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**ON FAULT LINES INDICATED
BY THE SUBMARINE RELIEF
IN THE SHELF AREA WEST
OF SPITSBERGEN**

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ON FAULT LINES INDICATED BY THE SUBMARINE RELIEF IN THE SHELF AREA WEST OF SPITSBERGEN

BY

OLAF HOLTEDAHL

A year ago the writer published in this journal¹ an article giving some preliminary results of studies on the continental shelf off the coasts of Norway. In a general map, a system of supposed submarine fault lines was shown — fault lines along which the Scandinavian land-mass is believed to have been lifted up in fairly recent, in Tertiary-Quaternary times. The existence of such lines is indicated by the presence of longitudinal channels, separating the area of banks from that of the rocky land-mass (with the »skjærgård« — skerries — area as its outermost zone) and by the way in which many transverse submarine valleys are abruptly cut off towards the land, along lines lying in the continuation of the said longitudinal channels.

It was maintained that the transverse channels represent the outer, peripheral, remnants of old valleys, the inner parts of which cannot generally be traced any longer because of the uplift and erosion of the land-mass inside the fault line.

At about the same time another article "A New Example of a Submarine Fault Line along a Continental Border"² was published in which it was pointed out that the charts of the district off southwestern Greenland (even if not having enough soundings for the drawing of contour lines) show that also along this coast we have inside the banks longitudinal depressions situated along a remarkably straight line. The writer states that there can be no doubt that there exists along the west coast of Greenland a fracture similar to that which is so well marked in the submarine topography of many parts of the Norwegian shelf. "Along the said line, erosion at a time of lower (relative) sea level, has worked out longitudinal depressions — —" (l. c. p. 93).

¹ Den norske landmasses begrensning mot havet. Norsk Geografisk Tidsskrift, 5, 1935, p. 453.

² Det Kgl. Norske Videnskabers Selskab, Forhandlinger, 8, 1936, p. 91.

Due to other, more pressing, work, the large material of contour maps of the Norwegian shelf, and the accompanying text have not yet been prepared for print, but it is hoped that publication will take place before long. Meanwhile, the writer would like to draw attention to still another example of the same type of submarine relief in a northern region. Quite recently, Norges Svalbard- og Ishavs-Undersøkelser (Director: Adolf Hoel), has published a chart (S 9) of the west coast districts of Spitsbergen, from $76^{\circ} 30'$ to $79^{\circ} 30'$ N. L. The chart is, for the shelf area and the slope outside it, largely based on echosoundings of recent date. At first glance, the chart does not seem to show features very like those now known from the Norwegian coastal areas; a closer study, however, makes it evident that there exists a rather close correspondence with one particular Norwegian district, viz., the Andøy district of Northern Norway, the single district in this country from which Mesozoic strata are known. They occur in a down-faulted area on the east side of the island. Structurally, there is thus a considerable likeness with Prince Charles Foreland in Spitsbergen, where a belt of down-faulted Tertiary sediments occur on the east side, a likeness which was first pointed out by G. de Geer in 1910.¹

In Fig. 1 the submarine relief of a part of the Spitsbergen area, covered by the new chart, is shown; in Fig. 2, the Andøy district with environs. Due to the extremely irregular character of the relief of the skjærgård area of Norway, the 50 m contour line is only locally drawn in Fig. 2. A study of the maps reveals a number of corresponding features, not only as regards the trend of the coast line, but also in the submarine topography itself. To the north, in the Norwegian area, we see a longitudinal channel separating the skjærgård district of Senja Island and the bank outside. This channel belongs to the system of longitudinal depressions above-mentioned. In the Spitsbergen area we have a corresponding depression between the land-mass west of Cross Bay and the bank area outside.

In the Norwegian district we find a well-marked outer boundary of the skjærgård area off Langøy, with, outside it, either a marginal depression, with banks still farther out, or broad transverse channels of the type characteristic of parts of the Norwegian shelf area. Off Andøy there is a relatively shallow, yet distinct depression rather far

¹ Kontinentale Niveauveränderungen im Norden Europas. Extrait du C. R. du XI. Congr. Géol. Intern., p. 854.

to the north, in continuation of the boundary line further south, and this longitudinal depression leads one into the deep submarine valley at the continental slope west of the extreme north of the island. To the south, the depression outside Langøy curves round the southern end of the island, a marked border line between the rocky land-mass and the area outside it proceeding, however, also further towards the SW, off the skjærgård area of Austvågøy.

