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Bathymetrical Measurements in the Southern Weddell Sea during the German Antarctic Expedition 1979/80 to the Filchner/Ronne Ice Shelf

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Summary: Routine bathymetrical measurements were carried out during the whole cruise of the expediton to the Filchner Ice Shelf. Together with earlier investigations the depth data from the expedition yield a first bathymetrical map of the southern Weddell Sea.
The map shows three distinct morphological features:
1. the well-known Filchner trough with depths of more than 1000 m in its centre; 2. a morphological high north of Berkner Island with average depths of 250 m to 300 m which extends until the continental slope; 3. the ocean bottom slopes down west of the high reaching a depth of 600 m close to the Antarctic Peninsula.
At 57 °W a ridge with a central depth of 350 m is met. The morphological high extends southwards under the ice shelf and surfaces through Berkner Island and Hemmen Ice Rise. This feature is of considerable oceanographic importance since it intersects the water circulation between the eastern and western ice shelves.
The bathymetrical records contain various iceberg scours. Many grounded icebergs were found on the morphological high. However, scours were also recorded from a depth range of 300 m to 500 m. These scours are most likely of fossil nature and originate from times when the sea level was lower due to an increased world-wide glaciation.

Zusammenfassung: Während der Expedition zum Filchner-Ronne-Schelfeis 1979/80 wurden bathymetrische Messungen routinemäßig auf allen Fahrtabschnitten durchgeführt. Die Meßdaten ergeben zusammen mit früheren Untersuchungen ein erstes geschlossenes Bild von den Tiefenverhältnissen im südlichsten Teil der Weddell-See.
Die bathymetrische Karte zeigt drei ausgeprägte morphologische Strukturen: 1. der schon länger bekannte Filchner-Graben mit Tiefen über 1000 m im Zentralbereich; 2. ein morphologisches Hoch nördlich Berkner Island, das sich bis zum Kontinentabhang hinzieht und im Mittel 250 m bis 300 m tief ist; 3. ein Abtauchen des Meeresbodens westlich des Hochs bis zu Tiefen von 600 m am Rande der Antarktischen Halbinsel, unterbrochen von einem schmalen Rücken bei ca. 57 °W mit einer Zentraltiefe von 350 m. Das morphologische Hoch erstreckt sich offensichtlich unter das Schelfeis nach Süden und bewirkt, daß das Eis im Berkner-Bereich (Berkner-Insel) auf dem Meeresgrund aufliegt. Diese Struktur ist von erheblicher ozeanographischer Bedeutung, da sie die Wassermassenzirkulation zwischen dem nördlichen Filchner-und Ronne-Schelfeis unterbindet.
Die bathymetrischen Aufzeichnungen zeigen eine Anzahl von Eisbergspuren im Untergrund. Das Auftreten solcher Spuren auf dem morphologischen Hoch ist leicht erklärlich, da hier stets auf Grund liegende Eisberge anzutreffen sind. Es wurden aber auch Eisberggruppen im Tiefenbereich zwischen 300 m und 500 m registriert, die als fossile Spuren aus Zeiten, als der Meeresspiegel wegen stärkerer weltweiter Vergletscherung wesentlich tiefer lag, zu deuten sind. Solche Spuren sind von besonderem Interesse für die Rekonstruktion früherer Eisausbreitungen.

INTRODUCTION

Bathymetrical data are rare in the southern Weddell Sea because not too many vessels have operated in these waters. Routine bathymetry has therefore been part of the scientific programme of the German Antarctic Expedition to the Filchner/Ronne Ice Shelf 1979/80. Echo sounding was carried out during the whole cruise of this expedition. The route of the vessel operating along, and perpendicular to, the ice shelf margins from December 1979 through February 1980, was selected according to the marine biological and oceanographic reseach work and is shown in Fig. 2 of FUCHS et al. (1981)

MEASUREMENT AND EVALUATION OF DATA

A Simrad (Model EK-12) echo sounder, being standard equipment of the expedition's ship POLARSIRKEL, was used for continuous profiling of the bottom topography. The depths were recorded on wet paper giving a read-off accuracy of about ±2% to ±3%. The accuracy of the absolute depth recording was controlled against the depth measurements made with the oceanographic CTD probe which was attached

