.1. Spreading ridge and Basement high

The Bransfield spreading ridge is a conspicuous feature in the deeper parts of the strait, and is extremely well defined on seismic profiles compared to spreading centers described in other marginal basins (JEFFERS and ANDERSON, 1990).

All seismic profiles across central Bransfield Strait are summarized in Fig. 2. The topographic expression of the spreading center varies along the strait. At the northeastern limit of central Bransfield Strait, line 2 shows a typical two-peak spreading ridge 200 m high. In line 6 the spreading center ridge is about 600 m high and connects southward with a basement high covered by the basin sediments. To the southwest, two neighbor profiles of lines 8 and 10 do not show the spreading ridges. Although these two lines show similar bathymetry, the basement topography is

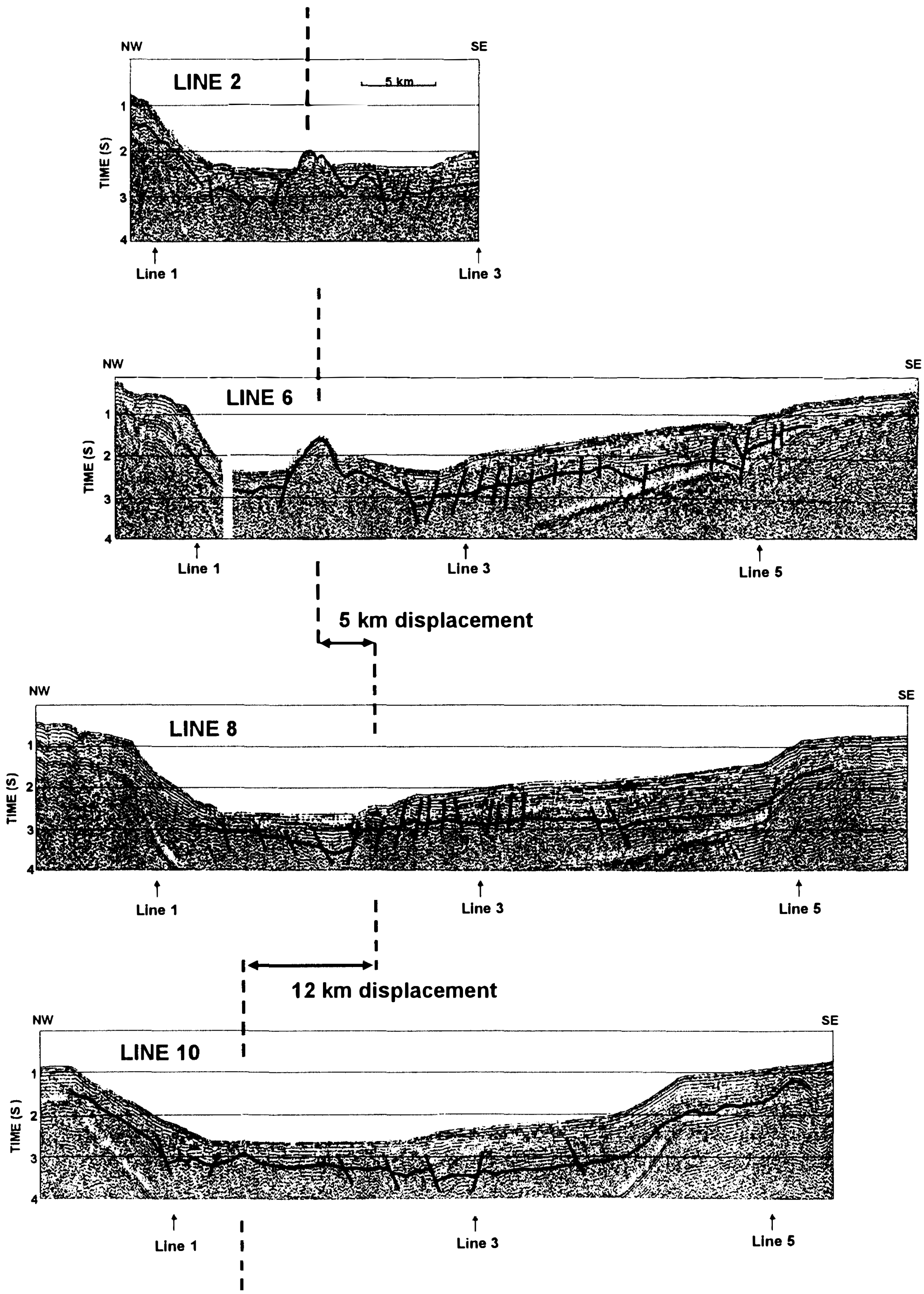

Fig. 2. Seismic profiles across the central Bransfield Strait. Solid lines represent the top of the basement and faults. The line numbers with arrows beneath each profile represent the point of intersection with the lines parallel to the strait. Dashed lines represent an axis of the spreading center in the strait.

