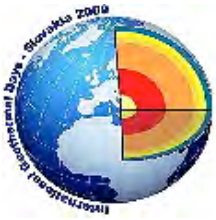

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VIII.1.

NEW RESULTS FROM THE REGIONAL HYDROGEOTHERMAL EVALUATION IN SLOVAKIA

Anton Remšík*, Marián Fendek**, Igor Bajo***, Daniel Marcin*

*State Geological Institute of Dionýz Štúr, Bratislava, Slovakia
**Faculty of Sciences, Comenius University, Bratislava, Slovakia
***GEO Slovakia, s.r.o., Košice, Slovakia

INTRODUCTION

Owing its natural conditions, Slovak Republic has a significant potential in geothermal energy. Until done investigation and survey have quantified this potential on 5 538 MW_t. It is an alternative territorially spread source of energy. The significance of its use relates both - economic aspects as well as ecology. Altogether 26 geothermal areas, resp. structures for obtaining and use of geothermal water were distinguished in Slovakia. Particular geothermal areas can be characterized with differing degree of available hydrogeothermal exploration results. Several areas have represented in the past (until 2000) an object of hydrogeothermal investigation, resp. exploration, using geothermal drills (Vienna Basin, Central depression of Danube Basin, Komárno elevated block, Komárno marginal block, Levice block, Skorušiná Depression, Tur□ianska kotlina Basin, Liptovská kotlina Basin, Levo□a Basin W and S part – only Popradská kotlina Basin, Dubnica Depression and Košická kotlina Basin – restricted to □urkov area). Recently (after 2000) the geothermal investigation was focussed into □iarska kotlina Basin – Central Slovakian Neogene volcanics – NW part, Horná Nitra Basin, Topo□□any embayment and Bánovská kotlina Basin, Humenné Ridge and Rimavská kotlina Basin and its compendious results we state gradually by particular areas. In some geothermal areas the hydrogeothermal investigation by geothermal drills has not been done yet (Trnava embayment, Pieš□any embayment, Tren□ianska kotlina Basin, Ilavská kotlina Basin, □ilinská kotlina Basin, Komjatice Depression, Central Slovakian Neogene volcanics SE part, Upper Strháre-Tren□ subsidence, Levo□a Basin - NE part, Beša-□i□arovce structure).

The hydrogeothermal investigation is systematic, aiming to examine all geothermal areas in Slovakia. This investigation (usually using geothermal borehole) is realized by means of regional hydrogeothermal evaluation of particular hydrogeothermal areas, being financed by the Ministry of Environment of Slovak Republic from the state budget. The regional hydrogeothermal evaluation of particular areas is done by methodology used in similar evaluation of regions in other countries of European Union presented in Atlas of geothermal sources of Europe (Hurter and Haenel, eds. 2002).

1. ŽIARSKA KOTLINA BASIN

In the geothermal area Central Slovakian Neogene volcanics - NW part only the regional

hydrogeothermal evaluation in the iarska kotlina Basin was done (Remšík et al., 2000). Previous research in the iarska kotlina Basin was related to prospection for geothermal water (Franko et al. 1973).

The iarska kotlina Basin represents the Inner Carpathian depression located among Neogene volcanic mountain ridges (Vtánik Mts., Pohronský Inovec Mts., Štiavnické vrchy Mts. and Kremnické vrchy Mts.), being infilled with products mainly of andesite and rhyolite volcanism (Badenian-Sarmatian) as well as Pannonian to Quaternary sediments with maximum depth of pre-Tertiary underlier (iar n/H. – Lova) around 3500 m beneath the sea level. The geological-geophysical interpretation of the iarska kotlina Basin (Remšík et al., 2000) resulted in new morphotectonic and geological schemes of the pre-Tertiary underlier, as well as maps of the surface and thickness of Triassic carbonates of Hronicum and Veký Bok Series, resp. Fatricum. The pre-Tertiary underlier in SE and NW part of the territory is built by Triassic limestones and dolomites of Hronicum and in middle part of the territory by Ipoltica Group (melaphyre series – shales, sandstones). The Mesozoic rocks (Triassic-Cretaceous) of the Veký Bok Series, resp. Fatricum are located in deeper setting beneath Hronicum.

