Geophysical Research Abstracts
Vol. 15, EGU2013-7055, 2013
EGU General Assembly 2013

The influence of fluid composition on barite growth

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Depending on the fluid composition, the mechanism of interaction of a fluid with a mineral surface will involve transport of ions either to or from a mineral surface. The principal control on the growth of barite, BaSO4, has been shown to be the dehydration of the Ba2+ ion at the mineral-fluid interface (Piana et al., 2006). This is also likely to be the case for other ions that could be incorporated into a growing surface. It follows that any chemical influence on the dehydration kinetics will determine the redistribution of ions between solid and fluid phases. Earlier work has shown that the influence of background electrolytes, apart from the constituent ions in the barite structure, have a significant effect on barite growth, and it was hypothesized that this was due to changing the dynamics of the water structure (Kowacz and Putnis, 2008).
Here using Atomic Force Microscopy (AFM), we show that barite growth is influenced by the pH of the solution. Previous research does not indicate any pH dependence on the growth of barite, as speciation predictions do not vary significantly with pH. However atomic-scale observations show that at low and high pH, growth rates change compared to pH values 4 – 9. In order to test the influence of pH on barite growth, influencing factors need to be held constant apart from the factor (pH) being tested. AFM observations of barite growth under conditions of constant supersaturation, temperature, Ba/SO4 ratio and ionic strength but changing growth solution pH have been studied. In natural systems, the presence of other ions, apart from Ba2+ and SO42- growth building units, must be considered. We also investigate the influence of ionic strength on the growth process. Direct observations of barite growth at the nano-scale afford the possibility of directly seeing the growth process.
Barite scale formation is one of the main problems in many industrial processes (such as, paper-making, chemical manufacturing, cement operations, off-shore oil extraction, geothermal energy production). It is especially problematic (and costly) in oilfields due to its low solubility and hardness resulting in solid layers of barite that can block pipes completely, reducing the production of an oil-well. Barite scale in oilfields is caused by mixing of the injected seawater (high in SO4) to increase the oil extraction maintaining the inner pressure in the reservoir, with formation water (high in Ba2+) in the reservoir. The partitioning of trace amounts of radium (Ra2+) into the barite also leads to the problem that the scale becomes radioactive. The reactions that lead to BaSO4 scale formation and the methods that could reduce or prevent it are poorly quantified. To be able to control crystal growth, we first need to understand how barite grows, the conditions for optimal growth, as well as any factors that inhibit or reduce this growth to a minimum.

Refs.: Piana S., Jones F., Gale JD. Journ. Amer. Chem. Soc. 128, 13568 (2006)
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Acknowledgement: C.R-A. acknowledges a Marie Curie Fellowship: EU ITN MINSC (Mineral Scale Formation, PITN-GA-2011-290040)