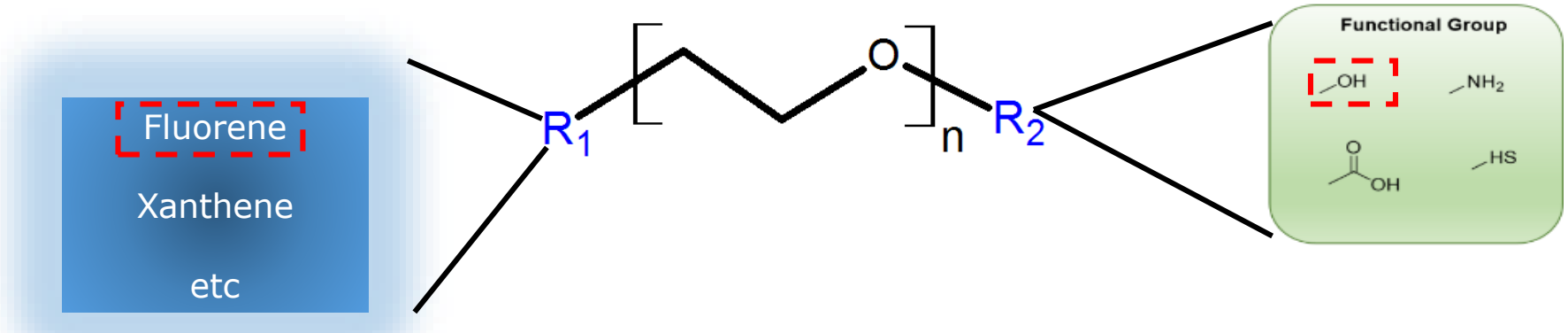
The mobility and interaction of colloidal-sized poly(ethylene glycol) in column experiments with carbonate rock

poly(ethylene glycol) [PEG]



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Aims of the study

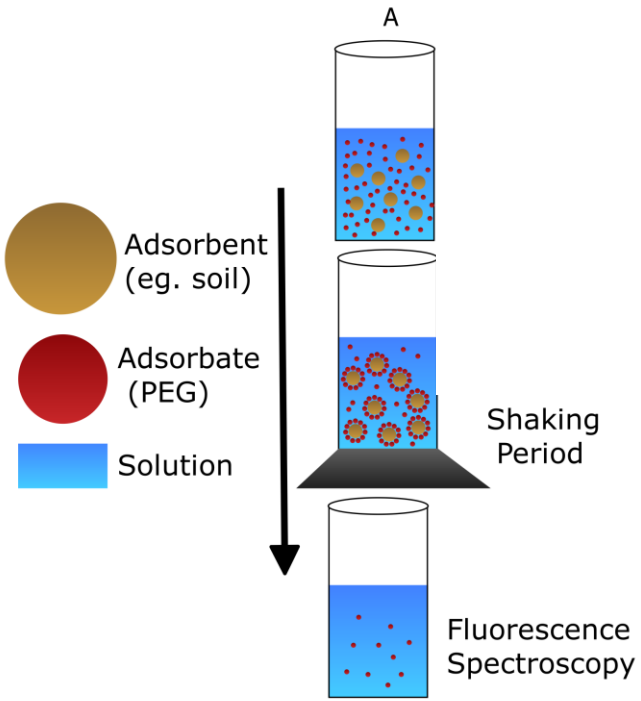
- Are there different adsorption sites in the carbonate media?
- How does the availability of adsorption sites affect the transport of organic colloids?
- Can we reconstruct PEG transport in the carbonate media with a continuum-scale model?

What is the role of adsorption in the transport of organic colloids in the natural porous media?

Soil Seepage

Groundwater

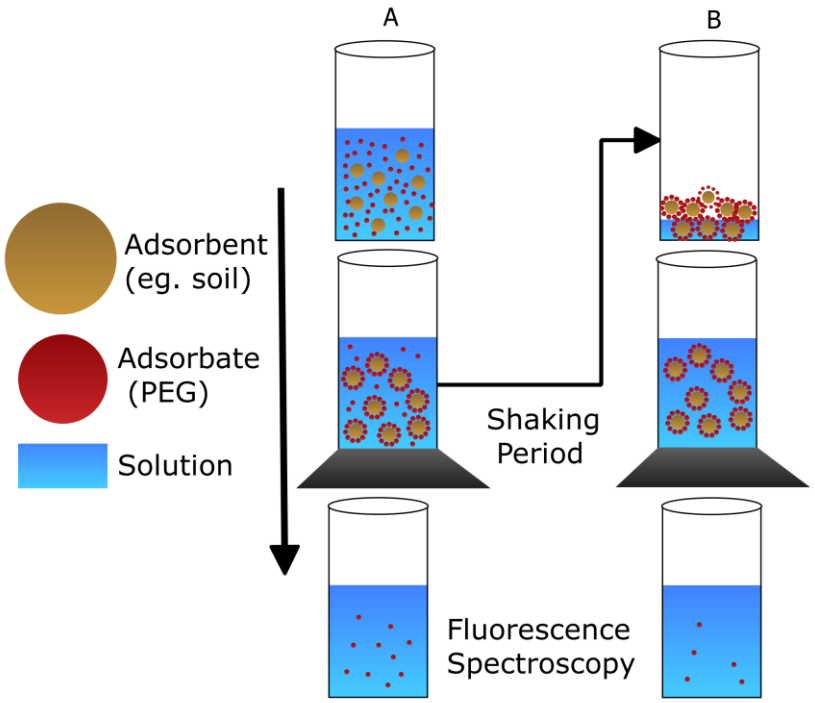
PEG adsorption on carbonate surfaces will continue untill an equilibrium is established in experiment A.



PEG in solution phase → PEG in adsorbed phase

PEG in solution phase ⇌ PEG in adsorbed phase

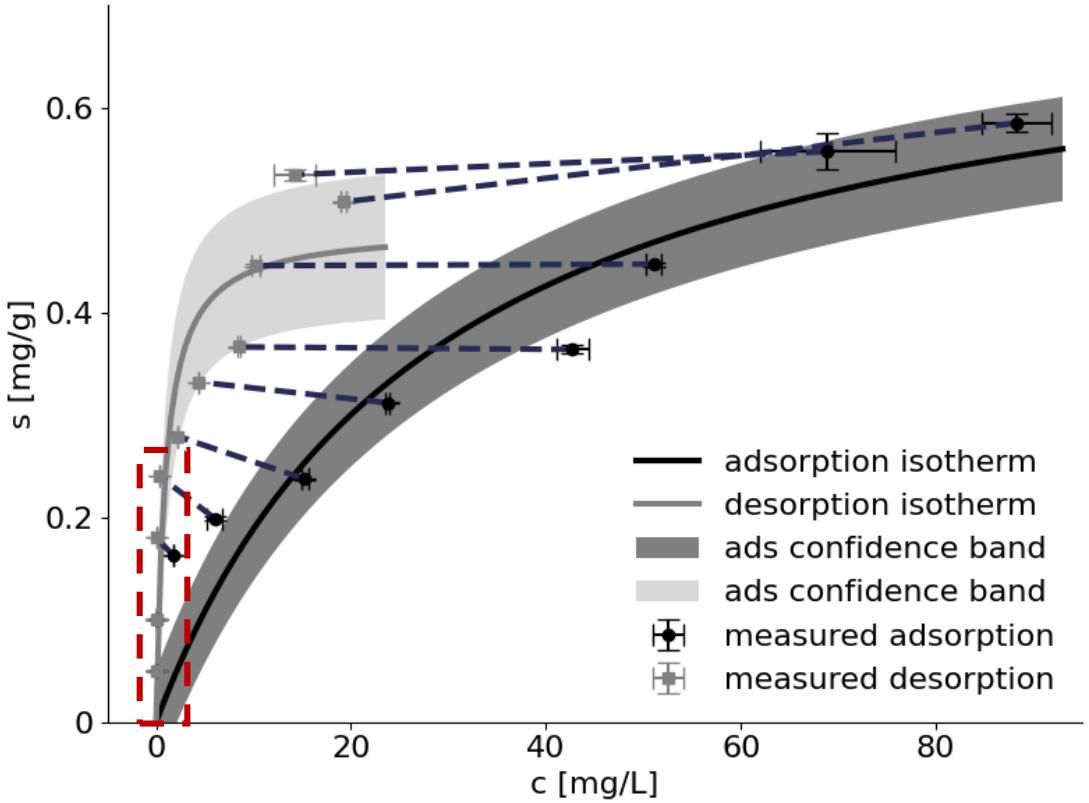
The equilibrium established in A was disrupted by replacing 80% of batch solution with NaCl aqeous solution in B.



