The Use of Sensor-Data for Investigating the Transport and the Reactivity of Fe(0) Nano-Particles

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Susceptibility Sensor for Measuring nZVI in Columns

Problem

For a detailed description of the transport and reactivity of nZVI (nano zero-valent iron) column experiments are a suitable tool. To be able to measure the concentration of the particles standard analytical methods are inappropriate, since they can only be applied after the experiment, are destructive and limited to an analytical background of iron in the soil material used. In addition, they cannot provide transient information during the experiment.

Approach

In order to quantify the concentration of nZVI in such column experiments a special setup was developed (see fig 1). A mobile sensor is moved along the column and measures the magnetic susceptibility with repeated scans. The data obtained is stored in a data base and is being processed after the experiment.

In order to get real concentrations along the column various steps of data processing are required.

The same setup can be used for transport experiments and for reactivity experiments. The differences in operation are described below.
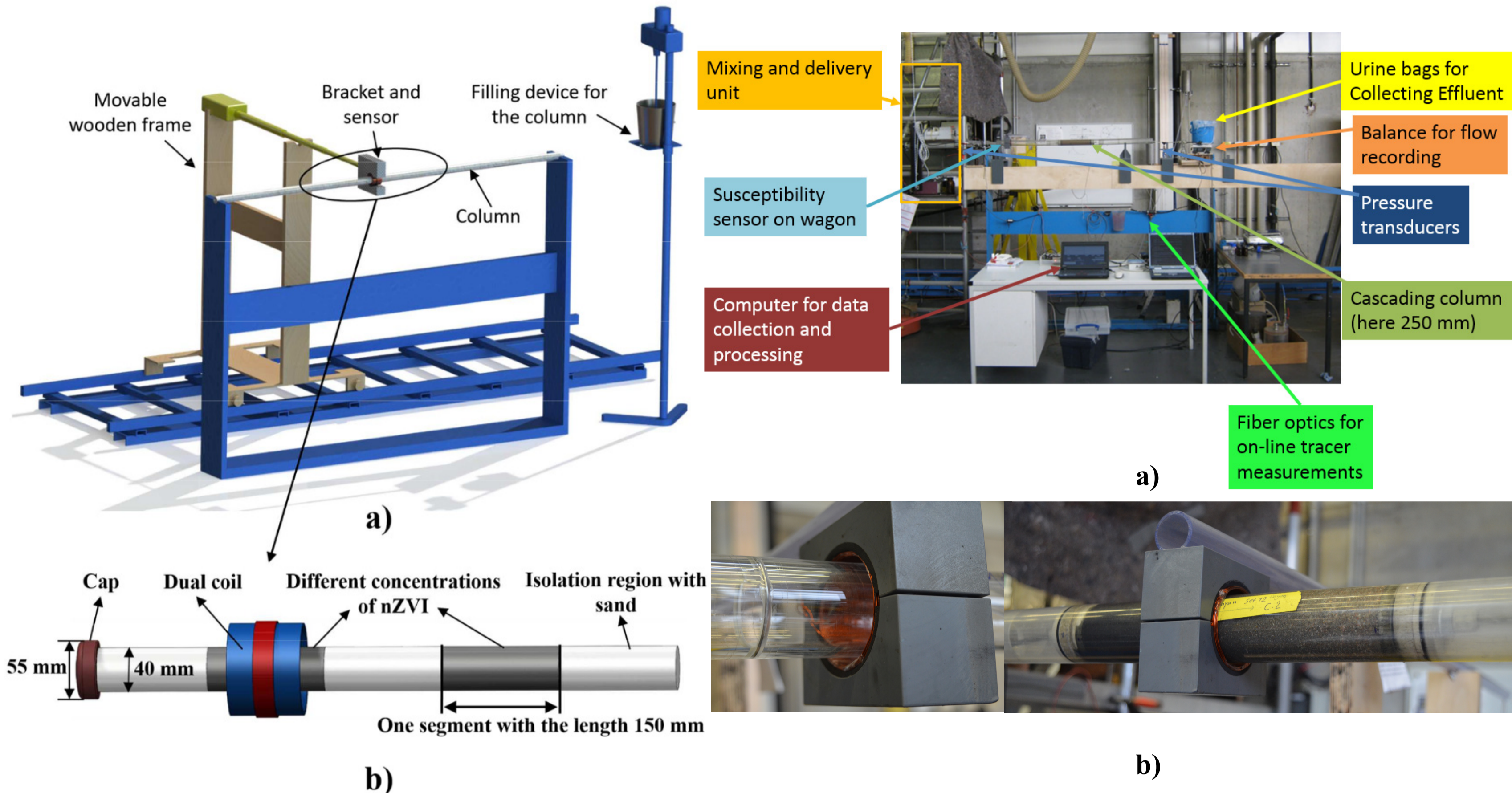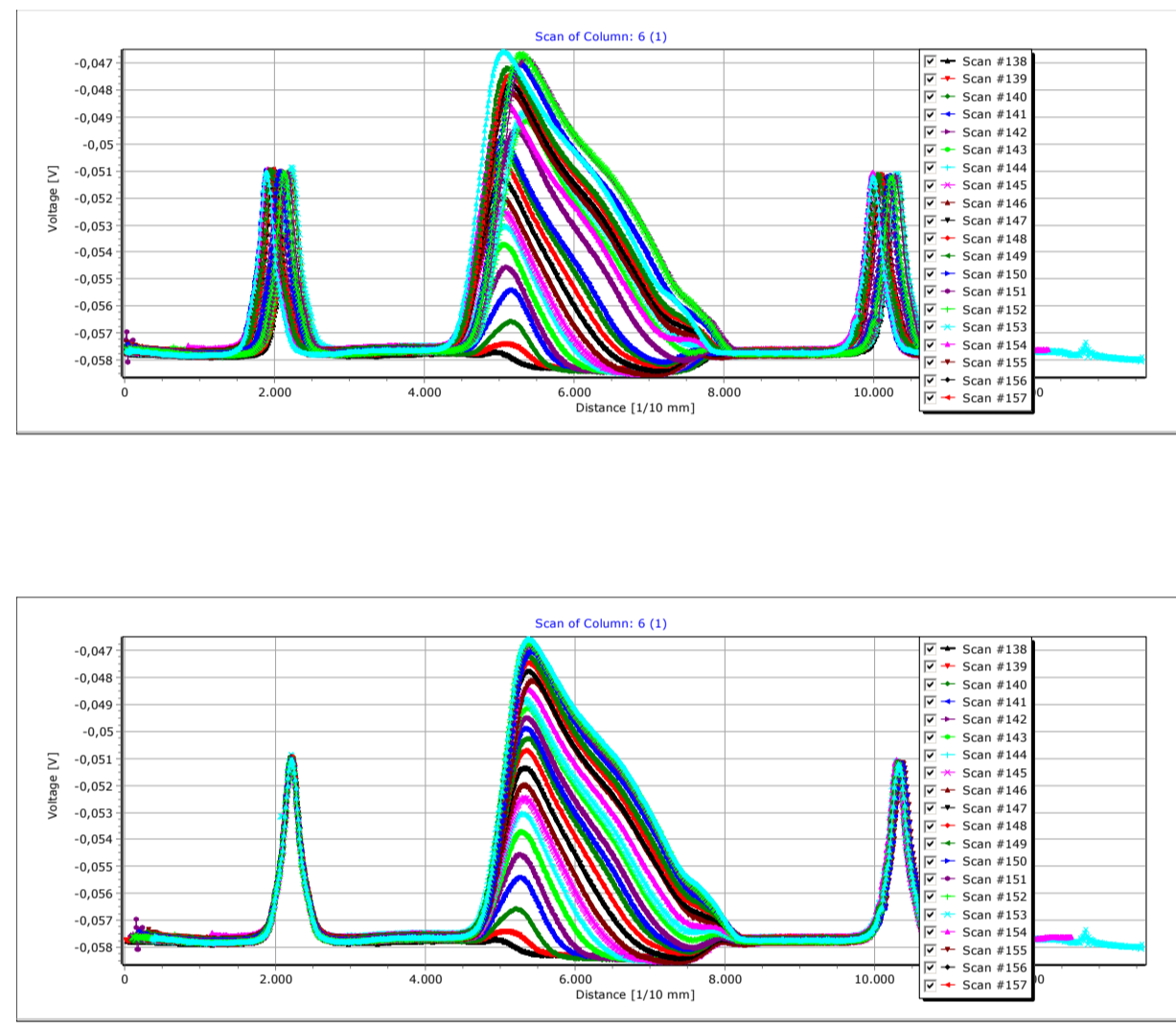