From the geothermic viewpoint the iarska kotlina Basin can be characterized as an active area. The temperatures in the depth 1000 m reach around 55-60 °C, the density of the heat flow varies from 80 to 100 mW/m^2 with characteristic value 95 mW/m^2. The sizeable (central) part of the pre-Tertiary basement of the basin is characterized by the temperatures 100 °C and higher at the depth – 2100 m a.s.l. and deeper. The highest temperatures are present in the central part of the basin in partial depression between Lova and iar n/H, where in the depths –3400 to – 3500 m is the temperature app. 130 °C.

Geothermal water in the nearest territory is known in 11 springs and two boreholes (ST-1, 2) in the Sklené Teplice village (efficiency 0.1-22.3 l/s, water temperature 24-53 °C, Ca-Mg-SO_4 type with mineralization 2.4-2.6 g/l), from boreholes ST-4 and ST-5 in their environment (efficiency 16.13 l/s and 4.4 l/s, the water temperatures 57 °C and 46.3 °C, chemical composition similar as in the case of Sklené Teplice), in Vyhne – spring Vyhnianka in adit and borehole H-1 (efficiency 5.3 and 5.0 l/s, water temperatures 33 and 36 °C, Ca-HCO_3 type with mineralization around 1 g/l), in Lukavica – borehole LKC-4 (efficiency 10.0 l/s, water temperature 35 °C, Ca-HCO_3 type with mineralization 0.37 g/l), Zlatno – borehole R-3 (efficiency 10.0 l/s, water temperature 35 °C, Ca-Mg-SO_4 type with mineralization 4.5-5.0 g/l). In the area of Banská Štiavnica based on the regional hydrogeological research in the Štiavnické vrchy Mts. (Remšík et al., 2007) in Neogene andesites and altered veinstone of the underlying Grüner vein, the geothermal water was found by borehole HR-1, reaching depth 910 m. The Na-Ca-SO_4-HCO_3 type water has total mineralization 2.447 g/l and temperature 46.4 °C. Suggested amount for offtake is 12.5 l/s (Tab. 1). The geothermal borehole RG-2, realized at the town iar nad Hronom, deep 2500 m, did not found the presence of the Triassic carbonates (collectors of geothermal water). Instead of carbonates the subsurface volcanic body was found.

Geothermal water in the iarska kotlina Basin is present in the pre-Tertiary basement and tied to Triassic dolomites and limestones of Hronicum and the Veký Bok Series, resp. Fatricum. The location of hydrogeothermal structures corresponds with the spread of Triassic dolomites and limestones of these tectonic units, as well as with the distribution of morphostructures of the basement, represented with sinking slope of the Hodruša-Štiavnica horst and iar Depression (Remšík et al., 2000).

Triassic limestones and dolomites of Hronicum build upper hydrogeothermal structures (Upper Sklené Teplice and Upper iar structures), where in the depths 200-300 m down to – 4100 m the geothermal water with the reservoir temperature around 20-150 °C are supposed. Triassic limestones and dolomites of the Veký Bok Series, resp. Fatricum build lower hydrogeothermal structures (Lower Sklené Teplice and Lower iar structures), where in the depths around 600 m (-200 m a.s.l.) down to ca 5000 m (-4700 m a.s.l.) the

geothermal water is supposed with the reservoir temperature around 30-160 °C.

Chemical composition of geothermal water in the □iarska kotlina Basin is dominated by Ca-Mg-SO_4, resp. Ca-Mg-SO_4-HCO_3 type, bearing mineralization of ca 3-5 g/l and CO_2, event. increased H_2S contents.

In the □iarska kotlina Basin (besides the Upper and Lower Sklené Teplice structures) in Triassic dolomites and limestones of Hronicum the boreholes deep 2700-3500 m (and deeper) would verify the geothermal water with the reservoir temperature 100-120 °C (and higher). In the Triassic dolomites and limestones of the Ve□ký Bok Series, resp. Krí□na nappe they are located beneath Hronicum. The drills deep 3200-4300 (and deeper) would verify the geothermal water with the reservoir temperature 110-145 °C (and higher).

The specific temperature-energetic potential of the natural amount of geothermal water for Triassic carbonates of the Cho□ nappe was determined to 0.091–6.307 GJ/m^2 with average value 3.251 GJ/m^2 and for Triassic carbonates of the Ve□ký bok Series, resp. Fatricum to 0.329–3.658 GJ/m^2 with average value 2.357 GJ/m^2.

The natural amount of geothermal water with temperature 60 °C (the Sklené Teplice structure) and 110 °C (□iar structure) represents 65.3 l/s, corresponding to prognostic amount of geothermal energy of natural sources 22.296 MW_t. The probable renewed usable amount of geothermal energy in the whole area of the Central Slovakian Neogene volcanics is evaluated to 109.0 MWt (Franko, Remšík and Fendek, eds., 1995).

