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Fabric dependence of length change behaviour during salt crystallisation in the pore space of porous building stones

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For a long time it is known that salt in the pore space leads to a damage of natural building stones. This can be traced back to physically induced stresses within the rock. If the stresses exceed the tensile strength of the material, damages in the form of micro cracks may results. This damage should be lead to a volume or a length change of the porous material. Beside the exposition, the salt type and the climatic conditions also the respective stone and its fabric have a significant influence of the material weathering resistant. Especially the pore space parameters, e.g. porosity and pore size distribution control the water transport mechanisms and lead to an enrichment of salts in different zones. The increasing scientific research in the last centuries has shown that there exists a huge quantity of parameters, having an influence on the weathering by salt crystallisation processes. However, the effective mechanisms of the stress development within the rock fabric are not yet understood.

In order to get more information about the fabric dependence of physical weathering by salt crystallisation in the pore space of natural building stone we performed length change measurements during weathering simulations and correlated the results with the fabric and petrophysical properties of the respective stones. Various types of sand- and limestone's with different fabric properties have been investigated. The petrophysical data contain pore space properties (porosity, pore radii distribution), tensile strength data and water transport properties (capillary water uptake, water diffusion coefficient, drying velocity). The length change of the samples during salt crystallisation was measured with a special modified dilatometer. The cylindrical samples (15x50 mm) were cyclic loaded with a 10 percent sodium sulphate solution. A wetting cycle of four hours and a following drying cycle (30 % relative humidity) of 16 hours have been applied. The temperature was hold at 20 ˚C.

The length change behaviour shows different phenomenon during salt solution absorption and during drying which results in different residual length changes. These differences are controlled by the rock fabric, whereas the portion of clay minerals, the effective porosity and the pore size distribution as well as the resultant water transport properties are very important parameters.

For stones with a high content of clay minerals in the initial loading cycles an expansion can be observed during the absorption stage. This is a result of swelling of clay minerals. After drying a residual strain remains which can be attributed to the inclusion of cations in the interlayers of the clay minerals. Rocks with a lower content of clay minerals show no significant length change of samples in the initial loading.

During increasing loading cycles two totally different length change behaviours can be observed for the investigated samples. Rocks with a high portion of micro pores beside a pore radii maximum in the range of capillary pores show an increasing of expansion during the adsorption stage associated with a high residual strain after drying. In contrast to this behaviour samples with narrow pore radii maximum and only a few portions of micro pores exhibit a contraction. This contraction can reach extreme values about 8 mm/m. Up to now the cause for the material shortening remains an open question. Samples which show this dilatation behaviour are much more resistant in the salt crystallisation test than samples with a high content of micro pores.