



## **Transpression, transtension and reactivation during basin evolution: a case study from northern Scotland and Orkney**

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The onshore Devonian sedimentary rocks of the Orcadian basin host significant amounts of fracturing, faulting and some localized folding. Most published accounts have assumed Devonian ages for the supposedly extensional faulting in the Orcadian Basin, with some limited inversion and reactivation proposed during the Carboniferous. More recently, however, regional studies, palaeomagnetic dating of fracture fills and structural studies in the adjacent basement rocks suggest that significant amounts of faulting may be related to the development of the contiguous offshore West Orkney Basin (WOB) during the Mesozoic.

New field and microstructural analyses of the structures found within the Devonian cover sequences in Scotland and Orkney reveal 3 main groups of structures based on orientation, kinematics and infill. All are transtensional or transpressional on local to regional scales mainly due to reactivation of pre-existing structures:

Group 1 faults trend ENE-WSW, N-S and NW-SE and display predominantly sinistral strike-slip to dip-slip extensional movements. They form the dominant structures in the eastern part of Caithness, and to a lesser extent Orkney. Gouges/breccias associated with these faults display little or no mineralization or veining.

Group 2 structures are closely associated systems of metre- to kilometre-scale N-S trending folds and thrusts related to a highly heterogeneous regional inversion event recognized locally throughout the field area, but especially on Orkney. Once again, fault rocks associated with these structures display little or no mineralization or veining.

Group 3 structures are dextral oblique NE-SW trending faults and sinistral E-W trending faults with widespread syn-deformational carbonate mineralisation ( $\pm$  pyrite and bitumen) both along faults and in associated mineral veins. In a few localities (e.g. Dunnet Head, Scarfiskerry, E. Scapa Fault) strike-slip inversion events have occurred at this time leading to localized transpression or transtensional folding during reactivation of pre-existing Devonian faults. Crucially, these later folds are synchronous with carbonate and associated mineralisation events. Preliminary Re-Os dating of syn-deformational pyrite in 2 faults in the Caithness Area gives model ages of  $268.4 \pm 4.9$  &  $266.4 \pm 5.2$  Ma (Permian).

We propose that the deformation episodes are related to: i. Devonian sinistral transtension (ENE-WSW extension) related to the Great Glen Fault Zone (GGFZ) in part controlling the formation of the Orcadian basin and proto-WOB (= Group 1); ii. Late Carboniferous – Early Permian inversion (local E-W shortening) related to dextral reactivation of the GGF (= Group 2 structures); iii. Permo-Triassic rifting (NW-SE extension) which formed both new faults and locally reactivated earlier structures (= Group 3).