2. HORNÁ NITRA BASIN

The Horná Nitra Basin represents the intermontane depression among the core mountains of Strá□ovské vrchy Mts., Tribe□ Mts., □iar Mts. and volcanic mountain range Vtá□nik, being infilled by Paleogene, Neogene and Quaternary rocks. The pre-Tertiary underlier in the southern part of the basin is formed by the rocks of Ipoltica Group, in the central part by the carbonates of Hronicum and in northern part by carbonates of Fatricum and Mesozoic of Tatricum. The depth range of Mesozoic rocks varies from the north to south in the range 1000–3500 m.

Regarding geothermic conditions the temperatures in the Horná Nitra Basin reach 500–3000 m beneath surface with maximum values in the central part of the basin between towns Nováky and Prievidza. Towards the margins of the basin they lower. In the depths 500 m beneath surface the temperatures reach 22.5–32.5 °C, in depth 1000 m 35–50 °C, in depth 1500 m 50–65 °C, in depth 2000 m 60–80 °C, in depth 2500 m 70–90 °C and in depth 3000 m beneath surface they will reach values 80–100 °C.

The density of the temperature flow in the Horná Nitra Basin represents values in the range 70.2–84.4 mW/m^2 with statistic mean 79.2 ± 4.6 mW/m^2. The supreme values above 75 mW/m^2 are typical for the central part of the basin between towns Nováky and Prievidza. They are probable related to the geodynamics of the basin origin.

In the Horná Nitra Basin the geothermal water is known from springs and wells. They are connected with the carbonates of Fatricum and Hronicum, which is reflected also in their chemical composition. Water from carbonates of Hronicum is of Ca(Mg)-HCO_3 type with total mineralization up to 1 g/l and water from Fatricum of the Ca(Mg)-SO_4 type with total mineralization 1.31 g/l. Temperatures vary in relation to the source. In the area of Bojnice highly elevated block they are in the range 30–51.2 °C, in the central part of Horná Nitra Basin - well Š1-NB II 63 °C, at Chalmová village around 39.5 °C and in geothermal well FGHn-1 at Handlová the temperature 19.4 °C was found (Tab. 1).

The specific temperature-energetic potential of natural amount of geothermal water for Triassic carbonates of the Cho□ nappe varies in the range 1–8 GJ/m^2. The highest value even above 8 GJ/m^2 is characteristic for central part of the basin between towns Nováky and Prievidza with decreasing trend towards the margins of the basin.

Regarding the sources of geothermal energy, the temperature-energetic potential of the

territory of the Horná Nitra Basin was determined to 29.12 MW_t, representing at average temperature of geothermal water 60 °C the sources of geothermal water with value 140 l/s (Fendek et al., 2004).

3. TOPOĽČANY EMBAYMENT AND BÁNOVSKÁ KOTLINA BASIN

This geothermal area represents northern spur of the Danube Basin between mountain ranges Pova□ský Inovec Mts., Strá□ovské vrchy Mts. and Tribe□ Mts. The dominant morphotectonic structures of the territory are represented by the Bánovce Depression in the northern part of the territory, covering the central part of the Bánovská kotlina Basin, with 2800-2900 m thickness of the Paleogene and Neogene rocks and distinct elevation – Závada-Bieliky block in southern part of the territory with the thickness of Tertiary rocks from several metres up to ca 1200 m. The pre-Tertiary underlier is built with Paleozoic-Mesozoic rocks of Hronicum, in the deeper setting, beneath Hronicum, resp. locally directly beneath the Tertiary rocks are supposed the Mesozoic rocks of Fatricum.

The temperatures in the depth 1000 m beneath the surface in the space of the Bánovská kotlina Basin and northern part of the Topo□□any embayment vary in the level 25–45 °C, and in depth 1500 m they reach 35–55 °C, in the depth 2000 m 45–70 °C, in the depth 2500 m 60–85 °C and in the depth 3000 m under the surface they range in the extent 75–95 °C. Noteworthy there is the formation of the anomaly with increasing temperatures in the central area of the Bánovská kotlina Basin in depths 1500–2500 m beneath the surface (in the territory between villages Svinná and Dr□kovce), which probable relates to the large thickness of Tertiary sediments in this part of the basin. The temperature on the surface of pre-Tertiary underlier increases with increasing thickness of Tertiary rocks. From the margins towards the central part of the studied territory it reaches ca 80 °C. Density of temperature flow in the territory represents values 55.1–74.2 mW/m^2 with average value 63.5 ± 7.6 mW/m^2.