PEG in solution phase ⟵ PEG in adsorbed phase

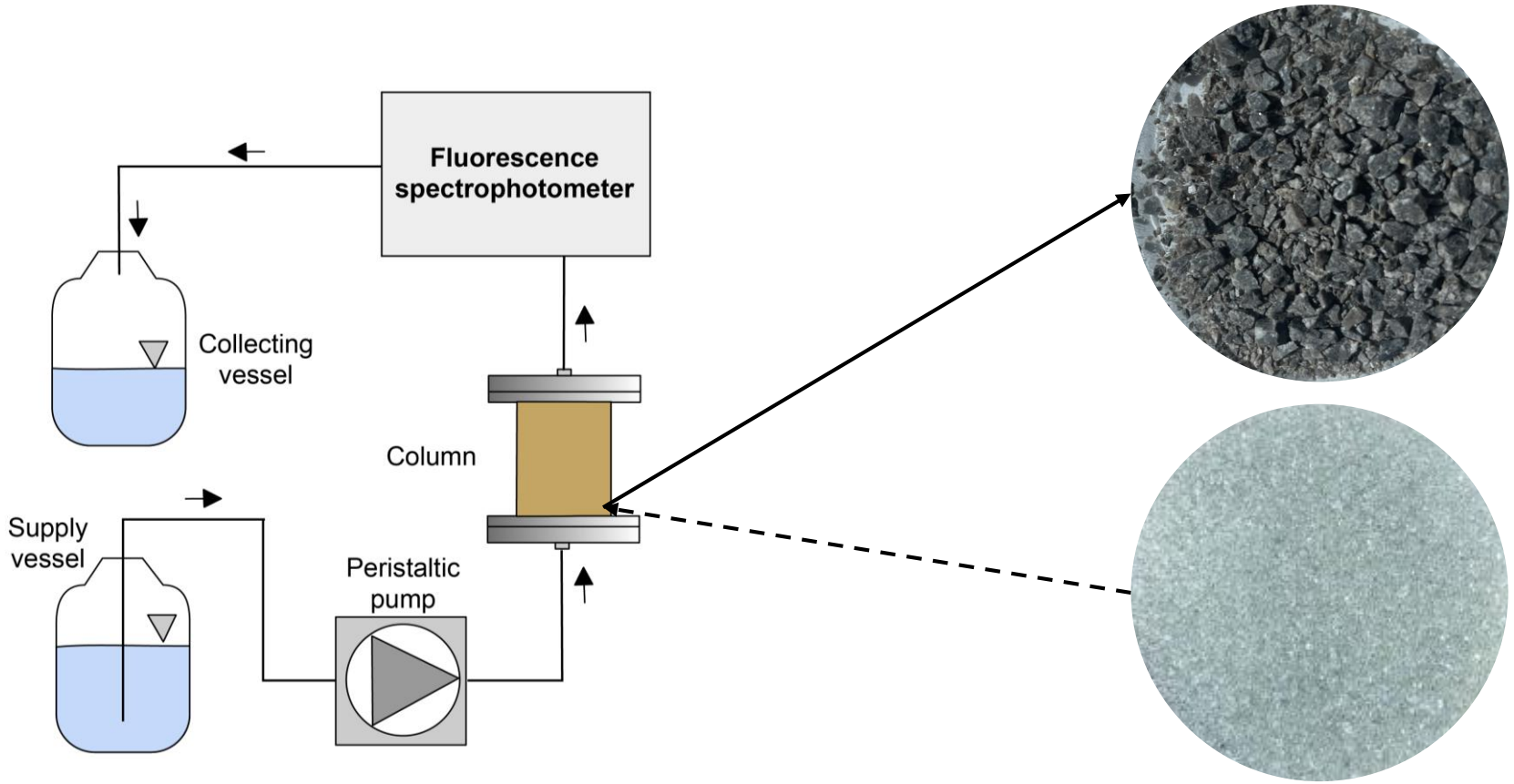
PEG in solution phase ⟷ PEG in adsorbed phase

About 0.24mg/g of PEG was irreversibily adsorbed accounting for about 30% of maximum adsorption capacity.



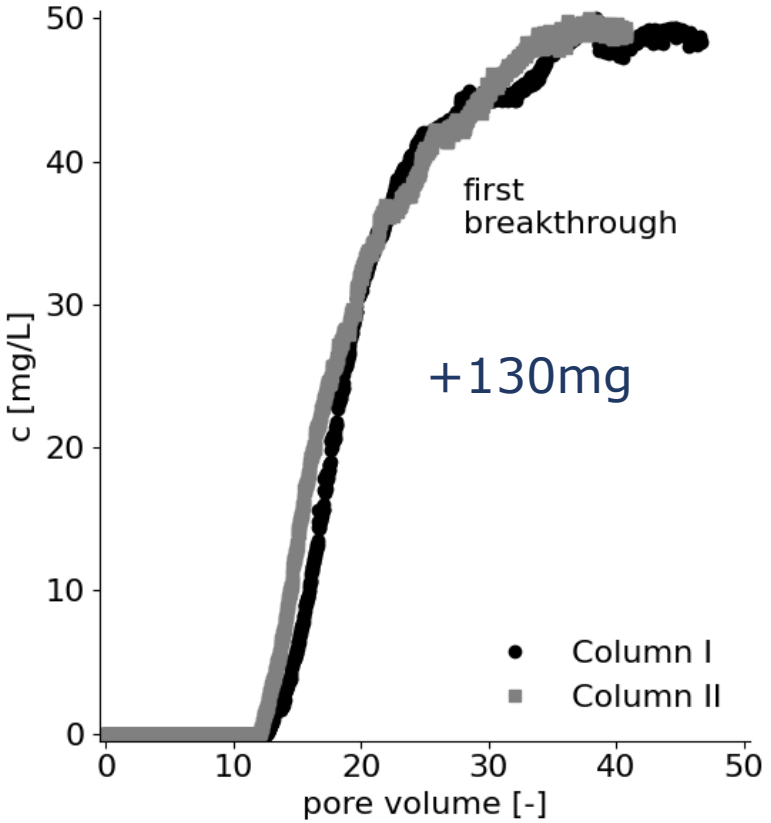
K [L/mg]	Smax [mg/g]
0.035 ± 0.04	0.73 ± 0.033

Carbonate materials were sampled from columns for scanning electron microscopy analysis.

