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Investigation of CO_2-rock-wellbore cement interaction – experimental study

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When regarding carbon dioxide injection into deep geological reservoirs, it is well recognized that CO_2-water-rock interactions play important role for long-term safety of the well-bores, as the acid gas can cause possible alteration of reservoir and cap rocks, as well as at the cement-rock interface [1].

An experimental study on selected sedimentary rocks, including sandstones, limestones, dolomites and anhydrite was performed. The mineral composition of rocks was determined with the use of polarizing microscopy and SEM and X-ray diffraction methods.
The samples (composed of rock and well-bore cement) were exposed to CO_2-saturated brine, under static conditions in the autoclave reactor at 70°C and 15 MPa. The duration of the experiment was 250 days. After the test, the composed rock samples were examined by SEM analysis, with use of Scanning Electron Microscope FEI Quanta-650 FEG, equipped with an energy dispersive analyzer (EDX).

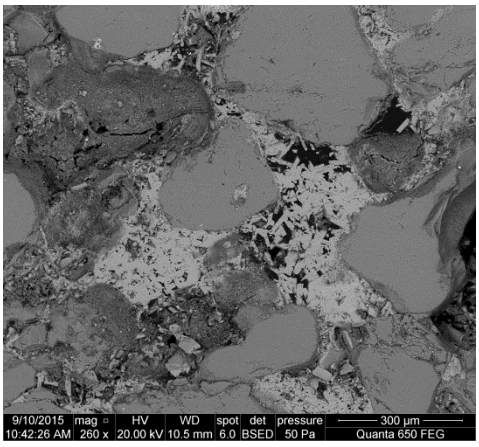

Figure 1: SEM image of sandstone. Dissolution of rock cement and secondary precipitation of calcite in pores (white elongated crystals)

Sandstones which were subjected to the investigation are highly-porous rocks. In course of the experiment, the secondary porosity forms, as a result of rock cement dissolution, and the degradation of some grains. The main components of rock cement which are subject to dissolution are carbonates: calcite, siderite and dolomite; or sulphates (anhydrite). Plagioclase and K-feldspar grains, as well as lithic clasts show intense alteration. On the other hand, newly precipitated clay minerals, carbonates and sulphates occlude sandstone pores, and eventually reduce the pore space (Figure 1).

In case of carbonate rocks (limestones and dolomites), local dissolution of $CaCO_3$ takes place, which is the reason of the appearance of some voids. In the case of anhydrite rock the significant increase of porosity is caused by dissolution of mineral anhydrite [2].

In a process of CO_2 injection the pores and fissures formed in rocks, and at the cement-rock interface, can be a potential migration path for acid gases. It should be noted however, that alteration of the predominant host rock minerals is usually very slow, and therefore the real time experiments should be supported by computer modelling investigations.

References:

[1] Gaus I (2010) Int. J. Greenhouse Gas Contr. 4: 73-89

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