The Lancaster Field: the anatomy and structural evolution of a fractured basement reservoir

Holdsworth, R.E.[1,2] Trice, R.[3], Hardman, K.[1], McCaffrey, K.J.W.[1,2] Morton, A.[4], Frei, D.[5] Dempsey, E.[6], Bird, A.[6], Rogers, S.[7]

1 Department of Earth Sciences, Durham University, DH1 3LE, UK; 2 Geospatial Research Ltd, Durham DH1 4EL, UK; 3 Hurricane Energy plc, Godalming,GU7 2QN, UK; 4 HM Research, St Ishmaels SA62 3TJ and CASP, University of Cambridge, CB3 0UD, UK; 5 Department of Earth Sciences, University of the Western Cape, 7530 Bellville, South Africa; 6 Department of Geography, Geology and Environment, University of Hull, HU6 7RX, UK; 7 Golder Associates Ltd, Vancouver, Canada

Abstract: Hosting up to 3.3 billion barrels of oil in place, the upfaulted Precambrian crystalline rocks of the Lancaster Field, offshore west of Shetland, give key insights into how fractured hydrocarbon reservoirs can form in such old rocks. The Neoarchaean (ca 2700-2740 Ma) charnockitic basement is cut by deeply penetrating oil-, mineral-and sediments-filled fissure systems seen in geophysical and production logs, and thin sections of core (Figs 1a-b). Mineral textures and fluid inclusion geothermometry suggest that a low temperature (<200 °C) near-surface hydrothermal system is associated with these fissures. The fills help to permanently prop open fissures in the basement, permitting the ingress of hydrocarbons into an extensive well-connected oil saturated fracture networks (Figs 1b-c). U-Pb dating of calcite mineral fills constrains the onset of mineralization and contemporaneous oil charge to the mid-Cretaceous onwards from Jurassic source rocks flanking the upfaulted ridge (Fig 1a). Late Cretaceous subsidence and deposition of mudstones sealed the ridge, and was followed by buoyancy-driven migration of oil into the pre-existing propped fracture systems. These new observations provide an explanation for the preservation of intra-reservoir fractures ('joints') with effective apertures of two meters or more, thereby highlighting a new mechanism for generating and preserving fracture permeability in sub-unconformity fractured basement reservoirs worldwide.