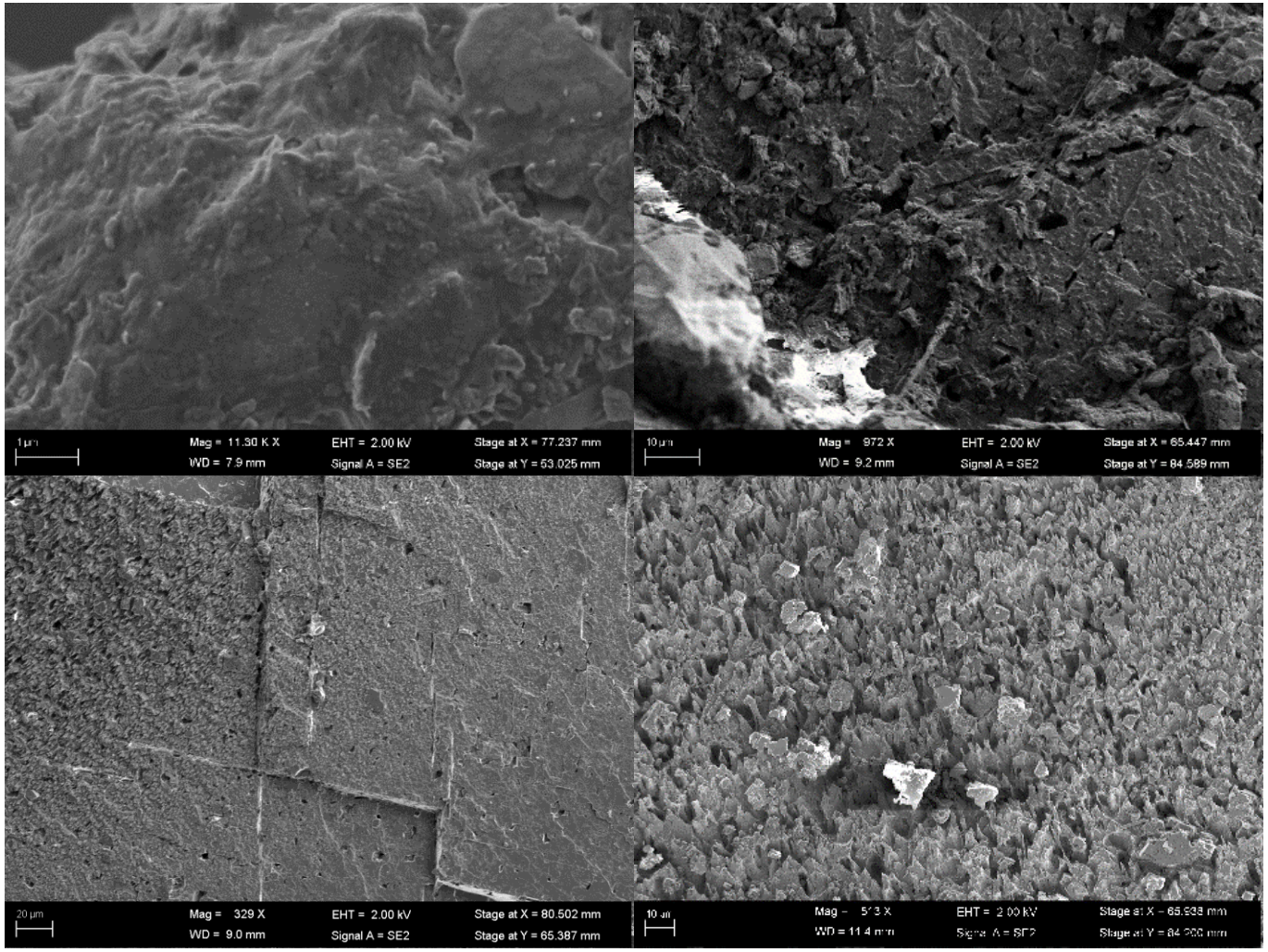


source: Ritschel et al. 2021

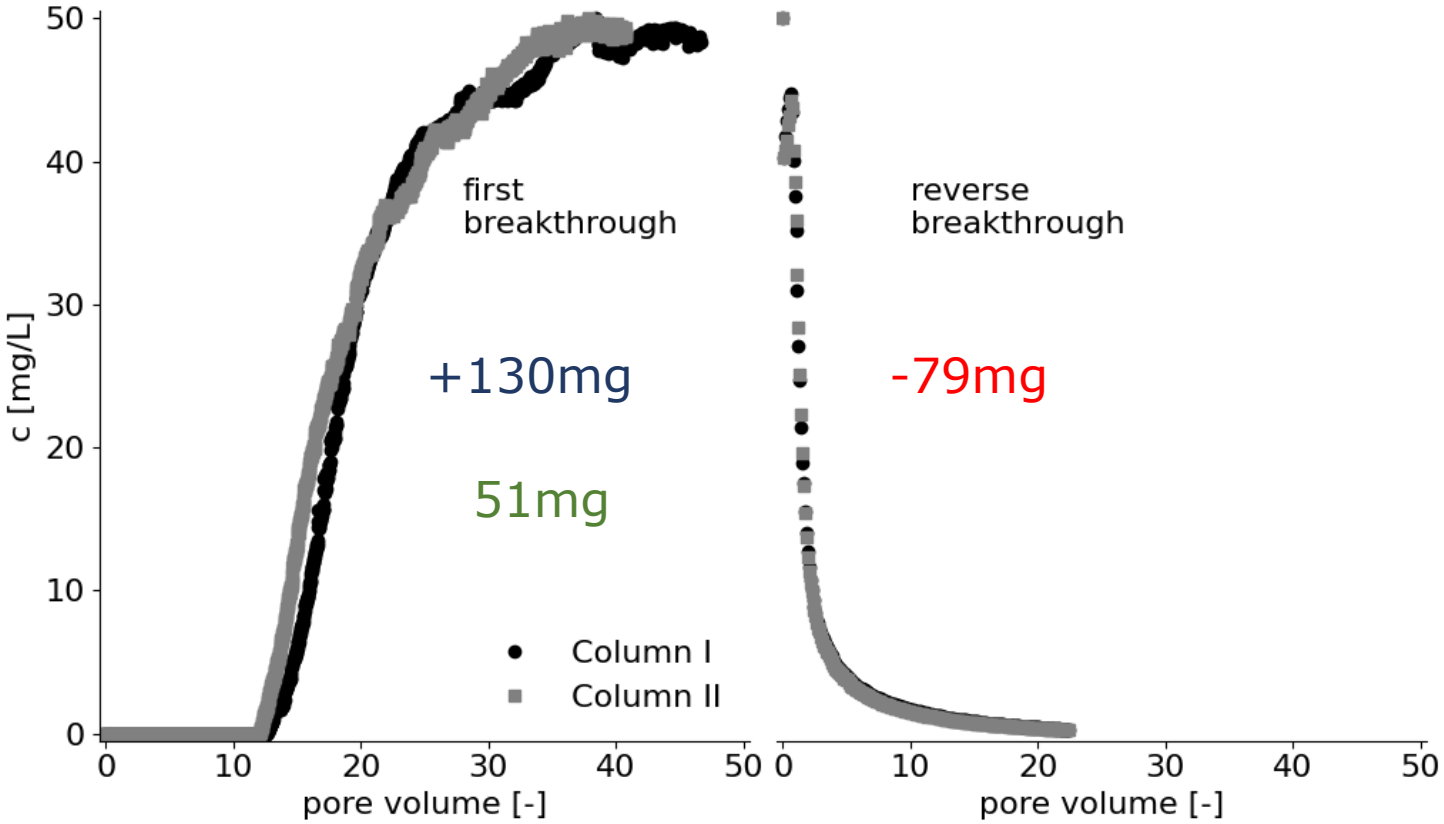
The entire first breakthrough occured after about 30 pore volumes in each column.



