The application of ichnology in unravelling the controls on porosity preservation at depth, in the Ula Formation, NCS

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The Upper Jurassic Ula Formation represents an excellent natural laboratory to analyse the influence of bioturbation on reservoir properties and quality. Work by Gowland (1996) on the UK-equivalent Fulmar Formation suggested a shoreface depositional system, where a wave-energy controlled gradient extends from the upper shoreface down through the lower shoreface, into the shoreface to shelf transition zone. This depositional gradient is reflected in reservoir quality potential, whereby the coarsest grained, ‘cleanest’ sandstones are deposited in the more proximal zones, with the distal lower shoreface to transition zone acting as a zone of lithological transition from sandstone-siltstone lithologies.

More recent work on the Ula Formation (Baniak et al., 2014) supported the model proposed by Gowland (1996), suggesting the shoreface was influenced by storm wave activity. A similar wave-energy-controlled facies belt system was inferred, with distinct trace fossil assemblages diagnostic of each facies belt. Gowland (1996) however, also proposed a ‘speculative shelf sand’ model for elements of the Fulmar Formation that did not conform to the ‘bioturbated shoreface’ model. This model was largely based on the presence of common *Rhaxella* sponge spicules, which in association with common belemnites suggested a more open shelf depositional setting.

Here, it is established that the Ula Formation comprises both a shoreface and an offshore component. Cleaner sandstones representative of deposition in the upper shoreface and proximal parts of the lower shoreface vary between cross-stratified to highly bioturbated, with a trace fossil assemblage dominated by *Ophiomorpha* and *Palaeophycus,* which grades into *Teichichnus-*dominated communities in siltier lithologies prevalent in distal parts of the lower shoreface. The offshore expression of the Ula Formation displays a similar suite of sedimentary structures and trace fossil communities which are representative of deposition towards the high energy, axial parts of the offshore depocentres (equivalent to the upper shoreface) and more quiescent, lower energy marginal settings. Ecological tiering profiles expressed in trace fossil assemblages are unique in the offshore setting due primarily to the more episodic nature of sand supply. This led to episodes of hiatus which resulted in firmground colonisation events (e.g. Taylor et al.,2003) expressed as deeper-tier *Diplocraterion* and/or *Thalassinoides* burrows which overprint the ‘background’ softground assemblages. As such, ichnological data forms a key component in erecting a set of diagnostic criteria used to differentiate shoreface from offshore expressions of the Ula Formation.

The Ula Formation represents a well-studied example of a deeply buried petroleum system. We demonstrate a depositional facies control on one of the main porosity preservation mechanisms. Grain-coating microcrystalline quartz sourced from the dissolution of siliceous sponge spicules is restricted to the offshore expression of the Ula Formation, meaning that deeply buried prospects have better reservoir potential if they comprise offshore-dominated facies. Ichnological data represents one of the more robust ways of determining the environment of deposition during preliminary work on cored sections.