

Water-rock Interactions and Infiltration Calculations

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Rainfall composition, uncontaminated shallow groundwater data and the mineralogy of the rocks with which the infiltrating waters interact make it possible to calculate the rate of precipitation infiltration.

At the studied region shallow groundwater occurs in Upper Pannonian and Pleistocene formations, in the western part of the area in drift sand, in the eastern part in loess. The average groundwater depth is about 7.8 m. The samples were collected from outside (primarily) and from inside (secondly) of settlements, by drilled wells, dug wells or springs. Near uniform sample distribution was ensured with 249 water samples. The ion concentrations indicate an almost uniform shallow groundwater composition, typical for hilly regions, with Ca^{2+} - Mg^{2+} - HCO_3^- dominance.

To calculate the infiltration fraction (and the water-rock interaction) the NETPATH modelling program was used. NETPATH version 2.0 (Plummer et al. 1994) is an interactive code for modelling net geochemical reactions along a flow path.

The initial water and final water constituents used are: Na^+ , K^+ , Ca^{2+} , Mg^{2+} , Cl^- , HCO_3^- , SO_4^{2-} , NO_3^- , H_2SiO_3 , pH and $^\circ\text{C}$. The phases used are: $\text{CO}_2(\text{g})$, calcite, dolomite, K-feldspar, plagioclase, chlorite, illite, kaolinite, Ca-montmorillonite, Ca/Na ion exchange, Ca/Mg ion exchange, quartz, gypsum and nitrate salt ($\text{Mg}(\text{NO}_3)_2$). There is no gypsum and nitrate salt in these rocks, but these phases are essential to calculate the changes of dissolved sulfate and nitrate content in the groundwater.

As chlorine is a conservative element, it was used to calculate the evaporation factor. For the whole region 29.2, (Table 1) for

the loess area 26.4, for the drift sand area 46.3 was found, which means very low infiltration fractions: 3.4%, 3.8% and 2.2% respectively. These data show an enormous pollution, especially on the drift sand area. Outside of settlements the rate of infiltration was 6.6%, which is almost real, showing that the pollution of groundwater is primary and not connected to the agriculture, but to the pollution from inside of settlements. Considering the unpolluted samples and modelling data for $\text{NO}_3^- < 40 \text{ mg/l}$ result in 8.9-13.6% infiltration (except the drift sand), which correlates with the recharges calculated on the basis of base flow measurements carried out on surrounding areas. The low value (5.06%) for the drift sand area indicate, that the "unpolluted" samples still contain some human contamination.

Observations: 1. The relative high rate of dolomite dissolution is not reasonable; 2. The water-rock interactions can go on with or without Ca/Na ion exchange. In the case of ion exchange there is no need for K-feldspar dissolution, and the amount of clay mineral precipitation is less; 3. The amount of gypsum and nitrate salt required to balance the calculations is so small, that it has no influence on the process.

The present-day slightly acidic meteoric waters interacting with given minerals, near $\text{CO}_2(\text{g})$ absorption and adequate recharge, generate shallow groundwater free of human influence. The calculations could be corrected with tritium isotope data and compared with the PHREEQCI geochemical model.

Plummer LN, Prestemon EC & Parkhurst DL, *An Interactive Code (Netpath) for Modeling Net Geochemical Reactions Along a Flow Path Version 2.0*, USGS, 130, (1994).

| Phases | Whole region | Whole region | Outside of settlement | Outside of settlement | Loess | Loess | Drift sand | Drift sand |
|----------------------------|--------------|--------------|-----------------------|-----------------------|----------|----------|------------|------------|
| $\text{CO}_2(\text{g})$ | 0.18950 | 0.20303 | 0.39224 | 0.42111 | 0.22597 | 0.22597 | | |
| Calcite | 0.04359 | 0.00108 | 0.09572 | 0.00498 | | | 0.05717 | 0.04233 |
| Dolomite | 0.15231 | 0.16680 | 0.23390 | 0.26484 | 0.18912 | 0.18912 | | 0.00742 |
| Illite | -0.00391 | -0.06187 | -0.00256 | -0.12629 | -0.06692 | -0.06343 | -0.02657 | -0.04053 |
| Kaolinite | | | | | | -0.00271 | | |
| Plagioclase | 0.01248 | 0.05112 | 0.01543 | 0.09792 | 0.05549 | 0.05549 | 0.00868 | 0.01891 |
| K-feldspar | | 0.03478 | | 0.07424 | 0.03743 | 0.03533 | 0.01556 | 0.02393 |
| Chlorite | | | | | | | 0.01051 | 0.00973 |
| Gypsum | 0.01201 | 0.01201 | 0.02024 | 0.02024 | 0.00017 | 0.01005 | 0.01293 | 0.01293 |
| $\text{Mg}(\text{NO}_3)_2$ | -0.01010 | -0.01010 | -0.01043 | -0.01043 | 0.01005 | -0.01010 | -0.00981 | -0.00981 |
| Ca/Na exch. | 0.01063 | | 0.02268 | | -0.01010 | | 0.00281 | |
| Evap. coeff. | 11.26 | 11.26 | 7.344 | 7.344 | 10.638 | 10.638 | 19.775 | 19.775 |

"-" precipitation; "no sign" dissolution

Table 1: Example of models which meet the requirements