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ATLANTIC-TYPE CONTINENTAL MARGINS: DISTINCTION OF TWO BASIC STRUCTURAL TYPES *

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ABSTRACT

Large areas of the Atlantic ocean continental margin do not fit with the classic atlantic type continental margin model in which only simple geometrical arrangements have been distinguished. A new structural type, related to marginal offsets and corresponding fracture ridges is fundamentally different from the classic margin. Consequently, it is proposed to distinguish the rifted atlantic-type margin, the pacific-type margin and the transform faulted or strike-slip margin as three different and fundamental types of continental margins.

Atlantic-type or seismically inactive continental margins are believed to result from continental break-up, followed by sea floor spreading and subsidence. Several models of evolution, often based on the gulf of Suez-Red Sea-East African rift valleys present day system, have been proposed (Heezen, 1968; Dewey and Bird, 1970; Falvey, 1974). They all imply an initial distension, resulting in the formation of grabens with a coarse clastic continental sedimentation: after a period of some tens of million years, a marine sedimentary progradation (commonly initiated with evaporite deposits) and a regional subsidence occur and tend to give the present continental margin configuration. Second-order phenomena, such as normal faulting, carbonate platform construction, gravity and salt tectonics may, later, concur to modify the structures of the sedimentary cover resting on a block-faulted and collapsed basement (Hsü, 1965) believed to be around the Atlantic of Precambrian or Paleozoic age. The models essentially differ on the nature of the deep mechanisms involved in the initial crustal thinning process and in the following subsidence (Dewey and Bird, 1970, Falvey, 1974, Hsü, 1965, Bott, 1971, Drake **et al.**, 1968. Sheridan, 1969). Three simple types of Atlantic continental margin development have however been distinguished (Falvey, 1974) on the basis of the existence, or not, of pre-rift and rift valley basins. Nevertheless the only geometrical arrangement which has been considered until now is the one in which the continental margin is parallel to the sea-floor spreading axis.

A schematic map of the Atlantic (figure 1) shows that large areas of the Atlantic continental margins, namely along large continental offsets, do not correspond to such a simple geometry and on the contrary that the spreading oceanic crust motion is parallel to the continental boundaries. In such areas the formation

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Fig. 1 — General schematic map of the Atlantic ocean showing the important and known fracture zones and their prolongations. Dotted areas indicate the limit of the 2 000 m line. Hatching shows the area of continental margin structurally controlled by marginal fracture ridges. Black triangles indicate the approximate position of the mid-oceanic ridge.