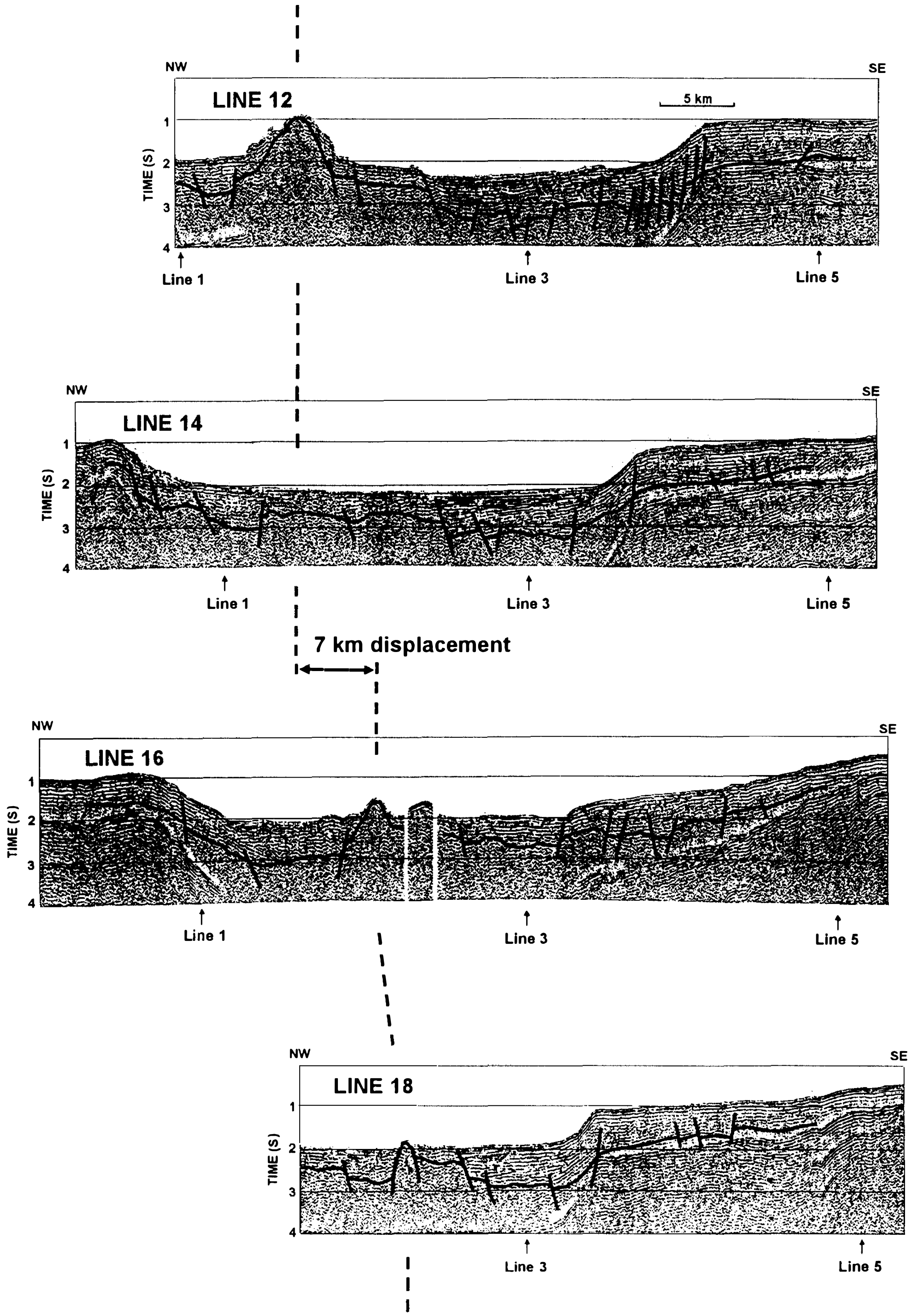

Fig. 2. (Continued)

somewhat different. In line 8 a basement high occurs beneath the front of the southern slope, whereas in line 10 no distinct highs can be seen except a small basement mound beneath the northern slope. The basement highs in two lines seem to be the corresponding structure with the spreading ridge of other lines. The depth to the basement beneath the southeastern slope in line 10 is deeper by 0.6 s than that in line 8. A prominent ridge more than 800 m high above the surrounding sea floor appears in line 12. This ridge is the submarine volcano 'Orca' that is the largest spreading center in the study area (GONZÁLEZ-FERRÁN, 1991). The basement high in line 12 extends 5 km southward of the ridge and is bounded by a large fault. Instead of a spreading ridge in line 12, a basement high occupies the same area beneath the basin floor in line 14. Line 16 shows a 400 m-high spreading ridge in two symmetric peaks. A relatively small fault cuts the basement high extending southward from the spreading center. In line 18, a subtle ridge appears on the basin floor and a basement high is bounded on its southern side by a normal fault.

The trend of the Bransfield spreading center varies along the strait. In the two easternmost lines 2 and 6, the spreading centers appear at the middle of the basin floor and abrupt change in the trend occurs at lines 8 and 10 without a ridge on the basin floor. The basement high in line 8 is displaced 5 km southward from the ridge in line 6. In line 10 a subtle basement high appears beneath the foot of the northern slope. The prominent ridge (Orca volcano) in line 12 also shifts to the northern side of the basin. Approximately 12 km of displacement is seen between lines 8 and 10. The spreading center moves by 7 km toward the middle of the basin between lines 12 and 16.

