Characterising Fracture Networks in the Lewisian Gneiss Complex, NW Scotland: Implications for Petroleum Potential in the Clair Field Basement, Faroe-Shetland Basin

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Fractured crystalline basement rocks are increasingly a target for hydrocarbon exploration in the development of existing fields. In the Clair field that lies 75km west of the Shetland Islands in the Faroe-Shetland basin, the primary clastic reservoirs of Devonian and Carboniferous age overlie and onlap fractured Lewisian basement. Fractures in the basement are thought to play a significant role in providing conduits for fluid movement and potentially hydrocarbon storage.

To help understand the characteristics of the Clair basement structure, the L. Archaean - E. Proterozoic Lewisian Gneiss Complex (LGC) NW Scotland is being tested as a suitable analogue. Analysis of the Clair basement from well data and core suggests that it has affinities with the LGC in terms of age, lithologies and fracturing style. The LGC comprises tonalite-trondhjemite-granodiorite gneisses, mafic-ultramafic dykes, together with subordinate metavolcanic & metasedimentary sequences that were accreted as a series of terranes during the Precambrian. The LGC contains a complex fracture network with three prominent regional fault sets, each of which is associated with characteristic fault rock and mineral assemblages.

The present project focuses on analysing offshore and onshore regional data and correlating the findings with results from analyses of well and outcrop data. Regional data comprises 2D fault analysis of seismic attributes from the basement horizon and 2D lineament maps created from high resolution NEXTMap® digital elevation models (DEM). Well and outcrop data comprises 1D line samples that have been used to characterise the spatial and textural attributes of the fault networks.

Regional datasets show that NE-SW fault trends are dominant throughout, with NW-SE faults preferentially developing in areas of pre-existing basement anisotropy, such as phyllosilicate-rich ductile shear zones. Spatial analysis of 2D samples provides similar results for both onshore and offshore domains. 1D spatial analysis of well and outcrop fracture set data show power-law relationships, suggesting that scale-invariant properties of the fracture sets measured at outcrop or from basement wells can be used as an estimation for the fracture sets seen at regional scales. These results, along with the similarities in fracture mode, fill and other attributes suggest that the fracture network recorded on the mainland LGC provides a fitting analogue for the fractured basement within the Clair Field.