

## Time Scale of Water-Rock Interaction Processes in the Fresh-Saline Water Interface of Coastal Aquifers

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### ABSTRACT

The goal of this work is to estimate the time scale of water-rock interaction processes in the fresh-saline water interface (FSI) in a coastal aquifer. For this purpose we conducted high resolution groundwater sampling of the FSI of the coastal aquifer of Israel. Seasonal and diurnal variations of the FSI were investigated in a research well located 70m (landwards) from the sea shore and perforated all along the length of the pipe.

Sampling of groundwater was conducted with a bailer in the FSI zone and below and above it as well. In addition, sampling with high vertical resolution (15 cm) was done with Multi Layer Sampler (MLS; Ronen et al., 1987). The groundwater was analyzed for major ions, alkalinity, dissolved inorganic carbon (DIC) and  $\delta^{13}\text{C}$  of the DIC ( $\delta^{13}\text{C}_{\text{DIC}}$ ).

The chemistry of the groundwater at the FSI zone indicates that the composition is not controlled only by simple mixing of freshwater with seawater but also by cation exchange. The calcium is up to 50% higher than in seawater (Figure 15), while the potassium is significantly depleted. The mass balance shows that the cation exchange occurs in different magnitude during the year.

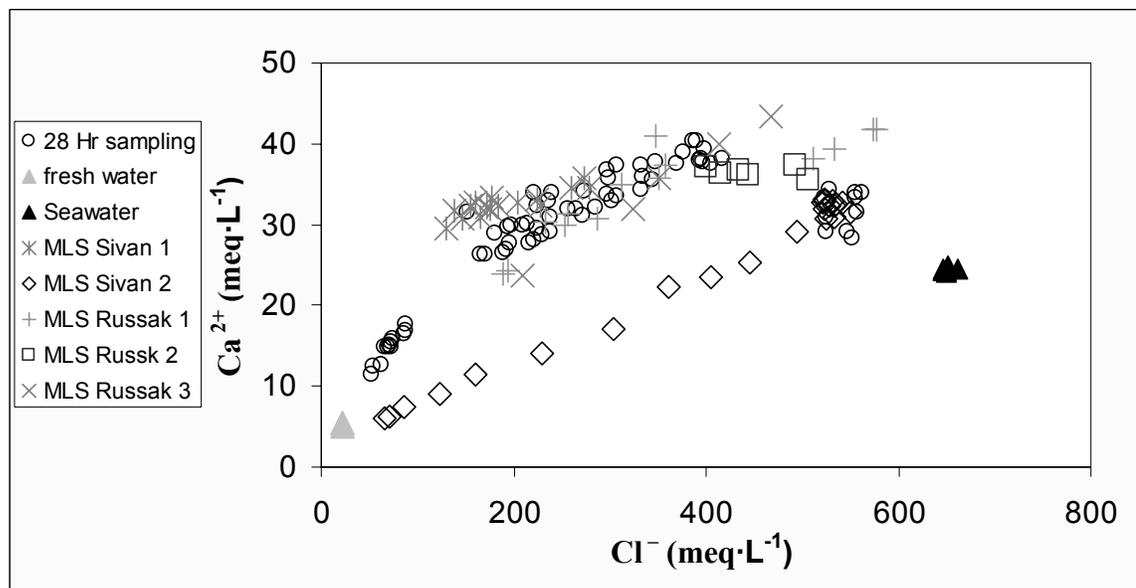


Figure 15. Calcium versus Chloride (field results)

The diurnal behavior of the FSI was examined by sampling water in six depths, every 2 hours for 28 hours. Water samples were taken above the FSI (depth of 20 m), below the FSI (depth of 27 m) and in four depths within the FSI. These depths were chosen following an electrical conductivity measurement by a submersible profiler. Thin pipes were fitted to the well, reaching each of the selected sampling depths, and the groundwater was sampled by a peristaltic pump.

