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Distribution of Water Depths on the Arctic Continental Shelf Seaward of the Continental Land and Ice mass

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INTRODUCTION

During a study to assess the relative importance of geologic processes at different depths on the Antarctic continental shelf, we determined the depth distribution and area of the shelf. The shelf was divided into four areas; less than 200 m, 200 to 500 m, 500 to 1000 m, and areas with no depth data. The areas were measured in 10 degree longitudinal segments seaward from a coastline determined by icewalls, ice shelves, ice tongues as well as the Antarctic Land mass.

The seaward portion of the continental shelf off Antarctica is marked by shoals, ramps, cross shelf troughs (Johnson, et al., 1982; Domack, 1982; Moriwaki and Yoshida, 1983; Dunbar et al., 1985; Barnes, in press). In many cases the shelf profile slopes toward the continent (Dunbar et al., 1985) and depths in excess of 1000 m may be found in depressions along the coast (Johnson et al., 1982; Domack, 1982). As a result of the variable shelf morphology, the depth of the shelf break varies between 300 and more than 700 meters, and the break is often shallower than water depths shoreward of the break (Johnson, et al., 1982). Thus assigning a depth for the seaward edge of the "shelf" is arbitrary.

An average shelf depth of 450 m (Anderson et al., 1983) and 500 m (Dunbar et al., 1985) has been reported based on shelf bathymetric transects. Careful examination of the General Bathymetric Chart of the Oceans (GEBCO, 1980), Chart 5-18, indicates that, of the two largest shelf areas, the Ross Sea is generally deeper than 500 m, while the Weddell Sea is generally shallower than 500 m. Another obvious characteristic of the Antarctic shelf is the vast areas of the continental margin covered with ice shelves and glacial ice tongues.

METHODS

For the purpose of this study, the 200, 500 and 1000 m contours were selected as they were prominent isobaths on the GEBCO chart. The 1000 m isobath was selected as the seaward limit of the shelf only because data exist to define the isobath nearly everywhere off the continent. Furthermore, where bathymetric data was present, the shelf break was almost always only a few kilometers inshore from the 1000 m isobath. Thus the total area of the "shelf" defined for this study is the sum of the area inshore of the 1000 m isobath to a coast consisting of land, an ice wall, ice tongue, or ice shelf and includes areas of "no data" inside the 1000 m isobath.

A computerized digitizing and area computing program was used to determine the areas from GEBCO chart number 5-18 (GEBCO, 1980); a polar stereographic projection at a scale of 1:6 million at 75 degrees south. The digitizing program scale factor used in this study was 111.12 km for the chart distance of one degree of latitude at 75 degrees south.

The conventions used in digitizing are as follows:

- Digitizing was done in 10 degree segments of longitude.
- Areas of "no data" were digitized separately.
- Ice shelves and ice tongues were considereded the inner limit of the data. Thus areas below sea level overlain ice shelves, ice tongues and other continental ice were not digitized.
- The seaward edge of the "shelf" was arbitrarily selected at 1000 m although 700-900 m might be more appropriate based on the literature.
- Areas less than 1000 m deep excluding areas of "no data" were digitized.
- Areas within the 500 and 200 m contour were also digitized when data were available.

ERRORS

Because the GEBCO chart 5-18 is not equal, area errors were introduced by assuming a constant scale for digitizing. I used the convention that one degree of latitude is 111.12 km and measured this scale at 75° south. North and south of 75° a degree of latitude on the map projection measured from 110km at 60° to 116km at 85° south.

At 75° south, five degrees of longitude should measure 289 km (Robinson et al., 1978). Using the scale convention of 111.12 km per degree of latitude, five degrees of longitude along the 75th parallel measured 289 km. Thus, there would be no scale error at this latitude. At 80° south, there was a one km discrepancy (193 km measured vs 192 km calculated), while at 70° and 65° south, the measurement differed form the calculated values of 382 and 472 km by 6 and 12 km, respectively.

The linear latitudinal and longitudinal variability, when multiplied to determine the area, indicates errors of 0% at 75° south to over 5% at 65° south. Most of the continental shelf lies between 70° and 80° south where the projection error is between 1.6 to 2.5%. Off Wilks Land and the Antarctic Peninsula which both lie between 70° and 65° south the projection, error increases to 5.4%.

Additional errors were introduced by subjective judgment used in tracing of the contours on the digitizing table. Repetitive digitizing of several 10 degree segments several days apart indicated a variability of less than 5% in area. Summing the scale error and the subjective variability leads me to conclude that the area measurements reported here are accurate within 10%.

RESULTS AND OBSERVATIONS

Total area of continental shelf landward of the 1000 m isobath and seaward of the coast and floating and grounded ice affixed to continents is nearly 3 million sq km (Table 1). Almost a quarter of this shelf area - 0.73 million sq km (24.5%) - has no depth data. Most of the data gaps underlie the coastal areas with a persistent ice pack such as the Amundsen and western Weddell Sea. Were data available, I suspect that the area of the shelf less than 500 meters would increase most noticeably. Of the remaining three quarters of the shelf, over half or 1.2 million of the 2.3 million km sq is less than 500 m deep, while only .14 million km sq or about 6% is less than 200 m. The remaining 1.0 million sq km is between 500 and 1000 m deep, of which most appears to be less than 700 m deep. The dearth of shelf depths less than

200 meters can be explained in part by the absence of data inshore, partially by the depression of the shelves by continental ice, and the related fact that bedrock surfaces at the "coastline", as defined by this study and others (Drewry, 1983), is below sea level.

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