16. On "Marginal Channels" along Continental Borders and the Problem of their Origin

By

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ABSTRACT.—Fairly recent oceanographic investigations by Soviet scientists in the sea off the Antarctic continent have shown that a very marked depression exists in the inner part of the shelf area south of Australia. This depression has an orientation parallel to the trend of the coast line and is evidently of the same type as the submarine "marginal channels" or trenches which have been described from various northern coastal regions (off Norway, W. Greenland, N.E. Labrador, N. Ellesmere Land, etc.). The Soviet authors have independently arrived at the same conclusion regarding these phenomena in the southern area as the present writers have in the northern one, namely that the depressions probably indicate the existence of crustal fractures along which the land mass inside them has been uplifted in Cenozoic time. Certain problems concerning the origin of the channels are briefly discussed.

It has been shown (see H. HOLTEDAHL 1958, 1959, O. HOLTEDAHL 1960) that in the inner part of shelf areas outside various northern lands (Norway, W. Greenland, N. E. Labrador, etc.) there exist more or less marked depressions ("marginal channels"). These run parallel to the coast and separate a relatively narrow belt with uneven, rocky floor from the fairly even banks where bedrock is overlain by loose deposits. In other parts of the same shelf regions steep slopes, in line with the inner wall of the longitudinal depressions, lead down to deeper shelf areas, the latter having generally the character of "transverse channels".

These particular features have been taken by the writers as an indication of the presence of crustal fractures, most likely fault lines, associated with the Cenozoic (probably mainly Tertiary) uplift of the high land inside. The inner, irregular shelf area is structurally closely connected with the land mass, which towards the sea has been broken down and levelled, to a great extent by marine and glacial abrasion (skjærgaard area, strandflat etc.).

In this connection the discovery by Soviet scientists of a gigantic marginal depression in the inner shelf area of the Antarctic continent (LISICIN and ŽIVAGO 1957, 1958) is a point of great importance, and it may be of some interest to discuss this marginal depression in comparison with the northern ones mentioned above.[1]

For distances of hundreds of kilometers the Antarctic continental shelf south of Australia (Figs. 1 and 2) can be divided into three morphological parts.

[1] It has previously been known that outside the East Antarctic coasts there exist a number of relatively shallow banks, believed to represent terminal moraines. See, e.g., the map on p. 42 in H.-P. KOSACK: Die Antarktis. Eine Länderkunde. Geographische Handbücher herausg. von Hermann Lautensach. Heidelberg 1955.

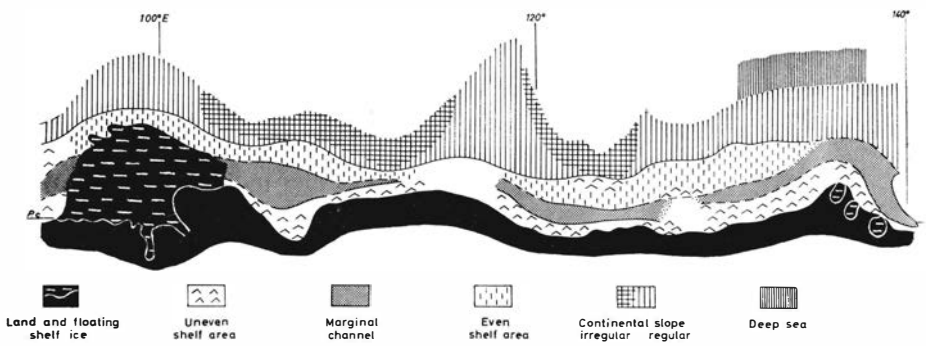

Fig. 1. Continental shelf and slope off East Antarctica, from the Shackleton Shelf Ice eastwards. Distance W.–E. about 2500 km. Redrawn from Fig. 6 in ŽIVAGO and LISICIN 1957.

