

Revised Interpretation of Tectonic Features in the Southern Weddell Sea, Antarctica, from New Seismic Data

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Summary: One of the key areas for the reconstruction history of Gondwana is the Weddell Sea. The Alfred Wegener Institute (AWI) carried out two *Polarstern* cruises in 1986/87 (MILLER & OERTER 1989) and 1989/90 (MILLER & OERTER 1991) to collect geophysical and bathymetric data in this region. One of the main objectives was to verify the existence and shape of the Explora-Andenes Escarpment, which has been interpreted as an East Antarctic plate boundary (KRISTOFFERSEN & HAUGLAND 1986). The new data give more detailed insights into the structure and evolution of the Explora Escarpment. To the west (19° W) the escarpment vanishes as a topographic feature. We interpret a newly discovered structure, denominated „Polarstern Bank“ (71°30' S, 25° W, the proposed plate boundary) as the result of an uprising of the basement during the Late Cretaceous. We propose that the Explora Escarpment and the Andenes Escarpment have different genetic origins.

Zusammenfassung: Das Weddell-Meer ist eines der Schlüsselgebiete für die Rekonstruktion Gondwanas. In den Jahren 1986/87 (MILLER & OERTER 1989) und 1989/90 (MILLER & OERTER 1991) führte das Alfred-Wegener-Institut (AWI) zwei *Polarstern*-Expeditionen in das südliche Weddell-Meer durch, um geophysikalische und bathymetrische Daten zu sammeln. Eines der Hauptziele dabei war die Verifikation der Existenz und Ausdehnung des Explora-Andenes-Escarpments, das als ostantarktische Plattengrenze interpretiert wird (KRISTOFFERSEN & HAUGLAND 1986). Die neuen Daten ermöglichen detaillierte Einsichten in die Struktur und die Entwicklung des Explora-Escarpments. Nach Westen (19° W) verschwindet das Escarpment als topographische Struktur. Wir interpretieren eine neu entdeckte Struktur, die „Polarstern Bank“ genannt wird (71°30' S, 25° W, am Ort der vorhergesagten Plattengrenze), als das Ergebnis einer Basement-Anhebung in der Ober-Kreide. Wir vermuten, daß das Explora- und das Andenes-Escarpment einen unterschiedlichen genetischen Ursprung haben.

INTRODUCTION

Since 1976 several geophysical expeditions were carried out in the Weddell Sea embayment (HINZ & KRISTOFFERSEN 1987). During the season 1986/87 the Alfred Wegener Institute (AWI) in close cooperation with the Renard Centre of Marine Geology (RCMG) started its first marine geophysical expedition into the Weddell Sea. The main subject was to collect multichannel seismic data in the embayment additionally to the existing seismic network in order to map sedimentary and tectonic units constraining the rift-drift history of the breakup of Gondwana. One of the main targets was the region between the known parts of the Andenes and Explora escarpments, where no seismic data were available (Fig. 1). Combined with the results of the expedition in 1989/90, we found a new geological structure, which will imply a revised interpretation of the geological structures in this regions. The results of both expeditions will be briefly summarized in this paper.

EXPLORA ESCARPMENT

The proposed over 1000 km long lineament (KRISTOFFERSEN & HAUGLAND 1986, HINZ & KRISTOFFERSEN 1987) has been subdivided into the eastern Explora Escarpment (10°-17° W) and the Andenes Escarpment west of 23° W. The latter is thought to consist of several segments trending about ENE (60°-80°). While the Explora Escarpment is well defined in the seafloor topography (0.3 - 2 km elevation), the Andenes Escarpment is totally buried by sediments (KRISTOFFERSEN & HAUGLAND 1986).