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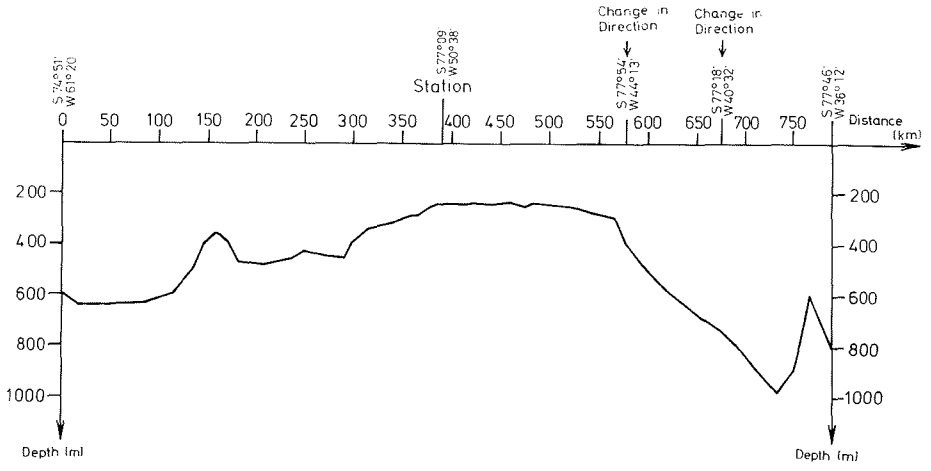

Fig. 2: Bathymetrical profile along the ice front of the Filchner/Ronne Ice Shelf.

Abb. 2: Tiefenprofil entlang der Barriere des Filchner-Ronne-Schelfeises.

300 m. On the southern side, the morphological high surfaces in Berkner Island where the ice shelf is grounded over a large area. West of the high, the depth of the shelf bottom reaches average values of 400 m to 500 m while gently sloping down from 250 m to more than 600 m close to the Antarctic Peninsula. Fig. 2 shows the bottom topography along the ice front accentuating these morphological features. The grounded ice shelf area acts as a barrier intersecting the free circulation of watermasses between the Filchner and Ronne Ice Shelves in their northern portions. As in the Filchner depression (CARMACK & FOSTER, 1975; FOLDVIK & GADE, 1978), the oceanographic investigations (GAMMELSRØD & SLOTSVIK, 1981) strongly suggest a clockwise circulation of water masses under the northern Ronne Ice Shelf and in the southwestern Weddell Sea. Between Berkner Island and the Antarctic Peninsula a sharp ridge is found at 57 ° W. The water depth on its centre is about 350 m. Its extent under the ice shelf and into the Weddell Sea is still unknown.

A striking feature in the bathymetrical record is the appearance of small and sharp depressions or notches (Figs. 3a, 3b). These features result from grounded icebergs moving with currents and tides scratching their marks into the bottom. Such iceberg scours have also been reported in the eastern Weddell Sea by the Norwegian expedition of 1978/79 using side scanning sonar (ORHEIM, pers. comm.). The iceberg scours which we met during our cruise in the southern Weddell Sea are marked by crosses in Fig. 1. Only those features have been attributed to the action of grounded icebergs which present sharp and prominent contours in rather smooth and even surroundings. Further criteria for their identification are their dimensions. Fig. 3 shows typical examples from different dephts. Estimates of the width range between a few hundred and thousand metres. The depths of the scours vary between 10 and 30 m. The existence of iceberg scours on the morphological high, in a depth range between 200 and 300 m (Fig. 2), is obvious. Many grounded icebergs have been observed in this region during the 79/80 field season showing that the process of scouring is steadily going on. The size of those icebergs was of the order of some hundreds to thousand metres. The morphological high blocks the icebergs on their westward drift within the Weddell-Gyre.

Prominent iceberg scours have also been detected in depth ranges between 300 and 500 m (Figs. 1, 3). These scours must be of fossil nature, as suggested earlier by ORHEIM (pers. comm.), originating from ages when the sea level was much lower due to an increased worldwide glaciation. It can be anticipated that the equilibrium thickness of icebergs was always the same. On the other hand, it may be argued that very large icebergs may calve from ice shelves which are much thicker, on the inland side, than 250 or 300

