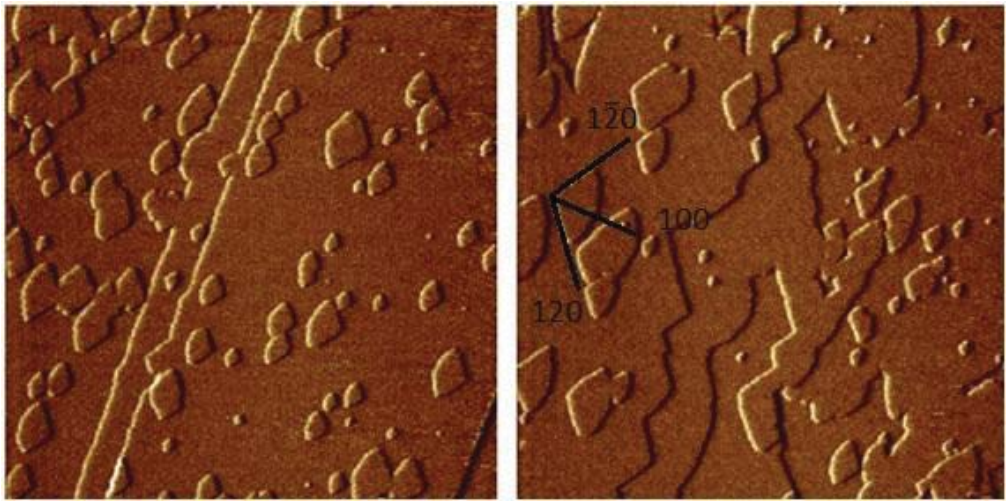
The influence of pH on barite nucleation and growth

Barite ($BaSO_4$) scale formation is one of the main problems in many industrial processes. 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. Because of the use of phosphonates acids as inhibitors of barite growth, we consider interesting to study the effect of pH variation on barite nucleation and growth. These additives work in high pH solutions when they are highly deprotonated and the interaction between the cations of the crystal surface and phosphonates groups reach a maximum because of the electrostatic attractions (Van Rosmalen, 1983).

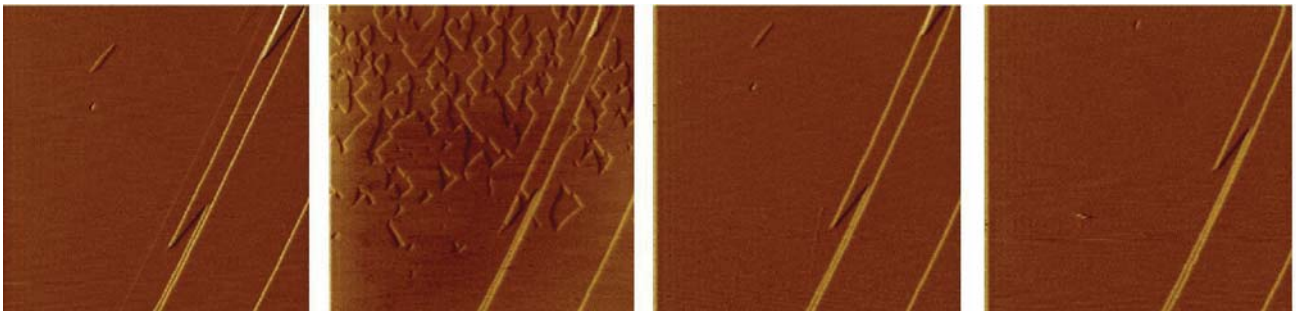
With the aim of testing the effect of pH on barite growth, influencing factors need to be held constant apart from the factor (here pH) being tested. Atomic force microscopy (AFM) experiments giving observations at a nano-scale show that barite nucleation and growth rates are influenced by the pH of the growth solution. In AFM image 1 “normal growth” (without changing pH of growth solution) is shown.

- Nucleation rate: 1,48 nucleus/ μm^2
- Incubation time: 300 s approximately
- Growth rate [100]: 0,37 +- 0,03 nm/s



AFM IMAGE 1: Barite growth pH=7. Normal growth with successive layers. We can observe the opposite orientation of the islands in consecutive layers.