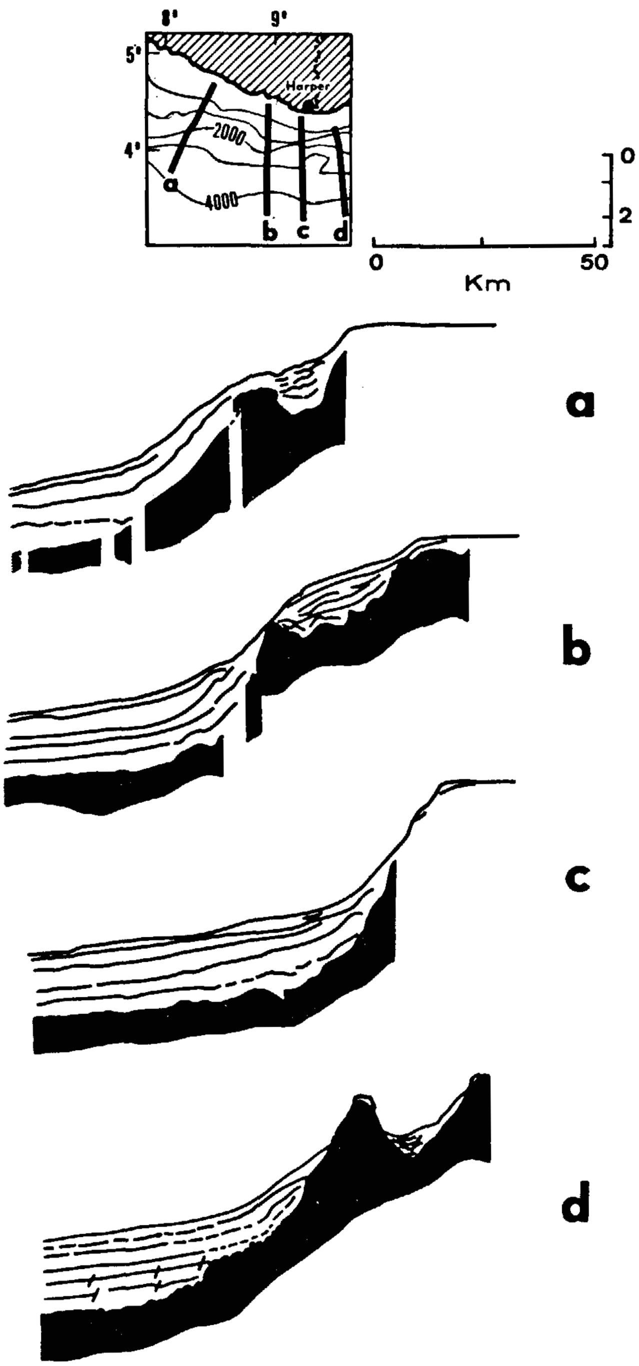

Fig. 2 — Four interpretations of seismic lines, across the Liberian continental margin and the Saint-Paul Fracture zone prolongation. Acoustic basement is in black (simplified from Schee *et al.*, 1974). Note the existence of marginal ridges intersecting the margin and bordering to the south several marginal basins. Vertical scale is the same as figures 2, 3, 4, 5.

of marginal fracture ridges, produced first by shearing between sections of continental crust, have been postulated (Le Pichon and Hayes, 1971). Such ridges may have constituted the basic structural framework of continental margins (Francheteau and Le Pichon, 1972).

Recent surveys (Behrent **et al.**, 1974; Schlee **et al.**, 1974) off Liberia have indicated that the continental margin, south of this coutry, is intersected by one or more oceanic fracture zones. Their trends are expressed by a series of aproximately East-West trending basement rises (figure 2) intersecting the slope south of the city of Harper and bounding, to the south, several small marginal basins. Eastward of Harper, the slope is very steep and almost devoid of sediment. An identical structure characterizes the prolongation of the Romanche fracture zone into the continental margin between Ivory Coast and Ghana (fig. 3). There, the path of the fracture zone is marked by a large basement rise (Arens, 1971; Delteil **et al.**, 1974; Mascle, 1975; Emery **et al.**, in press) known as the Ivory Coast rise. This rise is bounded to the South by a 150 km-wide marginal plateau, which narrows to the east where it is finally relayed by the triangle-