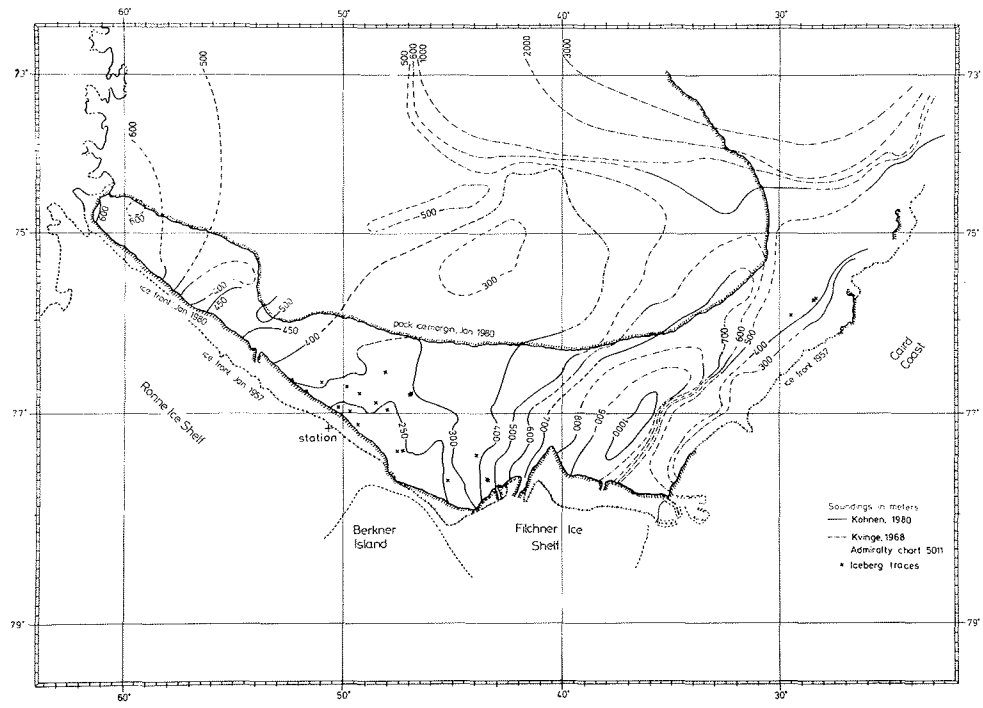

Fig. 1: Bathymetrical chart of the southern Weddell Sea.

Abb. 1: Bathymetrische Karte der südlichen Weddell-See.

to a special cable also calibrated for depth logging. A bias of 2% resulting in too great depths was found by comparison. The bathymetrical depth data plotted in the graphs (Figs. 1, 2) were corrected accordingly. No corrections have been applied for water level changes due to tides and swell. The maximum tide variation in the area west of Berkner Island was found to be 2,65 m (GAMMELSRØD & SLOTSVIK, 1981). The position of the ship was determined by satellite navigation equipment (Type: Nautikon) offering an accuracy of the position of approximately one minute in latitude (= 1 nautical mile). Depth readings were most often taken from the record at satellite fixes. Intermediate positions for additional depth values were obtained by interpolation. The total error of the sounding data is estimated to approx. ±3% to ±4%.

RESULTS

A bathymetrical chart of the southern Weddell Sea was compiled from the depth soundings (Fig. 1). Fig. 1 contains the isobaths (solid lines) computed for the area of operation as well as those extended to the north (dashed lines) using bathymetrical data from KVINGE (1968) and British navigation charts (Admiralty Chart 5011). The continental shelf shows an average depth of 400 to 500 m extending northward over a few hundred kilometres.

The most prominent features in the depth chart are the well known Filchner depression, the morphological high north of Berkner Island and again a depression west of 52° W. The morphological high, which runs NNE until it reaches the continental slope at 74° S, separates the deeper waters of the southeastern from those of the southwestern Weddell Sea. The average depth of the shelf in this area is about 250 m to

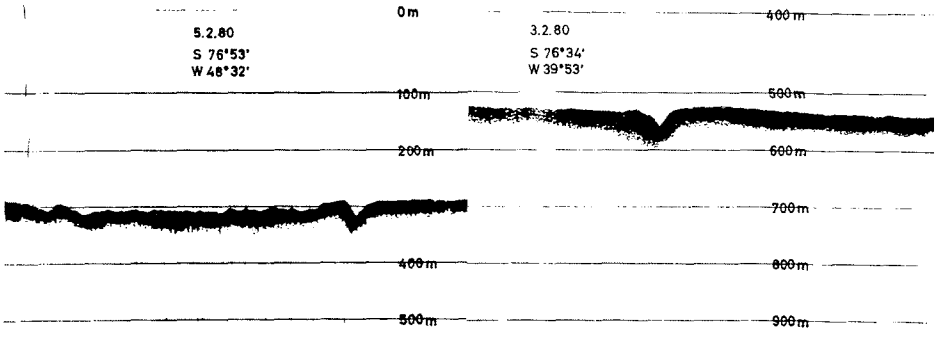

Fig. 3: Examples from the bathymetrical record showing iceberg scours in different depths.

Abb. 3: Beispiele von Eisbergspuren in der bathymetrischen Registrierung aus zwei verschiedenen Tiefen.

m. It is, however, hard to understand that such big icebergs would only produce scours as small as observed here.

No iceberg scours have been found in the southwestern part of the Weddell Sea between 52° W and 61° W. No large tabular icebergs have been observed in this region either. The bottom of the shelf is too deep for grounding of average sized icebergs to occur. The absence of scours in these depths suggests that the front of the ice shelf had moved considerably farther north at times of a low sea level.

RECOMMENDATIONS

The circulation of water masses under the Ronne Ice Shelf is not only of oceanographic interest. The transport of water under the ice controls the bottom melt rate which is one of the major components in the mass balance of ice shelves. The glaciological regime of the Ronne Ice Shelf can only be understood if the oceanographic properties are understood. More efforts are required to establish the flow pattern and to measure the temperature and salinity distribution along the ice front. The observation of iceberg drift may throw additional light on water circulation. The investigation of iceberg scours is of considerable interest in the understanding of iceberg drift, sea level changes and former ice shelf extensions.

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