Following the Explora Escarpment we mapped the seafloor topography between 19° and 13° W using a HYDROSWEEP swath sonar system (GUTBERLET & SCHENKE 1989). The bathymetric data show that the escarpment exhibits three different main strike directions in this area (Fig. 2). Each change in strike is accompanied by the occurrence of a canyon cut at right angles to the strike of the escarpment. One of those is a well developed structure, the Wegener Canyon (14° W). Detailed seismic surveys in this area reveal a tectonic fault which could

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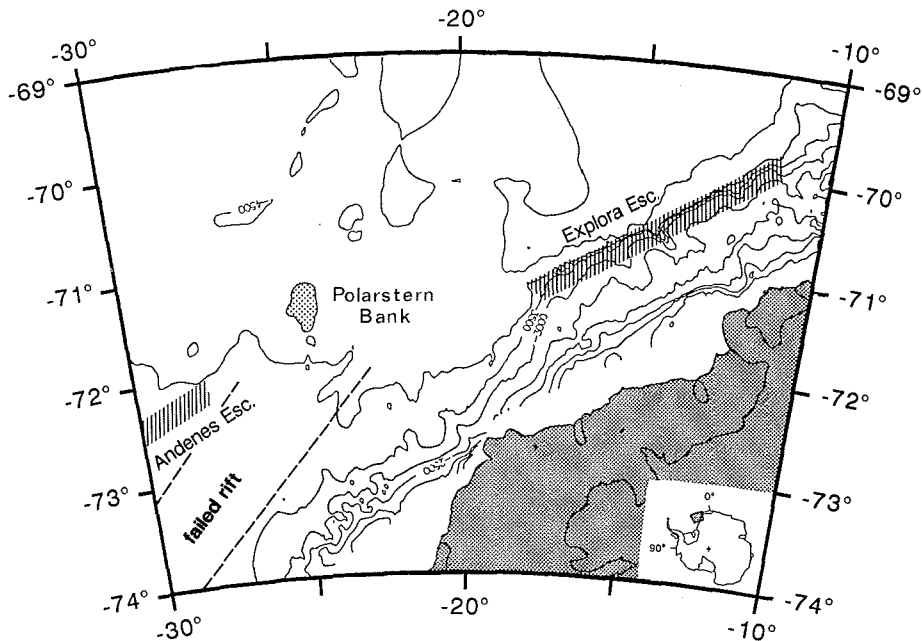


Fig. 1 : Overview map with data from GEBCO database and bathymetric informations (SEABEAM, HYDROSWEEP) from recent *Polarstern* cruises. The location of the Explora and Andenes escarpments (diagonal ruling), the failed rift (HINZ & KRISTOFFERSEN 1987) and the Polarstern Bank (dotted) is shown.

Abb. 1: Übersichtskarte aus Daten der GEBCO Datenbank und bathymetrischer Information (SEABEAM, HYDROSWEEP) von kürzlichen *Polarstern*-Expeditionen. Dargestellt sind die Lokationen des Explora- und Andenes-Escarpments (schraffiert), des „failed rifts“ (HINZ & KRISTOFFERSEN 1987) und der Polarstern-Bank (gepunktet).

explain the existence of the canyon (KAUL 1991). The new seismic data show a 10-15 km wide zone in the southward prolongation of the canyon, where the sediments are disturbed and exhibit a vertical offset of 200 ms TWT. The Wegener Canyon can be interpreted as simply the morphological expression of the edge of a tilted and rotated basement block constituting the last continental fragment of the rifted margin (HENRIET & MILLER 1990). This model can be considered for the second canyon at 17° W as well.

It can not be ruled out that the segmentation of the continental margin along the Explora Escarpment is an inherited feature, e.g. related to different crustal rifting stages, as the northward rotation of the escarpment shows striking similarities to apparently northward rotating strike directions of magnetic anomalies M29 to M0 (LABREQUE & BARKER 1981). An alternate model has been proposed in which this margin developed into a transform boundary after initial rifting (NORTON & SCLATER 1979). Eventually the margin may have been overprinted by wrench faulting (HENRIET & MILLER 1990).

If we follow the Explora Escarpment towards the SW (Fig. 1), it disappears as a distinct topographic feature. At present there are no seismic data available which would allow a definite answer with regard to the possible continuation of the escarpment beneath the sedimentary cover. We infer that it either ends at this point or bends into a southern direction.

ANDENES ESCARPMENT

In order to investigate a possible continuation of the Explora Escarpment into the Andenes Escarpment we shot several lines between 19° W and 27° W (area of the proposed onset of Andenes Escarpment, KRISTOFFERSEN & HAUGLAND 1986).

