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Crystallization of Calcium Carbonate in a Large Scale Field Study

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The long term efficiency of geothermal facilities and aquifer thermal energy storage in the carbonaceous Malm aquifer in the Bavarian Molasse Basin is seriously affected by precipitations of carbonates. This is mainly caused by pressure and temperature changes leading to oversaturation during production.

Crystallization starts with polymorphic nuclei of calcium carbonate and is often described as diffusion-reaction controlled. Here, calcite crystallization is favoured by high concentration gradients while aragonite crystallization is occurring at high reaction rates. The factors affecting the crystallization processes have been described for simplified, well controlled laboratory experiments, the knowledge about the behaviour in more complex natural systems is still limited.

The crystallization process of the polymorphic forms of calcium carbonate were investigated during a heat storage test at our test site in the eastern part of the Bavarian Molasse Basin. Complementary laboratory experiments in an autoclave were run. Both, field and laboratory experiments were conducted with carbonaceous tap water. Within the laboratory experiments additionally ultra pure water was used. To avoid precipitations of the tap water, a calculated amount of CO_2 was added prior to heating the water from 45 - 110 °C (laboratory) resp. 65 - 110 °C (field). A total water volume of 0.5 L (laboratory) resp. 1 L (field) was immediately sampled and filtrated through 10 - 0.1 μm pore size polycarbonate filters and analysed by SEM/EDX.

The results indicate that turbulent flow regime during the heat storage test inhibited the crystallization of aragonites up to temperatures of 100 °C. Within the autoclave experiments, calcite crystallization was favoured by strong diffusion gradients even at high temperatures.