Fig. 1: Measurement setup a) overview with rack, column and wagon, b) detailed view of column and sensor [1]
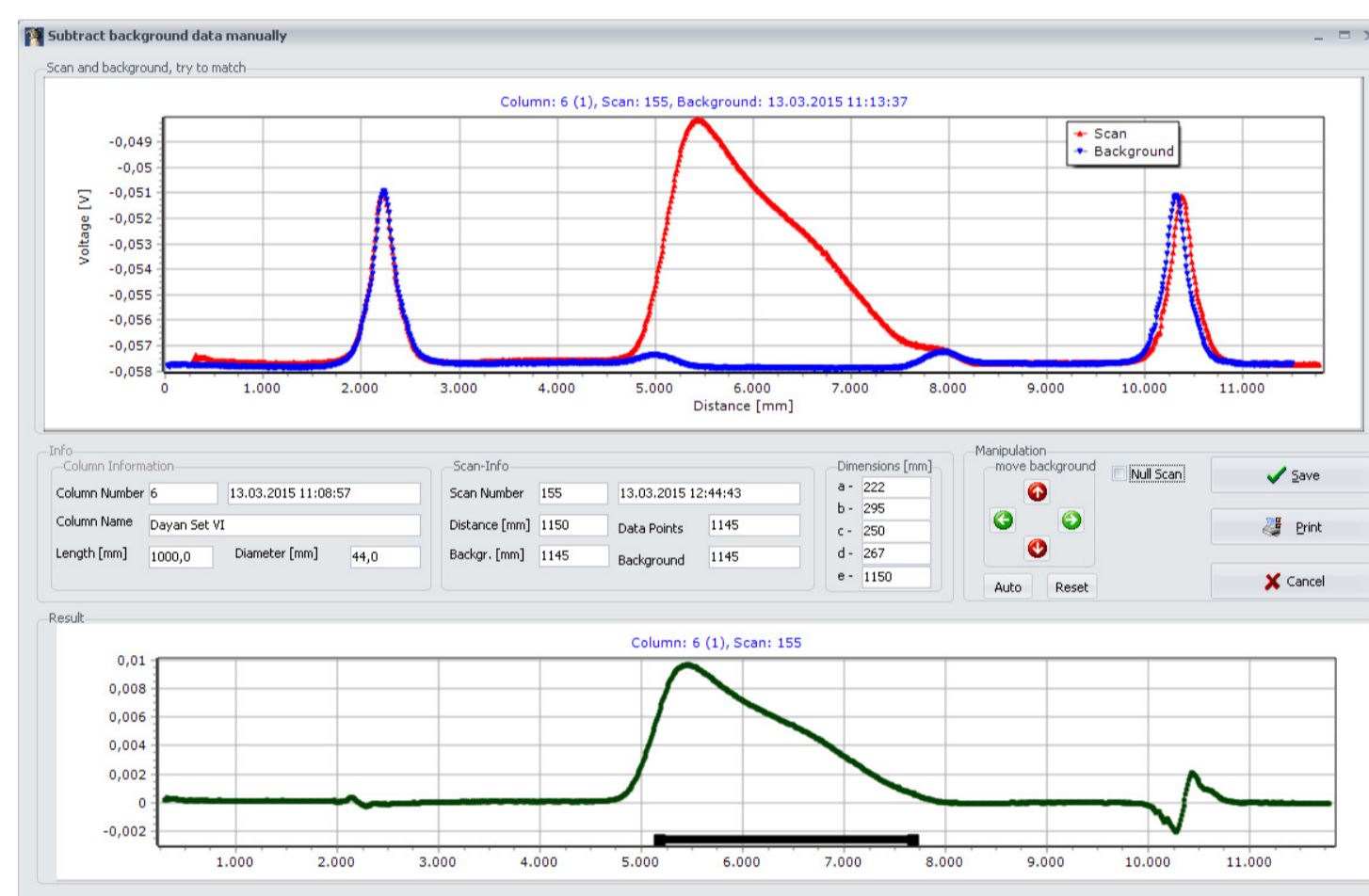
Fig. 2: Photo of transport setup with all installations and measurement devices (a) overview, (b) details
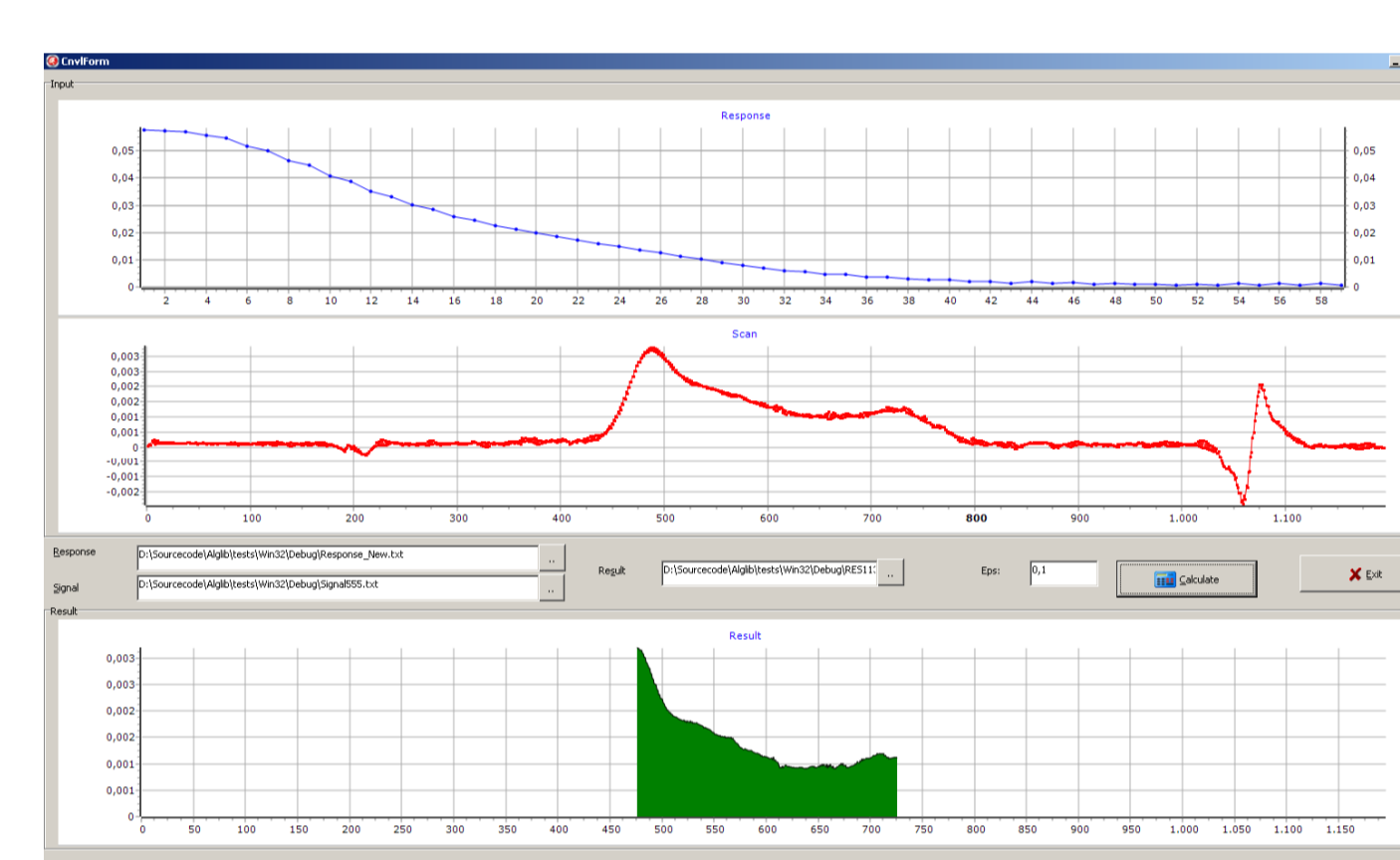
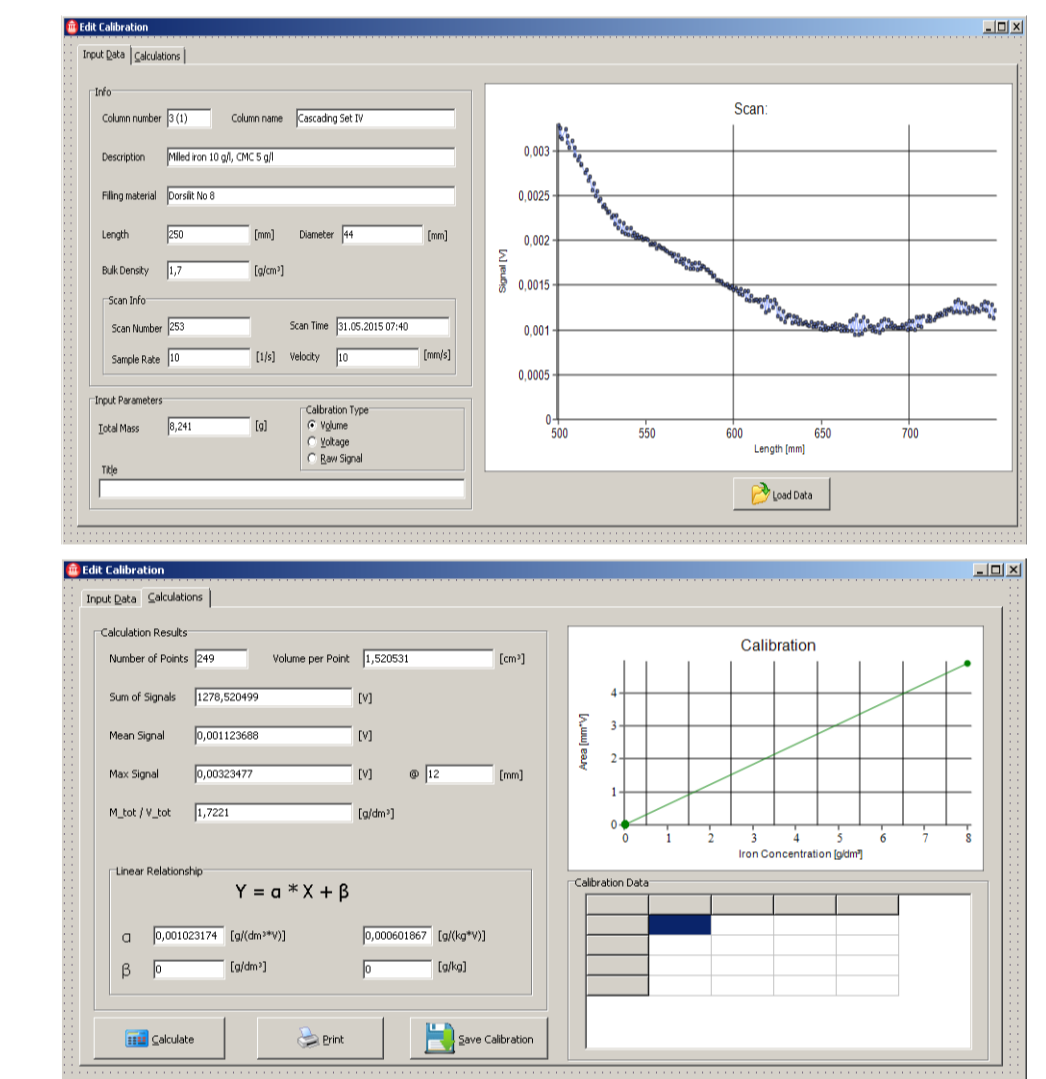## Data processing