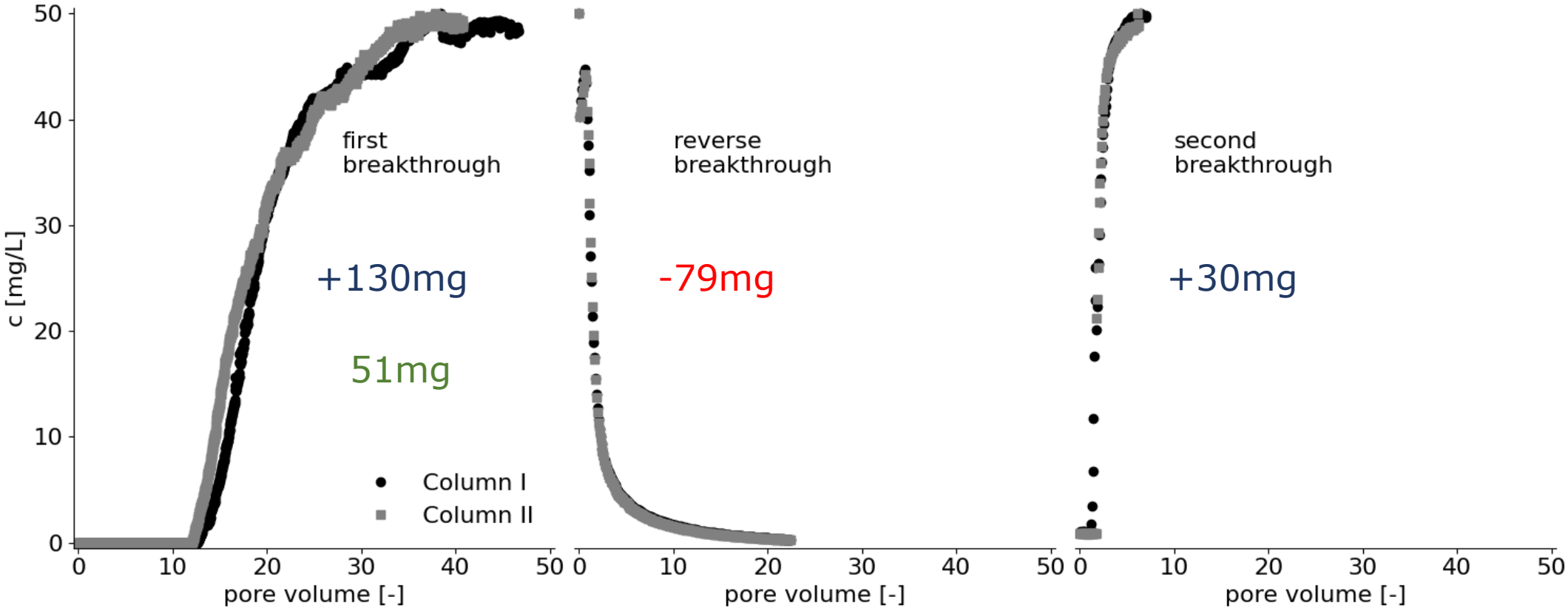
Surfaces of carbonate materials were modified after first breakthrough experiment.



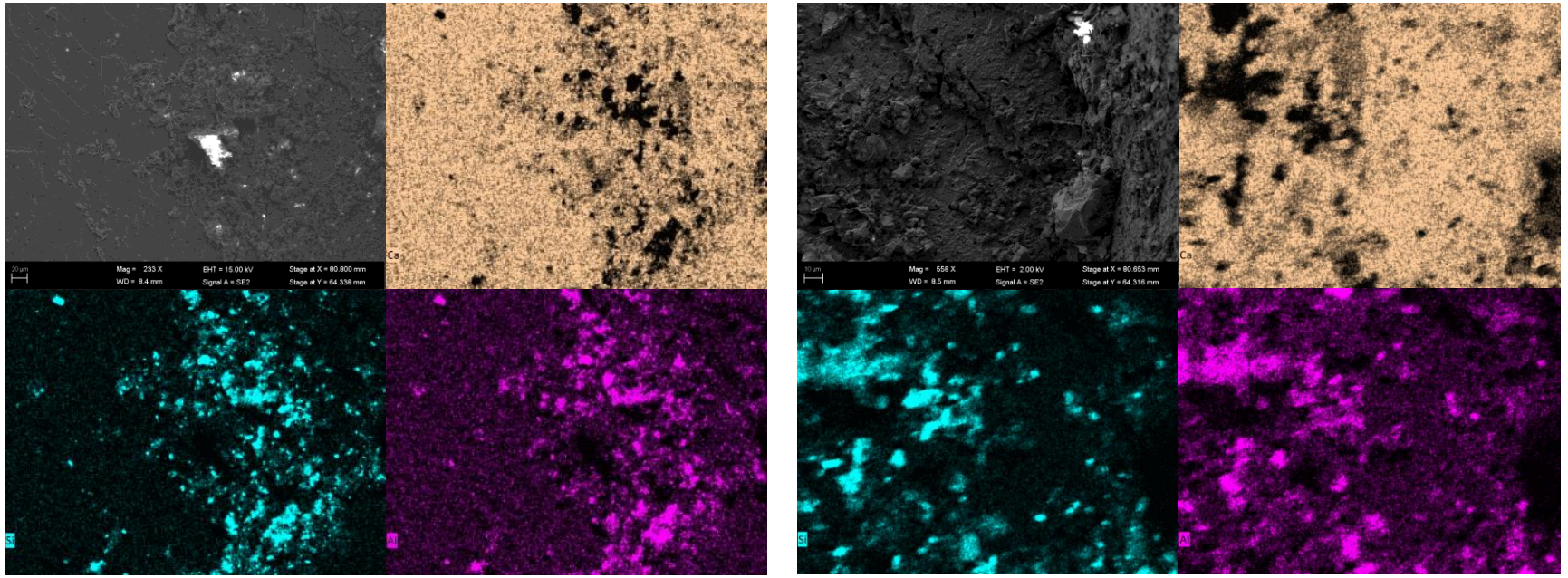
Columns were rinsed until a negligible concentration of PEG in column effluent was attained.



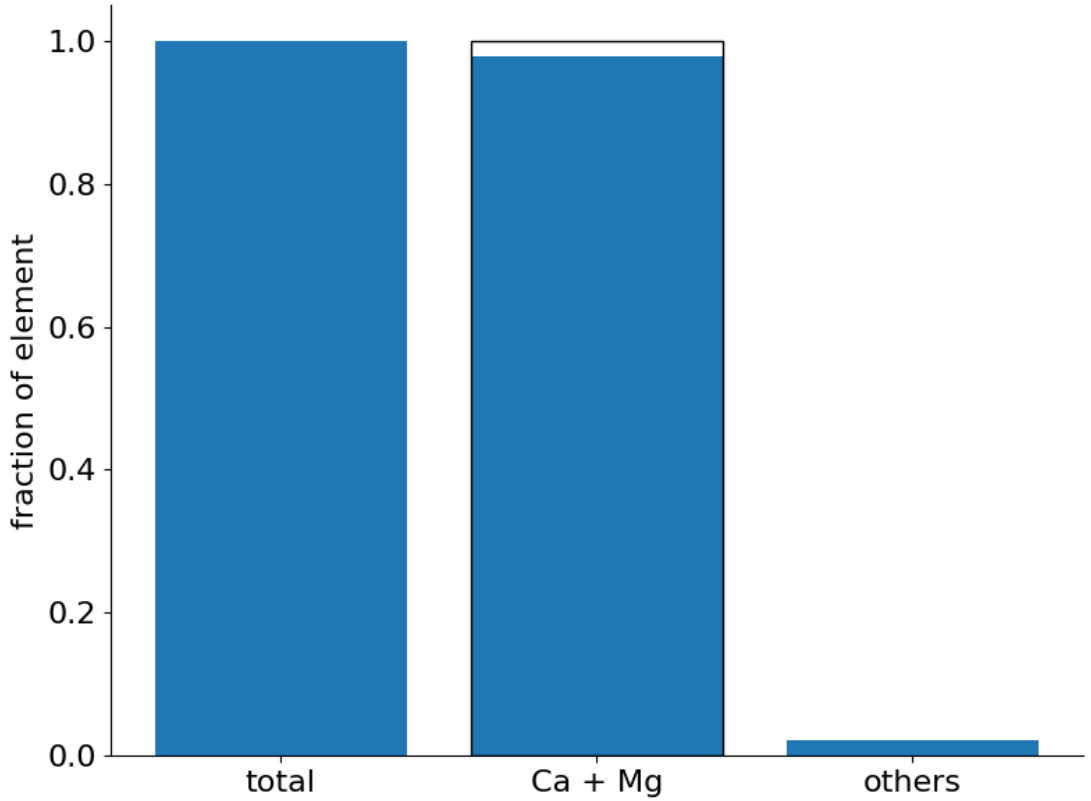
The second breakthrough was obtained by reapplying PEG tracer to columns.



