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Impact of Fault Rock Properties on CO₂ Storage in Sandstone Reservoirs

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SUMMARY

Over the years of research and development in CO₂ sequestration technology, saline aquifer and depleted petroleum reservoirs have been considered as potential reservoirs for geological storage of CO₂ (Baines & Worden, 2004; Bergmo et al., 2009; Hermanrud et al., 2009).

The storage capacity of a reservoir is determined by five factors: the formation thickness, the area of the storage site, rock porosity, CO₂ density and the storage efficiency (Cooper, 2009). Main challenges for capacity estimation is geological heterogeneities within the reservoir, specially the presence of sub-seismic fractures, faults and deformation structures. An optimal CO₂ storage reservoir needs to have high porosity and good permeability and right communicational properties. Within sandstone reservoirs, deformation bands and faults may act as barriers, introduce compartmentalization and hence reduce the injection rate and the total capacity of the reservoir or compartments. In addition, CO₂ injection in aquifers/reservoirs creates a fluid pressure increase, which leads to changes in the stress state of the aquifer/reservoir and the sealing rocks above and below. This might affect and reactivate faults both within and around the reservoir (Li et al., 2007), which might have undesirable consequences.

With these in mind, the main challenge is to enhance our understanding of the processes and products of brittle deformation in porous sandstone in order to forecast the distribution and impact of faults on reservoir/aquifer performance and seal properties. This will contribute to improve risk assessment and optimized planning for the choice of reservoir/aquifer for CO₂ storage. In the light of this, our main focus within our ongoing research have been to rise to the above challenge by an integrated, cross-disciplinary, comprehensive study which combines analysis of empirical outcrop and possibly subsurface data, experiments using physical analogues, micro-structural analysis and numerical modeling.

Our research based on natural and analogue examples reveal that faults and their associated deformation structure in sandstone reservoirs can reduce the petrophysical properties of porous sandstone considerably (Tveranger et al., 2008; Braathen et al., 2009). Permeability is decreased up to 4 orders of magnitude within deformation bands (Torabi & Fossen, 2009). On the other hand, the thickness, microstructure and hence the petrophysical properties of faults and deformation bands can change along them at short distances, changing and in most cases reducing the ability of the faults and bands to act as barriers to fluid flow (Torabi et al., 2008; Torabi and Fossen, 2009).