The prevailing part of the territory of the Bánovská kotlina Basin and northern part of Topo□□any embayment is characterized by the density of the heat flow 60–70 mW/m^2.

Geothermal water in described territory is known from springs and boreholes. It is associated prevailingly with Triassic carbonates of Hronicum, located in the underlier of Tertiary rocks. Chemical composition of this geothermal water is represented with Ca-Mg-HCO_3 type with mineralization around 0.48-0.78 g/l (Tab. 1). Similar geothermal water of Ca-Mg-HCO_3 type with mineralization around 600 mg/l, was found in Triassic carbonates of Hronicum by 998 m deep geothermal well FGTz-2 at the town Partizánske with efficiency at pumping 12.5 l/s and 33 °C water temperature at borehole collar (Fendek et al., 2004a).

In the territory of Topo□□any embayment and Bánovská kotlina Basin two hydrogeothermal structures are assigned, namely the Bánovce structure, being overlapped with Bánovce Depression and Závada-Bieliky structure, overlapped with Závada-Bieliky elevation (Remšík et al., 2007a). The Bánovce hydrogeothermal structure overlaps with extension of Hronicum, built mainly by Triassic carbonates, in the underlier of Tertiary rocks and forms decisive part of the territory of Bánovská kotlina Basin. The surface of this structure is located in the depth below ca -100 m a.s.l. (depth ca 400-500 m) down to -2600 m a.s.l. (depth 2800–2900 m), where the temperature is from 20 °C to ca 80 °C (Ruskovce). The Závada-Bieliky hydrogeothermal structure represents the Závada-Bieliky elevation an is also overlapped with the spread of Hronicum in the underlier of Tertiary rocks, built mainly by Triassic carbonates, forming the major areal spread of hydrogeothermal structure. The surface of the structure (besides the outflow area of Bieliky therms) is present in the depth around -100 m a.s.l. (depth ca 350-400 m) to -1300 m a.s.l. (depth around 1500 m), where the temperature (away of outflow area of Bieliky therms) is from 20 °C to ca 50 °C. In both hydrogeothermal structures the renewable sources of geothermal water, resp. geothermal energy, are present.

The value of specific heat-energetic potential of natural amount of geothermal energy for

Triassic carbonates of Hronicum in these structures varies in the range from 0.5 GJ/m^2 (margins of the territory, mainly in the Bánovce Depression) to 5.5 GJ/m^2 (central part of Bánovce Depression - Ruskovce and outflow area of Bieliky therms), the average values represents 2.145 GJ/m^2.

In the Bánovce structure the natural amount of geothermal water was accounted to 64 l/s and corresponds to geothermal energy 6.653 MW. In the Závada-Bieliky structure the natural amount of geothermal water represents 77.7 l/s and corresponds to total amount of geothermal energy 5.816 MW. Together in the Bánovce and Závada-Bieliky structures the total amount of geothermal water 141.7 l/s was accounted (reservoir temperature of the water is 35-42 °C, superficial temperature of the water 33-40 °C, reference temperature of the water is 15 °C) and corresponds to total amount of geothermal energy 12.469 MW (Remšík et al., 2007a).

4. HUMENNÉ RIDGE

It is built with the strip of Mesozoic rocks of the NW-SE trend, mainly in the underlier of the Tertiary rocks, coursing along the Klippen belt from the Levo□a Basin in the territory north of Prešov through towns Humenné and Sobrance to state boundaries with Ukraine, where it continues. It is built by Fatric Triassic-Cretaceous sediments. The Mesozoic sequences are owing to intensive compression significantly faulted with lensoidal setting and alternation of carbonates and pelitic rocks.

The activity of the heat field increases from the Klippen belt towards basin from 75 to 90 mW/m^2. Similar picture is offered also by the temperature field – temperature in the depth 1000 m increases from 45 to 55 °C, resp. in the depth 2000 m from 75 to 95 °C. This picture deforms only the temperature field in the area of Humenské vrchy Mts. with the temperature minimum 40 °C in the depth 1000 m, resp. 70 °C in the depth 2000 m, which is not observable in the depth 3000 m. The average temperature gradient in the interval 0–1000 m is ca 39 °C/km, in interval 1000–2000 m it is ca 36 °C /km.

