Geophysical Research Abstracts
Vol. 17, EGU2015-15891, 2015
EGU General Assembly 2015

Non-stationary filtration mode during chemical reactions with the gas phase

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An experimental and numerical study of filtration accompanied by chemical reactions between displacing fluid and solid skeleton is considered. Glass balls (400-500 μm in diameter) were placed in 1 cm gap between two glass sheets and were used as model porous medium. The baking soda was added to the glass balls. The 70% solution of acetic acid was used as the displacer. The modeling porous medium was saturated with a mineral oil, and then 70% solution of colored acetic acid was pumped through the medium. The glass balls and a mineral oil have a similar refractive index, so the model porous medium was optically transparent.
During the filtration, the gas phase was generated by the chemical reactions between the baking soda and acetic acid, and time-dependent displacement of the chemical reaction front was observed. The front of the chemical reaction was associated with the most intensive gas separation. The front moved, stopped, and then moved again to the area where it had been already. We called this process a secondary oxidation wave.
To describe this effect, we added to the balance equations a term associated with the formation and disappearance of phases due to chemical reactions. The equations were supplemented by Darcy's law for multiphase filtration.
Nonstationarity front propagation of the chemical reaction in the numerical experiment was observed at Damköhler numbers greater than 100. The mathematical modelling was agreed well with the experimental results.