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Topic of Master's Thesis/ Bachelor's Thesis/ Project Work for

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Investigation of transmissibility development due to precipitation processes in pore-network models using a thin-strip concept

The investigation of salt precipitation processes is important for different technical and environmental applications. The precipitation of salt in building materials generates stresses and thus damages the buildings. Further the salinization of soil in arid regions leads to a degredation of soil and a reduction in crop yield.
To investigate this processes in detail a pore-network model is used which resolves the porous medium on the pore scale. A network of pore-bodies representing the larger void spaces and pore-throats representing the connections inbetween resolves the pore space of the porous medium. A mass balance is solved for every pore-body, for which the flow resistance is neglected. The flux is calculated in every pore throat based on the pressure difference of the adjactent pore-bodies and a resistance factor which depends on the throat geometry (e.g. the throat diameter). Due to the precipitation of solid salt the pore space decreases which also leads to a decrease of the transmissibility of the throats.
As no information of the salt concentration is available in the pore-throats the amount of precipitated salt in the throats and change in throat diameter can just be estimated. So far this is based on the change in pore-body volume $V_i - V_i^{t-1}$ over time t in the adjactent pore-bodies. The following simple relationship presented by Nogues et al. [1] is used for the throat diameter d_{ij}:

$$d_{ij}^t = d_{ij}^{t-1} + d_{ij}^{t-1} \cdot \left(\frac{V_i^t - V_i^{t-1}}{V_i^{t-1}} + \frac{V_j^t - V_j^{t-1}}{V_j^{t-1}} \right). \tag{1}$$

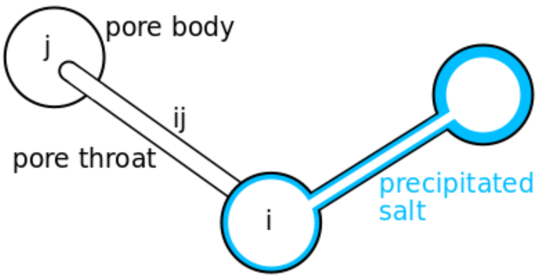

Figure 1: Pore-network model.

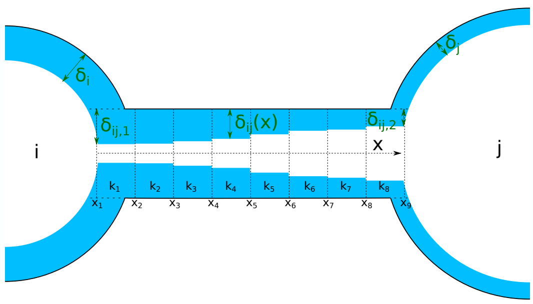

Figure 2: Thin-strip concept.

Here a uniform thickness of precipitated salt is assumed along each pore throat. As the throat diameter has an great effect of the overall transmissibility of the system a more detailed thin-strip concept should be investigated [2]. Here a microscopic model describes the transport processes in the pore throat and the movement of the fluid-solid interface in two-dimensions. By integrating over the width of the throat an one-dimensional description is derived which can be solved using a discretization along the throat. With that precipitation processes in the throat and inhomogeneous precipitation patterns can be considered in more detail.
The aim of this thesis is to implement the thin-strip concept for the pore-throats (in python or C++) and couple it to the existing pore-network model [3] implemented in DuMu^x (C++). This is followed by detailed investigation of the capabilities of the thin strip concept and a comparison with the original concept (equation 1). The Master's Thesis/ Bachelor's Thesis/ Project Work shall be summarized in a report and presented in an oral presentation.

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References

[1] Juan P. Nogues, Jeffrey P. Fitts, Michael A. Celia, and Catherine A. Peters. Permeability evolution due to dissolution and precipitation of carbonates using reactive transport modeling in pore networks. *Water Resources Research*, 49(9):6006–6021, 2013.

[2] T. L. van Noorden. Crystal precipitation and dissolution in a thin strip. *European J. Appl. Math.*, 20:69–91, 2009.

[3] Kilian Weishaupt, Vahid Joekar-Niasar, and Rainer Helmig. An efficient coupling of free flow and porous media flow using the pore-network modeling approach. *Journal of Computational Physics: X*, 1:100011, 2019.