Principles of Groundwater Flow

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1 The polder problem

1. We consider a vertical cross section of an INFINITELY LONG POLDER. The polder consists of a confined aquifer with hydraulic conductivity k_1 [m/s] and thickness D [m]. The **top** layer has thickness b [m] and hydraulic conductivity k_2 [m/s]. We refer to h_p [m] as 'Polder level'. Note that $h(+\infty) = h_p$. The ambient air temperature is 23 °C.

   The hydraulic head distribution in the Polder satisfies the general solution of the well-known *Polder Problem*[1]:

   $$h(x) = C_1 e^{+\frac{x}{\lambda}} + C_2 e^{-\frac{x}{\lambda}} + h_p \tag{1}$$

   Where λ is the seepage factor

   $$\lambda = \sqrt{\frac{k_1}{k_2} bD} \tag{2}$$

   and C_1 and C_2 are yet unknown constants.

   (a) Determine the constants C_1 and C_2

   (b) Explain in words why it follows from Equation 1, that the following equalities must both hold:

   $$Q'(0) = \frac{k_1 D}{\lambda}(h_0 - h_p)$$

   $$Q'(0) = \int_0^{+\infty} q_z(s) ds$$

2. Balance the following redox equation (using H^+ and H_3O^-)

   $$MnO_2(s) + {S_2O_3}^{2-} \longrightarrow MnOOH(s) + {SO_3}^{2-}$$

2 Mineral compositions

Table 1 contains information about the composition of certain minerals.

Mineral	Albite	Anorthite
SiO_2	68.74	43.19
Na_2O	11.82	0.0

Table 1: Mineral compositions in oxide wt. %

3 Kaolinite in cuprite

3.1 Chemical composition

Kaolinite is a clay mineral, with the chemical composition $Al_2Si_2O_5(OH)_4$. Cuprite is a brownish-red mineral. The average kaolin price is estimated to reach ~~$160~~ $180 per ton by 2025.

3.2 Deposits in Nevada

Recent measurements show deposits of the mineral kaolinite in cuprite in the Nevada desert, as seen in Figure 1.

References

[1] Leonardo Alfonso, Arnold Lobbrecht, and Roland Price. Optimization of water level monitoring network in polder systems using information theory. *Water Resources Research*, 46(12), 2010.

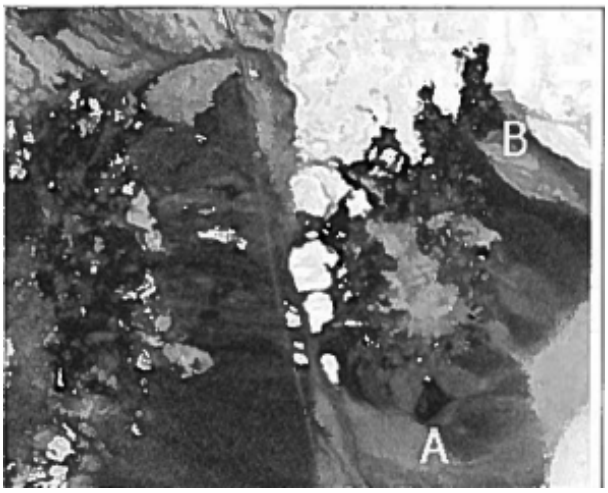

Figure 1: SAM result for Kaolinite in Cuprite, Nevada desert in the USA deribed on an AVIRIS image.