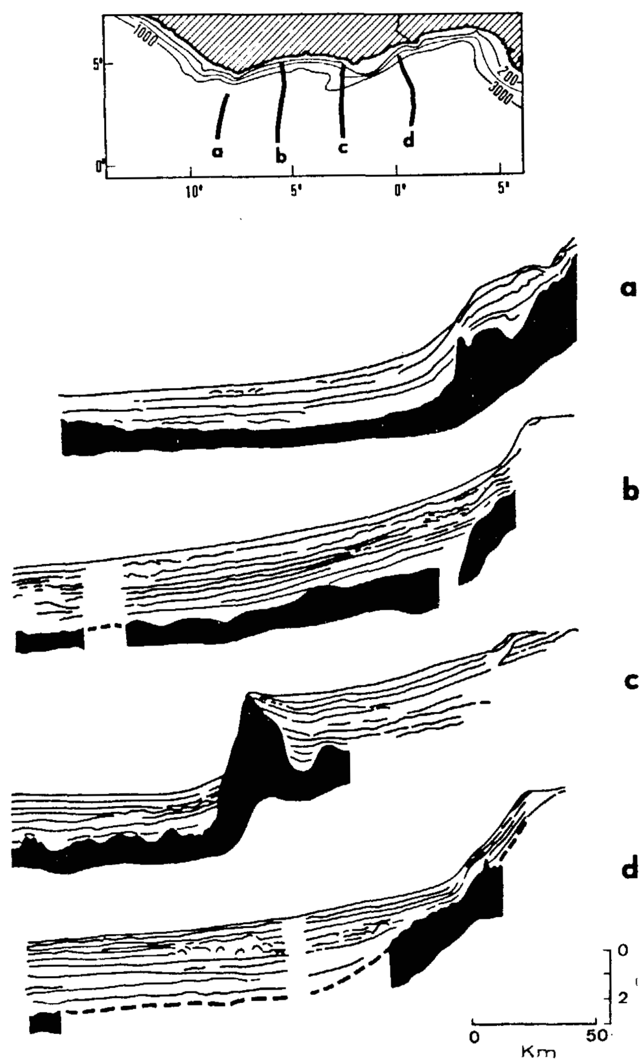

Fig. 3 — Four interpretations of seismic lines across the Ivory coast margin showing the Saint-Paul Fracture zone (a, b) and Romanche Fracture zone (c, d) prolongations into the margin. Note (c) the large marginal basin narrowing eastward (d) and the steep slope and narrow ghanean continental shelf (simplified from Emery *et al.*, in press).

shaped and narrow Ghanean shelf. Dredging and photographs taken along the Ghanean slope also indicate the absence of recent sediment and the presence of phyllitic shales of probably Paleozoic age (Mascle and Shmit, 1974).

South of South Africa, the general shape of the shelf is strikingly similar to the one of the Ghanean shelf. Actually, geophysical work carried out on the South African margin has shown (fig. 4) the presence of complex basement rise structures similar in all respects to the one we mentioned south of the Liberia and Ivory Coasts. Those basement rises, which equally border small marginal basins to the south, appear to be connected to one or more fracture zones (the Agulhas fracture zone) (Francheteau and Le Pichon, 1972; Larson and Ladd, 1973; Emery et al., 1975) as previously postulated. On the opposite side of the South Atlantic the Falkland fracture zone is considered to be the conterpart of the Agulhas Fracture Zone (Francheteau and Le Pichon, 1972). We may consequently expect to find similar structures on the northern Falkland Argentinian margin. Effectively, figure 5 (Lonardi and Ewing, 1971) shows the presence of a very important basement scarp bordering to the north the Falkland plateau.

