A 100 hour pump test in the 1B mine pool of the Sydney Coal Field, Nova Scotia, Canada

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Extended Abstract

Cape Breton University's Industrial Research Chair conducted a 100 hour pump test at the Neville Street Wellfield (Cape Breton Island, Canada) in order to validate the hypothesis that the electrical conductivity can be used to estimate the iron concentration of the mine water at the point of discharge. Besides flow measurements, chemical parameters and on-site parameters of the mine water were measured during the pump test.

As has been shown, the total iron concentration is correlated with the electrical conductivity. Consequently, the iron concentration can be predicted by using electrical conductivity measurements of the mine water. Therefore, electrical conductivity probes can be used to estimate the iron concentration of the mine water extracted by the different wells. In the future, the well with the lowest electrical conductivity shall be switched on first and then, in the order of higher electrical conductivities, the other pumps shall be switched on.

Based on the results of the physico-chemical measurements it became clear that the 100 hour pump test gradually picked up deeper mine water while the pumps lowered the mine water table. Though the water table was only lowered by 0.8 m, the chemical composition of the discharged mine water changed significantly as indicated by an increase of electrical conductivity. Statistical investigations showed that there are two groups of mine water, each consisting of two subgroups. The first group might be characterised as near surface water, the other one as deeper mine water. Deeper mine water is not deep mine water yet, as the deeper mine water still contains nitrogen. This should not be the case for deep mine water.

Elevated chloride or sodium mass concentrations in mine waters are either an indication for sea water, for formation water, or municipal waste. All samples show Cl^- mass concentrations between 120 and 160 mg L^{-1} (mean 139 mg L^{-1}) and Na^+ mass concentrations between 110 and 200 mg L^{-1} (mean 150 mg L^{-1}). Therefore, there is no indication for an uptake of sea water during the pump test.

During the course of the pump test, the oxygen mass concentration gradually decreases. This fact is another indication of an uptake of deeper mine water while the mine water table is lowered. Because the last samples still contain 35–40 % of oxygen it is unlikely that really deep mine water was taken up during the test.

Principal Component Analyses (PCA) is usually conducted before a hierarchical cluster analyses to identify the relevant parameters for the clustering. All the parameters in component 1 of the PCA were used to calculate the hierarchical cluster analyses using Squared Euclidean Distance and the WARD linkage method. It shows clearly that the ten mine water samples analysed during the pumps test can be divided into two significantly different groups. The first group consists of the water samples of the first six pumping steps and the second group of the last four samples. From the order of the samples in the graph it can be deduced that the mine water chemistry changes, as more and more pumps are switched on. If the mine water chemistry did not change significantly, all samples would fall into one group. The most interesting result is the fact that the last four samples, relating to pumping steps B-193, B-185, B-176, and B-198, form one group. This is a clear indication for an uptake of deeper mine water starting with the last four pump steps.

To investigate the relation between the total unfiltered iron concentration and the electrical conductivity (25 °C), a regression analyses was conducted. The simplest equation was the linear model and was chosen to represent the relationship between the electrical conductivity (κ in µS cm^{-1}) and the total unfiltered iron mass concentration ($Fe_{tot,unfiltered}$ in mg L^{-1}) at the well field (Figure 1). Based on those results the total unfiltered iron mass concentration can be calculated with the following equation (error range is the 95 % prediction interval):

$$Fe_{tot_{unfiltered}} = 1.402 \cdot 10^{-2} \times \kappa - 2.394 \cdot 10^{1} \pm 1.250 \text{ [mg L}^{-1}\text{]} \quad (1)$$

For the future, long-term operation of the Neville Street Wellfield, an optimization of the pump scheme control is mandatory. So far, the operational sequence of the pumps relied on biannually chemical analyses of the mine water,

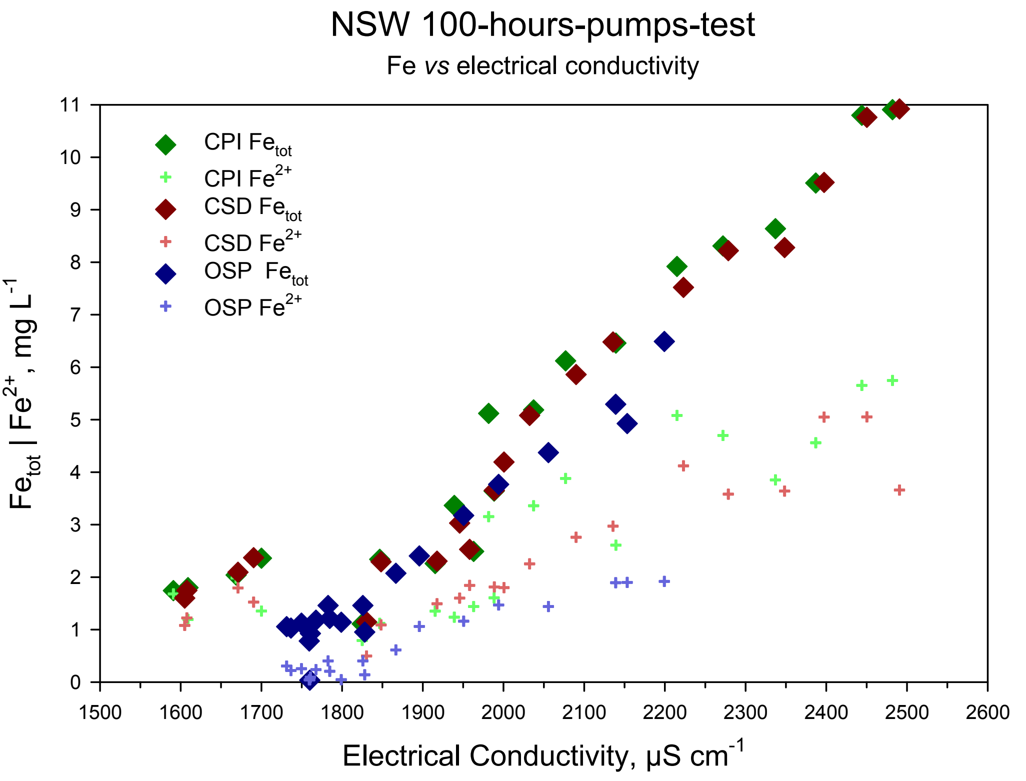

***Figure 1**. Iron versus electrical conductivity (25 °C). Fe_{tot} is plotted in diamonds and Fe^{2+} in lighter coloured crosses.*

whereupon the first pump to be switched on had the lowest and the last one the highest total iron concentration. Though the results of those complete analyses are important for the prediction of the mine water chemistry's development, they are no longer needed to control the pumping scheme at the well field as the sequence of the pumps can be based on the electrical conductivity.