2.2. *Faults*

All lines across the strait normally show that the spreading ridge and basement highs are bounded on both sides by normal faults (Fig. 2). To the southern side, the landward-dipping normal fault has large vertical displacement ranging from 300 to 800 m along the strait. This fault shows good lateral continuity throughout the central area of the strait. To the northern side, the landward-dipping fault with vertical offset of 200–300 m also shows good lateral extent. The basinward-dipping faults at the feet of both marginal slopes run throughout the strait. Numerous normal faults with narrow spacing of 1–2 km occur at the front of the southern slope to the Antarctic Peninsula in lines 6, 8, and 12. These faults disrupt severely the basement and overlying sediments, indicating active extension in Bransfield Strait.

Line 3 parallel to the axis of the strait shows clearly the topographic variation and deformation in the basement along the strait (Fig. 3). The depth of the basement gradually increases from the SW end of the profile to the just west of the intersection with line 10, but decreases rapidly from line 10 to the northwest. The basement is nearly exposed to the sea floor near the intersection with line 6. The depth difference between the deepest and the shallowest depths of the basement is up to 1.3 s (about 1100–1300 m). Several faults occur densely at the deepest area of the basement near line 10 and intensely deformed the basement. These features may indicate the presence of a large fault zone. It is likely that the absence of the spreading ridge and the large displacement of the axis of spreading center in lines 8 and 10 result from

