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Differential seafloor spreading of the North Atlantic and consequent deformation of adjacent continental margins

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One of the main assumptions of the theory of plate tectonics is that all plates are rigid. However, in some plate reconstructions, the fits improve if the continents deform. Moreover, along parts of the North Atlantic continental margins, there is good evidence for post-rift deformation, in the form of inverted basins and compressional domes. Possible causes of these features are (1) tectonic stress from the Alpine orogeny, (2) ridge push, (3) a mantle plume under Iceland, and (4) differential spreading at mid-oceanic ridges. Here we investigate the last of these possibilities, focussing on the spreading history of the Reykjanes, Aegir and Mohns ridges. In particular, we consider jumps in plate velocity across the main fracture zones, and their possible effects on Tertiary deformation of the continental margins.

We have reconstructed the opening of an area of the northern North Atlantic, 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 in a plane that is tangent to the Earth's surface. 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. The algorithm converts these motions into rotations on a sphere. Thus we obtain a palinspastic restoration of the opening of the North Atlantic, including the full pattern of displacement of all material points. The pattern depends on the kinematic boundary conditions for the restored area. For example, we have investigated what happens if the western side of the area is rigid, whereas the eastern side is deformable. Our reconstructions then show that the spreading history of the Aegir ridge was different from those of the nearby Mohns and Reykjanes ridges. In the late Eocene to early Oligocene, there was a change in the direction and rate of spreading of the Aegir ridge, so that its eastern side rotated relative to the northern Mohns zone and southern Reykjanes zone. This generated strike-slip displacements along the Jan Mayen Fracture Zone and the Faeroe Fracture Zone. The late Eocene to early Oligocene was also 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. We therefore suggest that differential seafloor spreading in the North Atlantic was responsible for some of the post-rift deformation on the continental shelf of N.W. Europe.