In the corresponding Spitsbergen area a very striking submarine feature is the broad transverse depression, the deeper part of which, below 250 m, runs from the continental slope to the slope which borders the southern part of the Prince Charles Foreland land-mass towards the west. North of the inner part of this depression a longitudinal channel occurs, with a small bank to the west. Further northwards, just west of the Foreland, the soundings are too few to allow of a regular drawing of contour lines being taken; but at several places in the continuation of the depression just mentioned, greater depths have been sounded near the land than farther out. In the writer's opinion, a fault line most probably passes northwards as suggested in Fig. 1.

Mr. B. Luncke, of Norges Svalbard- og Ishavs-undersøkelser, has kindly drawn the writer's attention to the fact that two echo diagrams, running W—E west-north-west of the mouth of Kings Bay, show in the outer part, very near to the continental slope, a distinct, sharp notch indicating a relatively very narrow and deep groove in the sea bottom — a groove running about N-S in the area marked by an **x** on the map, Fig. 1. This groove may possibly represent the continuation of the supposed fault line west of Prince Charles Foreland.

At the southern end of the Foreland, the longitudinal depression of the west side curves eastwards and is joined by the Foreland Sound channel, a depression for which the geological structure indicates a Graben character. As to the district farther south there is, in the continuation of the Foreland Sound channel, a marked longitudinal depression, as seen just south of the mouth of the Ice Fjord, with a bank outside it.

The general geographical character of the coast line and of the areas just outside it, is largely different in the two regions here considered, a feature which to some extent is due to the fact that in Spitsbergen glaciers still fill up many depressions (down to the coast line), but to some extent also to the different resistance of the rocks to marine

abrasion, the Spitsbergen district made up of sedimentary, the Norwegian one of hard plutonic, rocks. In other respects there is, as stated above, a marked correspondence in the submarine relief. However, it must be emphasized that except for the purely marginal features, the geological structure of the two regions is undoubtedly very different. Spitsbergen belongs to a part of the crust that has been very mobile in Cainozoic time, with fault or flexure phenomena (mainly parallel to the old Caledonian trend lines) occurring far inside the present west coast, while in the Scandinavian region the land-mass has probably been lifted up more or less as a compact block, although in the district particularly shown in Fig. 2, dislocations have cut into the land area well inside the main marginal border lines. This district is the only one in northern Norway where the marginal fault line seems to join the continental slope.

The loose boulder of a conglomerate containing Neocomian fossils, found by Th. Vogt¹ on the shore line of a small island at about the northern end of Austvågøy, is thought by the said geologist to be of a more or less local origin, and possibly to have its home in the Langøy district, where a characteristic diorite rock, similar to that of a large pebble occurring in the conglomerate, has a wide distribution. Comparing with the Spitsbergen area, one might perhaps point to the possibility of Post-Paleozoic sediments having once occurred, or to some extent still occurring, along a zone from the Eidsfjord district and northwards to the known Andøy deposit, because such a zone, geographically, would correspond to the Foreland Sound area of subsidence. On the other side, considering the different structural character of Spitsbergen and Norway just emphasized, it may be equally possible that there has never existed in the Norwegian district such a marked belt of down-faulting as in the northern area. As a matter of fact, we see in Spitsbergen how the channel west of Cross Bay, the Foreland Sound depression and the longitudinal channel south of the mouth of the Ice Fjord, lie more or less along the same straight line. As to the last mentioned channel, the fault line which probably is responsible of its existence, may be a continuation of the fault line which, according to Orvin,² crosses the outermost, south-western

¹ J. P. J. Ravn og Thorolf Vogt, Om en blok av Neocom fra Hanø i Vesteraalen. Norsk Geologisk Tidsskrift, 3, 1915, p. 1.

² Geology of the Kings Bay Region, Spitsbergen. Skrifter om Svalbard og Ishavet, Oslo 1934, map p. 82.