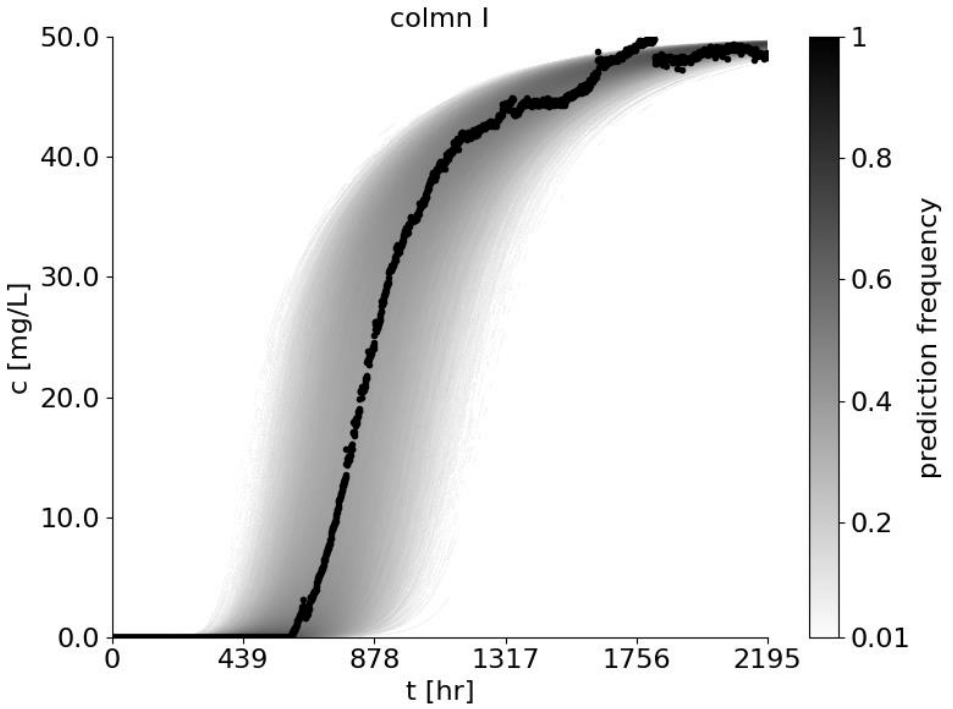
Patches of clay minerals were observed on the surfaces of carbonate in obtained EDX images.

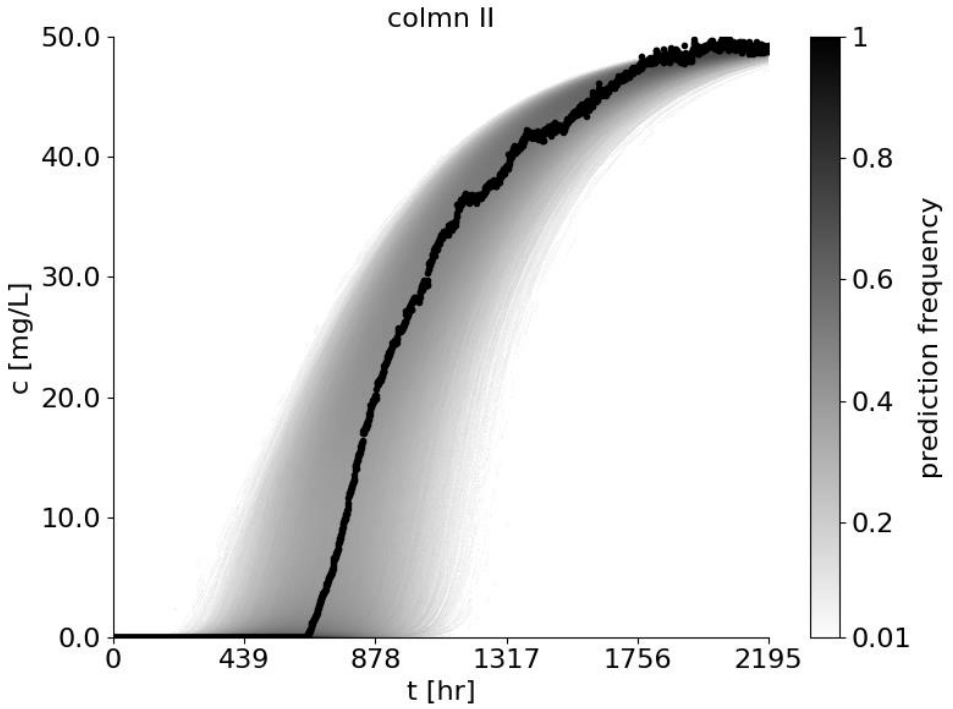


Calcite and dolomite account for about 96% of carbonate material used in experiment

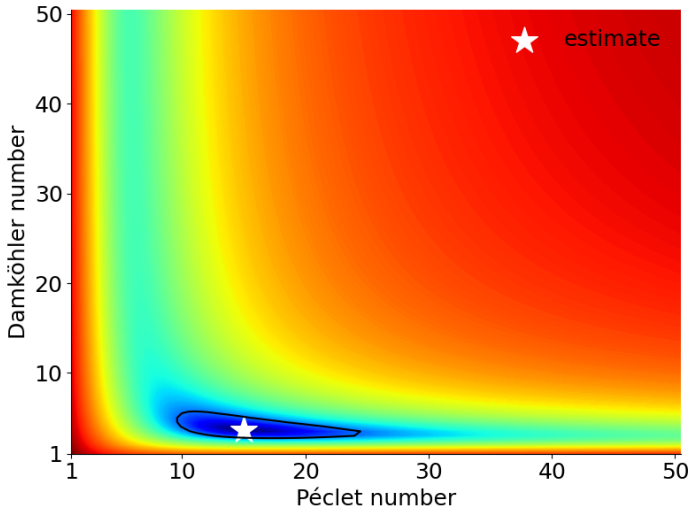


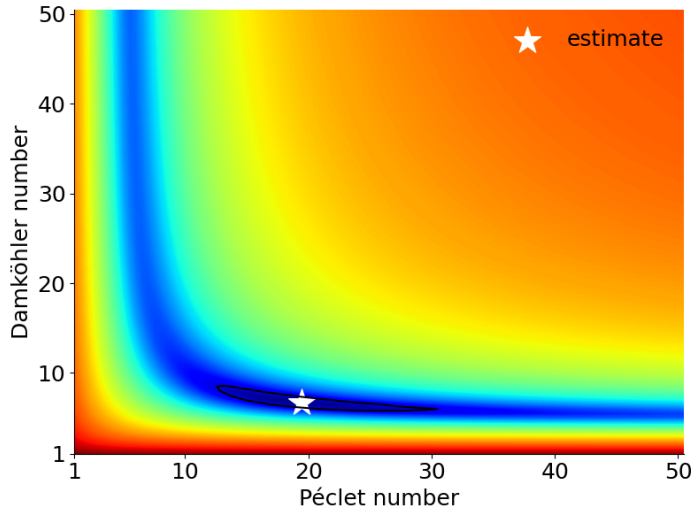
Model predictions were able to account for relevant processes that affected PEG transport in carbonate media.



