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Ridge-plume interaction and differential spreading along the northern North Atlantic ridge and resulting Cenozoic compressional deformation of the NE Atlantic margin

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The northern North Atlantic ocean and its adjacent continental margins have specific and unusual features: association of the ridge with a major mantle plume, a history of ridge jump and extinction, and intraplate deformation on the margins (inverted basins and compressional domes). Reconstructions of the opening of the North Atlantic ocean, on the basis of two rigid plates (Eurasia and Europe), lead to unacceptable misfits. Furthermore, plate velocities vary significantly across the Jan Mayen Fracture Zone. However, a subdivision of the North Atlantic ocean into micro-plates leads to better fits.

We have developed a method for palinspastic reconstruction of the opening of the northern North Atlantic ocean, using magnetic anomalies. Instead of traditional Euler poles, we have used an iterative least-squares method, which minimizes the gaps and overlaps between conjugate anomalies. For this purpose, we have subdivided the northern North Atlantic region into a finite number of oceanic blocks, lying between magnetic anomalies and fracture zones. Minimization of the gaps and overlaps involves rigid translations and rotations of the blocks. We have tested various restoration models, (1) either on a plane that is tangent to the Earth's surface or on a sphere, and (2) assuming that either the European side of the ridge or Greenland is stationary. We thereby obtain a full pattern of displacement for all material points, allowing us to calculate mean spreading rates and strike-slip displacements along the main fracture zones.

Our reconstructions show that the spreading history of the Aegir ridge was different from those of the nearby Mohns and Reykjanes ridges. The curvature of the Aegir ridge results from variations in the direction and rate of spreading. The spreading rate increased significantly between anomalies 13 and 15 (late Eocene to early Oligocene), for all ridges and particularly for the Aegir ridge (up to 52 mm/y). Furthermore, the rates were greater in the northern part of the Aegir ridge than in its southern part, triggering a rotation of the Aegir zone, relative to the northern Mohns and southern Reykjanes zones. This relative rotation generated left-lateral strike-slip motions along the Jan Mayen and Faeroe fracture zones (up to 70 and 84 km, respectively). The late Eocene to early Oligocene was one of the main periods of inversion on the continental shelf of N.W. Europe, especially in the Faeroe-Rockall-Shetland area and at the ends of the Jan Mayen and Faeroe fracture zones. This was also the approximate time when the Iceland plume was on the eastern margin of Greenland, close to the Aegir ridge, and started to pulse. During the Oligocene, the ridge moved above the mantle plume, spreading at the Aegir ridge decreased progressively until it ceased totally, and the Kolbeinsey ridge took over. Since 20 Ma, our results show variations in spreading rates between the ridge systems, north and south of the Jan Mayen Transform Zone (JMTZ). This generated strike-slip motions along both eastern and western parts of the JMTZ. The Miocene was also a period of inversion on the Norwegian margin at the ends of the JMTZ and of regional exhumation in Greenland and Scandinavia.

We therefore suggest that the interaction of the Icelandic mantle plume with the North Atlantic ridge was responsible for (1) differential seafloor spreading in the North Atlantic, in the Late Eocene to Early Oligocene and in the Miocene, and (2) for some of the post-rift deformation on the continental shelf of N.W. Europe.