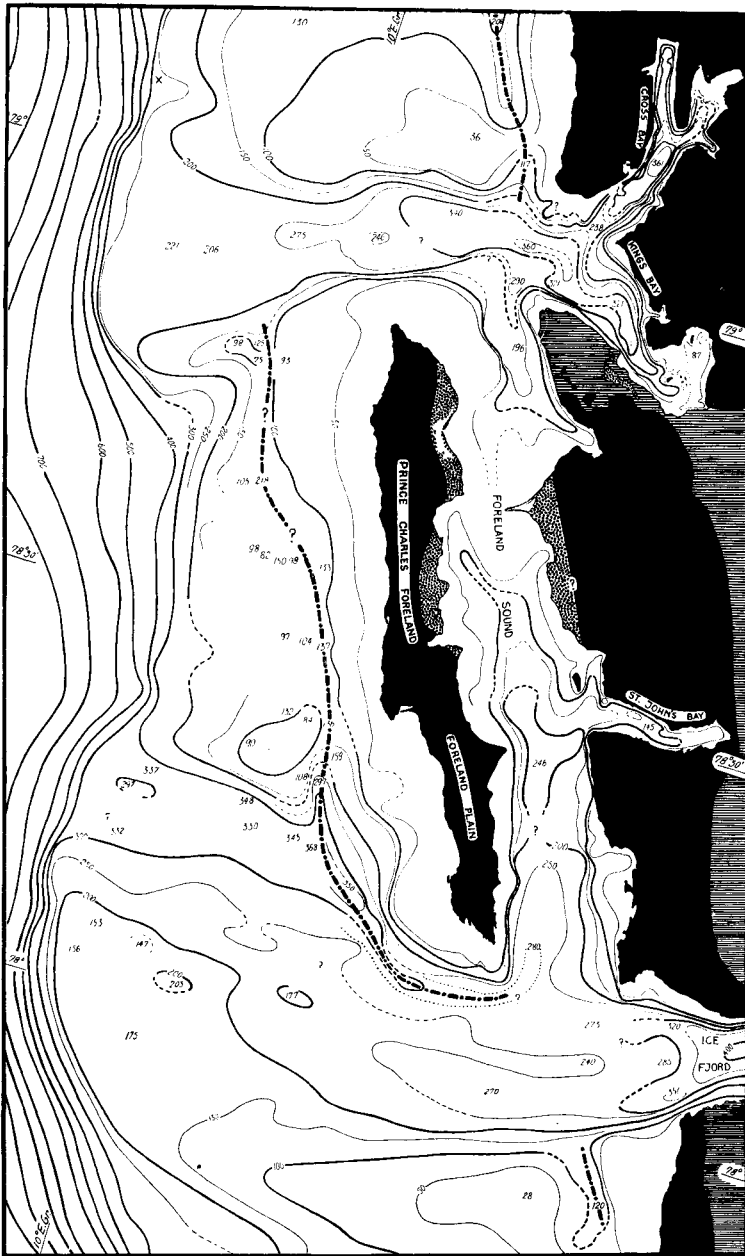


Fig. 1. A part of the Spitsbergen shelf area, with supposed submarine fault lines especially marked. Depths in meters. Black: Pre-Devonian rocks; ruled: Upper Paleozoic; dotted: Tertiary. The glaciers are not shown.