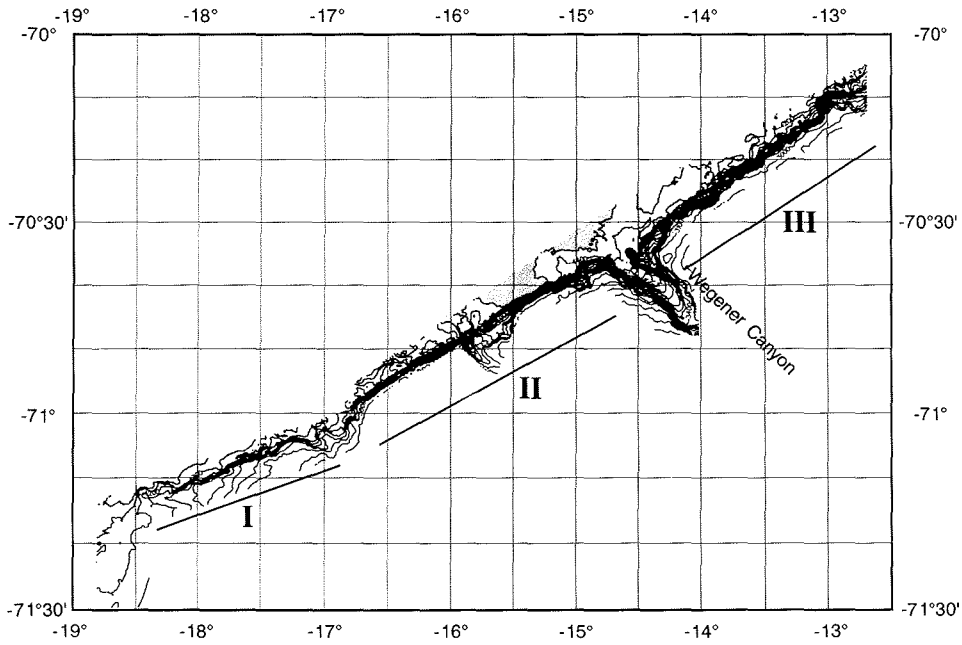


Fig. 2: Bathymetric map of the Explora Escarpment (I = 70° strike, II = 60° strike, III = 55° strike). Zones of weaknesses as the result of tectonic movements led to strong disturbances in the shape of the Explora Escarpment, thus enabling the formation of canyons.

Abb. 2: Bathymetrische Karte des Explora Escarpments (I = 70° Streichen, II = 60° Streichen, III = 55° Streichen). Schwächezonen als Folge tektonischer Bewegungen führten zu starken Störungen in der Form des Explora-Escarpments, was die Bildung der Canyons ermöglichte.