Geothermal water, tied with Triassic dolomites and limestones of Fatricum is known preferably from the drills. At the town Sobrance (with present natural outflows) the water with temperature 19.5–29.5 °C was registered by wells deep 100–400 m and verified with one well deep 823 m. In the well MLS-1 in the Podskalka area the geothermal water in the depth 896–1719 m was found. The geothermal well GTH-1 Kalu□a (Bajo et al., 2007), deep 600 m, found water with temperature 34.4 °C, being hosted by Triassic carbonates. The efficiency at pumping reached 2.0 l/s (Tab. 1). Chemical composition of the water from the borehole MLS-1 (Podskalka) is characterized as mixed Ca-(Mg)-Na-SO_4-HCO_3-Cl type with mineralization 0.83 g/l and in the case of both wells GTH-1 Kalu□a and TMS-2 (Sobrance) of Na-Cl type with mineralization 4.7 and 10.56 g/l.

In the frame of Humenné Ridge Bajo et al. (2007) have distinguished six partial hydrogeothermal structures (namely: Kapušany, Zlatník, Merník-Oreské, Kalu□a, Sobrance and Sejkov), being formed by uplifted or sinked blocks of Mesozoic rocks. The collector of geothermal water was represented by Triassic carbonates with variegated thickness ranging from 880 to 1100 m. The depth of the surface of Triassic carbonates varies in the wide range from the superficial occurrence (Humenské vrchy Mts.), down to depth 2250 m. There are assumptions that 1700–3000 m deep geothermal wells would trap geothermal water with temperature 60–100 °C, efficiency 10–16 l.s^{-1} and mineralization 5–10 g.l^{-1}.

The total volume of geothermal water with above stated temperatures in the area of Humenné Ridge (Bajo et al., 2007) is accounted on 341 l/s. The renewable volume of geothermal water represents 237 l/s. The geothermal energy (heat output) of the Humenné Ridge represents 750.5 MW.

5. RIMAVSKÁ KOTLINA BASIN

The Rimavská kotlina Basin forms eastern part of the South-Slovakian Basin being infilled with Tertiary rocks. The pre-Tertiary underlier is built mainly with Mesozoic elements of Silicicum, locally also Meliaticum

and Turnaicum. In the easternmost part it is built with Middle to Upper Triassic limestones and dolomites sinking here from Slovak Karst. The majority of pre-Tertiary underlier consists from Lower Triassic variegated shales containing infolded Middle Triassic limestones and dolomites in tight synclinal zones.

Geothermal activity of the territory is standard. The activity of the heat field increases from the northern margin of the Rimavská kotlina Basin towards southeast to town Torna□a from 60 to 65 $mW.m^{-2}$ and in the southwestern direction to Hajná□ka up to 80 $mW.m^{-2}$. In the temperature field in the depth 1000 m the situation is different with temperature increasing from the north towards south from less than 35 °C to more than 50 °C. In the depth 1500 m, in which the Triassic carbonates of Silicicum can occur, the temperature increases from the north southward in the range 45-70 °C.

The geothermal water is known from natural outflows and boreholes. It is connected with Triassic limestones and dolomites of Silicicum in the underlier of Tertiary rocks. The water temperature from shallow boreholes varies in the range 17-18.5 °C, the efficiency of boreholes in Králiky and Torna□a is in the range 17-23 $l.s^{-1}$ and at the village Hrn□iarske Zálu□any it reaches 2.7 $l.s^{-1}$. The small amount of water was verified by the wells BC-2 in Cakov and RKZ-1 in Bátka. Geothermal water was found by the well deep 158-1022 m, their efficiency was in the range 3.3-45.0 l/s, with the water temperature 18-33 °C (Tab. 1). Chemically it represents Ca-Mg-HCO_3 type with mineralization 1.7-5.9 g/l. Recently in the Rimavská kotlina Basin the regional hydrogeothermal exploration is done, supported by the geothermal borehole FGRk-1 Ivanice, deep 1050 m (Fendek, 2005).

Probable regenerated usable amount of geothermal energy in the Rimavská kotlina Basin, associated with Triassic carbonates of the Silica nappe is evaluated to ca 26 MWt (Franko, Remšík and Fendek, Eds., 1995).

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Tab. 1. Review of geothermal wells in investigated areas.