Step 1: Horizontal alignment of positions

Step 2: Subtraction of background

Step 3: Deconvolution

Step 4: Calibration

Investigating Transport

With the setup decribed above transport experiments can be performed which allow for the detailed description of the transport behavior of nano- or micro-sized iron particles under different conditions and in different formulations (additives). Below the influence of carbomethylcellulose (CMC) is shown for improving the mobility of a specific particle. The left figure shows an accumulation of the iron, whereas the right figure shows a breakthrough after 8 pore volumes.
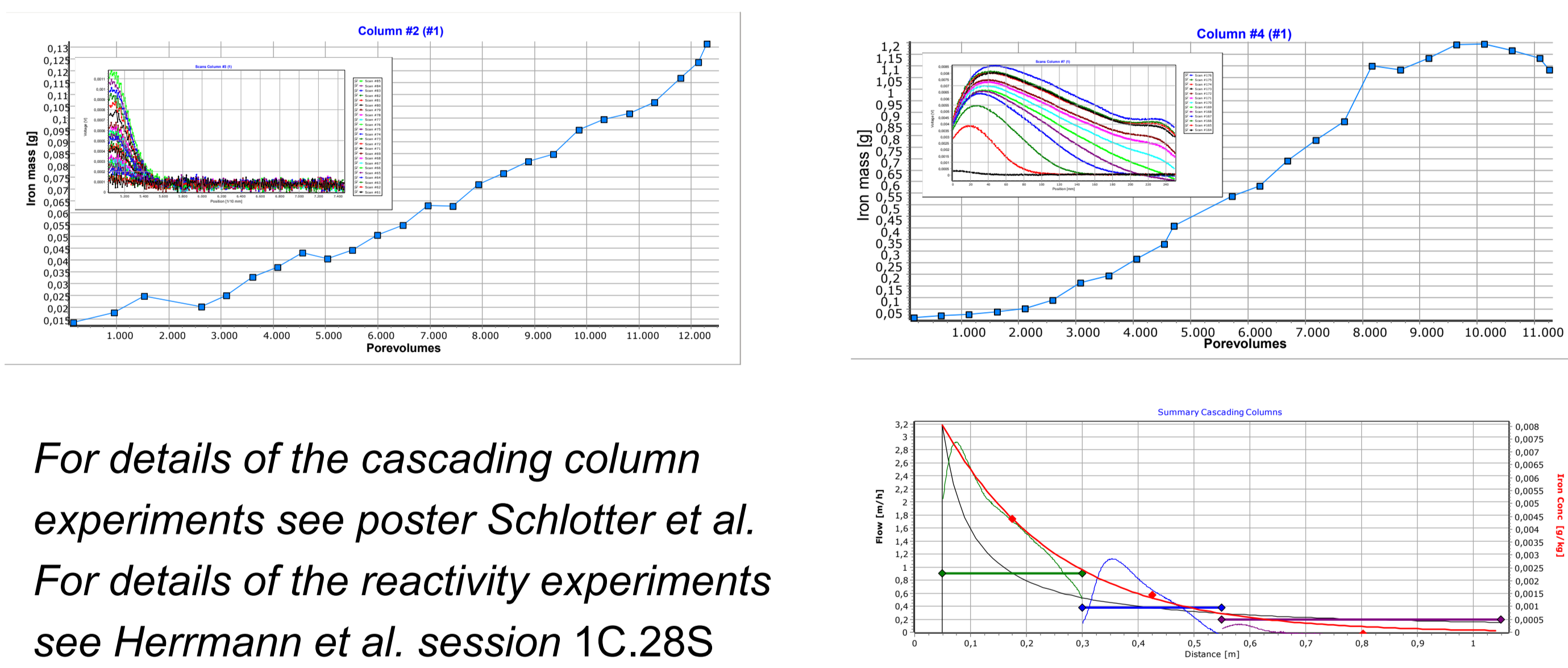
For details of the cascading column experiments see poster Schlotter et al.
For details of the reactivity experiments see Herrmann et al. session 1C.28S

