Estimation of the origin and groundwater flow directions in the area influenced by the construction of the highway tunnel Višňové, northern Slovakia

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Abstract: The origin of unexpectedly high inflows (max. 367 $l.s^{-1}$) of groundwater into the longest highway tunnel (7.5 km) in Slovakia, driven in a granitoid core of the Malá Fatra Mts., northern Slovakia, is discussed. Natural isotope tracers confirm an important role of static groundwater there. In the future, outflow of 80 $l.s^{-1}$ from the tunnel is expected.

Key words: isotopes of H, O, S, tritium, water balance, tunnel

Introduction

Planned highway in the northern Slovakia, passing mountainous terrain, should cut the country by series of tunnels. The longest one (7.5 km) is the tunnel of Višňové near Žilina, northern Slovakia (Fig. 1). The works already started with narrow surveying gallery, constructed in the period of 1998-2002. Its main part was driven through crystalline rocks (medium grained biotitic and biotite-muskovitic granodiorites) of crystalline core of Lúčanská Malá Fatra Mts. In the westernmost interval of 1.47 km, it cuts Mesozoic rocks with the dominating grey dolomites and guttenstein limestones with interbeds of dolomites and marl shales (Ondrášik et al., 2000). The gallery was driven in the altitude of 390-552 m, whereas mountains itself reach the altitude of about 1300 m. Two independent galleries (the W and the E one) were constructed using different technology (classical mining NRTM/shield), to meet under the ground.

During the tunneling, numerous unforeseen concentrated inflows of groundwater were registered, in spite of the granitic nature of the rock mass. The total measured discharge at the entrance was 2-3 times higher at the eastern entrance of gallery, reaching the maximum 326 $l.s^{-1}$. To estimate the origin, age and groundwater circulation pathways, quantitative and qualitative monitoring of the main tunnel inflows was carried out, partly including environmental isotopes of precipitation, surface streams, exploited springs, geothermal wells and also the mineral water source "Fatra". Drilling of deep observation boreholes completed the groundwater-monitoring network. Unfortunately, more attendance to groundwater monitor-

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ing was given only after the first apparent technological problems caused by concentrated inflows, bound to important tectonic faults and mylonitised rocks (HYČKO & TOMANOVIČ, 2001). To estimate the origin and groundwater flow directions in the influenced area, three methods were used: delineation of the recharge area of the tunnel based on water balance estimation, environmental isotope research and tracing tests (MICHALKO ET AL, 2002).

RESULTS AND CONCLUSIONS

Numerous unforeseen concentrated inflows of groundwater registered during the tunneling reaching the maximum of 367 $l.s^{-1}$ sum from both tunnel sides. The total measured discharge at the entrance was 2-3 times higher at the E entrance of gallery driven merely in the granites. The total volume from both (W and E) tunnel mouth counts together 23 883 859.3 m^3 of groundwater discharged in the period of 24.11.1998 - 07.10.2002, what means the average discharge of 164,83 $l.s^{-1}$. Using THORNTHWAITE (1948) method for evapotranspiration determination, the average value of 643 mm of effective precipitation in the area was calculated for the period of 1999 - 2001. This value was compared with possible static (accumulated) groundwater in the rock environment effect on the inflows, using estimates of pos-

