Bridging Scales in Salt Precipitation: From Pore Scale to REV Scale.

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Soil salinization causes severe problems in agriculture, especially in arid and semi-arid regions, as it leads to soil degradation and reduces plant growth. During evaporation from a saline-water-saturated soil, salt accumulates near the top of the soil. Depending on the conditions, the increasing salt concentration will either lead to precipitation once the solubility limit is reached or due to the increase in the liquid density a gravitationally unstable situation is given, where instabilities in the form of fingers will develop. Hence, salt can be transported downwards. Salt precipitation and its alteration on the pore geometry has been investigated on the REV-scale and on the pore-scale. The development of the instabilities has been analysed using REV-scale simulations.

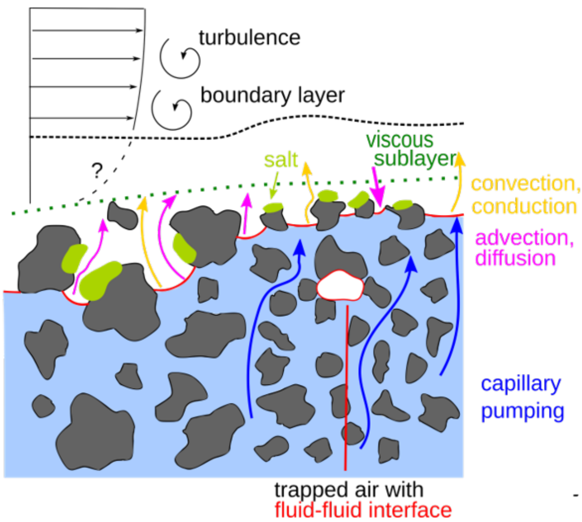

Figure 1: Schematic illustration of transport mechanisms during evaporation from a saline-saturated porous medium on pore scale.

Salt precipitation and the resulting pore-local geometry alteration were implemented into a pore-network model. To account for these alterations, known relationships from literature and newly developed ones by Lars von Wolff and Carina Bringedal have been used. The different methods were analysed on their ability to mimic the local geometry changes within the pore space due to salt precipitation. Based on these calculations of the pore-network model, the permeability can be upscaled using Darcy's law and the continuity equation. Thus, we can evaluate the overall change of the permeability due to salt precipitation in the pore-network model. The findings of the upscaled permeability can be used to improve the numerical simulations on the REV-scale. On the REV-scale, we analysed the relevant processes to identify the influence of different parameters like soil-hydraulic properties, evaporation rate, or salt properties on the precipitation process. In Bringedal et al., 2022, the appearance of instabilities during evaporation from a one-phase system was investigated using a linear stability analysis and through numerical simulations on the REV-scale. The linear stability set criteria for the onset of instabilities for a large range of parameters, whereas the numerical simulations provide information about the development of the instabilities after onset. Through the combination of both methods, we can predict the occurrence of instabilities and their effect on the salt concentration near the top boundary. This analysis is currently extended for two-phase systems.

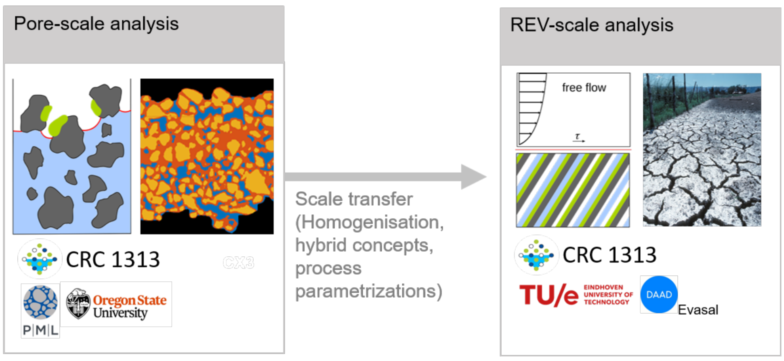

Figure 2: Project overview: Bridging scales from pore scale analysis to REV-scale analysis.

In future work, we plan to extend the pore-network model to different geometries and for two-phase systems. Additionally, we plan to improve the REV-scale models with the help of the pore-network model. This will be done by identifying relevant parameters for salizination processes on the pore scale and using suitable upscaling methods for the use on the REV-scale. Parallel, we will include data-based information provided by Sander Huisman from Forschungszentrum Jülich to improve the quality and extend the salt parameterization in our REV model.

References

Bringedal, C., Schollenberger, T., Pieters, G.-J., Duijn, C., & Helmig, R. (2022). Evaporation-driven density instabilities in saturated porous media. *Trans-*

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