(1) The inner shelf which is highly irregular and, except for narrow trenches, relatively shallow (less than 200 m deep). (2) The outer shelf which is much more even and regular, and, evidently, covered by loose deposits. The depth is 150–500 m. Locally there occur ridges, running parallel to the coast and probably representing end moraines. (3) A depression which separates the inner and outer shelf areas. The average depth is about 700 m, but locally the depth may be as much as 1400 m. The character of the cross-section varies considerably from place to place, and marked longitudinal ridges and depressions of a second order have been met with.

Owing to insufficient sounding data, it has not yet been definitely proved that the depression is quite unbroken and continuous, but this is believed to be the case. Somewhat west of the Shackleton Shelf Ice the depression seems to merge with the continental slope.

The similarity in general character between this continental shelf area and the northern shelf areas mentioned above seems indeed to be a very striking one. Some profiles crossing marginal trenches are, for comparison, shown in Fig. 3. The depth of the Antarctic marginal depression below the present sea-level, however, generally far exceeds the depth encountered in similar depressions in the northern areas. These have in the Norwegian shelf region a maximum depth of about 250 m, but here the bank areas outside the trenches are usually very shallow, often only about 50 m deep. Off Greenland the maximum depth of the marginal depressions appears to be about 500 m, with a minimum depth of the corresponding bank area of 40–50 m. Off Labrador the maximum depth of the longitudinal trenches is 600 m, with a corresponding minimum bank depth of about 150 m. The beautifully curved trench in the easternmost part of the Labrador shelf with its convexity towards the land is at its greatest depth 300 m, with a minimum depth of the bank of 150 m. The insufficiently known depression off N. Ellesmere Land shows depths of at least 800–900 m, while the banks outside locally have depths of only 60–70 m.

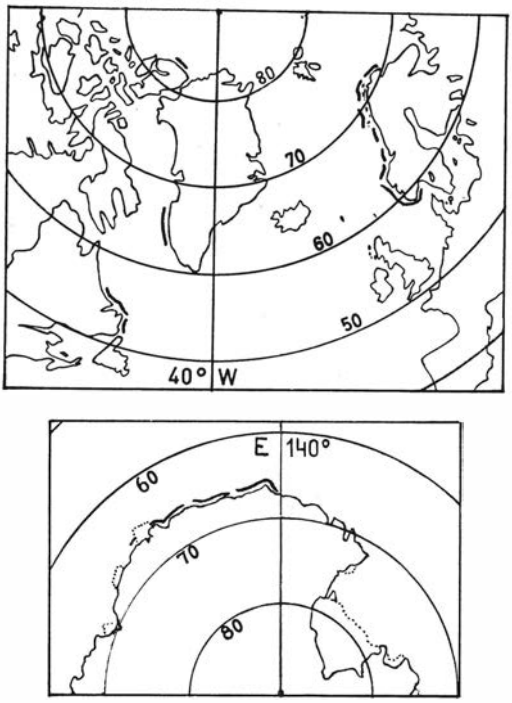

Fig. 2. Maps showing supposed marginal fault lines outside some northern and southern lands, based on the existence of "marginal channels" or steep seaward slopes in corresponding position.

We must bear in mind, however, that the Antarctic shelf area has a considerably greater average depth than the northern shelf areas now discussed.

Considering the origin of the longitudinal depression off the Antarctic continent, the Soviet scientists believe that it has been formed by marginal fractures related to vertical movements of the continent (1957, p. 28, 1958, p. 15) and this general conclusion thus agrees with that of the present writers regarding the northern areas.

