Actual and Potential Utilisation of Mine Waters in the Spišsko-gemerské Rudohorie Mts., Slovakia

Peter Bajtoš

State Geological Institute of Dionyz Stur, Regional Centre, Markušovská cesta 1, Spišská Nová Ves, 052 40, Slovak Republic, e-mail: bajtos@sguds-snv.sk

Abstract
Quantitative and qualitative parameters of mine water outflows occuring in the Spišsko-gemerské Rudohorie Mts. (Spiš–Gemer Ore Mts., abbr. SGR, Slovakia) were studied. Regional estimation of their exploitable amounts, convenient for potable water supply, was assessed. On the present, only small portion of total assumed exploitable amount of 322,8 l/s is exploited for potable water supply. Relatively frequent necessity of water treatment, due to increased level of some metal compounds (mainly Fe, Mn, Sb, As), limits enhancement of their utilisation, because of the lack of economically effective water treatment technology.

Key words: mine waters, potable water supply, exploitable water amount, the Spiš–Gemer Ore Mts., Slovak Republic

Introduction

A few hundreds of abandoned underground mines occur in the Spišsko-gemerské Rudohorie Mts. (Spiš–Gemer Ore Mts., abbr. SGR, Slovakia), as result of historical or latter ore exploitation. As this region is without substantial natural groundwater resources, possibilities of mine water utilisation as drinking or service water has been reflected for long time. However, the first mine water exploitation dates from 1980s in SGR, when parts of Gelnica town and Hnilčík village started to be supplied throught public ducts from local abandoned adits. Since 1986, hydrogeological surveys of several mine sites were made. As result of these activities, exploitable amounts of mine water were proven for drinking water supply of Markušovce, Nálepkovo and Poráč villages. Many unused mine water outflows were documented in frame of regional hydrogeological mapping in scale 1 : 50 000 (Malík et al. 1990, Scherer et al. 1999), showing great potential for improvement of local public water supply. The article presents a current stage of knowledge regarding quantitative and qualitative characteristics of mine water sources occuring in SGR, including the regional estimation of their exploitable amounts, convenient for potable water supply.

Methods

Mine waters of underground abandoned ore mines dispersed in the Spišsko-gemerské Rudohorie Mts. was studied, using regional hydrogeological and hydrogeochemical mapping and monitoring. Database of quantitative and qualitative parameters of mine water outflows was created, consisting of archive and new field measurement data (mine water yield, water temperature, pH, electric conductivity of water) and laboratory test results of mine water sampling. Database was used for regional assessment of exploitable amount of mine water in SGR. For this purpose, the classification of groundwater exploitable amount proposed by Jetel (2004) was used, slightly modified considering input data and specific character of mine water sources. Exploitable mine water amount is graded into three different levels: Q_P – maximum („natural“) exploitable amount determined only by natural conditions, Q_{ETK} – really exploitable amount in actual qualitative conditions, Q_{DOK} – proved exploitable amount, i. e. the part of the Q_{ETK} sufficiently evidenced by documentation corresponding to the valid regulations. Q_P was determined as sum of characteristic yields of all registered mine water outflows, Q_{ETK} as sum of characteristic yields of those mine water outflows that meet standards for potable water supply. Quality of mine waters is graded into four categories, in accordance with Decree of the Ministry of Environment of the Slovak Republic No. 636/2004 Coll. as follows: A_1 – water suitable for drinking without treatment or after disinfection or simple physical treatment, A_2 – physical or chemical treatment and disinfection necessary, A_3 - intensive physical, chemical treatment and disinfection necessary, K – water inconvenient for water supply. Qualitative categorization of individual sources was made on the base of choosen chemical compounds (Sb, As, NO_3, F, Cr, Cd, Cu, Ni, Pb, Hg, Se, NH_4, TDS, Cl, Mn, SO_4, Na, Zn, Fe, ^{226}Ra, ^{222}Rn). Hydrochemically

undocumented outflows of mine water were classified as either probably convenient (A_N category) or probably inconvenient (K_N) for drinking by analogy, considering mineral deposit type. Microbiological, biological and organic compounds are not mentioned because of lack of data.

Results and Discussion

Total number of 393 mine water outflows were documented in the studied area (fig. 1), linked to hydrothermal siderite-sulphidic veins (328 sources), antimonite veins (33), metasomatic siderite deposits (13), stratiform uranium deposits (9), stratiform sulphidic deposits (7), magmatogenic Sn-W mineralisation (2) and stratiform gypsum deposit (1). All deposit types are hosted within Paleozoic metamorphic rocks of the Gemericum tectonic unit (part of Inner Western Carpathians), classified from the hydrogeological point of view as low permeable hydrogeological massif. In these circumstances, the mine water yield and its regime is controlled mainly by the near-surface extent of the mine, the possibility of atmospheric water infiltration (via openings, fractures, and faults) and the climatic conditions of the locality (Bajtoš 2000).

