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Structural and kinematic analysis of the inversion structures in the NE Atlantic margin. Insights from the Mizen Basin (Celtic Sea, offshore Ireland)

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The Mesozoic extensional basins developed along the north-western European margin were affected by Late Cretaceous-Cenozoic age intra-plate shortening which led to the growth of a series of mild compressional inversion structures. While these structures are primarily controlled by reverse reactivation of normal faults, other mechanisms such as folding and strike-slip faulting play a key role in defining the size and geometry of these structures. These mechanisms are combined in response to a number of factors that include pre-extensional basement fabrics, orientation and style of the extensional structures and changes in stress orientations. This work examines the controls of these mechanisms on the evolution of inversion structures from the Mizen Basin (offshore south of Ireland).

The Mizen Basin represents the NW termination of the Celtic Sea basins and consists of two NE-SW trending half grabens developed as a result of the reactivation of both Caledonian and Variscan faults. The partially inverted basin contains a series of syn-inversion sequences that are much better preserved than in most of the Celtic Sea basins and so provides a unique opportunity to constrain the timing of inversion in the Celtic Sea basins. In addition, the excellent 3D seismic coverage of the basin makes this area an excellent location to study the kinematics and modes of deformation of the intra-plate shortening-related structures.

Sediment thickness and fault displacement distributions indicate that the basin bounding normal faults were active from Early Triassic to Late Cretaceous under a NW-SE direction of extension. A later phase of Barremian to Cenomanian (Early to Late Cretaceous) N-S oriented extension gave rise to E-W-striking minor normal faults and reactivation of the pre-existing basin bounding faults that propagated upwards as arrays of segmented normal faults. The late Mesozoic E-W striking segmented fault arrays, that link downwards onto the early Mesozoic basin bounding faults, were subsequently reactivated in N-S compression during Middle Eocene to Oligocene times. A set of NW-SE trending dextral-strike slip faults that formed at the same time caused local shortening on the hanging walls of the main faults. During the Miocene, a significant decrease of fault activity is recorded, with shortening accommodated primarily by folding rather than faulting at this time. No syn-inversion sequences older than Middle Miocene are observed.

The segmented array of normal faults formed during Cretaceous extensional reactivation of the basin-bounding fault was reutilised during subsequent compression. The distribution of reverse displacement on individual segments formed in compression mirrors the normal offsets that formed during the earlier extension and, relay ramps that transferred displacement between normal fault segments during extension, performed the same function during shortening. Therefore, the segmented geometry of the initial normal fault array, in combination with dextral strike-slip faulting, to a large extent controlled the geometries of anticlinal closures in the hanging-walls of the inverted faults.