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ELECTRO-DESALINATION OF SANDSTONE CONTAMINATED WITH SODIUM SULPHATE

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Abstract

Cultural heritage stone monuments are lost all over the world due to salt induced decay. When water accesses the pore network of a stone, the water may carry various salts in solution. Several mechanisms can subsequently cause crystal growth and crystallization-dissolution cycles, which can result in severe stone damage.

The damaging effect varies between salts and salt mixtures, and not all salts are equally harmful, e.g. [1] showed that evaporation from a saturated Na_2SO_4 solution caused more damage in limestone than evaporation from a saturated NaCl solution, because Na_2SO_4 easily forms supersaturated solutions, which is a mechanism for the generation of stress [2]. According to [3], at 20°C $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ is the stable form of sodium-sulphate at relative humidity (RH) between 71 % and 93 %. $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ occupies a 314 % larger volume than the anhydrous salt. Thus, the volume of sodium-sulphate changes significantly with changes in RH, which is likely to be a major factor involved in the development of crystal pressure. The topic of the present communication is removal of Na_2SO_4 from carbonaceous sandstone by electro-desalination (ED) in order to stop the decay.

ED is based on application of an electric potential gradient and electromigration of the ions from the damaging salts out from the stone. During ED electrodes are placed externally on the surface of the salt infected stone. The electrodes are placed in a poultice in which the ions from the salts concentrate during the treatment. When removing the poultices after the desalination, the ions of the salts are removed with them.

At both electrodes there are pH changes due to electrolysis reactions. The pH decreases at the anode and increases at the cathode. It is necessary to neutralize the pH changes in the poultice to prevent pH changes of the stone itself. Herinckx et al. [4] underlined the importance of avoiding stone acidification, as in experiments without pH neutralization; the stones were severely damaged next to the anode. Calcite rich clay poultice can be used for neutralization of the pH changes at the electrodes [5]. The calcite buffers the pH changes and the clay gives good workability, so the poultice can have optimal contact to the surface of the stone to be desalinated. When the calcite buffers the acid from the anode, Ca^{2+} ions are released. If these

ions do not precipitate with anions in the poultice, they are transported into the limestone by electromigration, and can possibly precipitate with dissolved SO_4^{2-} as shown in numerical-chemical modelling by [6]. The precipitation would happen in the stone closest to the anode. Should this happen, it may hamper the desalination and the formation of calcium- sulphates may even contribute to further salt weathering.

Compiling experimental results from various ED experiments it is evident, that chlorides and nitrates are removed faster than sulphates. This has most often been ascribed the generally lowest solubility of the sulphates. In case the acidification from the anode is not buffered in the poultice, sulphate is accumulating in the part closest to the anode in a calcareous sandstone during ED, and although accumulation was also seen in a similar experiment with poultice, the latter was less pronounced. Over time, the sulphate concentration decreased again in the stone closest to the anode [7]. Overall, from the experiments conducted, gypsum formation in the stone seems not to hamper sulphate removal by ED from different stones.

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