



CO₂–brine–rock interaction — First results of long-term exposure experiments at in situ P–T conditions of the Ketzin CO₂ reservoir

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ABSTRACT

Sandstone samples of the Stuttgart Formation at Ketzin have been experimentally treated with CO₂ and synthetic reservoir brine in high-quality steel autoclaves at simulated in situ P–T conditions (5.5 MPa, 40 °C). In order to observe mineralogical changes induced by CO₂, untreated samples are compared to CO₂-treated ones. Most samples show an analogous petrography of mainly quartz and plagioclase. Heterogeneities are related to minor mineral phases, such as K-feldspar, hematite, muscovite, biotite, illite, chlorite and opaque phase(s). These are attributed to the variability of the fluvial reservoir sandstone. The samples are weakly consolidated. Analcime, dolomite and anhydrite are only found as cement phases. During the experiments dissolution of anhydrite and plagioclase is observed. SEM micrographs of CO₂-treated samples show corrosion textures on mineral surfaces of intermediate plagioclase, as well as precipitation of euhedral albite crystals. Overall, the data indicate preferred dissolution of calcium-rich plagioclase, K-feldspar and anhydrite and stabilization or precipitation of albite.

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1. Introduction

Capture and subsequent geological storage of CO₂ is a key strategy within the portfolio of actions to reduce CO₂ emissions to the atmosphere. Deep saline aquifers are the most promising geological storage options on the regional to global scale based on their estimated storage capacities and their widespread distribution. For these deep saline aquifer systems, initial physico-chemical equilibrium between saline formation fluid and reservoir rock can be reasonably assumed. However, the injection of CO₂ into these saline aquifer systems disturbs this initial equilibrium and will trigger chemical interactions between injected CO₂, saline formation fluid and reservoir rock. These interactions include dissolution of certain minerals and precipitation of others and not only change the chemical, but also the physical properties of the reservoir system. The chemical interactions may lead to mobilization of certain, eventually harmful or toxic, elements while the changes in physical properties influence injectivity, storage capacity, as well as long-term safety and stability of the reservoir. Precise knowledge of the CO₂-induced interactions between injected CO₂, saline formation fluid and

reservoir rocks and of the resulting changes in chemical and physical properties of the reservoir system is therefore a prerequisite for any secure operation of a storage site. Unfortunately, due to the general lack of core samples from reservoir systems after onset of CO₂ injection, any information on CO₂-induced interactions at real storage sites are, at least up to now, indirect and mostly based on gas or fluid samples recovered from observation wells (e.g., Assayag et al., 2009). Experimental studies at simulated reservoir pressure and temperature conditions are an important and elegant way to overcome this problem. Such studies either focus on individual minerals (e.g., Daval et al., 2009; Hangx and Spiers, 2009) or on real reservoir rock samples (e.g., Kaszuba et al., 2003, 2005; Wigand et al., 2008). Kaszuba et al. (2003) studied CO₂–brine–arkose interactions during 139 days exposure experiments at 20 MPa and 200 °C. In these experiments, etch textures indicate dissolution of microcline, biotite and quartz. In addition, smectite and magnesite precipitated. In another experimental study at 20 MPa/200 °C and 77 days run duration, Kaszuba et al. (2005) observed dissolution of biotite and shale and concomitantly increasing concentrations of magnesium, iron and manganese in the brine. In these experiments, analcime crystallized during the run and lowered the sodium concentration of the brine. In batch CO₂-exposure experiments on Bunter Sandstone at 30 MPa/60 °C and 63 days run duration, Wigand et al. (2008) discovered dissolution of dolomite cement and etch textures on K-feldspar and albite; montmorillonite precipitated in cleavages of albite crystals. Given the vast mineralogical, chemical

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