Revealing tectonic evolution across the Northeastern Flemish Cap-Goban Spur margin

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In past years, a good understanding of the structure and tectonics of the Flemish Cap and the Goban Spur margin has been obtained based on seismic data, potential field data, and borehole data. However, due to limited data coverage and quality, the rift-related domains along the margin pair have remained poorly defined and their architecture has been primarily delineated on the basis of a small number of co-located 2-D seismic profiles. In addition, according to previous studies, the geophysical characteristics (e.g. velocity structure, crustal thickness, seismic patterns, etc.) across both the margins are strikingly different. Furthermore, from restored models of the southern North Atlantic, some scholars argue against the linkage of the Goban Spur and the Flemish Cap, questioning the widely-accepted “conjugate” relationship of the two margins. However, these restored models are mainly dependent on potential field data analysis, lacking seismic constraints, particularly for the Irish Atlantic Margin.

In this study, new long offset 2D multichannel seismic data, acquired in 2013 and 2014 by Eni Ireland for the Department of Communications, Climate Action & Environment of Ireland, cover the shelf, slope, and deepwater regions of the offshore Irish Atlantic margin. Combining these with seismic reflection data at the NE Flemish Cap, seismic refraction data, DSDP drilling sites, gravity and magnetic maps, crustal thickness maps, and oceanic isochrones, we integrate all constraints together to characterize the structure and evolution of both margins. These geophysical data reveal significant along-strike structural variations along both margins, and aid to delimit five distinct crustal zones related to different rifting stages and their regional extents. The geometries of each crustal domain are variable along the margin strike, probably suggestive of different extension rates during the evolution of the margin and/or inherited variations in crustal composition and rheology. Particularly, the along-strike exhumed serpentinized mantle domain of the Goban Spur margin spans a much wider (~42 - 60 km) area while it is much narrower (~25 km) at the NE Flemish Cap margin. In the exhumed domain, only peridotite ridges are observed at the Flemish Cap, while both peridotite ridges and a wide region of exhumed mantle with deeper basement are observed at the Goban Spur, indicative of a more complex evolutionary model than previously thought for both margins. Plate reconstruction of the Goban Spur and the Flemish Cap using GPlates reveals asymmetry in their crustal architectures, likely due to rift evolution involving more 3-D complexity than can be explained by simple 2-D extensional kinematics. In spite of uncertainties, the crustal architecture comparison between the two margins provides 3D seismic evidence related to the temporal and spatial rifting evolution on both sides.