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Transit time estimation of tunnel inflow in fractured granites

A. Balvín (1), M. Hokr (1), M. Šanda (2), T. Vitvar (2), and P. Rálek (1)

(1) Faculty of Mechatronics, Informatics and Interdisciplinary Studies, Technical University of Liberec, Czech Republic, (2) Faculty of Civil Engineering, Czech Technical University, Prague, Czech Republic

We study the water flow from surface to a tunnel in the average depth of 100 m to evaluate the water residence times in the fractured rock. Transport of ^{2}H and ^{18}O in groundwater was simulated by use of the lumped parameter approach. The area of interest is located in the Jizera Mountains near the Bedrichov municipality in the northern part of the Czech Republic.

Input concentrations of ^{2}H and ^{18}O were measured at Uhlířská experimental catchment in a 5km distance from the tunnel. The output concentrations were measured in the water supply tunnel near Bedřichov. The tunnel is built in compact granite, it is 2600 m long and has a maximal depth of 150 m. The samples were taken from seven different groundwater seepage sites and from the channel collecting all inflow to the tunnel, in 14 days intervals in the period from February 2010 to present. The groundwater discharges were distinguished by their intensity – three dripping ones and four with continual fluxes.

The residence times of the inflowing water were estimated with the dispersion model in the FLOWPC simulation program and cover the range of 2010-2011 years. In addition, we have made preliminary tests with "filtering" the infiltrated concentration data, e.g. assumption of larger ratio of winter infiltration, time shift between snowfall and snowmelt and use of soil water sampling instead of precipitation for the input. The best fit was achieved for spring V7 (for deuterium ^{2}H: water residence time T = 23.6 months, apparent dispersion parameter Pd = 0.28 and Nash-Sutcliffe coefficient 80.3 % and for oxygen ^{18}O: T = 30.9 months, Pd = 0.488 and N-S = 80.1 %, both for redistribution of rain), other fits were approximately 50-65 % (spring V6: T = 24.9 months, Pd = 0.26, N-S = 61.77 %; spring V1: T = 28.6 months, Pd = 0.24, N-S = 50.09 %, both for oxygen ^{18}O). The discharge in the shallow part of the tunnel is probably supplied by flow on the soil-bedrock interface, with a quick reaction to precipitation and dry in the remaining periods. Another type of inflow in the shallow part but in compact rock exhibits a very stable flow and quite stable gradually changing isotopic content. Several springs are probably supplied along a fracture with high velocity of water flow.

The outcomes of the application of this method contribute to the assessment of water flow through the fractured structures up to 150 m deep below the surface.

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Keywords: groundwater, natural tracer, FLOWPC, mean residence time, tunnel discharges.