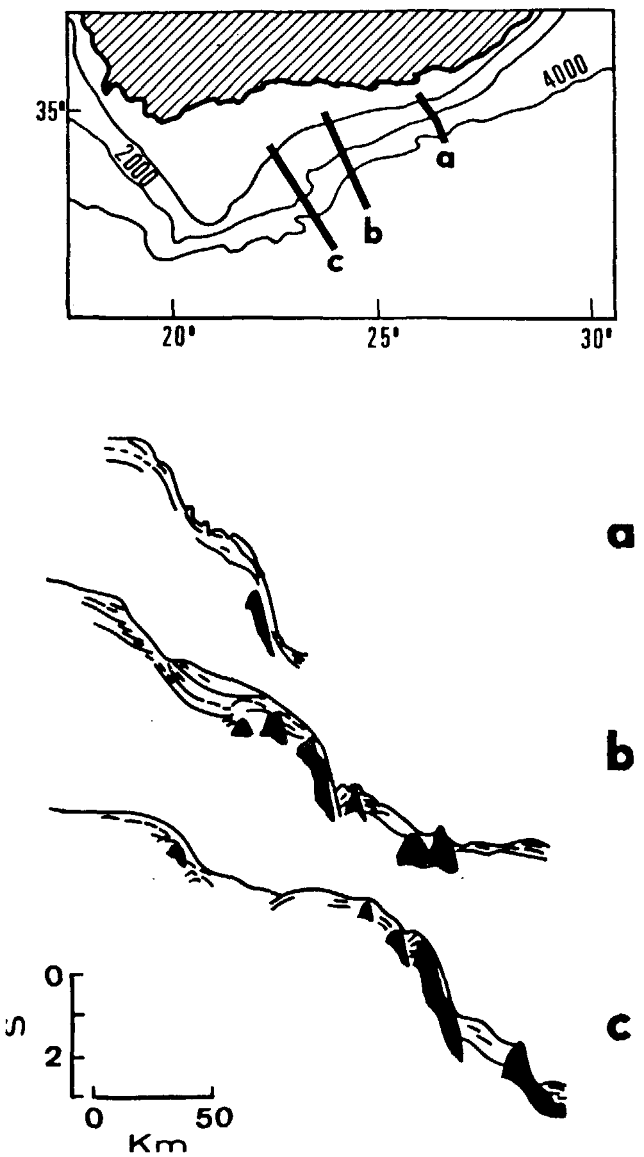

Fig. 4 — Three seismic lines interpretation (simplified from Scrutton, 1973, and from Scrutton and Duplessis, 1973) across the southern South African margin. The overall structure is strikingly similar to the one of figures 2 or 3, including the presence of marginal fracture ridges bounding to the south a series of marginal basins.

Around the South Atlantic, other marginal areas are presumably structurally controlled by similar basement ridges. The seismic reflection evidence from them is not so good as in the case of the southern limit of the São Paulo plateau and of part of the northern Brazilian margin. In both cases, possible tectonic readjustments may later have altered the original geological structures.

Except for the southern Newfoundland area, no major marginal offsets exist in the North Atlantic similar to those of the South Atlantic (Le Pichon and Fox, 1971). Nevertheless, south of Grand Banks several indications such as the presence of a sedimentary ridge underlain by complex basement ridges (Auzende et al., 1970) associated with the Newfoundland fracture zone as well as evidence of strike slip movements in the deep sedimentary sequences of the Grand Banks (Amoco, 1973), may indicate that the structure of the continental margins is, as a whole, comparable to the structures we just described in different areas around the South Atlantic. It should be noted that Keen and Keen (1973) already remark that «the structures of the southern margin of Grand Banks could have been caused by slippage along opposing continental margins».

South of Greenland, the existence of the Farewell fracture zone has been interpreted in relation with an opening phase of the Labrador sea during upper Cretaceous-Paleocene time (Le Pichon et al., 1971). This basement feature, capped by a sedimentary ridge, and extending southwest of Cape Farewell may indicate that in this area the structures of the Greenland margin have been controlled by strike slip motions during the initial opening of the Labrador sea. A new reconstruction of the Norwegian sea has recently been proposed (Le Pichon et al., 1974). It seems interesting to remark that the relative arrangement of both continental blocks, Greenland on one side and northern Europe

