The effect of long-term fluid-rock interactions on the mechanical properties of reservoir rock - a case study of the Werkendam natural CO$_2$ analogue field

Suzanne Hangx (1,2), Pieter Bertier (3), Elisenda Bakker (1), Georg Nover (4), and Andreas Busch (2)
(1) Utrecht University, Netherlands (s.j.t.hangx@uu.nl), (2) Shell Global Solutions, Rijswijk, Netherlands, (3) RWTH Aachen University, Germany, (4) Bonn University, Germany

Geological storage of CO$_2$ is one of the most promising technologies to rapidly reduce anthropogenic emissions of carbon dioxide. During long-term geological storage of CO$_2$, fluid-rock interactions, induced by the formation of carbonic acid, may affect the mineralogical composition of the reservoir rock. Commonly expected reactions include the dissolution of carbonate and/or sulphate cements, as well as the reaction of primary minerals (feldspars, clays, micas) to form new, secondary phases. In order to ensure storage integrity, it is important to understand the effect of such fluid-rock interactions on the mechanical behaviour of a CO$_2$ storage complex. However, most of these reactions are very slow, which limits the ability to study coupled chemical-mechanical processes in the lab. A possible way to circumvent long reaction times is to investigate natural CO$_2$ analogue fields, which experienced CO$_2$-exposure for thousands of years.

In this study, we looked at the Dutch Werkendam natural CO$_2$ field and its unreacted counterpart (Röt Fringe Sandstone, Werkendam, the Netherlands). We focussed on CO$_2$-induced mineralogical and porosity-permeability changes, and their effect on mechanical behaviour of intact rock. Overall, CO$_2$-exposure did not lead to drastic mineralogical changes, though markedly different porosity-permeability relationships were found for the unreacted and exposed material. The limited extent of reaction was in part the result of bitumen coatings protecting specific mineral phases from reaction. In local, mm-sized zones displaying significant anhydrite dissolution, enhanced porosity was observed. For most of the reservoir the long-term mechanical behaviour after CO$_2$-exposure could be described by the behaviour of the unreacted sandstone, while these more ‘porous’ zones were significantly weaker. Simple stress path calculations predict that reservoir failure due to depletion and injection is unlikely.