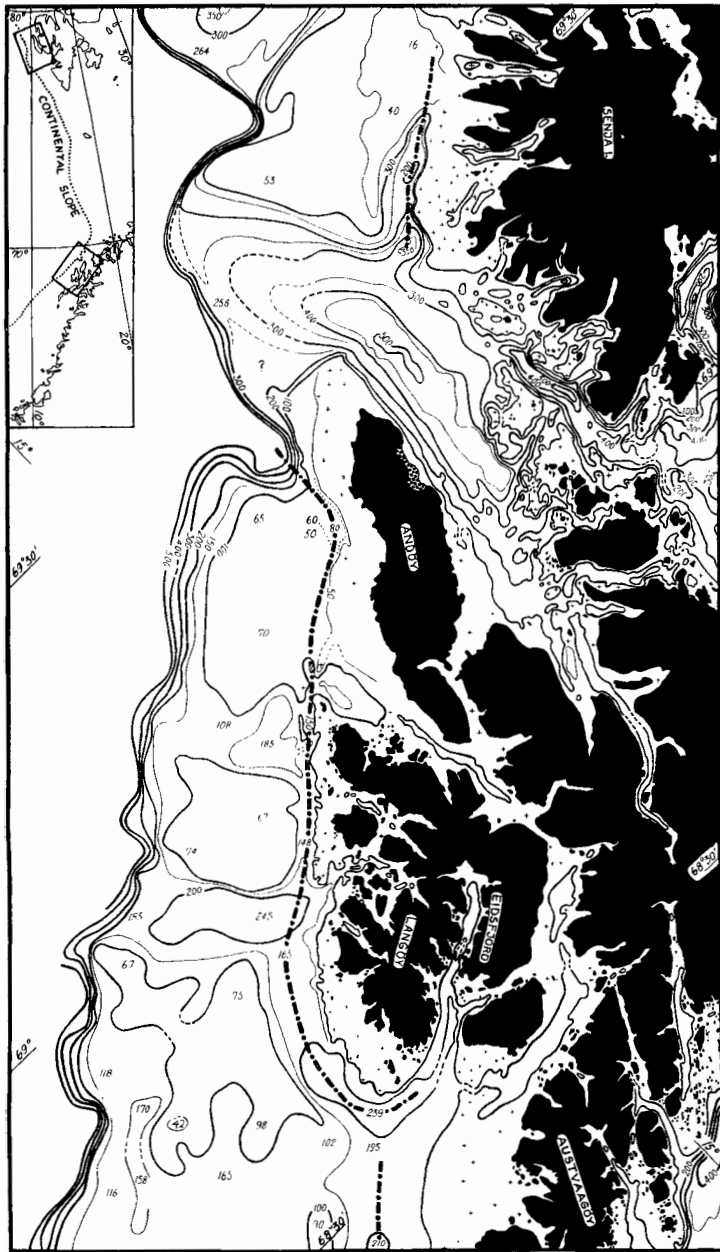


Fig. 2. A part of the Norwegian shelf area, with supposed submarine fault lines. Crosses mark shoals of depths less than 25 m. Black: Pre-Devonian rocks; dotted: Mesozoic.

part of the peninsula north of Bell Sound, with some down-throw on the west side. The submarine relief in the more southern part of the Spitsbergen shelf area included in the new chart (but lying outside the map area of Fig. 1) seems to indicate that another fault line exists much farther out, with no parallel feature seen in the Norwegian district.

The writer does not wish here to enter upon any more general discussion concerning the history of the shelf areas in question, the effect of glacial erosion etc. He might, however, where the Spitsbergen area is concerned, just mention that the irregular character of the depression south-west of the southern part of Prince Charles Foreland might be explained by the assumption that we have here the peripheral part of an old valley which has been cut off by the postulated dislocation, a valley, the form of which, especially on the south side, has been largely altered by erosion from ice masses streaming out from the Ice Fjord and the Foreland Sound depression.

The object of the article has been to show that in the coastal districts of Spitsbergen, a region where, with certainty, we know Cainozoic faulting to have been very active, submarine longitudinal channels occur strongly reminiscent of those which are so typical of so many Norwegian west coast districts. In the writer's opinion, the existence of submarine longitudinal fault lines may now be said to have been proved, or, at any rate, made probable, in the shelf areas of three northern regions, viz. off the west coast of Scandinavia, of Spitsbergen and of Greenland. The conclusion, therefore, seems very likely that corresponding lines also occur along other high coasts. The writer might in this connection point to the existence of relatively deep water inside a bank off the Labrador coast, just east of Hamilton Inlet (British Admiralty chart No. 1422). In the map of the shelf off New England and Nova Scotia, published by Shepard, Trefethen and Cohee in 1934,¹ the submarine topography might possibly indicate the existence of a fault line along the inner slope of Georges Bank, continuing north-eastwards just outside Nova Scotia, inside the banks of this district. An area where features similar to those of Spitsbergen might perhaps be expected, lies off the Scottish west coast. The geological structure of Great Britain and Spitsbergen show a number of corresponding features.² The old rock-mass of the Hebrides,

¹ Origin of Georges Bank. Bull. Geol. Soc. America, 45, p. 281.

² O. Holtedah, Some Points of structural Resemblance between Spitsbergen and Great Britain etc. Avh. utgitt av Det Norske Videnskaps-Akademi i Oslo, 1925, No. 4.

with Post-Paleozoic rocks in the sound to the east, corresponds, in such a comparison, to Prince Charles Foreland. However, in the west of Scotland, as in the adjacent oceanic areas (e. g., in the Færøy Islands) Cainozoic time is characterized largely by volcanic activity, which necessarily will cause a topography different from that which is brought about by a simple breaking up of the crust, without accompanying volcanic phenomena. Along the east coast of Scotland, between Peterhead and Dundee, the charts show a channel-like depression, yet only slightly marked, with shallower sea outside it. East of Peterhead, the channel has a depth of more than 60 fathoms, with 31 and 35 just outside. In any case, submarine features which might indicate the existence of marginal fault lines, should be looked for along all oceanic coasts bordering land of considerable height.

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