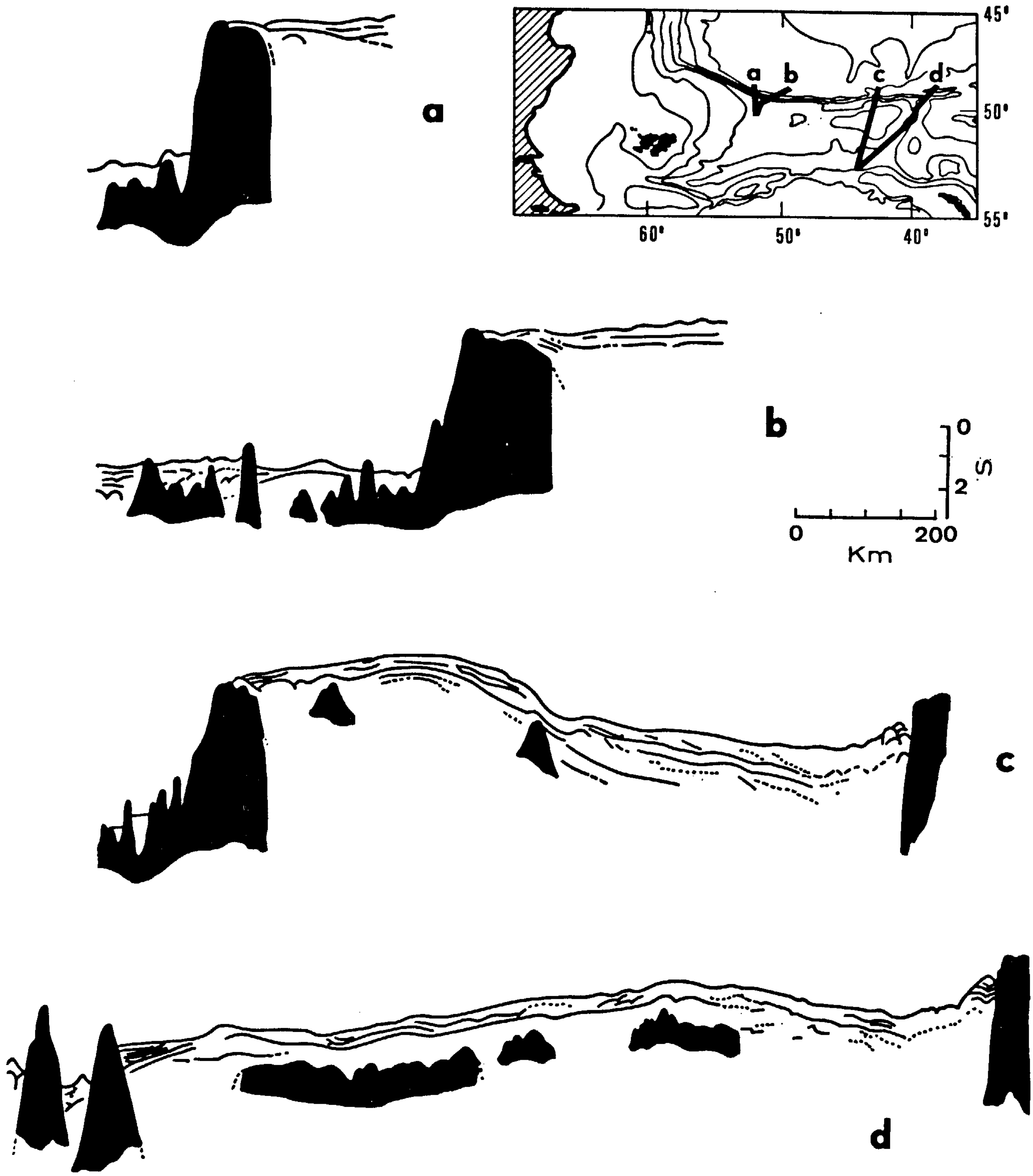

Fig. 5 — Interpretation of seismic lines across the Falkland plateau and scarp (simplified from Lonardi *et al*., 1971). Although much more developed that its probable african counterpart, maybe because of the proximity of the Sandwich islands arc), the Falkland scarp appears to be first a basement ridge (d, c, b) bounding to the north a large plateau (the Falkland plateau) and then (a) to constitute the steep slope of the Argentinian continental margin.

(including Norway, Barents sea and Spitzbergen) on the other side, is strikingly comparable to the Tertiary disposition of the Equatorial Atlantic between Brazil and the gulf of Guinea. This suggests that the continental margin off Spitzbergen may have an overall structure comparable to the well-known structures of the northern gulf of Guinea's continental margins.