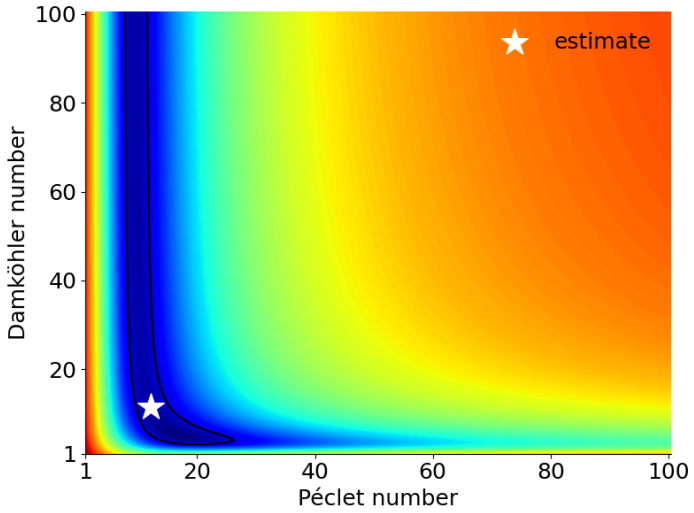


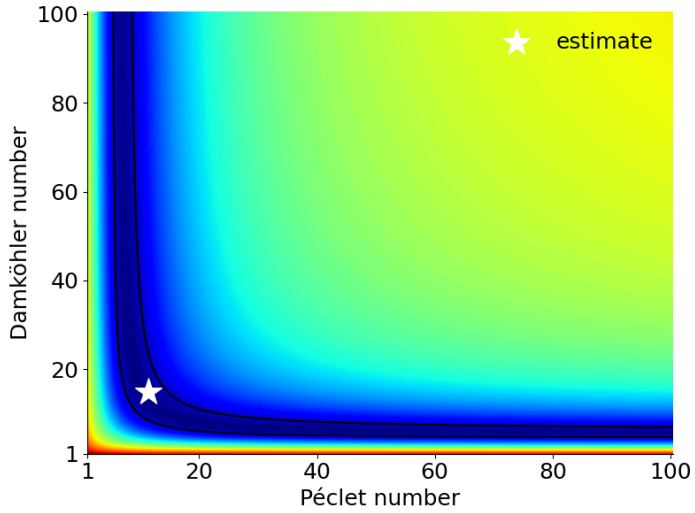
Applied model was able to accurately quantify transport due to dispersion and rate-limited mass exchange reactions.





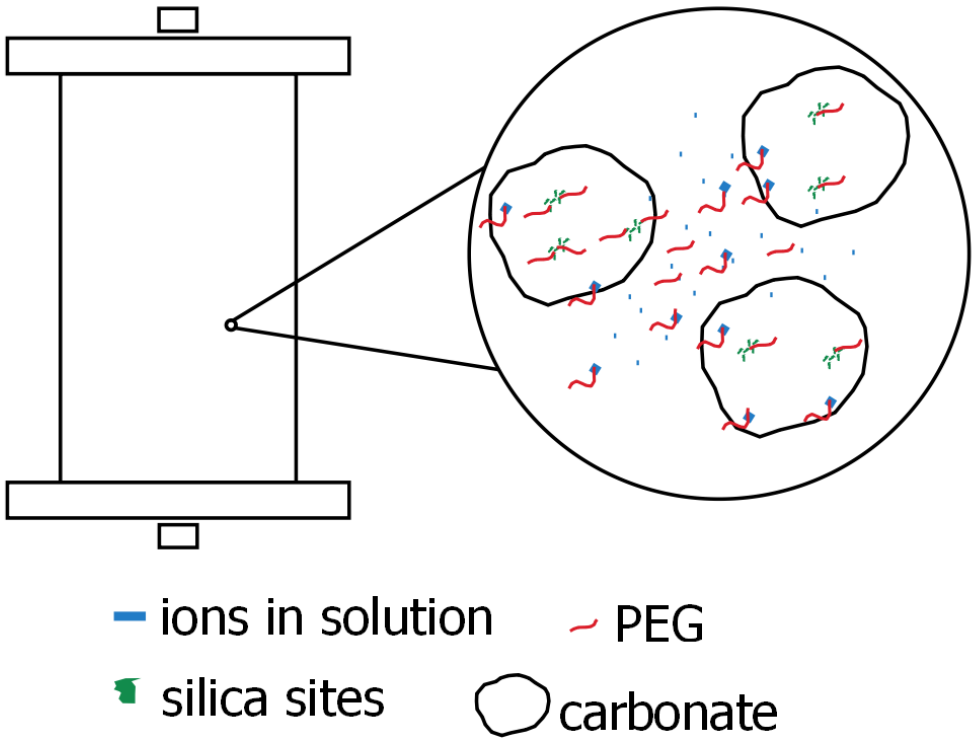
First BT



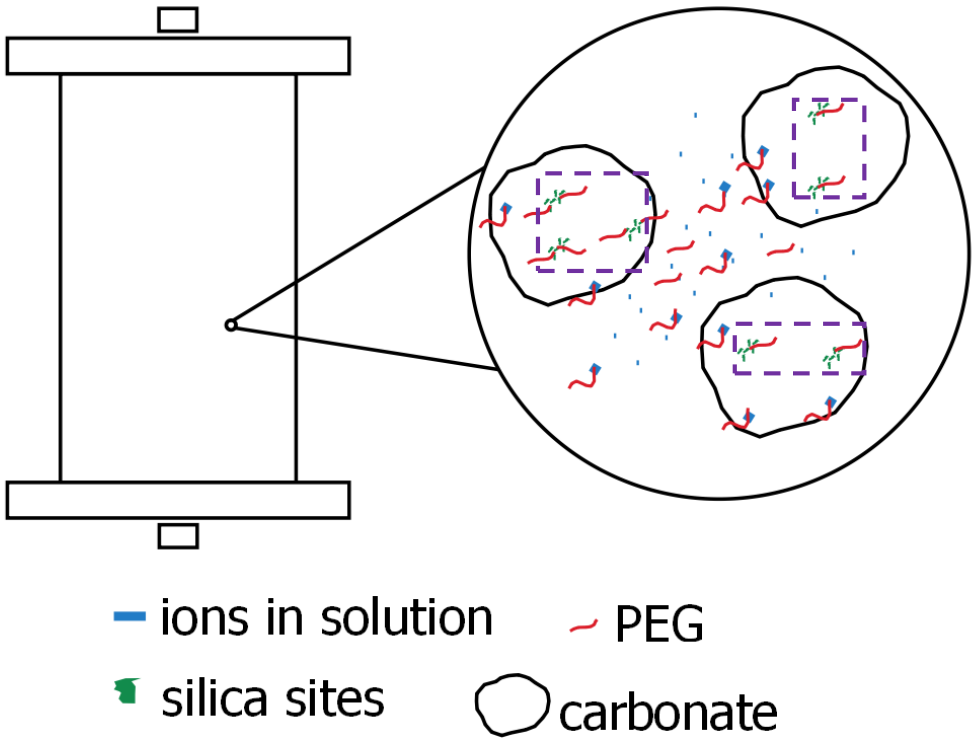


Second BT

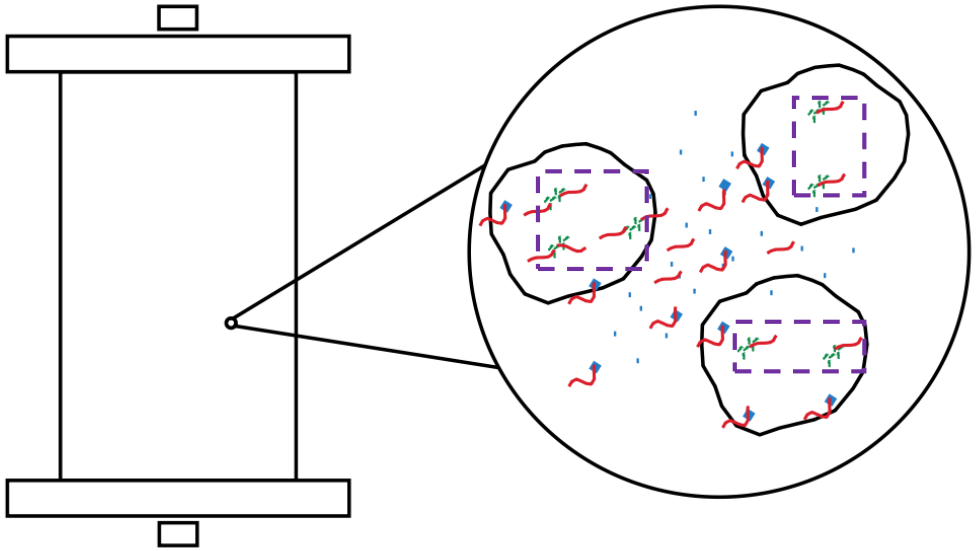
Fluid flow paths and porous media structure can be estimated through tracer application.

