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This paper integrates interpretations of modern long-offset seismic datasets with potential field anomalies derived from dense grids of 2D gravity and magnetic data to present a regional-scale synthesis of Devonian, Carboniferous and Early Permian basin development beneath the UK Central North Sea. The 95 000 km² study area has had little modern exploration for petroleum systems beneath the Upper Permian. Seismic interpretation and potential field modelling confirm that along the southern fringe of the Central North Sea, as in northern England, Lower Carboniferous basin development was strongly influenced by the disposition of granite-cored Lower Palaeozoic basement blocks – Farne Block, Dogger Block and Devil's Hole High. This study adds a previously unidentified WNW–ESE trending pre-Devonian basement block, the Auk–Flora Ridge, that exerted a profound control on Late Devonian to Mesozoic structural evolution of the south-Central North Sea. From the Flora Field, where it is overlain by relatively thick mid-Devonian to earliest Permian strata, the sub-Permian relief of this block becomes progressively shallower towards the NW. On its southern flank lies a parallel half-graben, akin to the Stainmore Trough in northern England, and interpreted as also containing several thousand feet of Lower Carboniferous strata. As indicated by the coal measures section in well 39/7-1, these strata are likely to include prolific source rocks, which have been modelled as being fully mature for oil generation in Quadrant 29. Potential field modelling extends this interpretation beyond the current seismic coverage, and suggests that Carboniferous to earliest Permian basin development in the Central North Sea was strongly influenced by an underlying Scottish–Norwegian SW–NE trending Caledonoid structural fabric. An earliest Permian, Lower Rotliegend unit thickens southwards towards the Auk–Flora Ridge, and rests unconformably on one or more undrilled NE–SW trending Carboniferous basins. Red-bed fluvial facies akin to those at Flora are likely to dominate the substantial post-Dinantian fill of these basins, but significant thicknesses of Westphalian coal-measure source rocks may also be present locally. As in central Scotland, the Dinantian strata underlying a widespread mid-Carboniferous unconformity in these basins are likely to contain further coal-measure intervals and local developments of oil-shale source rocks. These Westphalian and Dinantian source rocks are key elements of a Carboniferous petroleum system that remains largely untested across large areas of the Central North Sea.