

Determination of the pressure resistance of salt hydrates (preliminary results)

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Abstract

Water in combination with an anhydrous salt can lead to significant rock heave and structural damage to engineering constructions as recently reported by Alonso and Ramon^[1]. Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) crystals growing in a deep stratum located below the massive pile foundations of the Pont de Cani are responsible for a heave rate of 5 to 10 mm per month. Heaving of massive pillars gives evidence of an enormous pressure exerted from the gypsum crystals. This pressure also acts on the gypsum crystals, hence the pressure resistance of the gypsum crystals has to be very high to withstand the stress generated by a heavy weight pillar.

In general for a hydrated salt a maximum pressure exists above which the hydrated crystal follows the principle of Le Chatelier and reduces its volume by dehydration. According to thermodynamic considerations a mirabilite ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$) crystal is able to withstand 9 MPa at 25 °C before it dehydrates, or the other way round not more than 9 MPa can be exerted by the hydration of thenardite (Na_2SO_4) to mirabilite^[2]. Investigations of hydration pressures were carried out by Knacke and von Erdberg^[3], where thenardite was hydrated with liquid water. A maximum pressure of about 1.9 MPa was measured during the partial hydration to an overall water content of about 2 mol H_2O per mol Na_2SO_4 . Neither the complete hydration nor the maximum theoretical pressure was reached in these experiments. The aim of the present work is to present a method to measure the absolute pressure resistance of hydrated salts.

To avoid problems with partial hydration, clumping of the salt hydrate and overflow of added water an experimental setup was designed to measure the force required to dehydrate a hydrated salt at constant temperature and relative humidity. The salt hydrate is embedded between stainless

steel plates placed in a climatic chamber. An excess of force generates a pressure on the hydrated crystal which is above the crystals pressure resistance. At point A in figure 1 an initial force is applied and the only way for the crystal to decrease the pressure is by reducing its volume. In the first step, the crystal will dissolve since its solubility on the loaded sides is increased and therefore its volume decreases. Once the pressure dependent deliquescence humidity is reached (B) dissolution stops and if the investigated phase is metastable with respect to another phase, a solid state dehydration will continue the volume decrease until it reaches the pressure dependent phase equilibrium (C). At this point the crystal has reached its maximum pressure resistance and the measured force stabilizes. The maximum pressure can then be calculated from the measured force with a precision of approximately ± 0.013 MPa. For a better comparability, first experiments were carried out with mirabilite.

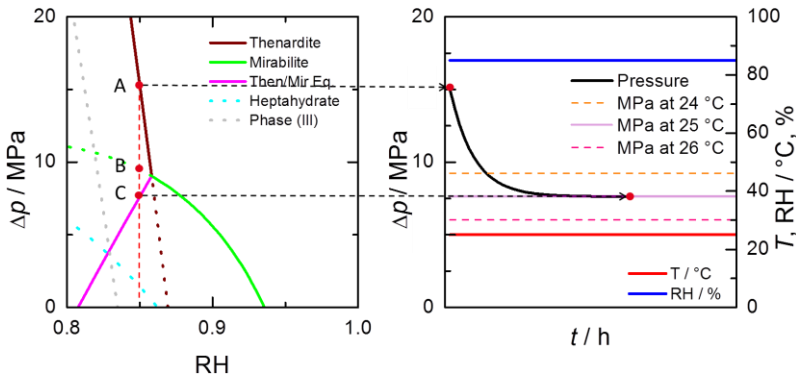


Fig. 1: Expected pressure evolution during an experimental run with mirabilite.

Keywords: Hydration pressure; Mirabilite; Experimental

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