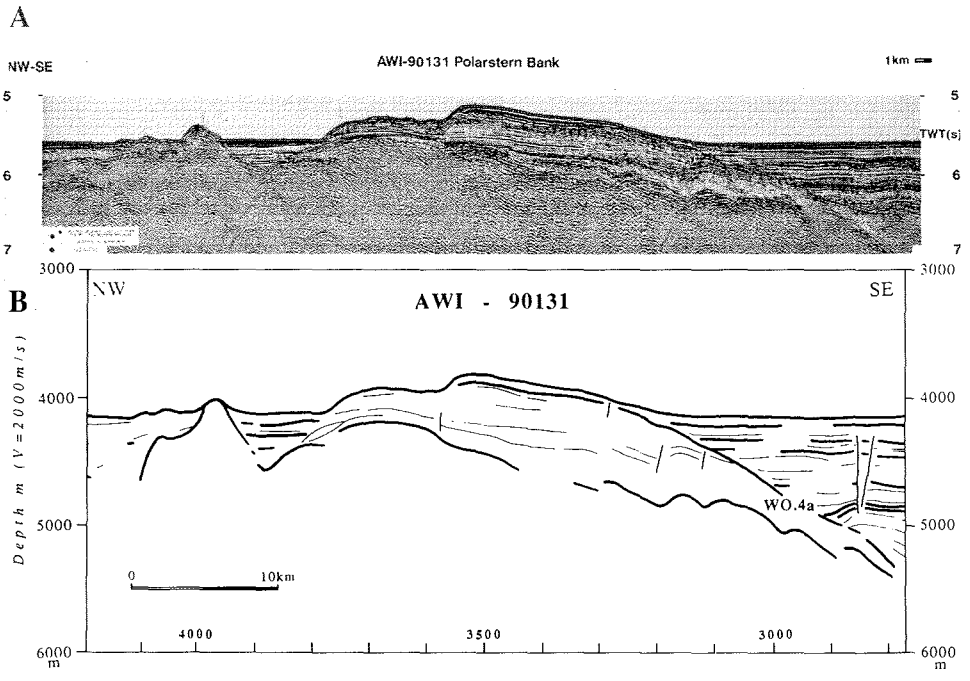


Fig. 3: A = Multichannel reflection seismic line AWI-90131 (stacked) crossing Polarstern Bank. B = line drawing interpretation of line AWI-90131.

Abb. 3: A = Mehrkanalreflexionsseismisches Profil AWI-90131 (gestapelt) über die Polarstern-Bank. B = Interpretation von Profil AWI-90131.