Locality well	Year	Depth of well (m)	Perforated segment (m)	Age, lithology of collectors	Q (l/s)	T at collar (°C)	Heat output (MW_t)	M (g/l)	Chemical type of water
Topo□□any embayment and Bánovská kotlina Basin									
Malé Bielice	1974	160	80-100	Paleogene,	8.5	40	0.89	1.1	Ca-Mg-HCO_3
MB-3	1983	102	27-90	carbonatic	+8.3	39	0.83	0.8	
Ve□ké Bielice	1982	160	133-139	breccia	+1.7	32	0.12	1.5	Ca-Mg-HCO_3
VB-3	1985	2106	1512-	Paleogene,	+2.0	55	0.33	5.9	
Brodzany	2004	998	1917	carbonatic	+12.5	33	0.94	0.7	Ca-Mg-HCO_3-SO_4
HGT-9	2000	500	401-970	breccia	+18.8	20	0.37	0.7	
Topo□□any	1984	2025	265-474	Triassic,	+17.0	40	1.78	0.7	Na-HCO_3-SO_4
FGTz-1			2000-	carbonate					
Partizánske			2025	Triassic,					Ca-Mg-HCO_3
FGTz-2				carbonate					
Partizánske				Triassic,					Ca-Mg-HCO_3
HGTP-1				dolomite and					
Bánovce n.				limestone					Ca-Mg-HCO_3-Cl
Bebravou				Triassic,					
BnB-1				carbonate					
				Triassic,					
				dolomite					
Hornonitrianska kotlina Basin									
Koš Š-1-NB II	1980	1851	1677-	Triassic,	22.0	59	4.08	0.8	Ca-Na-Mg-HCO_3-SO_4
Chalmová	1983	150	1851	carbonate	+5.0	39	0.50	1.9	
BCH-3	1992	200	30-120	Triassic,	+13.4	33	1.01	1.3	Ca-Mg-SO_4-HCO_3
Chalmová	2002	475	50-194	carbonate	+2.5	19	0.05	0.4	
HCH-1			370-430	Triassic,					Ca-Mg-SO_4-HCO_3
Handlová				carbonate					
FGHn-1				Paleogene-Triassic,					Ca-Mg-HCO_3
				breccia,					
				dolomite					
Central Slovakian Neogene volcanics, part NW									
Kremnica KŠ-1*	1967	531	476-531	Mesozoic,	23.2	47	3.10	1.5	Ca-Mg-SO_4-HCO_3
	1967	92	19-78	carbonate	5.0	36	0.44	1.1	
Vyhne H-1	1975	710	660-710	Triassic,	10.0	35	0.84	5.0	Ca-Mg-HCO_3-SO_4
Zlatno R-3	1980	876	792-851	limestone,	10.0	35	0.80	0.4	
Lukavica	1981	1820	1453-	dolomite	16.0	57	3.00	2.6	Ca-Mg-SO_4-HCO_3
LKC-4	2005	910	1695	Neogene-	+12.5	46	1.63	2.4	
Sklené Teplice	2000	2500	748-829	Triassic,	-	-	-	-	Ca-Mg-HCO_3
ST-4			-	porphyrite,					
Banská				dolomite					Ca-SO_4-HCO_3
Štiavnica HR-1				Triassic,					
□iar nad				carbonate					Na-Ca-SO_4-HCO_3
Hronom RG□-2				Triassic,					
				carbonate					
				Neogene,					
				andesite,					
				altered					
				veinstone					
				-					

Rimavská kotlina Basin									
Bátka RKZ-1	1989	658	435-658	Triassic,	-	-	-	-	-
Torna□a HM-5	1973	158		carbonate	45.0	18	0.56	1.8	$Ca\text{-}HCO_3$
Cakov B□-3	1984	876	489-874	Triassic,	3.3	29	0.19	5.9	Ca-Mg-HCO_3
Rimavské Janovce GRS-1	2003	1022	767-1008	limestone	$^{+}$13.0	33	1.01	1.7	
Ivanice FGRk-1	2007	1050	618-1050	Triassic, carbonate	-	-	-	-	Ca-Mg-HCO_3
				Triassic, carbonate					-
Humenné Ridge									
Sobrance	1975	823	487-625	Neogene,	4.0	29	0.25	11.9	Ca-Na-Cl-SO_4
TMS-1	2005	600	454-594	sand, sandstone	$^{+}$2.0	34	0.16	4.7	Na-Cl
Kalu□a GTH-1				Triassic, limestone and dolomite					

* well drilled from adit; $^{+}$ efficiency at pumping