Examining saturated and unsaturated hydraulic parameter changes as a result of geochemical reactions in tailings

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1. INTRODUCTION

Water flow and solute transport in the unsaturated zone is governed by the hydraulic properties and the hydraulic conductivity function. However, geochemical reactions induce changes in the hydraulic properties as oxidation occurs in reactive materials. Transient flow experiment can be designed to indirectly estimates these changes. This is an easy and practical method which relies on easily measureable parameters. Our aim was to test the hypothesis of induced hydraulic properties changes due to geochemical reaction using inverse numerical modelling.

2. HYDRAULIC PROPERTIES ESTIMATION

- One dimensional vertical flow in rigid porous media is governed by Richards equation,

$$C(h)\frac{\partial h}{\partial t} = \frac{\partial}{\partial z}\left[k(h)\left(\frac{\partial h}{\partial z} - 1\right)\right]$$

- Initial and Boundary condition
  - $h(z,t) = h_0(z) \qquad t = 0, 0 \le z \le L$

$$k(h)\left(\frac{\partial h}{\partial z} - 1\right) = E(t)$$

- van Genuchten-Mualem hydraulic function

$$S_e(h) = \frac{(\theta(h) - \theta_r)}{\theta_s - \theta_r} = [1 + (\alpha h)^n]^{-m}$$

$$K(S_e) = K_s S_e^{\,0.5}\left[1 - \left(1 - S_e^{1/m}\right)^m\right]^2$$

INVERSE ANALYSIS

- Hydraulic parameters α and n determined by minimisation of objective function

$$O(b) = \sum_{i=1}^{2}\sum_{j=1}^{M}\left[h(z_i - t_j) - h^*(z_i, t_j, b)\right]^2$$

- Solution by Levenberg-Marquardt algorithm
- Solution was implemented in HYDRUS-1D

3. MATERIALS AND METHODS

- Material Composition
  - ➢ Dolomite (25%)
  - ➢ Pyrite (25%)
  - ➢ Quartz (35%)
  - ➢ Chlorite (15%)
- Two categories of particle size range
  - ➢ <75 µm
  - ➢ 75-200 µm
- Column: 4 cm, bulk density: 1.4 g/cm3
- Nine drying and wetting cycles over nine months
- Initial hydraulic parameters determined by desiccation
- Curve fitting in RETC
- Transient water flow experiment by evaporation
- Mass of water loss was measured by a balance
- Hydraulic conditions in the tailings measured by tensiometer

