Characterizing flow heterogeneities in a red-bed fluvial succession: Triassic St Bees Sandstone Formation (NW England, UK)

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Red-bed successions of fluvial origin represent porous media which host important hydrocarbon and geothermal resources; additionally, they serve as important groundwater aquifers. Hence, a quantitative study on the geological heterogeneities present in such successions at a range of scales and burial depths is important to provide insights for both groundwater protection and enhancement of fluid recovery in reservoirs.
The fluvial St Bees Sandstone Formation represents an ideal succession for the study of heterogeneity, since it accumulated in a series of rapidly subsiding rift basins, which allowed the accumulation and preservation of fine-grained mudstone and siltstone of floodplain interbedded with a medium-grained channel-sandstone. Additionally, vertical joints terminate at bedding surfaces forming cubic matrix blocks (1.5x1.5x1.5 m) that define a pervasive stratabound system. These matrix blocks are mainly developed in channelized fluvial architectural elements in which sandstones represent the most permeable lithology (porosity 9-26%; K_h= 0.1-4000 mD; K_v =0.02-860 mD). Mud-prone overbank architectural elements occur both at the top of channel belts and as interbedded bodies within channelized elements. Overbank elements are characterized by lower porosity and permeability values (porosity 3%-20%; K_h 0.01-263 mD; K_v 0.001-75 mD), and therefore represent an important lithological heterogeneity. Another heterogeneity is represented by white, in-channel silty sandstone drapes (porosity from 8% - 10%; permeability values of a few millidarcies) representing flow baffles.
A range of sedimentological and hydro-geophysical techniques reveal how bedding-parallel fractures dominate the flow at shallow depths (<200 m). Vertical stratabound joints, which are de-limited by bedding fractures, enhance water flow by establishing connection between sub-horizontal fissures. Upscaling of intergranular permeabilities and pressure build-up derivatives indicate how the matrix represents a significant component for conducting flow in the deep St Bees Sandstone aquifer (200-1100 m). Despite this, temperature and conductivity logs reveal how bedding fractures connected by stratabound joints still provide partial contribution to flow up to depths of 1100 m.

Sedimentology and microfacies development within a slope to basin floor mudstone succession: Carboniferous Bowland Shale Formation, NW England (UK)

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The Bowland Shale Formation comprises a succession of organic-rich mudrock deposited in a series of fault controlled half -graben during the Carboniferous (~335Ma to ~313Ma) in the Pennine Province (U.K.), and represents the largest potential target for shale gas exploration within the UK. Variations in sedimentology and diagenesis play a major role in controlling reservoir quality but current knowledge for the Bowland Shale is limited, leading to significant uncertainty for exploration. Centimetre-scale sedimentary logging, thin section analysis, and geochemical techniques (TOC & RockEval™) based on 125 m of continuous core from the Bowland Basin enables the study of sedimentological processes acting within a slope-to-basin-floor mudstone succession. Deposition within the mudstone succession is dominated by turbidites and debrites. Lenticular fabric (lenses 50 < 800 μm) occurs within all mud-rich facies. The lenses represent remobilised soft-sediment mud-rich clasts, providing evidence for traction throughout the succession. Finer-grained facies within the Bowland Shale Formation contain the highest TOC values (< 12 wt. %). Variation in organic matter content within facies appears linked to the degree of dilution from reworked sediments, i.e. the development of lenticular fabric. Depositional (carbonate) composition shows a strong control on the development of carbonate cements within the formation. Deposition of the Bowland Shale within the studied section is interpreted to represent a system of slope aprons originating from a carbonate-rich shelf. Facies variations demonstrate a change from a carbonate dominated to a mixed carbonate and siliciclastic shelf environment. The sedimentology of mudstone successions provides key insights into basin processes which in turn have a significant impact on bulk rock properties, and thus prospectivity, within these unconventional reservoirs.