As regards the more fundamental cause of the assumed dislocation, LISICIN and ŽIVAGO find it probable that it is connected with the changing ice-loads on the Antarctic continent in Pleistocene time. Considering the features of the northern regions the present writers do not find this explanation very feasible. In the first place the well-known (glacial-)isostatic (and very moderate) land elevation in northern Europe and North America which succeeded the Last Glaciation, does not show peripheral crustal fractures. Furthermore, the general landward dip of the surface of the Scandinavian land mass (and of parts of Labrador) cannot be logically explained on a basis of changing ice-loads alone. In the case of Norway, the subsidence of the "Norwegian Channel" depression off the southwest coast, primarily no doubt a Graben structure and most probably belonging to the same system of marginal fractures as those

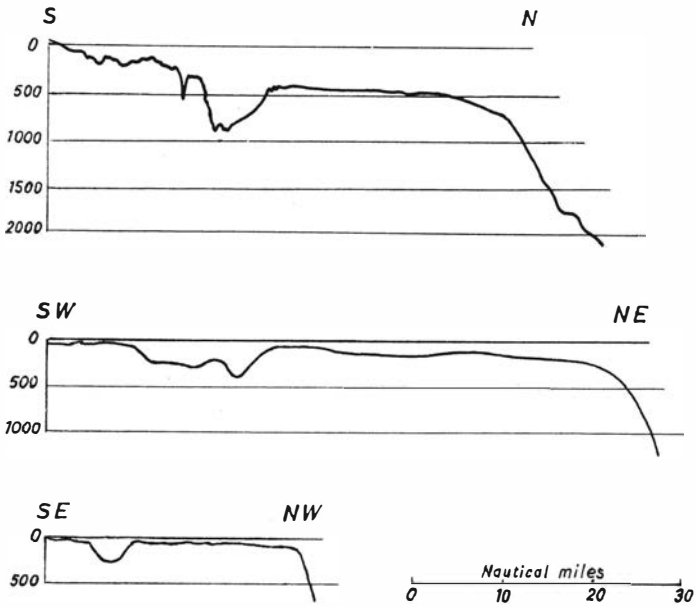

Fig. 3. Profiles of shelf areas with marginal channels. *Above:* from the Sabrina Land–North Land region in the Antarctic. After ŽIVAGO and LISICIN 1937. *Middle:* somewhat east of Makkovik, Labrador (H. HOLTEDAHL). *Below:* off Senja Island, across western part of Sveinsgrunnen bank, northern Norway (O. HOLTEDAHL).

along which the marginal trenches further north have been formed, cannot have any causal relation to glacial isostasy. The same must be said of certain relief features in the shelf area just north of Norway, features bearing a direct relation to the system of lines which farther southwest is marked by marginal channels.

It might be mentioned that marked marginal trenches are known to exist in regions such as southwest Greenland, northeast Labrador, and East Antarctica, where the coast lines on the two sides of oceanic basins show marked parallelism and thus have been of particular interest in the discussion on continental drift. In this connection reference should be made to the hypothetical and very schematical profile, Fig. 36 in DU TOIT's well-known book of 1937, "Our Wandering Continents". If we here replace Baffin Land with Labrador and introduce fault lines just outside the high land masses, the structural picture will be much like that suggested in various Norwegian publications on these problems.

The fact that marginal channels of the type here dealt with have so far been described only from regions which have undergone Quaternary glaciation is no doubt both an important and puzzling one. It has been mentioned (SHEPARD, 1959, p. 106) as an objection to what we might call the tectonic theory. The problem has recently been discussed in a short review by the French geographer,

ANDRÉ GULLCHER (1959), who suggests the explanation that in Tertiary time there existed along the continental borders a "Randschwelle" with a tendency to crack, and that then, during the Quaternary, isostatic (glacial) changes created dislocations in these marginal zones (l.c., p. 349). Possibly an explanation may be found along other lines: that in shelf areas once covered by thick ice masses, pre-existing depressions of either a purely tectonic or a combined tectonic-erosional origin might have been deepened or kept open by glacial processes. In any case it is not easy to see how depressions of the type here dealt with could have been formed by exogenic agencies alone.

There are many problems in connection with the marginal channels. A main point is this that they seem everywhere to separate an uneven rocky ground on the inside from a more even outer belt where rather thick masses of loose deposits evidently exist. One main prerequisite for an advance in our understanding of these most interesting phenomena is a knowledge of the thickness and character of the loose cover in the outer shelf areas under consideration.

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