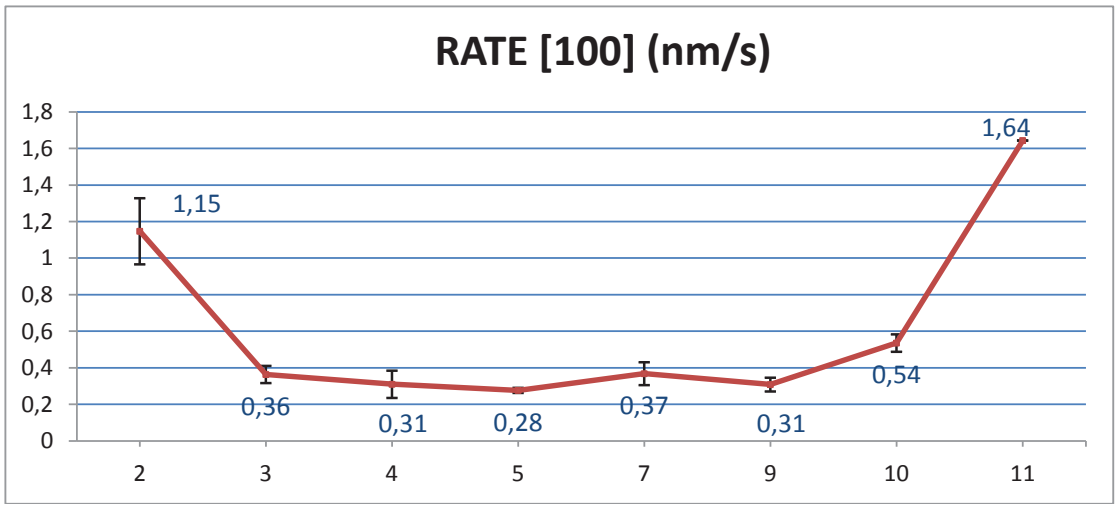
In the testing of high pH we observed immediately a higher nucleation density and fast growth but no more growth after the first completed layer (template effect, J. M. Astilleros).



(a) (b) (c) (d)

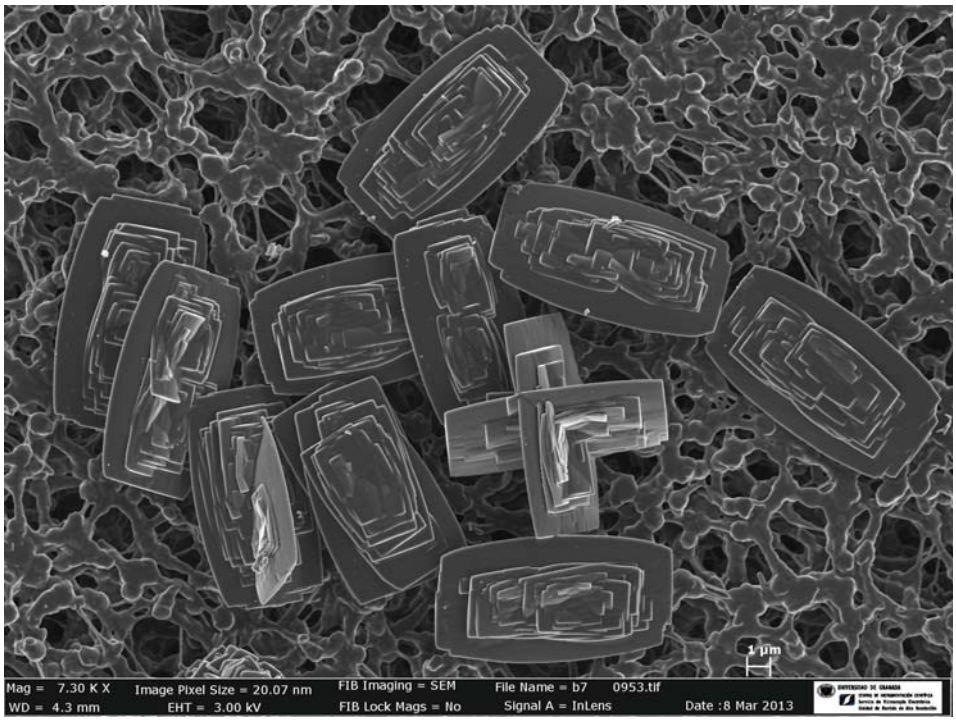
AFM IMAGE 2 (PH=12)

a) Before injecting the growth solution
b) First scan after injecting growth solution
c) Second scan after injecting growth solution.
d) Approximately 2000 s after solution was injected

