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Lab experiments on the formation artificial flowback from hydraulic fracturing with energized fluid

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We performed laboratory experiments reproducing the impact of CO2-based energized fracturing fluid on sample reservoir rocks in order to obtain simulated fluids of chemical composition, similar to the frac fluid flowback from gas saturated unconventional formation.

The autoclave, with a given rock sample inside (eg. Silurian gas shale from Baltic Province - Poland), was filled with fracturing fluid, consisting of 50% vol. gas, with additives: foaming agent, polymers, clay swelling inhibitor, scaling inhibitor and biocide. Mineralogical composition of rock samples, was determined by X-ray diffraction analysis. Autoclave reactor equipped with a heating mantle was placed on a shaker table. The reaction was carried out for 20 days at 80°C, from initial pressure of 250 bar. At regular intervals, frac fluid samples were taken from the reactor for chemical analysis, reducing the pressure each time by 10 bar, and maintaining the temperature constant. This procedure allowed for simulation of slow filtration of fluid, with simultaneous decrease in pressure.

Analyses of the flowback (reacted fracturing fluid), as expected, showed a significant increase in the concentrations of all the analytes, compared with the fluid before the reaction. The increase in major ions concentrations was the most distinct for sulfates, in case of microelements the highest growth was recorded for iron. The changes in chemical composition of the frac fluid result from its impact on the reactive components of rocks (mainly carbonates, silicates and pyrite) and to a lesser extent, from its interactions with the material of the autoclave built (Hastelloy). This latter phenomenon has been taken into account in determining the background concentration of metal cations in the simulated flowback. Further experiments were carried out for the blank fluid (we analyzed the composition of fluid in the autoclave, without any rock sample placed in it, in the experimental conditions for 3 days). They have shown that the reaction of the fracturing fluid with alloy, of which the autoclave is built, could be responsible for some part of the metal cations in fluid analyzed after the experiment. This share as high as approximately: 25% - for cobalt and 30% - for total iron.

The formation of the chemical composition of artificial flowback is the result of interactions between fracturing fluids and the reservoir rock. Our experiments allow for an assessment of the composition of the flowback from different formations, evaluation of its impact on the environment, and selection of the recycling technology. It was also found that for a proper assessment of simulated flowback composition it is necessary to determine the background, resulting from the interactions of the test medium with the construction material of the autoclave.