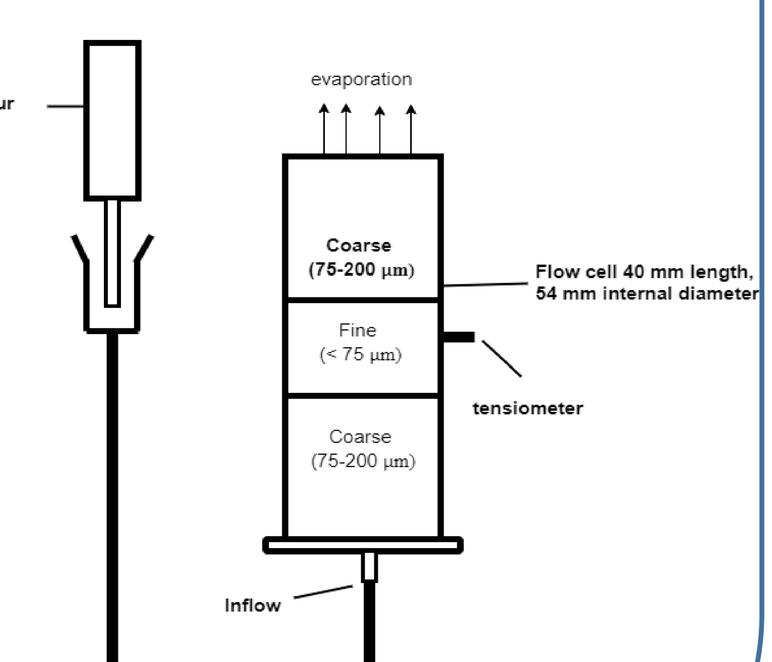

Fig 1: Evaporation Experiment

4. RESULTS

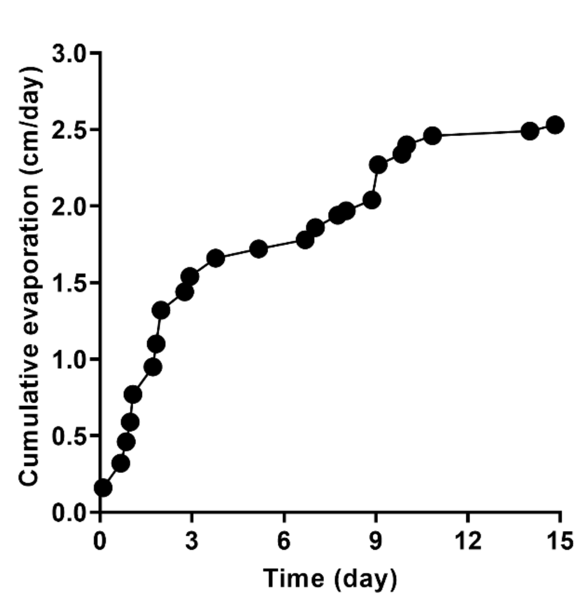

Fig 2: Cumulative water loss vs time

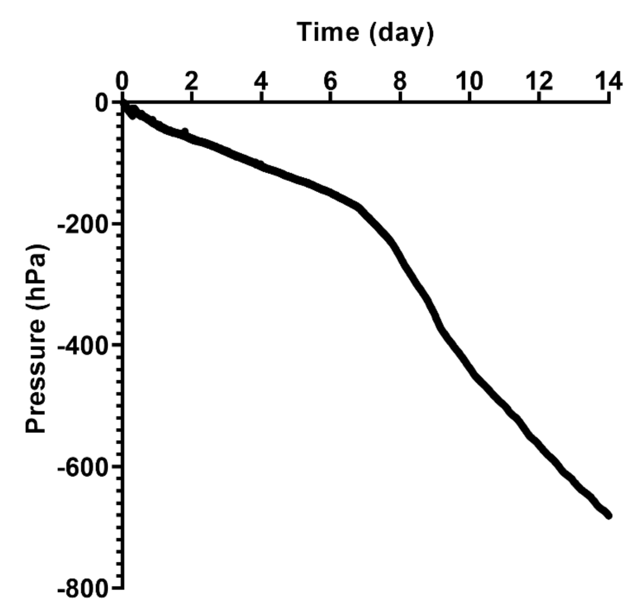

Fig 3: Time series of hydraulic condition in the column

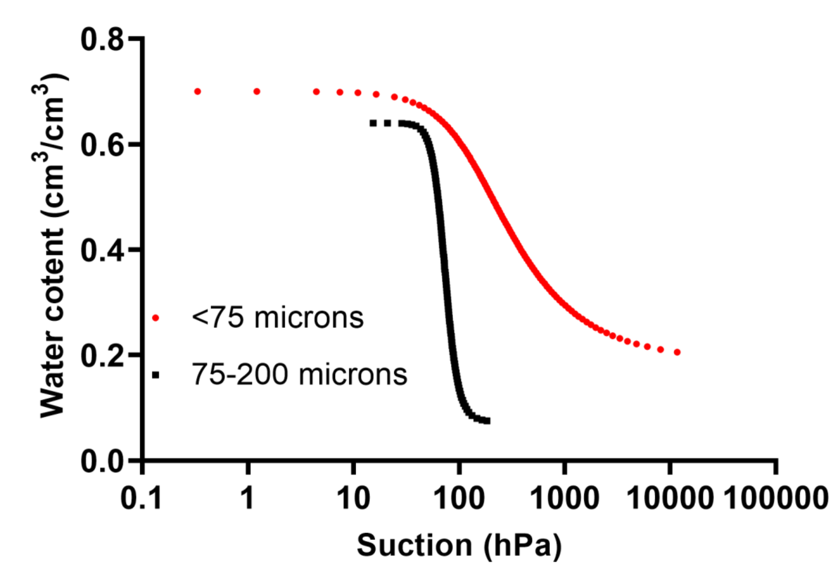

Fig 4: Initial water retention curve for different particle sizes

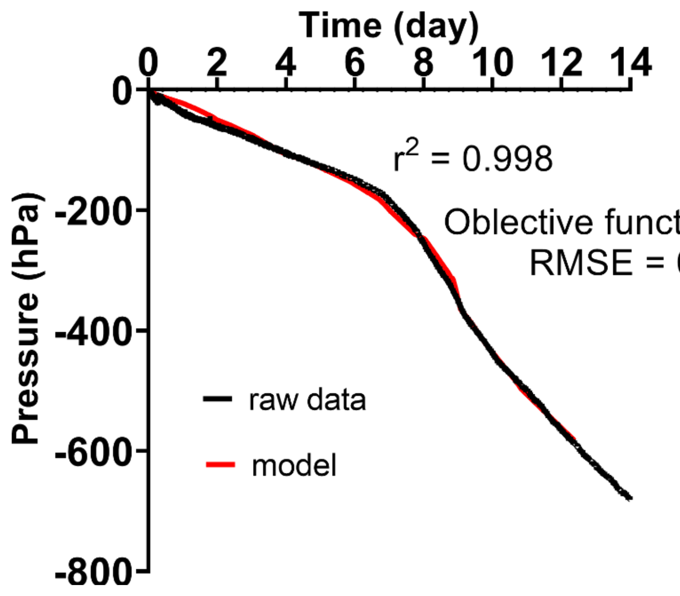

Fig 5: Plot of inversely modelled hydraulic conditions in the column

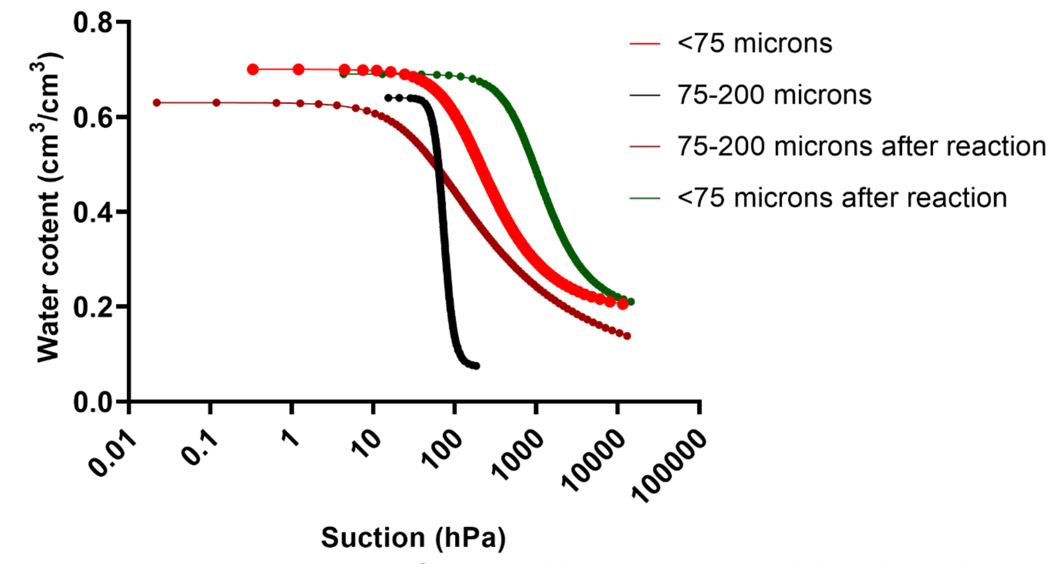

Fig 6: Comparison of initially measured hydraulic parameters and inversely measured parameters

Table 1: Initial parameter and optimised values after changes

Parameter	Initial value		Optimised value	
	Fine	Coarse	Fine	Coarse
K_s(cm/day	1.06	128.76	1.05	127.47
$O_s(cm^3cm^{-3})$	0.7	0.64	0.69	0.63
$O_r(cm^3cm^{-3})$	0.19	0.07	0.19	0.07
n	1.78	7.36	1.36	2.09
$\alpha(cm^{-1})$	0.007	0.01	0.0013	0.026

5. CONCLUSION

- The model results show that hydraulic parameters of the studied material changed over time
- The inverse model was effective in establishing these changes
- On the assumption of the saturated volumetric and saturated conductivity decreased by 1% during this period the alpha and n parameters of the coarse and fine material changed with time

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