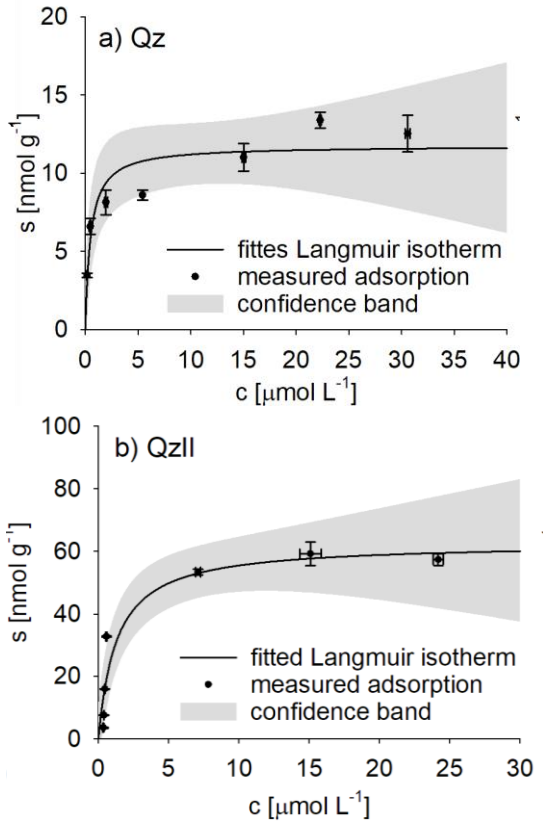


PEG adsorbed onto available silica sites.



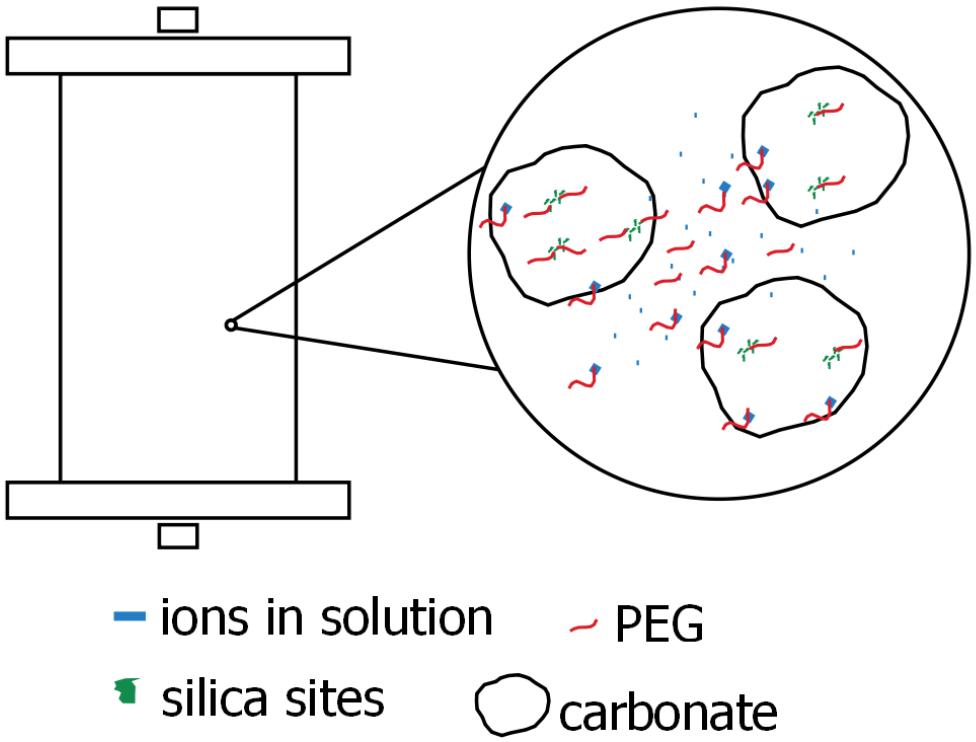
Previous studies have domonstrated PEG's affinity to silica surfaces.



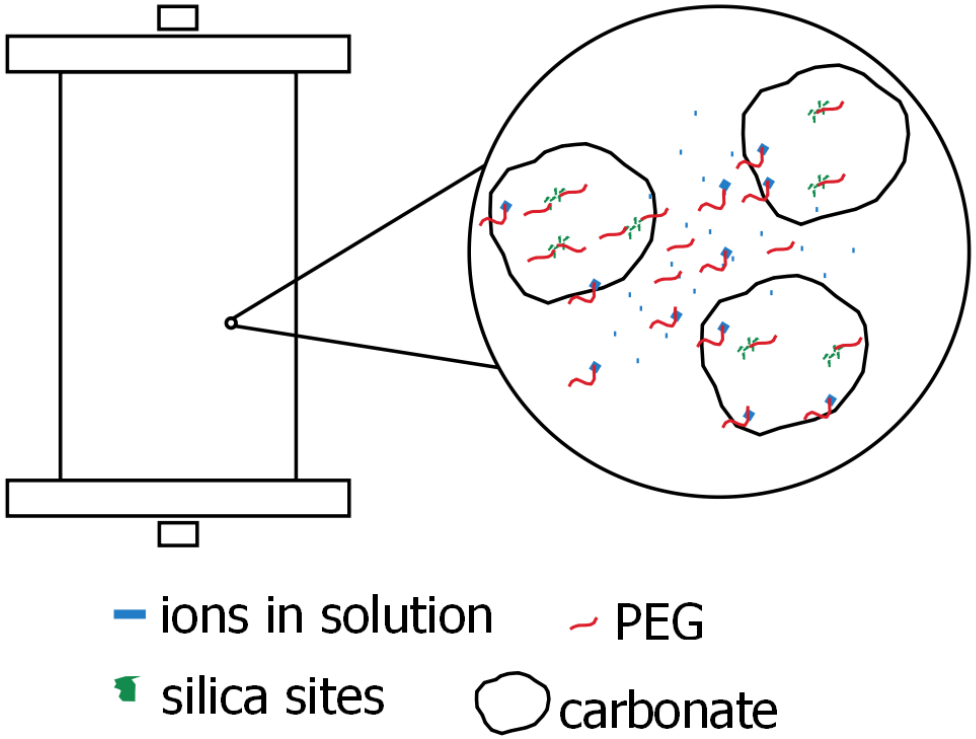


source: Ritschel et al. 2021

PEG adsorption to ions in solution contributed to further adsorption onto carbonate surfaces.