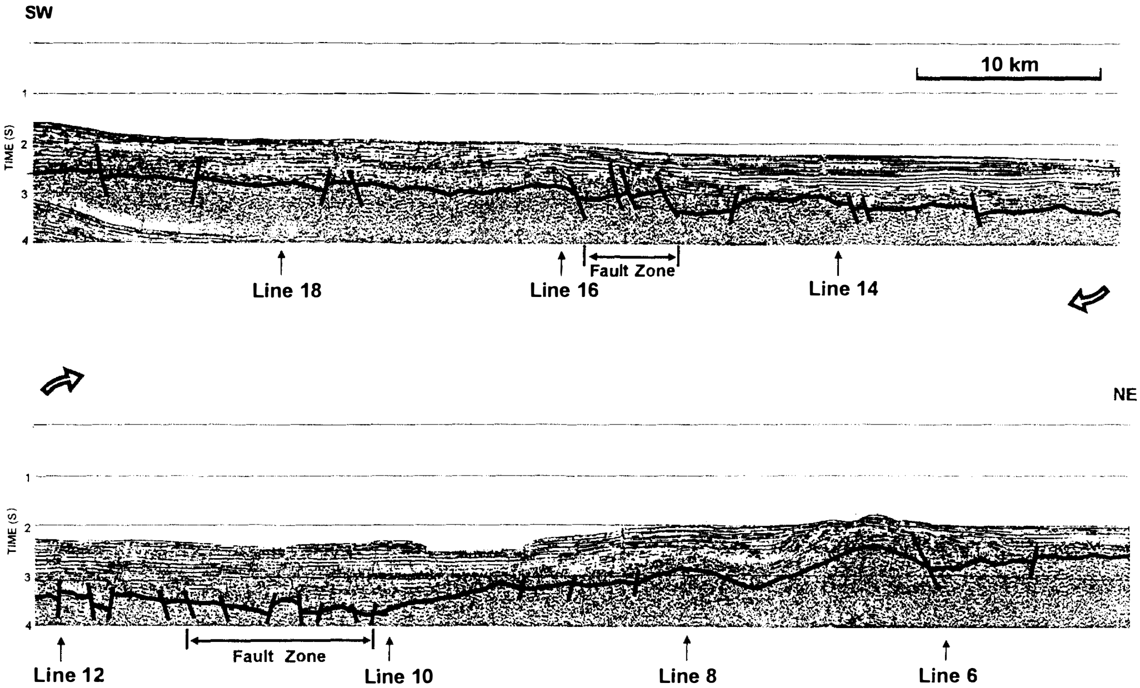

Fig. 3. Seismic profiles of line 3 parallel to the axis of Bransfield Strait. Solid lines represent the top of the basement and faults. The line numbers with arrow beneath each profiles represent the point of intersection with the lines across the strait.

deformation by this large fault zone. Another large deformation in the basement is observed just east of line 16, where bathymetry becomes deeper rapidly by more than 0.2 s and basement is disturbed by numerous faults with the offset of up to 0.4 s. This feature may be also related to the absence of the ridge in line 14.

On the basis of the faults identified from individual seismic lines, a fault map of the strait is made as shown in Fig. 4. The map shows clearly the traces and styles of faults in the area, so the strait can be divided into three segments–eastern, central, and western segments– by the fault geometry.

The eastern segment, including lines 2, 6, and 8, shows quite different fault geometry from other segments. Numerous basinward-dipping faults with narrow spacing occur on the southern slope. None of these faults continue to the central segment. The boundary between the eastern and central segments is consistent with the location of the large fault zone. In the central segment, a landward-dipping fault which forms the southern boundary of the basement high, shows good continuity throughout the segment. A number of basinward-dipping faults with short length are observed on the southern slope in this segment. In the western segment including lines 16 and 18, the general trends of faults rotate about 30° counterclockwise in the northern part and clockwise in the southern part on the axis of the spreading center. The faults which run between lines 14 and 16 (Fig. 3) seem to form the boundary between the eastern and western segments.