Investigating Reactivity

For the assessment of the reactivity of the particles glass columns are filled with a mixture of sand and the particles. A flow of a contaminant solution is passed through the columns. By taking scans at the beginning of the experiment and after certain times the consumption of the iron can be tracked. Below monthly scans are shown of a column with a low reactive particle (right figure) and a column with a highly reactive particle are shown.
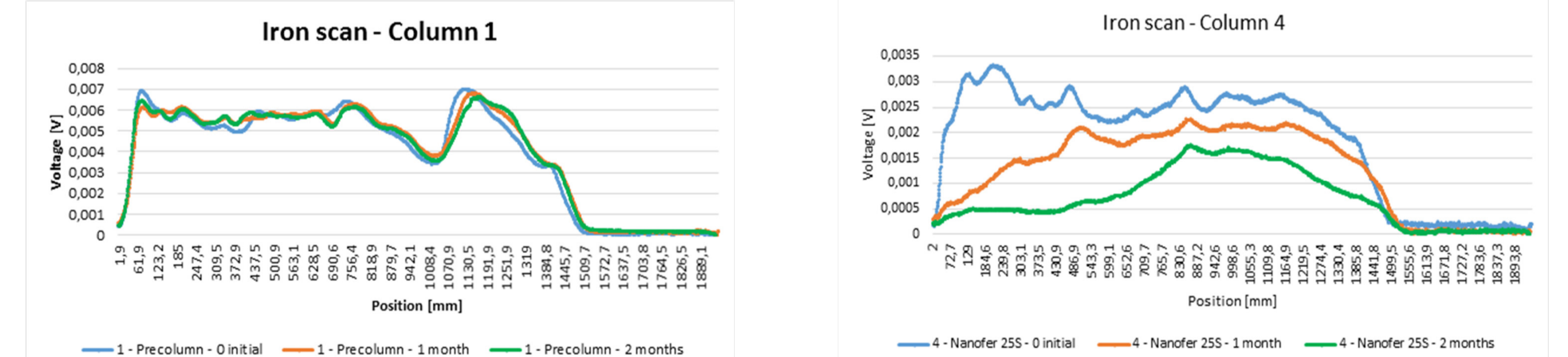
In combination with analytical measurements of the reaction products balances can be made. In this way, the characterisation of the reactivity of the particles can be described and the reactivities of different particles can be compared.

Column	Initial Scan area [V.mm]	Initial ZVI [g]	After 1 Month Scan area [V.mm]	After 1 Month ZVI [g]	After 1 Month Remaining ZVI [%]	After 2 Months Scan area [V.mm]	After 2 Months ZVI [g]	After 2 Months Remaining ZVI [%]	Final Measured ZVM [g]
1 – Precolum	7,55	11,22	7,76	11,53	102%	7,74	11,89	103%	11,89
4 -Nanofer25S	3,70	5,5	2,48	3,68	67%	1,38	2,05	37%	1,86

Conclusions

A new susceptibility measurement system has been developed for the non-destructive quantification of iron particles in columns. The setup can be used to investigate the transport behavior of particles in columns as well as the reactivity of the particles in long-term experiments. With the data additional analyses are possible in order to describe the behavior of the particles and to compare different types of iron particles.

Literature:
[1] Hua Li, Remus Banucu, André Buchau, Norbert Klaas, Wolfgang M. Rucker (2015, paper accepted): Optimization of a Concentration Measurement Sensor for Nano Sized Zero Valent Iron Using Numerical Simulation. IET Science, Measurement & Technology.
[2] A. Buchau, W. M. Rucker, C.V. de Boer and N. Klaas, "Inductive detection and concentration measurement of nano sized zero valent iron in the subsurface," IET Sci. Meas. Technol., 2010, Vol. 4, Iss. 6, pp. 289-297.
[3] Hua Li, C. V. de Boer, A. Buchau, N. Klaas, W. M. Rucker and H. Hermes, "Development of an inductive concentration measurement sensor of nano sized zero valent iron," System, Signals and Devices (SSD), 2012 9th International Multi-Conference, pp. 1-7.

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