The influence of wave movement on the evaporation behavior of experimentally evaporated seawater

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Seawater from the North Sea was progressively evaporated in an incubator under controlled temperature and humidity conditions. The experiments were performed to investigate the trace element distribution of Br, Sr, Rb and Li between brine and different evaporite minerals during evaporation and following phase transitions. Sr, e.g., is incorporated in calcite, gypsum, anhydrite, polyhalite and celestine, but anhydrite and polyhalite also occur as phase transitions from gypsum and anhydrite, respectively.

Altogether, 75 kg seawater were evaporated. The air temperature was set at ~27°C (resulting in a water temperature of ~25°C), and the humidity was varied from 60% to 20%, dependent on the degree of evaporation. Wave movement was realized using a ventilator, where the airflow was set at max. 3.5 m/s. Both, solution and precipitated minerals, were sampled regularly and analyzed using ICP-OES and ICP-MS. The minerals were furthermore investigated using SEM and optical light microscopy.

During the experiments it pointed out, that wave movement results in different appearance of the precipitates and in different mineral paragenesis, particularly in a late stage of evaporation. If the wave movement is low, few cm big cauliflower-like carnallite-kieserite intergrowth, growing from small brine filled pores, occur at the developed salt crust. If the wave movement is high, no carnallite and kieserite intergrowth was observed, and single carnallite and kieserite crystals were much smaller (<< 1 mm).

The behavior of Sr was not significantly affected by different evaporation conditions. In all experiments, the Sr content in the solution increased from 7 mg/l to 64 mg/l, and decreased in the course of progressive evaporation to 8 mg/l. This behavior can be explained by plentyful development of Sr incorporating minerals like gypsum and anhydrite. Celestine was already found in assembly with gypsum, so it seems to precipitate continuously during evaporation.

The Br content in the brine increased from 60 mg/l to 4050 mg/l and is in line with available data, e.g. [1], and thermodynamic models [2].

[1] Herrmann *et al* (1973) *Contr. Mineral. Petrol.* **40**, 1-24. [2] Schramm *Goldschmidt Conference 2014*, this volume.