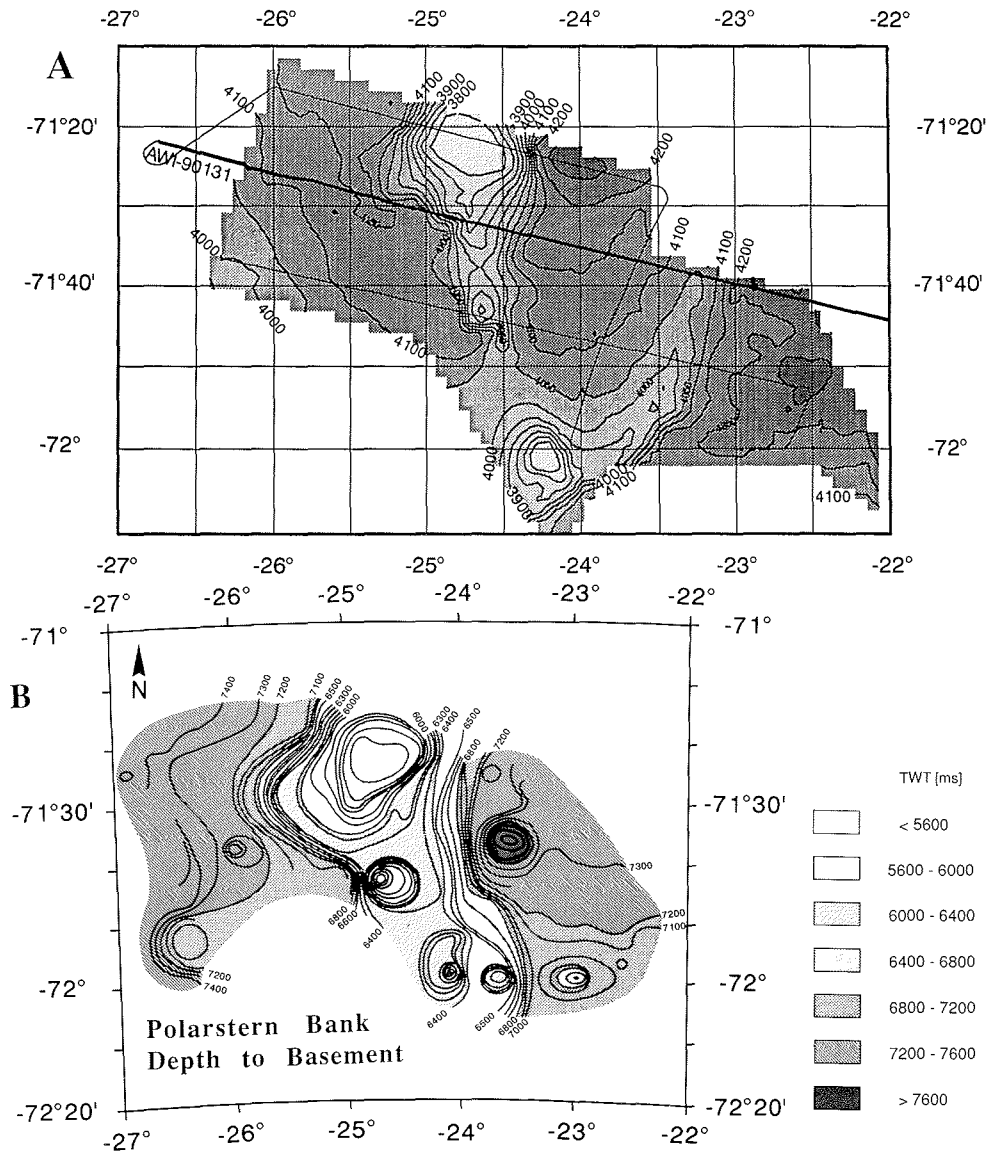


Fig. 4: A = Bathymetric map of Polarstern Bank including the seismic lines. B = Mapped basement depth around Polarstern Bank.

Abb. 4: A = Bathymetrische Karte der Polarstern Bank, die auch den Verlauf der seismischen Profile enthält. B = Isochronenkarte des Basements im Bereich der Polarstern-Bank

These new data disclosed a hitherto unknown feature at approximately 25° W and 71°30' S (Fig. 3). HYDROSWEEP sonar data reveal the isolated character and the limited size of the structure (Fig. 4): the maximum East-West width is 15 km, the elevation above seafloor reaches 400 m. Heavy ice conditions unfortunately prevented to investigate the area north of 71°20' S. The structure is characterized by a seismic basement, otherwise only slightly disturbed, rising nearly up to the seafloor (Fig. 3). Structural mapping of this basement (Fig. 4) confirms the narrow E-W extension and the apparently N-S trending strike derived from the bathymetric data. The gravity shows a smooth, positive, free air anomaly with a maximum value of 20 mgal. All characteristics of

the observed structure, derived from seismic, gravity and bathymetric data, suggest that it is not structurally or morphologically connected with either the Explora or the Andenes Escarpment. We therefore denominate this structure Polarstern Bank, after R.V. *Polarstern*.

On the seismic data it can also be observed that the basement of Polarstern Bank has apparently been uplifted with part of its original sedimentary cover (Fig. 3). These early sediments are overlapped on the flanks of the bank by younger sediments, which reach thicknesses of about 1.5-2.5 km. Through correlation across the existing set of interconnected MCS lines it was possible to date this onlap surface. Within the frame of the agreed seismostratigraphic terminology for the Weddell Sea (HENRIET et al. 1989) it has been identified as the WO.4a unconformity and thus provides a lower age limit of late Lower Cretaceous (Albian) for the development of this structure. Thus, the event is probably not related to the initial rift phase in that region. Most likely the uplifting of the Polarstern Bank results from delayed deep crustal intrusions in the northern continuation of the mid-Jurassic failed rift basin axis (HINZ & KRISTOFFERSEN 1987).

Apart from the Polarstern Bank we did not observe any indication for other basement structures between the Explora and the Andenes escarpments. This further supports our interpretation that both escarpments have to be seen as individual features.

CONCLUSION

Although the Explora Escarpment clearly represents an initial Antarctic plate boundary, be it an original rifted margin or one subsequently developed into a transform boundary, our data do not allow us to conclude the same for the Andenes Escarpment. Moreover, no indication has been observed for a basement structure between the Explora and Andenes escarpments, apart from the Polarstern Bank. Since the bank is situated in the prolongation of the failed rift basin axis (HINZ & KRISTOFFERSEN 1987), we infer that the basin is not limited to the north by the lineament. So the Polarstern Bank and the failed rift basin intersect the proposed Explora-Andenes lineament. Therefore we suggest that the two escarpments have different genetic origins and that they cannot be considered as a continuous plate boundary.

As at the present seismic data are not available in important target regions, it is clear that geophysical programmes must be continued in the Weddell Embayment in order to develop a final model for the initial break-up of Gondwana.

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