Gravimetric Determination of Ocean Tidal Effect on the Fimbul Ice Shelf, Princess Martha Coast, Queen Maud Land

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Abstract

The amount of vertical motion of the Fimbul Ice Shelf in Antarctica due to ocean tides was determined by use of a gravimeter and was found to be in the range of 0,70–1,65m. This agrees well with the theoretical average tidal range of 1,2m.

Samevatting

Die vertikale beweging van die Fimbul-ysbank weens seegetye is gravimetries bepaal as 0,70–1,65m. Hierdie waarde is van dieselfde orde as die teoretiese gemiddelde getybereik van 1,2m.

Introduction

The scientific programme of the 6th South African National Antarctic Expedition, 1965, included a project for the gravimetric determination of the amount of vertical movement in a floating ice shelf caused by the tidal effect of the ocean.

Similar investigations had been carried out in the Arctic by *Le Schack* (1964), *Le Schack* and *Haubrich* (1964), and *Plouff* (1964), and in the Antarctic by *Pratt* (1960) and *Thiel et al.* (1960).

It has previously been determined that during summer when a wide coastal lead exists along the ice coast-line, tidal oscillations and high frequency motions of a non-tidal origin are so large that it is virtually impossible to take gravity readings close to the ice front. The project was therefore scheduled for the winter months when, owing to increased pack-ice cover, movement and vibration of the gravimeter cross-hair would be sufficiently diminished to allow the beam to oscillate in the field of the ocular scale. During the period August 5 to August 25, 1965, the authors stayed at Substation (70° 15′S, 2° 45′W), a little hut located approximately 3m below the snow surface, which was built by the Den Norske Antarktisekspedisjonen during the IGY (Figs. 1 and 2). A Worden gravimeter (Prospector Model No. 621) was used for the observations.

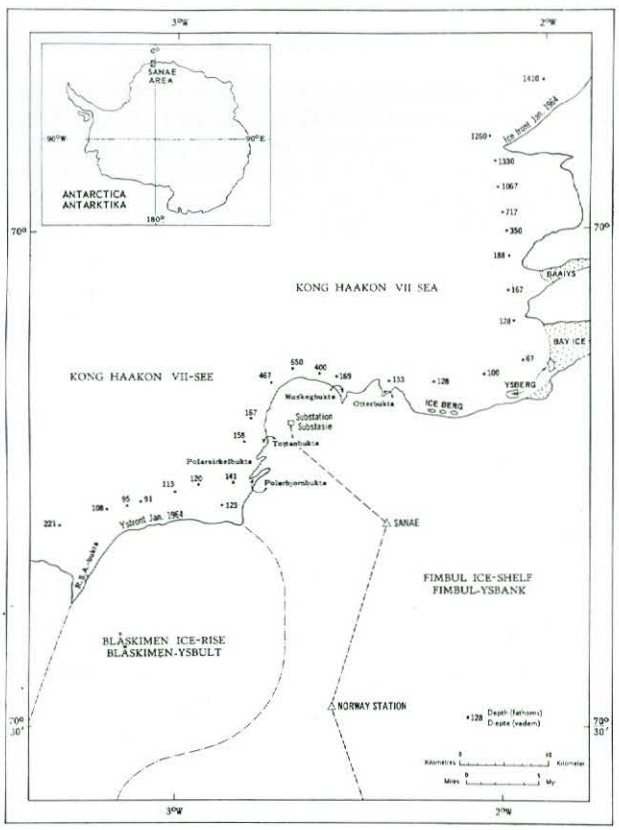

Fig. 1. Locality map, Fimbul Ice Shelf.

Method of Observation

The position of the cross-hair was recorded at intervals of 5 seconds for periods of 10 minutes at a time. These observations were done bihourly for a period of 20 days. By averaging these 5-second readings to an eyepiece value, the change of gravity was obtained. This eyepiece value was converted into instrumental scale-units which, when multiplied by the small-dial constant of the meter, gave the required gravity values in mgal.

