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From continental hyper-extension to seafloor spreading: New insights of the Porcupine Basin from wide-angle seismic data

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Exploring the deep structure and the sedimentary stratigraphic record of rift basins plays an important role in understanding the geological processes of their formation. The Porcupine Basin is a large V-Shaped sedimentary basin offshore Ireland of Late Palaeozoic to Cenozoic age, which acts as a natural laboratory to study continental rifting due to the fact that different rifting stages from north to south along the rift axis. Here we investigate the crustal structure and sedimentary stratigraphy of the Porcupine Basin along three wide-angle seismic profiles (two across the basin axis and one along) and thirteen seismic reflection profiles. Both refractions and reflections recorded by OBSs(Ocean Bottom Seismometers) are inverted jointly for a travel-time tomography, following a layer stripping strategy. The three P-wave velocity models clearly image the deep structure of the basin for the first time and we interpret them in the context of coincident seismic reflection profiles.

Our results revealed three distinct crustal domains along rifting axis: southward hyper-extended continental crust, a ∼40 km-wide transition zone of exhumed mantle, and a 7 – 9.5 km thick oceanic crustal domain, overlain by a ∼ 8 km thick unit of consolidated Mesozoic sediments that are covered by 2 km thick Cenozoic sediments. In the southernmost basin, two layers of crust were observed with velocities ranging from 5.8 – 6.5 km/s and 6.6 – 7.1 km/s, respectively. The corresponding thickness is 2 – 3 km and 4 – 7 km, which shows a typical character of oceanic layer 2 and an over-thickened magmatic oceanic layer 3, implying that seafloor spreading occurred in the south. A transition with exhumed mantle along rift axis was observed ∼40 km to the north, whereas hyper-extended continental crust was observed further north.

Due to lack of a clear magnetic anomaly pattern and drilling information, we can only infer that a narrow region of seafloor spreading occurred during the time of Middle–Late Jurassic, as a result of continued rifting which initiated during Triassic time. We propose a south-north propagating rifting, which was dominated by non-uniform strain along the basin axis.