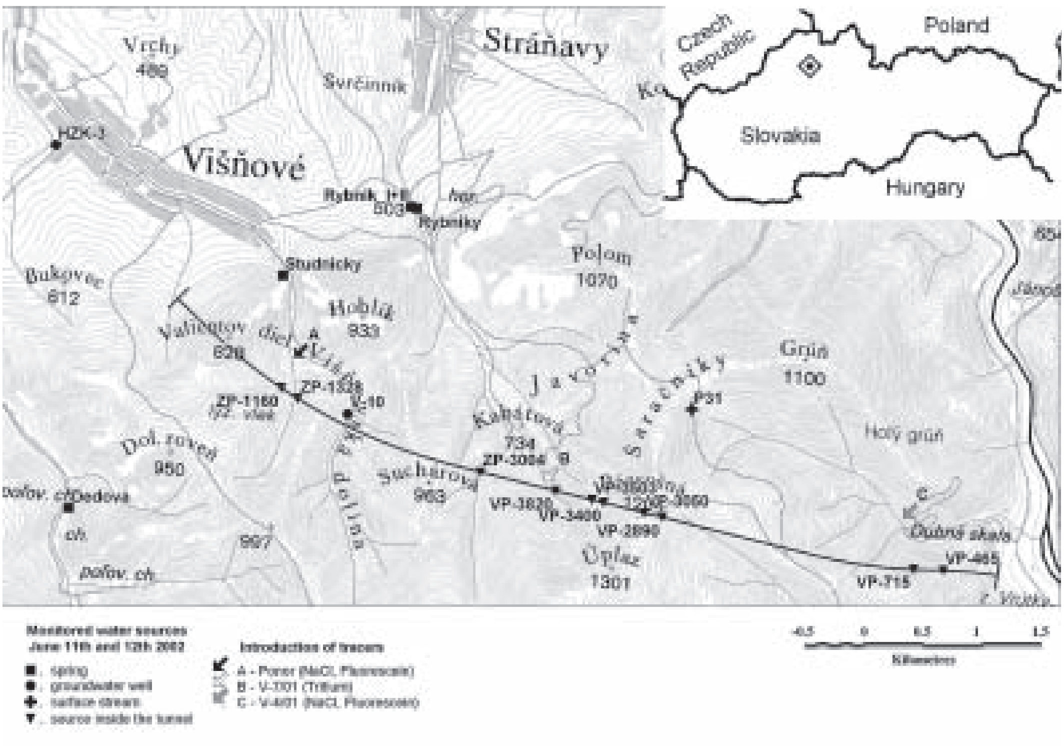

Figure 1. Situation of main sampled sources and places of tracer introduction

sible intervals of storage coefficient and average groundwater table decrease in the influenced area. Assumed high groundwater table drawdowns, indicating high portions of the static groundwater discharge, can be adequate to the partial values observed in the piezometers, and thus we assume that the contemporary discharge of groundwater on both tunnel mouths was created by high portion of the static groundwater volumes.

Considering groundwater isotope data in the tunnel and its vicinity, few types of groundwater are distinguished. Groundwater with risen temperatures, lower electric conductivity, light O and H without T present in central part of tunnel and in some monitoring wells can be identified with stagnant groundwater in crystalline core of Malá Fatra Mts. Isotopically similar groundwater (light H, O, no T), present in the exploited source of "Fatra" bottled mineral water, are in this source gradually replaced by younger waters due to pumping. In the W part of tunnel and in exploited springs in the W slopes of the Malá Fatra Mts. - mainly in Mesozoic rocks, discharges mainly younger groundwater with T in range cca 5TU-15TU, heavier O and H, and lower temperature. In the E marginal part of tunnel in granitoid rocks mixed groundwater are present. S_{SO4} in groundwater is derived mainly from Lower Triassic sedimentary sulfates and from "background sulfur" defined by Mansell et al. (1995). During 30 days of the tracing test, none of the three applied tracers (NaCl, fluorescein, artificial T) introduced in three different places, was detected in 11 monitored inflows inside the tunnel.

References

Hyčko, M. & Tomanovič, F. (2001): *Diaľnica D1 Višňové - Martin, tunel Višňové, 6*. etapová správa. Manuscript, Archive of the Geological Survey of Slovak Republic, 46 p., Bratislava.

Malík, P. & Michalko, J. (2002): Pôvod sulfátu rozpusteného vo vode vybraných krasovo-puklinových prameňov revúckeho zlomového pásma. Podzemná voda, 2/2002, pp. 67 - 78, Bratislava.

Mansell, S.J., Malík, P., Michalko, J., Fendeková, M. (1995): Stable isotopes in karstic groundwaters of the Veľká Fatra Mts., Slovakia.International Symposium on Isotopes in Water resources management, Vienna 20 - 24 March 1995, IAEA-SM-336, Vienna.

Michalko, J., Černák, R., Malík, P., Švasta, J. (2002): Prieskumná štôlňa Višňové - komunikačné skúšky, Záverečná správa, Manuskript, Archive of the Geological Survey of Slovak Republic, 29 p., Bratislava.

Ondrášik, R., Matejček, A., Holeša, Š., Vrábľová, K. (2000): Gravitational tectonics and slope deformations along the tunnel line Višňové in the Lúčanská Fatra Mts., Slovakia, Mineralia Slovaca, 32, pp. 429-438, Košice.

Thornthwaite, C. W. (1948): An approach toward a rational classification of climate. Geograph. Rew. 38, pp. 55 – 94.