The structural evolution of the Orcadian Basin, NE Scotland: multiple phases of regional rifting, reactivation and local inversion.

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The onshore Devonian sedimentary rocks of the Orcadian basin host significant amounts of fracturing, faulting and some localized folding. Here we present a new study based on field and microstructural analysis of the structures found within the Devonian cover sequences and their underlying Precambrian basement rocks in Scotland and Orkney. Three main groups of structures have been identified based on orientation, kinematics and infill.

Group 1 faults trend N-S to NW-SE and display predominantly sinistral strike-slip to dip-slip extensional movements, respectively. They form the dominant structures in the eastern part of the northern coastal section in Caithness, and to a lesser extent Orkney, and are likely related to E-W extension during regional sinistral transtension along the Great Glen Fault Zone (GGFZ) during the Devonian. 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 heterogenous 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. The inversion reflects E-W shortening with local reactivation of pre-existing Devonian normal faults linked to regional dextral reactivation of the GGFZ. Existing geological constraints suggest a late-Carboniferous or early Permian age of inversion.

Group 3 structures are dextral oblique NE-SW trending faults and sinistral E-W trending faults with widespread syn-deformational carbonate mineralisation (± pyrite and bitumen) both along faults and in associated mineral veins. Stress-inversion analyses consistently point to NW-SE regional extension during this event. In a few localities (e.g. Dunnet Head, Scarfskerry, E. Scapa Fault) strike-slip inversion events have occurred at this time leading to localized folding during reactivation of pre-existing Devonian faults. Crucially, these later folds are synchronous with carbonate and associated mineralisation events unlike the Group 1 and 2 fold structures which are consistently cross-cut by these veins.

The pyrites associated with the Group 3 structures are commonly enriched in rhenium (^{187}Re) (parts per billion) which decays to Osmium (^{187}Os). Re-Os dating of syn-deformational pyrite was carried out at the Total Laboratory for Source Rock Geochronology and Geochemistry at Durham University. Isotopic analysis showed that there was no appreciable common osmium present in the sulphides at the time of mineralization allowing us to derive model ages for the faulting. This indicates that the pyrite-bearing fracture systems formed at 267.5 ±3.4 Ma (mid-Permian). The Group 3 structures are likely related to intrusion of the Orkney Dyke swarm(249-268Ma and to the rifting that formed the offshore West Orkney Basin located to the north and west of the older Orcadian Basin.