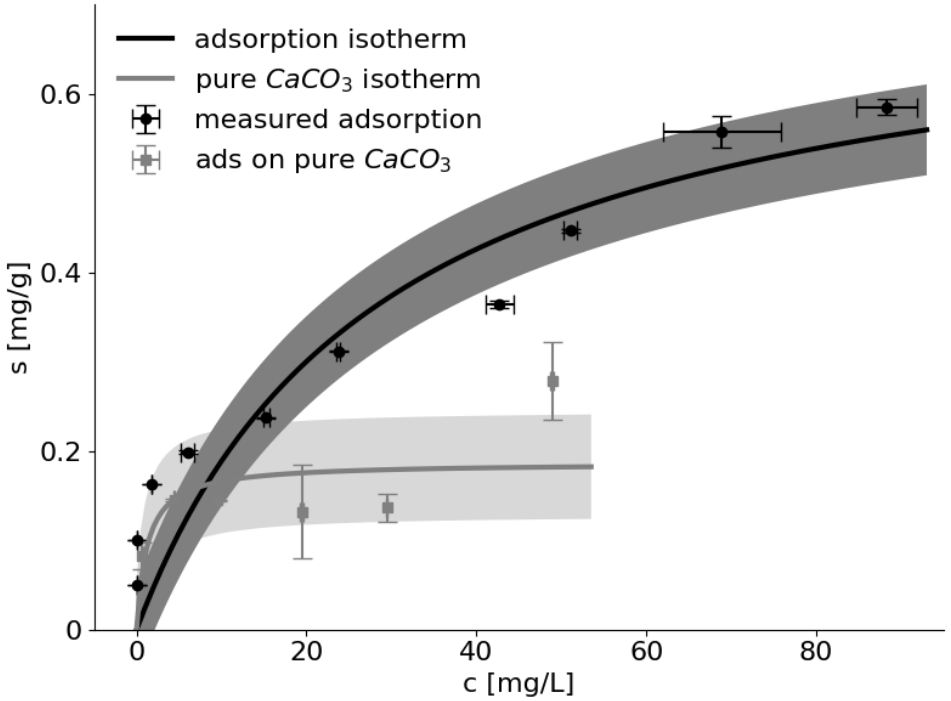


Complexation with ions in solution influenced dissolution capacity in carbonate media.



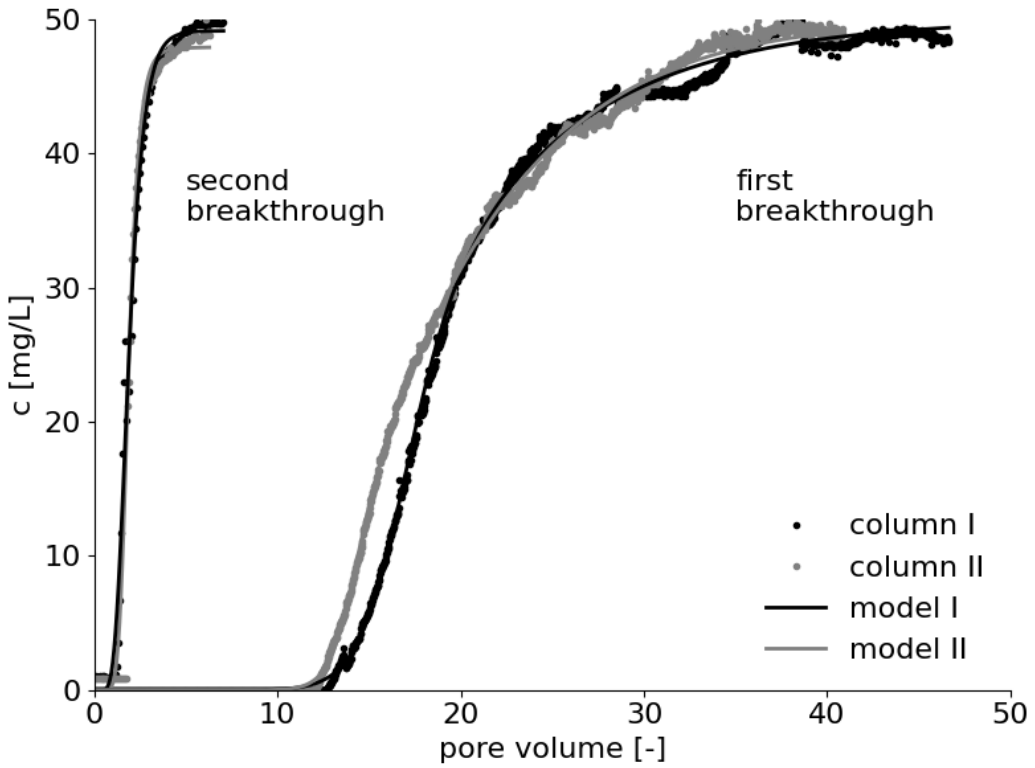
$$CaCO_3 \rightleftharpoons Ca^{+2} + CO_3^{-2}$$

There was also direct adsorption of PEG on pure carbonate sites.

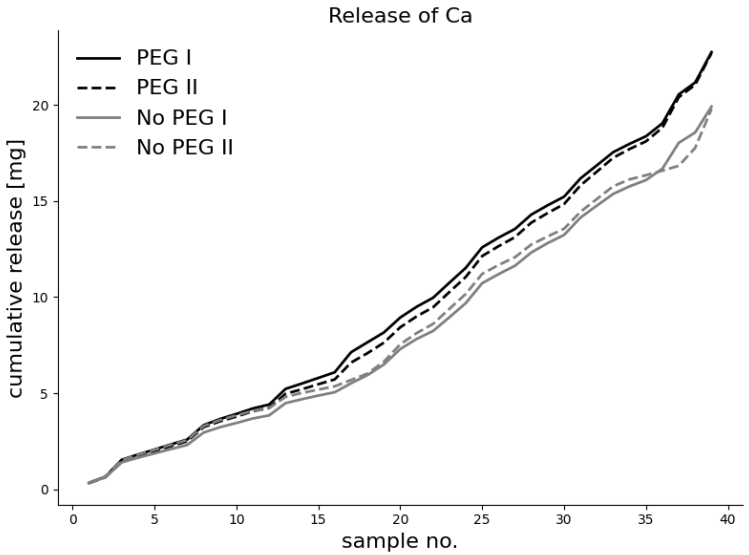


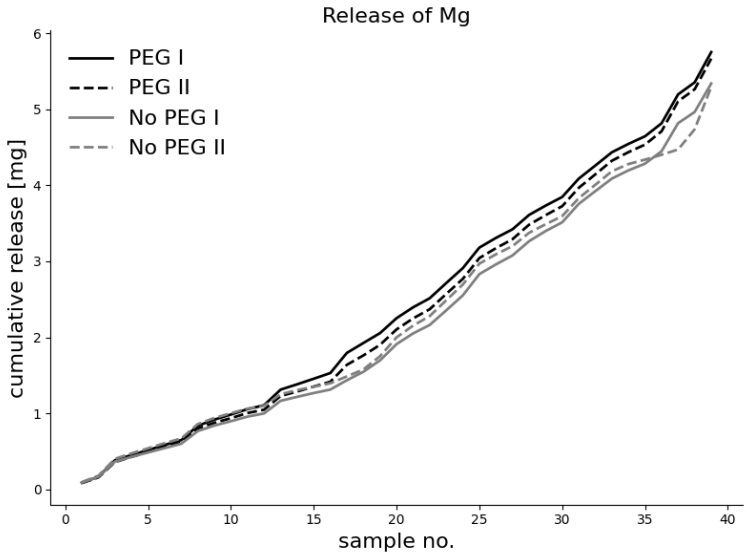
Substrate	K [L/mg]	Smax [mg/g)
Applied $CaCO_3$	0.035 ± 0.04	0.73 ± 0.033
Pure $CaCO_3$	0.80 ± 2.6	0.19 ± 0.09

Dissolution exposed new adsorption sites that contributed to kinetic adsorption.



Cummulative mass export of Ca and Mg was higher in columns with PEG.





Thank you!!!

Further reading

Ritschel, Thomas, Katharina Lehmann, Michaela Brunzel, Jürgen Vitz, Ivo Nischang, Ulrich S. Schubert, and Kai U. Totsche. 2021. “Well-Defined Poly(Ethylene Glycol) Polymers as Non-Conventional Reactive Tracers of Colloidal Transport in Porous Media.” *Journal of Colloid and Interface Science* 584 (February): 592–601. https://doi.org/10.1016/j.jcis.2020.09.056.