In this respect, published profiles (Malod et al., in press, Talwani and Eldholm, 1974) across the Spitzbergen margins indicate the existence of a large sedimentary basin, narrowing to the North and bounded to the West by the foot hills of the Atka ridge or its associated fracture zones.

Thus, we have evidence all around the Atlantic of a particular type of Atlantic continental margin, essentially related to the presence of large marginal offsets and to an initial opening motion which is approximately parallel to the continental crust instead of being perpendicular. Such a structural type appears fundamentally different from the classic rifted Atlantic continental margin and could be named transform faulted margin as already proposed by Keen and Keen (1973) or better, strike-slip continental margin. This new type should be considered as a fundamental distinction of continental margin or the active Pacific-type continental margin.

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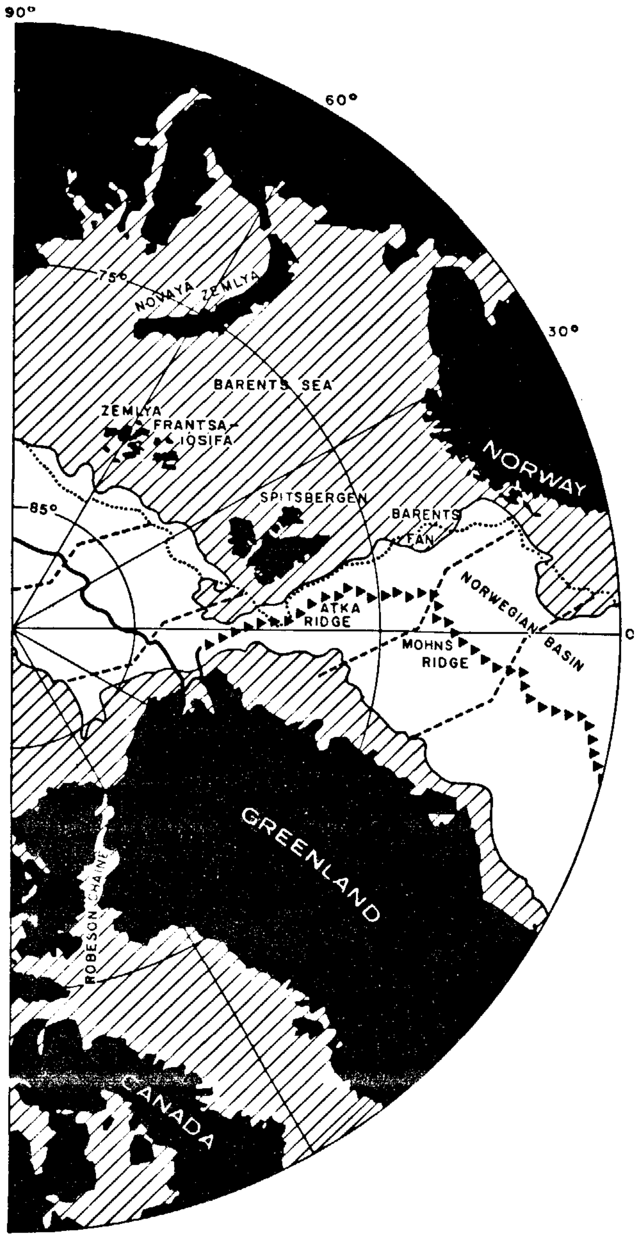

Fig. 6 — Polar projection of the northern Norwegian sea (simplified from Le Pichon *et al.*, in press.) Hatching indicate the areas less than 2 000 m depth; black triangle the Mohns and Atka ridges; dashed lines the theoretical opening flow lines. Note that the general arrangement of both continental areas (northern Europe and Greenland) is strikingly comparable to the arrangement between northeastern Brazil and gulf of Guinea during Cenozoic times. This suggests that the Spitzbergen margins, as a whole, has a structure comparable to the structure of Liberia to Ghana continental margin.

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