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Whitby Mudstone, flow from matrix to fractures

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Fluid flow from matrix to well in shales would be faster if we account for the duality of the permeable medium considering a high permeable fracture network together with a tight matrix. To investigate how long and how far a gas molecule would have to travel through the matrix until it reaches an open connected fracture we investigated the permeability of the Whitby Mudstone (UK) matrix in combination with mapping the fracture network present in the current outcrops of the Whitby Mudstone at the Yorkshire coast. Matrix permeability was measured perpendicular to the bedding using a pressure step decay method on core samples and permeability values are in the microdarcy range. The natural fracture network present in the pavement shows a connected network with dominant NS and EW strikes, where the NS fractures are the main fracture set with an orthogonal fracture set EW. Fracture spacing relations in the pavements show that the average distance to the nearest fracture varies between 7 cm (EW) and 14 cm (NS), where 90% of the matrix is 30 cm away from the nearest fracture.
By making some assumptions like; fracture network at depth is similar to what is exposed in the current pavements and open to flow, fracture network is at hydrostatic pressure at 3 km depth, overpressure between matrix and fractures is 10% and a matrix permeability perpendicular to the bedding of 0.1 microdarcy, we have calculated the time it takes for a gas molecule to travel to the nearest fracture. These input values give travel times up to 8 days for a distance of 14 cm. If the permeability is changed to 1 nanodarcy or 10 microdarcy travel times change to 2.2 years or 2 hours respectively.