GEOTHERMAL COUNTRY UPDATE FOR SLOVAKIA

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Abstract. The distribution of aquifers with geothermal waters and the thermal manifestation of geothermal fields in Slovakia has enabled the definition of 26 prospective areas and structures with potentially exploitable geothermal energy sources. In 1971 - 1994 a total of 61 geothermal wells were drilled. They verified 900 l/s of waters with temperature 20 - 92 "C. The total thermal energy potential of geothermal waters in all prospective areas amounts to 6608 MW_t.

1. HYDROGEOTHERMAL CONDITIONS

The geological structure of the West Carpathians in Slovak territory and favourable geothermic conditions create a suitable setting for the occurrence of geothermal energy sources. The distribution of aquifers with geothermal waters and the thermal manifestation of geothermal fields in Slovakia have made it possible to define 26 prospective areas and structures with potentially exploitable geothermal energy sources (Fig. 1). These include mainly Tertiary and intramontane depressions situated in the Inner West Carpathians (south of the Klippen Belt).

The temperature and heat flow density of geothermal fields are highly variable. At a depth of 1000 m, temperatures range from 20 °C (Komárno high block) to more than 70 °C (Eastern Slovakian basin. in which the most important parts are the KoSice basin, the Humenský chrbát Mts. and the Beša-Čičarovce structure). The geothermal gradient in the Inner West Carpathians (0 - 1000 m) averages 37 °C/km, so the (Eastern Slovakian basin - 40 - 60 °C/km) while heat flow density (Král, 1991) varies from 50 mW/m^2 (Vienna basin) to 120 mW/m^2 (Eastern Slovakian basin). The highest temperatures, geothermal gradient and heat flow density indicate that, with regard to geothermal properties, the Eastern Slovakian basin is the most active region in Slovakia,

Geothermal energy is related to geothermal waters which largely occur in Triassic dolomites and limestones of Inner Carpathian nappes and, to a lesser extent, in Neogene sands, sandstones and conglomerates (Central depression, Horn6 Strháre . Trenč graben, Dubnik depression) or in Neogene andesites and related pyroclastics (Beša - Čičarovce). These aquifers lie at depths of 200 - 5000 m (except in spring areas) and the temperatures of their geothermal waters range from 20 - 240 "C.

As far as temperature is concerned, geothermal waters in Slovakia (Tab. 1) are dominated by low-temperature ones (T < 100 "C) while medium-temperature sources (T = 100 -150 "C) are rarer and high-temperatures (T > 150 "C) are least frequent.

2. RESULTS OF RESEARCH AND EXPLORATION

Research, prospecting and exploration of geothermal waters has so far been carried out in 13 prospective areas in Slovakia (Fig. 1 - areas 1, 2, 3, 6, 9, 11, 12. 13, 18, 19, 20, 21, 26) and in one unprospective area (southern part of the Eastern Slovakian basin - a unsuccessful well).

In 1971 - 1994 (Table 2) a total of 61 geothermal wells were drilled (only 4 of them were unsuccessful) which verified 900 l/s of waters whose temperature varies from 20 to 92 °C. Thermal capacity of these geothermal waters amounts to some 184 MW_t (water temperature will be reduced to 15 °C during exploitation). Geothermal waters were captured by wells 210 to 2605 m deep, and their free outflow mostly ranged from 5 to 40 l/s (RemSik, 1993). Chemically, the waters are represented by Na-HCO_3-Cl, Ca-Mg-HCO_3-SO_4 and Na-Cl types. their T.D.S. is 0.7 - 20.0 g/l.

The evaluation of the thermalenergy potential (TEP) of geothermal waters in Slovakia's individual prospective areas is given in Fig. 1. The total TEP of geothermal waters in all prospective areas amounts to 6608 MW_t. