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Palinspastic reconstruction of the opening of the NE Atlantic: differential sea-floor spreading and resulting deformation of the NW European Margin

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The NE Atlantic Ocean opened progressively between Greenland and NW Europe during the Cenozoic. Sea-floor spreading occurred along three ridge systems: the Reykjanes Ridge south of Iceland, the Mohns Ridge north of the Jan Mayen Fracture Zone (JMFZ), and the Aegir and Kolbeinsey ridges between Iceland and the JMFZ. At the same time, compressional structures developed along the continental margin of NW Europe, but apparently not on the East Greenland Margin. We therefore investigate how compressional deformation of the NW European Margin may have resulted from variations in the amount and direction of sea-floor spreading along the various ridges.

One of the main assumptions of the theory of plate tectonics is that all lithospheric plates are rigid. However, reconstructions of the opening of the NE Atlantic Ocean, on the basis of two rigid plates (Eurasia and Greenland), lead to gaps and overlaps between the plates. Furthermore, the oceanic Jan Mayen Segment, between Iceland and the JMFZ, had a complex spreading history, including progressive separation of the Jan Mayen Microcontinent (JMMC) and a ridge jump from the Aegir Ridge to the Kolbeinsey Ridge. A subdivision of the NE Atlantic Ocean into micro-plates improves the fits, yet it remains difficult to reconstruct a simple spreading history for the Jan Mayen Segment using Euler rotation poles alone.

In order to reconstruct the complex spreading history of the NE Atlantic and to study the evolution of the European Margin during sea-floor spreading, we have developed a method for palinspastic reconstruction of the opening of an ocean, using magnetic anomalies and fracture zones. We first subdivide the oceanic domain into a finite number of blocks, lying between magnetic anomalies and fracture zones. Our iterative least-squares method then minimizes the gaps and overlaps between the blocks. This yields the rigid translations and rotations of the blocks. Thus the method provides a full pattern of displacement for all material points, allowing us to calculate the spreading rates of the ridges and strike-slip displacements along the main oceanic fracture zones.

Our model ensures a good fit of the magnetic anomalies for the complex Jan Mayen Segment and predicts differences in direction and rate of spreading between the Reykjanes, Kolbeinsey/Aegir and Mohns ridges. This differential sea-floor spreading generated relative rotations and displacements between the oceanic segments. We have determined two main periods of left-lateral strike-slip deformation along the main oceanic fracture zones: (1) from Early Eocene to Late Oligocene, along the Faeroe Fracture Zone; and (2) from Late Eocene to Early Oligocene, as well as during the Miocene, along the JMFZ. Such left-lateral motion and the relative rotation between the oceanic segments are compatible with the development of inversion structures on the NW European Margin at these times. The driving forces may have come from the Iceland Mantle Plume, which appears to have been in a position to generate differential sea-floor spreading along the NE Atlantic and resulting deformation of the NW European margin.