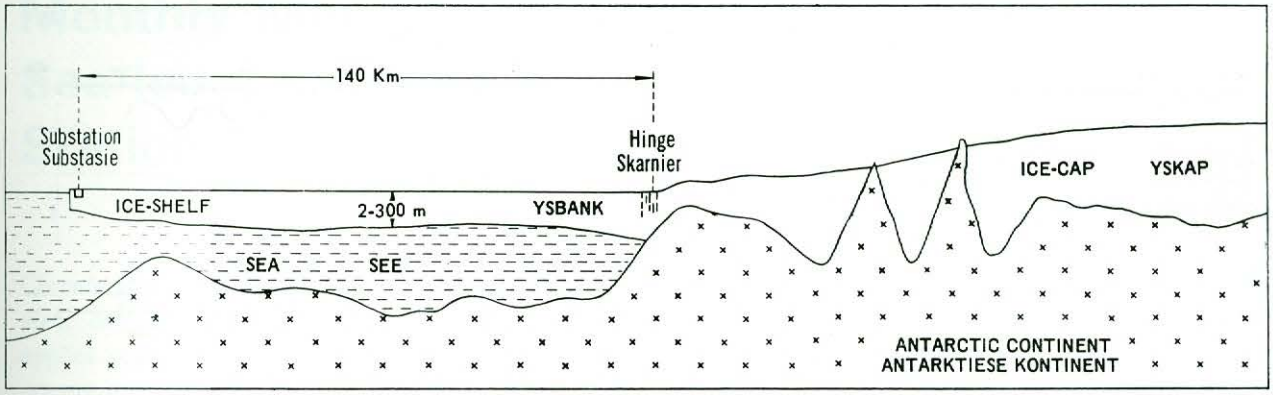

Fig. 2. Longitudinal profile through ice shelf and continent.

Interpretation

Plotting of the data showed that there were two types of vertical motion of the ice shelf:

(1) A short-period oscillation which caused the gravimeter to act like a seismometer (Figure 3) – these short-period movements are believed to be due mainly to ocean waves and interference effects caused by the resultant vibration of the ice shelf.

(2) A long-period oscillation due to the tidal effect of the ocean which is indicated by an actual change in gravity (Figure 4).

The correction for instrumental drift presented certain problems as it was not possible to obtain a drift-curve for the period of observation. On the assumption that the drift was linear, the available data were fitted to a line of equation

$$g = at + b$$

where g = gravity (mgal),
t = time (hours), and
a and b = constants to be determined by the method of least squares.

Earth-tide corrections are in the range of 0,003 to 0,03mgal (*Tidal Gravity Corrections for 1965*, 1964) and were not considered in the reduction of the gravity data. The change of gravity with elevation in air at the surface of the earth is 0,3086mgal/m; allowing therefore for the Bouguer correction for the changing height of the water column, *Thiel et al.* (1960) deduced the following equation whereby a direct computation of the amount of vertical movement from the observed gravity values can be made:

$$h(m) = 3{,}7653g(mgal)$$

From the different gravity values obtained, an average peak-to-peak movement of the ice shelf in the range of 0,70–1,65m was calculated.

Discussion

The results obtained at Substation compare favourably with the theoretical average tidal range of 1,2m for this area (*Oceanographic Atlas of the Polar Seas*, 1957). Other tidal observations along the South Atlantic coast of Antarctica are 0,6 to 3,2m (double amplitude) for Ellsworth Station, Weddell Sea (*Thiel et al.*, 1960) and 0,58 to 3,1m in the vicinity of Novolazarevskaya Station (*Dubrovin and Simonov*, 1964).

