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Electro-Desalination of Sandstones With Cracks

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1 Introduction

Electro-desalination (ED) is a method under development for the removal of salts from porous stones, where an electric DC potential gradient is applied to the salt infected stone (Ottosen and Christensen 2012), (Ottosen and Andersen, 2017). The method utilizes that ions in the pore solution are transported by electromigration towards the electrode of opposite polarity. The electrodes are placed externally on the stone surface in electrode compartments with poultice, and the ions from the salts concentrate in the poultice. When the poultices are removed after the ED, the ions of the salts are removed with them.

Damaged stones are often cracked, and thus it is relevant to investigate if the salts are removed efficiently around the cracks. This work is an experimental investigation of the influence from a major crack on the ED process.

2 Materials and Methods

The experimental work was conducted with Gotland Sandstone. Four rectangular stone prisms were cut from the same stone block. The prisms were 13.5 cm x 7.5 cm x 5.5 cm. A crack was cut half way through each prism in the middle, perpendicular to the longest side (and the electric field lines) (Figure 1). The width of the void was about 1 mm.

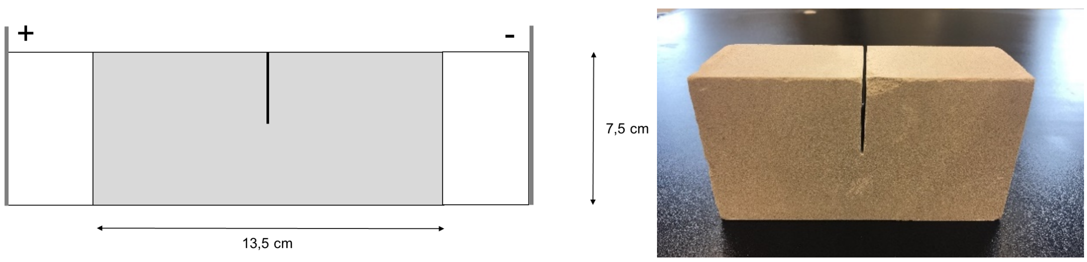

Figure 1. The setup for electro-desalination. The electrodes are placed in clay poultice on each end of the stone, and a crack is cut half into the stone perpendicular to the electric field.

A reference stone (REF) was made with no applied current. The REF stone was wrapped in plastic film for 2 weeks. Three ED experiments were made differing only in duration: 2, 4 and 5 weeks (ED_2, ED_4 and ED_5). A constant current of 10 mA was applied to the electrodes. After the experiments, the stone prisms were segmented with hammer and chisel into 8 segments. The upper row of four segments were named a-segments and the lower four b-segments.

3 Results and Conclusion

The concentrations of Cl and Na in the different segments after the REF and the three ED experiments are shown in figure 2. The decrease in concentrations is clear and the average concentrations were already about halved after two weeks.

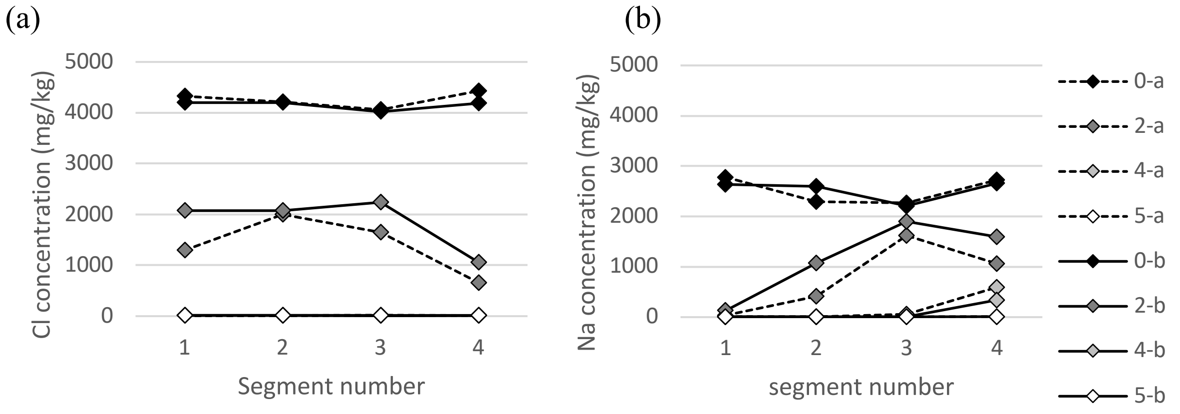

Figure 2. Concentration profiles of (a) Cl and (b) Na in the stone segments at the end of the experiments. The dotted lines are the profiles in the segment row with the crack (a-segments) and the full lines are the lower row of segments (b-segments)

The final Cl concentration in all segments in ED_4 was between 14 to 19 mg Cl/kg (figure 3), which corresponds to a reduction of more than 99.5% in comparison to the 4200 mg Cl/kg, which was the initial concentration in the ED. The final Cl concentrations were even lower than the concentration in the stone before the spiking (21.4 mg Cl/kg), and the Cl removal was successful all through the stone. Thus, the final Cl concentration in the segments next to the crack was not negatively influenced by the crack. The removal of Na was slightly slower than the removal of Cl. However, within one week longer treatment, the Na removal was successful, as in ED_5 the concentrations in the segments were between 7 and 11 mg Na/kg, which was also less than before the spiking (2520 mg Na/kg). In summary, Na and Cl were removed to very low concentrations in all stone segments during the ED treatment and after 5 weeks, the concentrations were lower than before the stones were spiked. Thus, the crack did not prevent successful desalination.

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