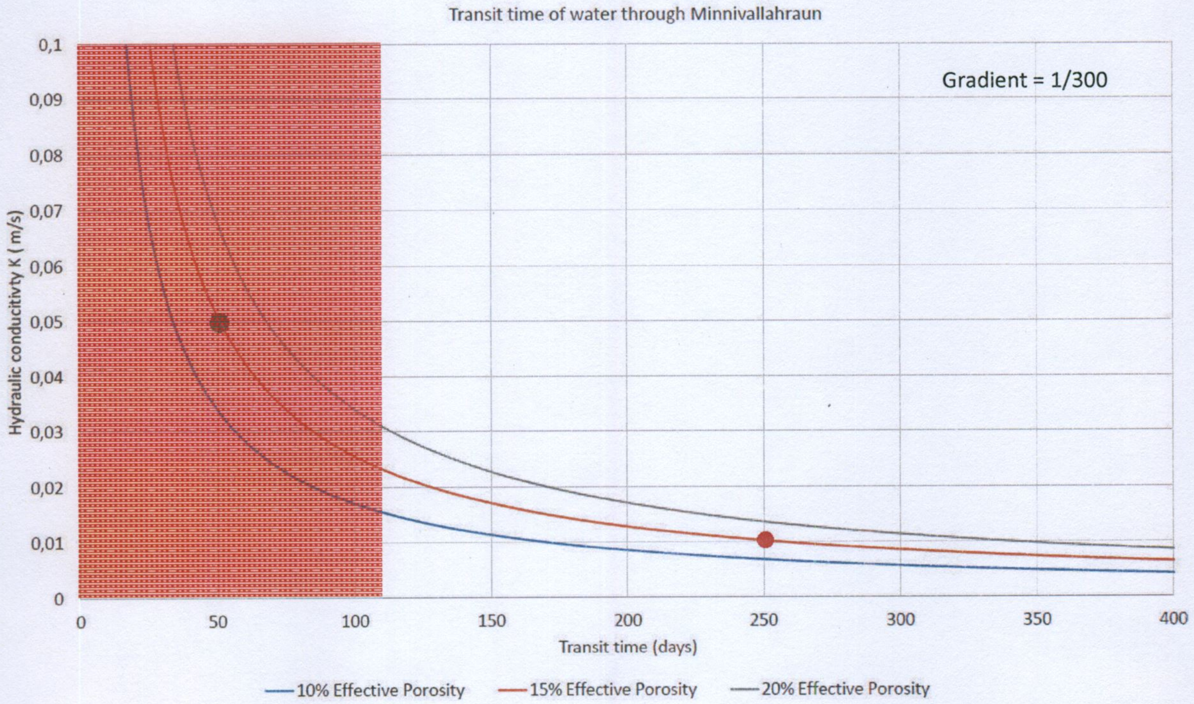

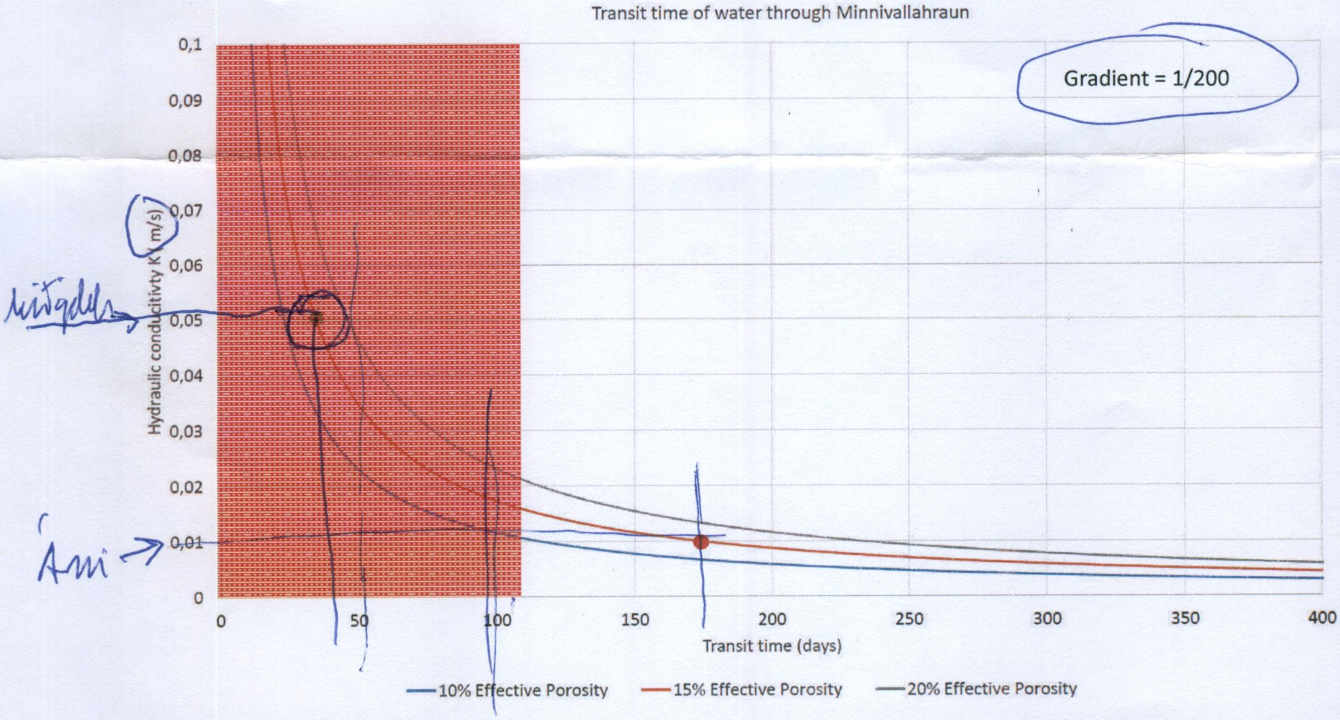

Figure PP: Transit time of water shown as a function of hydraulic conductivy in the range typical for lava in Iceland having K=10^{-1}–10^{-3} m/s for three values of effective porosity (10%, 15% and 20%). The upper graph with hydraulic gradient of 1/300 and the lower with 1/200. Both assume that the lenght of the aquifer is 5000m and Q=150.000 m^3/d. In Hjartarson (2008) the regional transit time was estimated based on hydraulic conductivity of 0,01 (shown with red dot). However, the average value within the given interval would be 0,05 (shown with green dot). The two give drastic differences in terms of transit time from 250 days to 50 days for the upper graph and 175 days to 40 days for the lower graph. Taking into consideration that E-coli bacteria survives longer than 100 years, if hydraulic conductivity is 0,05 m/s the E-coli bacteria would still be alive in both cases.

Mathematical Model

From a conceptual model an analytical model can be introduced to estimate aquifer parameters. In this case the effective porosity and hydraulic conductivity are unknown. To illustrate the relationship and effect on the transit time the groundwater system is idealized using Darcy's law which is a proportional relationship between the instantaneous discharge rate through a porous medium typically used when assessing hydrological parameters for porous media:

