Geophysical Research Abstracts
Vol. 13, EGU2011-7738, 2011
EGU General Assembly 2011

Mineralogical and petrophysical results of long-term CO2-exposure experiments on reservoir sandstone from the Ketzin pilot site, Germany

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Core samples of the Upper Triassic (Keuper) Stuttgart Formation from the Ketzin pilot storage site have been experimentally treated with CO2. The major objective of the experimental program was to investigate the effects of long-term CO2 exposure on the mineralogical and petrophysical properties of the target formation.

For the experiments, rock samples of the Stuttgart Formation were exposed to pure CO2 and synthetic reservoir brine in high-quality steel-autoclaves at simulated reservoir P-T conditions of 5 MPa and 40 °C. After 15 and 21 months, the first two sets of samples were removed from the pressure vessels. Before and after the experiments, thin section microscopy, X-ray Diffraction (XRD), Electron Microprobe (EMP) and Scanning Electron Microscope (SEM) analysis were performed to compare petrographical, mineralogical and/or compositional features of the samples. Additionally and after a petrophysical baseline characterization of the respective samples, Nuclear Magnetic Resonance (NMR) relaxation next to Mercury Injection (MI) experiments were executed in order to investigate the petrophysical parameters porosity, pore size distribution and (thereof derived) permeability.

The analyzed sandstones have a relatively uniform composition of mainly quartz and plagioclase. K-feldspar, illite, mica, chlorite and hematite are present in minor and varying quantities. The samples are weakly cemented by analcime, anhydrite and subordinate dolomite. Porosities of the untreated samples range from 17 to 32 %, permeabilities range from 1 to 100 mD (Zemke et al, 2010). Rietveld refined XRD data show no significant trends for the studied intervals. Only anhydrite contents uniformely decrease with experimental time. On freshly broken rock fragments of the CO2-treated samples, (intensified) corrosion textures were found on plagioclase and K-feldspar surfaces. BSE images of the respective twin samples show intensified alterations of feldspar minerals. The mineral composition derived by EMP analysis displays a slight change in the plagioclase chemistry and a preferred occurrence of albite after CO2 exposure.
Slight variations are also evident for the investigated petrophysical properties. NMR and MI data generally indicate increased porosities and a shift to larger pore sizes. The respective (calculated) permeabilities initially increase in samples treated for 15 months, but decrease in most samples treated for 21 months.
Based on the chemical evolution of the brine over time, not only calcium and potassium, but also sulfate concentrations, amongst others, increased (Wandrey et al, 2010).

The mineralogical-chemical and petrophysical measurements imply preferred dissolution of calcium out of plagioclase (albitization) next to the dissolution of K-feldspar and anhydrite as well as increasing porosities, on the one hand, opposed to slightly decreasing permeabilities, on the other. Due to the heterogenic character of the Stuttgart Formation, which formed in a fluvial environment (Förster et al, 2006), it is often difficult to distinguish between natural variability and CO2-related changes. Additional profound evaluation is needed to interconnect the changes indicated by chemical and physical measurements during CO2 exposure and to better understand CO2-brine-rock interactions occurring within the Ketzin reservoir.

Literature

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