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Multiphased extension along continental margins: a case study of the Porcupine Basin, offshore Ireland

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Mesozoic faulting has been recognised in several Irish sedimentary basins as part of the northward propagation of the Atlantic rift system. However, the contribution of older structural elements remains poorly constrained. The present study documents the succession of extensional phases in the northern part of the Porcupine Basin sensu largo, offshore west of Ireland, in which structural inheritance and fault reactivation is commonly observed. The correlation of 2D and 3D seismic lines with exploration wells enables the precise definition of four overprinted extensional systems that link to specific tectonic stages identified along the Irish margin.

The Porcupine Basin opened through a thickened continental crust that evolved during the Palaeozoic with the Caledonian and Variscan orogenic cycles. Extension initiated during the Carboniferous by reactivation of old structures, resulting in the migration of depocentres bounded by E-W, NE-SW and N-S structural trends. Subsequent episodic rifting occurred during several discrete events. The first rift episode, of Late Triassic to Early Jurassic age, is restricted to the North Porcupine Basin and most likely reactivated E-W structures of Caledonian age. Synrift sediments were generally deposited in a littoral setting that progressively deepened through time. The second episode, much more pronounced, occurred during the Upper Jurassic to lowermost Cretaceous (Neocomian). It resulted in shallow to deep marine deposition controlled by structural directions recognised in Caledonian and Variscan terranes. A third rift phase, evidenced by thick clastic deposition, locally occurred during the Aptian and finally died out with the opening of the Bay of Biscay located to the south of the region.

A series of extensional megacycles are recognised from seismic unconformities and faulting geometries. Initial extension strongly followed the structural architecture of the continental crust (i.e. ancient folds, thrusts or orogenic fronts). This is interpreted as an effect of orogenic collapse. It was followed by the rifting phase sensu stricto during which the successive extensional megacycles are internally composed of several rift pulses. The first rift pulses are narrow and controlled by numerous faults with deposition in continental conditions. Subsequent deformation progressively passed to more localised normal faulting during which a major deepening occurs in all the rift basins. This results in progressive marine flooding, possible detachment faults and a widening of the rift systems with basinal interconnection. In a more global view, faults stop when abuting either new oceanic basins (e.g. Bay of Biscay) or transversal lineaments (e.g. Caledonian and Variscan trends). Such an evolution implies asymmetry of the overall region and an oceanward propagation of depocentres. Therefore, extension migrates progressively from the initial deformation core by reactivating pre-existing structures and then stops once boundary conditions change.