Transform faults across Bransfield Strait have been described by many authors (Gambôa and Maldonado, 1990; González-Ferrán, 1991; Barker and Austin,

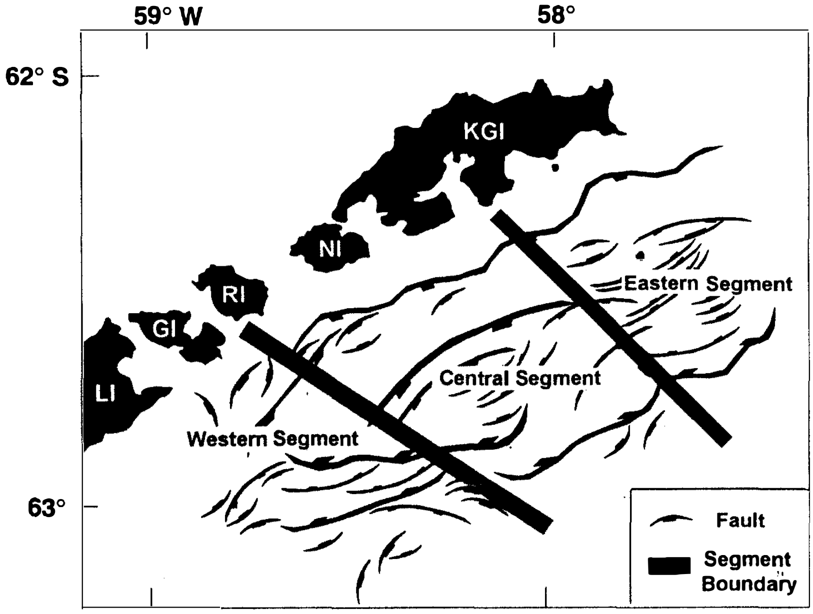

Fig. 4. Fault map of central Bransfield Strait. This area is divided into by three segments showing different fault geometry. Thick solid lines are the boundaries of segments. GI-Greenwich Island, KGI-King George Island, LI-Livingston Island, NI-Nelson Island, RI-Robert Island.

1994). GAMBÔA and MALDONADO (1990) delineated a fracture zone near the northern end of the King George Island. This fracture zone interrupts the Bransfield spreading center halfway along its length. They suggested 10 km of displacement in the axis of the spreading center and a change in polarity of the rift at both sides of the fracture zone. GONZÁLEZ-FERRÁN (1991) also demonstrated several transform faults across the axial rift of Bransfield Strait. He suggested that en echelon block movements in the strait were controlled by these fault systems parallel to the Hero and Shackleton fracture zones. BARKER and AUSTIN (1994) presented a structural map of the strait in which spreading ridges, basement highs, diapirs and transfer faults are delineated. The locations of the transfer faults proposed by them are approximately in agreement with the boundaries suggested in this study.

2.3. *Bathymetry*

Bransfield Strait is generally a deep asymmetric trough showing a steep northern slope to the South Shetland Islands and a gentle southern slope to the Antarctic Peninsula (JEFFERS and ANDERSON, 1990). Seismic profiles across the strait show that the bathymetry of the strait changes along its axis (Fig. 2). The northern slope is very steep, more than 15°, on the profiles of lines 2 and 6. The slope gradually becomes gentle to the southwest, so the dip of the slope in line 16 decreases to about 10°. On the other hand, the southern slope to the peninsula shows abrupt morphological change near line 10 where a large fault zone exists. The northeastern profiles (lines 2, 6, and 8) show a very long and gentle slope to the peninsula. Thick sediments (> 800 m) are deposited on the slope. The subtle shelf edge in line 8 becomes sharp in line