Mine water yields are reaching up to 15 l/s in individual sources. Frequency diagram shows lognormal distribution of characteristic yield values, those average is expressed by geometric mean G(Q) = 0,367 l/s. Arithmetic mean M(Q) is 0,99 l/s, median Md(Q) = 0,39 l/s and most frequent value Mo(Q) is 0,05 l/s. In comparison with springs occuring in studied region, yield of mine water outflows is twice as high in average.

Mine water sources linked to hydrothermal siderite-sulphidic veins are most numerous. Their total yield of 299,6 l/s creates 77,3 % of total documented mine water yield in SGR, at occurence frequency of 83,5 %. Relatively high mine water amount (33,8 l/s) is connected with metasomatic siderite deposits – 8,7 %, and antimonite veins (23,9 l/s) – 6,2 %. Mine waters of others deposit types do not exceed 2 % of total quantity 394,6 l/s.

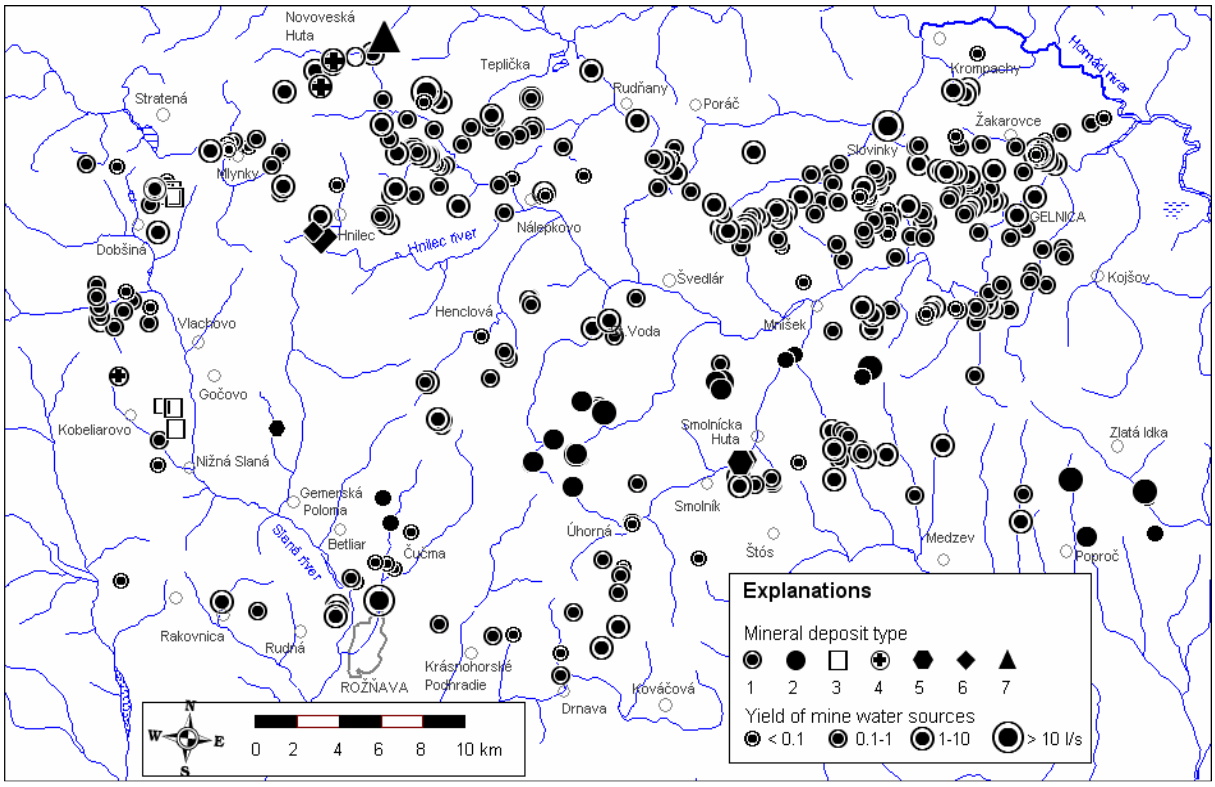
Table 1 *Documented amounts of mine waters in SGR graded into qualitative and quantitative classes. Explanation in text.*

