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Force of crystallisation of gypsum during of hydration of synthetic anhydrite rock.

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In tunnels cutting through anhydrite-rich rocks gypsum aggregates and fibrous gypsum veins are reported to develop soon after water gains access. The growth of the gypsum veins is associated with the build-up of differential stresses up to several MPa and may lead to large distortions. In the nature, fibrous gypsum veins are observed to develop under an overburden of maximal 300-700 m. Different models have been proposed to explain the origin of these veins. Taber (1916) proposed that gypsum creates its own space by crystallisation forces, pushing aside the vein walls. Natural fibrous veins are developed dominantly in horizontal orientations with vertical fibres. At these depths, the vertical direction is the only direction in which the veins can open without building up significant tectonic stresses. Evaporation experiments by Means and Li (2001) illustrate that it is possible to grow fibres against an external pressure in laboratory experiments. The aim of our study was to measure the force of crystallisation experimentally and to indicate if fibrous growth due to the force of crystallisation is possible.

In the reaction of anhydrite + 2 H_2O -> gypsum a volume increase of maximal 61% is possible because the water used in the reaction is built into the crystal lattice. During crystallisation, minerals can exert a force upon their environment. This force of crystallisation enables crystals to grow against an external pressure (overburden). In laboratory experiments was tried to measure the pressure exerted by synthetic anhydrite that reacted with water to gypsum. The conversion took place in a uniaxial cell, loaded with dead weights on top of it and to which water had free access. The expansion of the anhydrite due to the reaction could be measured with a dial gauge micrometer. Some experiments were done with natural anhydrite. Crystallisation against an external pressure might be regarded as an opposite to pressure solution. With a pressure solution related formula is tried to describe the force of crystallisation. This theoretical value has been compared with the experimentally obtained value. Other laboratory experiments were done to grow fibres by evaporation of solutions of salts that are better soluble in water than calcium sulphate. These are a variation on experiments done by Means & Li (2001). The gypsum and the fibres grown in laboratory were compared to gypsum fibres found in the field, using light microscopy and SEM Secondary Electron analysis.

The evaporation experiments made clear that it is possible to grow fibres under an external pressure in laboratory experiments. These fibrous veins were antitaxial, as the gypsum veins in the field are. We did not succeed to grow gypsum fibres in laboratory, but it was possible to measure the force of crystallisation during the reaction of synthetic anhydrite to gypsum. This force was related to a pressure of 11 MPa. The theoretically calculated value of 15 MPa is in relatively good agreement with this value. 11 MPa is related to an overburden of 450-600 meters of rock and soil; gypsum can be formed out of anhydrite at depths that are important in tunnel building and can form a possible explanation for the growth of gypsum veins up to these depths. If it is possible to develop fibrous veins under this pressure should be studied in a next project.

Means, W.D. & Li, T. (In press) A laboratory simulation of fibrous veins: some first observations. *J. Struct. Geol.*
Taber, S. (1916) The growth of crystals under external pressure. *American Journal of Science, 4th series, Volume 26, 532-556.*