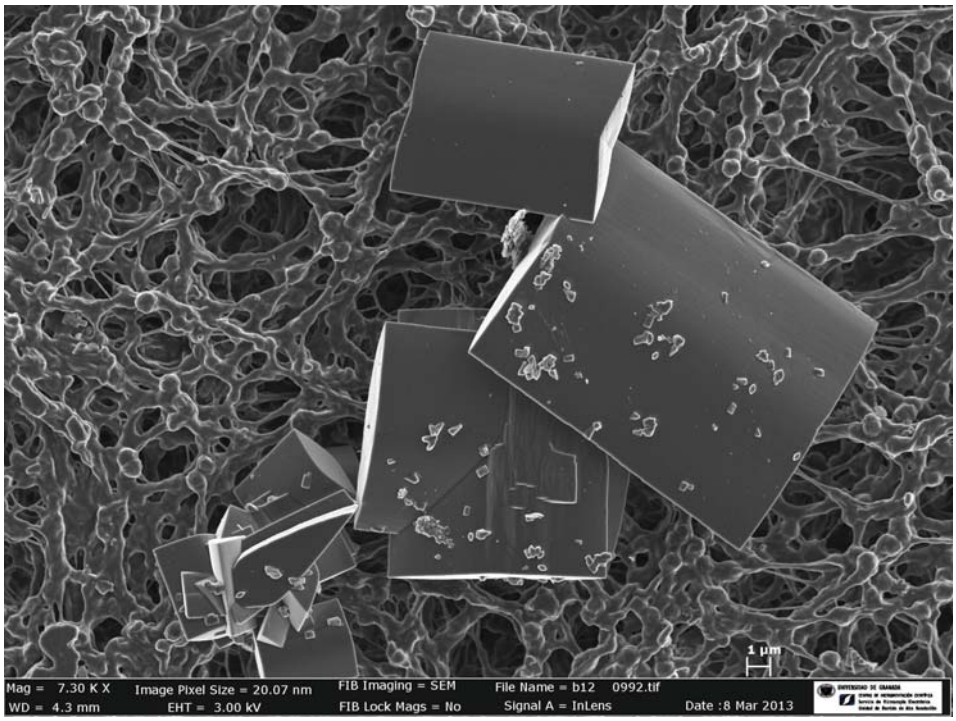


Growth rates of barite in [100] direction (nm/s) with pH variation

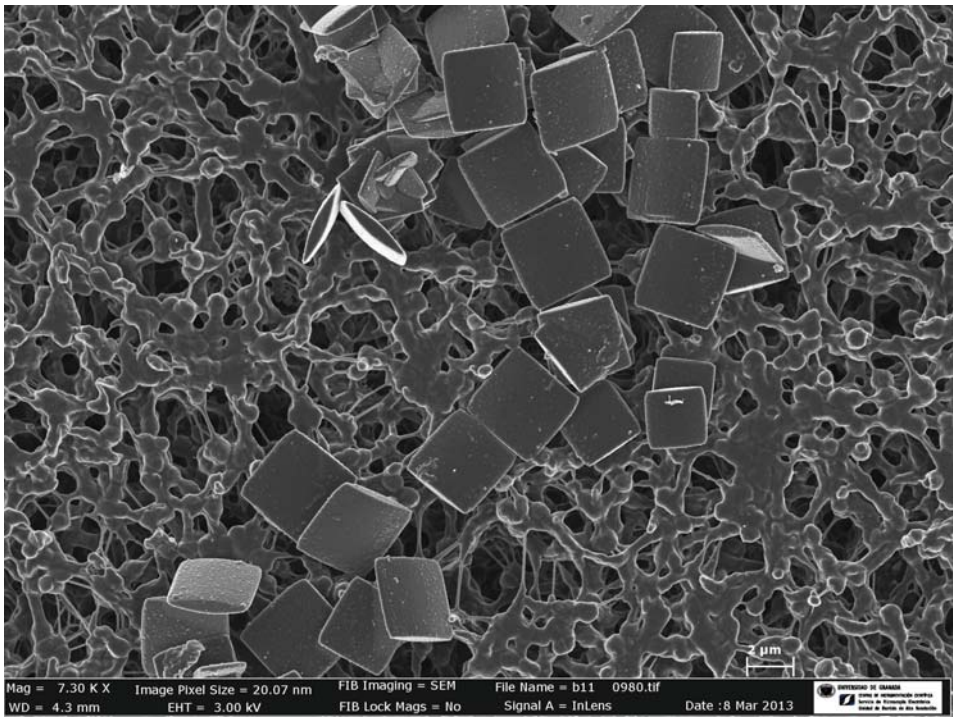
At the moment, we are working with a Spectrophotometer to test induction times and we observed the precipates of these experiments in FESEM (Universidad de Granada) to see changes in morphology. We could see some variation in the size and shape of the particles. The measurements of the change in conductivity during precipitation of $BASO_4$ are being studied. Calorimeter experiments were made in Oviedo to test changes in enthalpy and consequently in the hydration of Ba^{2+} with pH variation and we are waiting for the results.



FESEM Image 3: Barite precipitates with 0.00040M growth solution (7.300 X)



FESEM Image 4: Barite precipitates with pH= 2 and 0.00040M growth solution (7.300 X).



FESEM Image 5: Barite precipitates with pH= 12 and 0.00040M growth solution (7.300 X).

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