$$Q = K * A \; dh / dL$$

where Q is the total discharge (m^3/d), K is the hydraulic conducitivty (m/d), A the cross sectional area of the flow (m^2) and dh/DL the hydraulic gradient (-).

Thereof:

$$Q = q * b$$

where q (m^2/d) is referred to as the Darcy flux or specific discharge and b (m) the aquifer width.

From the Darcy's law the Dupuit equation can be derived (Fetter):

$$Q = K / 2L \, (h_1^2 - h_2^2)$$

The fluid velocity (v) is related to the Darcy flux (q) by the effective porosity (-). The flux is divided by the porosity to account for the fact that only a fraction of the total formation volume is available for the flow. The fluid velocity would be the velocity a conservative tracer would experience if carried by the fluid through the formation.

$$v = K / n_{eff} * dh / dL$$

where n_{eff} is the effective porosity.

To estimate transit time over a given length of the aquifer one uses:

$$t = v * L$$

From equations 1-5 one can derive the following two relationships assuming h_2=0 (Ketilsson et al., 2016) when the hydraulic conductivity is unknown:

$$t = L^2 / h_1 * n_{eff} / K$$

Having the hydraulic conductivity within a range the formula can illustrate the transit time through a given aquifer with known lenght and thickness and effective porosity.

It is important to note the assumptions of the Darcy Law in order to validate whether the conditions are valid for the case in question. The main assumptions are:

[List assumptions]