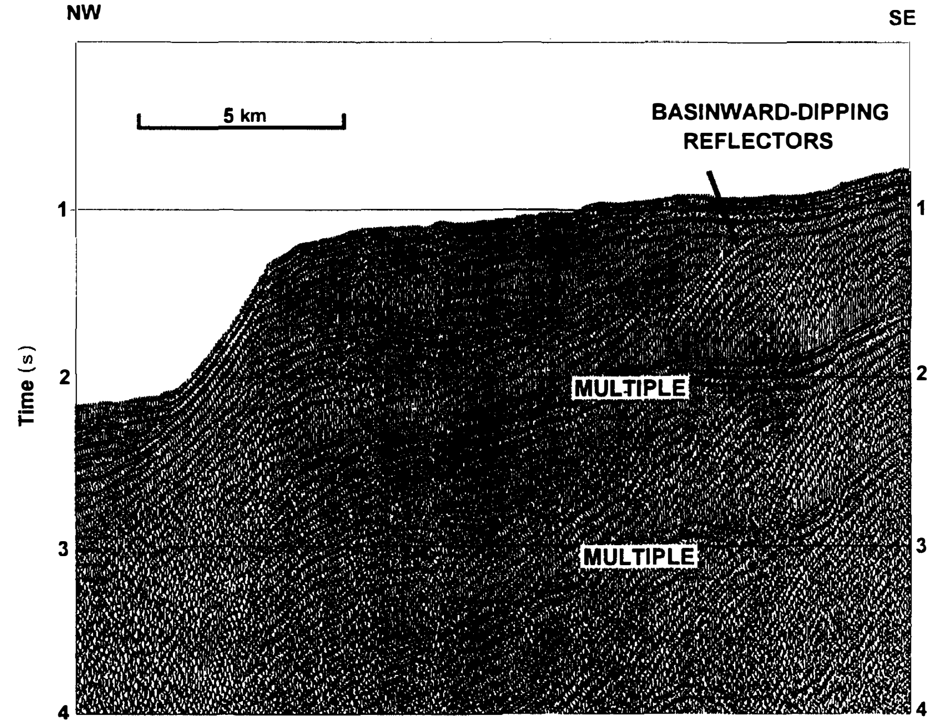

Fig. 5. Detailed profile of line 14 showing the basin-dipping reflectors which were formed during the initial stage of continental mass.

10. The basin floor in these lines is relatively narrow (< 10 km wide). The southwestern profiles (lines 12, 14, and 18) show a steep southern slope to the peninsula, having a sharp shelf edge and flat shelf. The slope becomes so steep to the southwest that in line 14 this slope is rather steeper than the northern one to the island. In these lines the width of the basin floor becames wider, up to 20 km, in line 14. Line 16 reveals an exceptional feature that shows a gentle southern slope without a shelf edge. This feature may be due to channel running near this line as shown in the bathymetric map (Fig. 1). The channel is probably related to a transform fault across the strait near line 16 as shown in Fig. 3.

2.4. Basinward-dipping reflectors

Four adjacent profiles (lines 8, 10, 12 and 14) show reflections dipping steeply in the basinward direction on the southern shelf to the Antarctic Peninsula (Fig. 2). These reflections form a 5 km wide band. Some diapirs occur together with these reflections and severely deform them in lines 10, 12 and 14 (Fig. 5). GAMBÔA and MALDONADO (1990) observed these reflections in the strait and interpreted them to represent intercalations of volcanic and volcanoclastic layers formed during the initial breakup of the continental mass. They suggested that these reflections were formed by the similar origin of the 'seaward dipping-reflectors' observed by HINZ (1981).

All lines showing the basinward-dipping reflectors are mainly located at the central segment (Fig. 4). This segment seems to be one of segments formed by differential block faulting in the initial stage of rifting (GONZÁLEZ-FERRÁN, 1991). This suggests that initial rifting activity was relatively stronger in the central segment.

3. Conclusions

New multichannel seismic profiles suggest that the structural variation of central Bransfield Strait is mainly controlled by transform faults across the strait. The axis of the spreading center in the strait is abruptly displaced about 12 km near King George Island, where most faults parallel to the strait do not continue and the morphology of the basin changes abruptly. In addition, numerous faults intensively deform the basement beneath this area. Such striking structural changes indicate the existence of a large fault zone in this area. The absence of the spreading ridge in this area may be caused by the large fault zone.

Central Bransfield Strait can be divided into three segments showing different fault geometry. The boundaries of these segments seem to be transform faults across the strait, including the large fault zone. Such segments were probably formed by differential block faulting in the initial stage of rifting. The basinward-dipping reflectors occur in the central segment, suggesting that rifting activity at the initial stage was relatively stronger in this region.

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