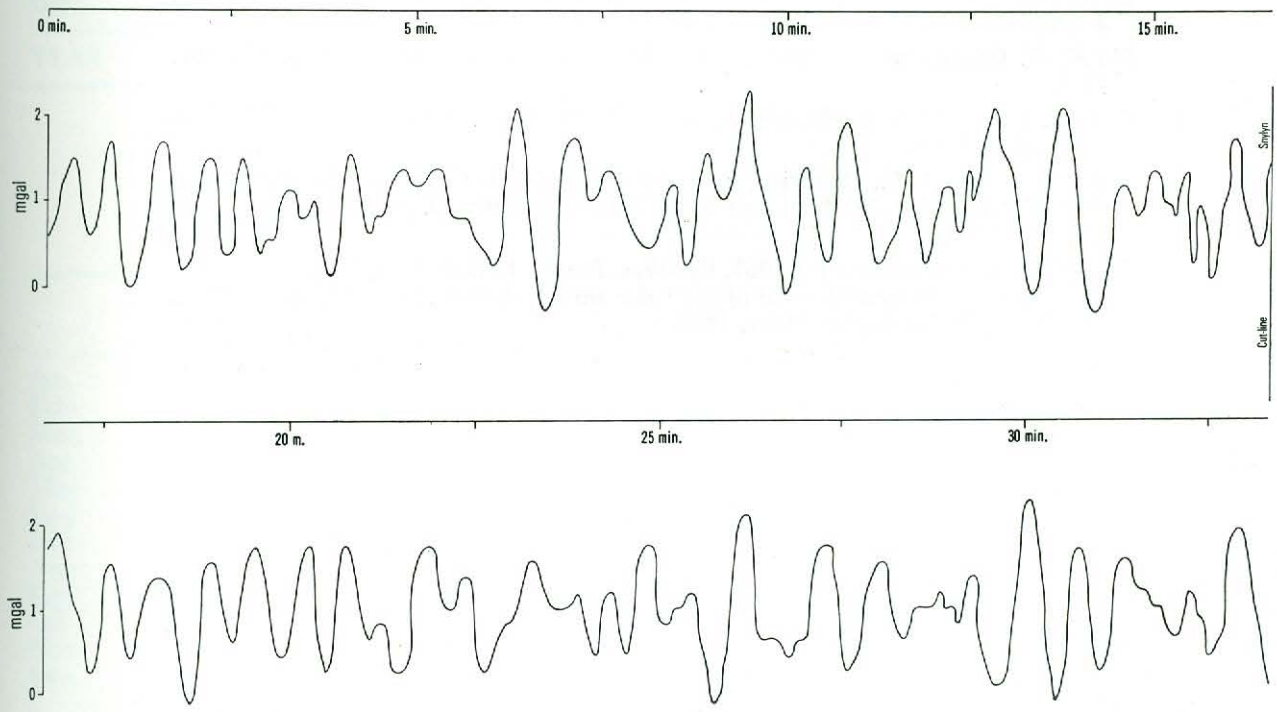

Fig. 3. Graph showing short-period oscillation of ice shelf.

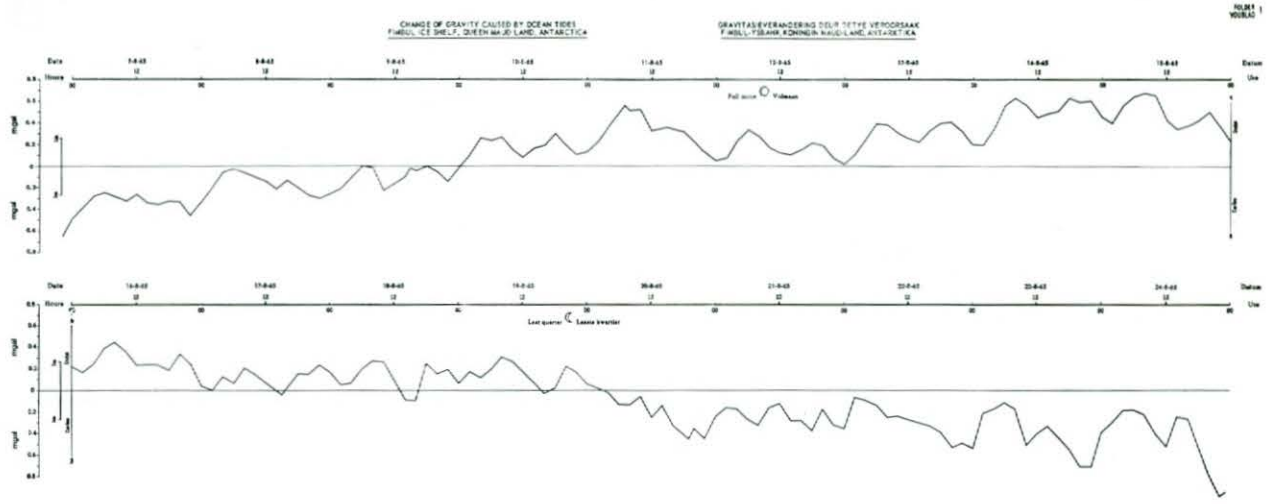

Fig. 4. Graph showing long-period oscillation due to tidal effect.

Acknowledgements

The authors wish to thank Mr R. J. Kleywegt of the Geological Survey, who assisted in the elimination of the excessive instrumental drift and Mr D. C. Neethling, Programme Director, Antarctic Earth Science Project, who made valuable suggestions during the preparation of this paper.

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