The diurnal variations in the chemical composition were mainly tidal and, similarly to the case of seasonal behavior, did not follow a simple freshwater and seawater mixing behavior (Figure 1). The differences between low tide and high tide may imply that cation exchange processes are fast and occur already on a daily scale; however more measurements and calculations are needed to corroborate this conclusion. It should be mentioned that the diurnal changes could be, at least partly, caused by the well artifact and do not necessarily represent the actual aquifer.

Cation exchange estimates were conducted in the laboratory using experimental column filled with coastal aquifer sediments taken near the research well. The column was first saturated with freshwater from the research well; then seawater was pumped into the column by peristaltic pump and the water at the exit of the column was sampled regularly. The experiments show clear indication for cation exchange with the same trends as observed in the field but in larger magnitude. The conservative ions (e.g. Cl<sup>-</sup>) showed a simple breakthrough curve between the two end members (freshwater and seawater). Calcium increased after salinization to a peak of much higher value than in seawater (45 and 52 meq·L<sup>-1</sup> compare to 24 meq·L<sup>-1</sup> in the Mediterranean Sea) and then decreased to seawater levels (Figure 2). Potassium concentrations after salinization were lower than expected from simple mixing. Sodium show little depletion relatively to its concentration and magnesium seem conservative as chloride. It should be noted that the same cation exchange pattern was observed either in low or high flow velocities (200 and 1000 m·y<sup>-1</sup>). Flow velocity of 1000 m·y<sup>-1</sup> is ten times higher than was described in previous experiments (Appelo et al., 1990; Gomis-Yagües et al., 1997). The present research included also analysis of δ<sup>13</sup>C<sub>DIC</sub>, and was not conducted in previous experiments. The δ<sup>13</sup>C<sub>DIC</sub> results indicate that slight oxidation of organic matter already occurs within the experimental column (Figure 2).

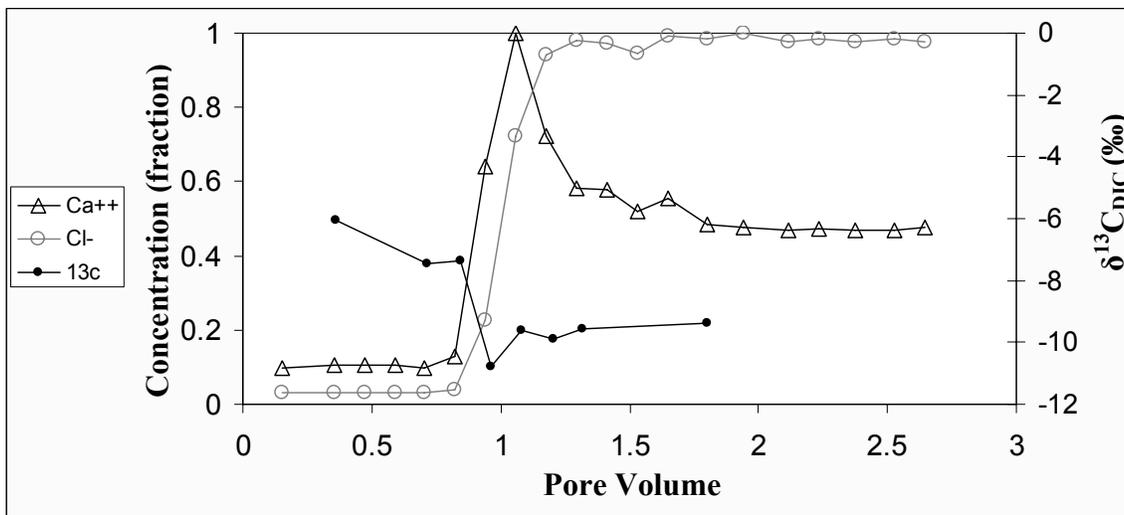


Figure 2. Seawater intrusion experiment results (200 m·y-1).

The diurnal field data was not conclusive for the role of tide in affecting the cation exchange processes within the aquifer. The cation exchange patterns observed in the well's vertical profiles however, were similar to those of the seawater intrusion column experiments. We conclude that cation exchange is an important process controlling the water chemistry of the FSI in the coastal aquifer of Israel on a seasonal time scale at least.

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