	Q_{ETK}				Q_K		Q_{ETK}	Q_K	Q_P
	A_1	A_2	A_3	A_N	K_N	K	A_{Total}	K_{Total}	SUM_{Total}
	mg/l								
I	0	0	0	0	0	0	0	0	0
II	4,8	27,0	21,0	0,7	0	26,3	53,5	26,3	79,8
III	16,7	26,7	4,8	203,9	14,7	26,8	252,1	41,5	293,6
IV	1,3	13,5	2,0	0,4	0,2	3,8	17,2	4,0	21,2
SUM	22,8	67,2	27,8	205,0	14,9	56,9	322,8	71,8	394,6

Documented amounts of mine waters are graded into 4 qualitative and 6 quantitative classes (tab. 1). From the quantitative point of view, degrees of data reliability are distinguished: I – long terming monitoring of yield, II – short terming monitoring, III – single or repeated measurements, IV – educated guess. Amounts of mine water derived from data collected in frame of regional hydrogeological mapping prevails (class III), folloving by those obtaining by short term monitoring, mostly not exceeding 1 year. Estimated amounts (IV) represent small portion of sum, whereas long terming maesurements of mine water yield absent. From the quantitative point of view, mine water amounts classified in categories A_1, A_2 and A_3 are suitable for drinking after variusly demanding water treatment. Together with probably suitable but hydrochemically undocumented amounts in A_N category they create really exploitable amount Q_{ETK} = 322,8 l/s in our classification of exploitable mine water amount. The rest amount Q_K = 71,8 l/s of waters inconvenient for exploitation represent possible sources of surface water contamination. These mine water sources are connected with stratiform sulphidic deposits, uranium deposits, gypsum layers and some of antimonite veins. Maximum („natural“) exploitable amount Q_P = 394,6 l/s.

On the present, 20 mine water sources are exploited for potable water supply (Q = 25 l/s). Most of them have been used since the end of last century, after mining expiration. All of them are outflows of mine water from adit collars, disinfected water is distributed to consumers through ducts by gravitational forse.

Figure 1 *Spatial distribution of mine water outflows in the Spišsko-gemerské Rudohorie Mts. Mineral deposit types: 1 - siderite-sulphidic veins, 2 - antimonite veins, 3 - metasomatic siderite deposits, 4 - stratiform uranium deposits, 5 - stratiform sulphidic deposits, 6 - magmatogenic Sn-W mineralisation, 7 - stratiform gypsum deposit.*



Conclusions

Taking into consideration scattered settlements in SGR, many mine water outflows can represent interesting drinking water sources of local importance, household water or water in agriculture and gardening. Only small portion of 7,8 % (25 l/s) is presently exploited, in comparison with total assumed or proven exploitable amount of 322,8 l/s for potable water supply. Most important current factor limiting their more extensive exploitation is relatively frequent necessity of water treatment, due to increased level of some metal compounds (mainly Fe, Mn, Sb, As). Economically effective water treatment technology could meaningly increase the exploitation of mine water sources in SGR.

References

Bajtoš P (2000) Mine water regime in the Spišsko – gemerské rudohorie Mts. Podzemná voda 2, 6, 74-80.

Bajtoš P (2004) Mine Water Issues in Slovakia. In: Wolkersdorfer Ch, Bowel R(Eds): Contemporary Reviews of Mine Water Studies in Europe. Mine Water and the Environment, 23, 4.

Bajtoš P (2007) Genesis of mine waters in the Spišsko-gemerské rudohorie Mts. and possibility of their utilisation. PhD. dissertation, Comenius University, Bratislava, 150 p.

Decree of the Ministry of Environment of the Slovak Republic No. 636/2004 Coll., stipulating the Requirements for the Quality of Raw Water and for the Water Quality Monitoring in Public Ducts

Jetel J (2004) Grading exploitable groundwater amount into the maximum (natural), really exploitable and proved amounts. Podzemná Voda, 10, 1, 35-42.

Malík P, Vrana K, Ivanička J, (1990) Hydrogeology of the Volovské vrchy Mts. in Hnilec watershed. Manuscript, Archive of Geological Survey of Slovak Republic Bratislava – Geofond (in Slovak)

Scherer S, Kordík J, Malík P, Bajtoš P, Gedeon M (1999) Hydrogeological and hydrogeochemical map of northern part of the Spišsko-gemerské Rudohorie Mts. 1 : 50 000. Manuscript, Archive of Geological Survey of Slovak Republic Bratislava - Geofond. (in Slovak)