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The influence of sub-seismic faults and small scale permeable features on cap rock integrity.

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Mudstones and shales frequently have low hydraulic permeabilities and hence form barriers to subsurface flow. As such, they are common cap rocks for hydrocarbon reservoirs and are being actively pursued as potential host rocks for geological disposal of radioactive wastes in a number of countries. Whilst the rock matrix permeability of mudstones is very low, their permeability can be significantly enhanced by the presence of faults and fractures. For example, Losh et al (1998) use seismic survey data to image gas leakage through a cap rock at a small number of locations that coincide with intersections between seismically resolvable faults. Such data can illuminate discrete leakage points and relate them to resolvable structures; however, they cannot identify more diffuse leakage zones that may be associated with the presence of sub-seismic structures.

Our research investigates the effect of small faults, with less than 10m of throw on the hydraulic integrity of mudstones. We have mapped the detailed architecture of a well exposed sub-seismic fault, which crosscuts a mudstone layer, at Girvan in Scotland. Our data show two distinct fracture sets accommodating past fluid flow events, the orientations of which indicate they probably occurred during different periods of deformation. Fracture mineralisation and alteration halos provide evidence for discrete flow paths through the cap rock. Analysis of the mudstone shows that it contains several small, <5cm deep, beds of high grain size. These beds show alteration similar to that surrounding one of the two fracture sets. We use grain size analysis to estimate permeability within both the surrounding mudstone and the higher permeability beds. These data are then used within a groundwater flow model. Results show that small fractures, clearly associated with the sub-seismic fault, act to connect the high permeability beds and form through-going flow paths that compromise the hydraulic integrity of the cap-rock.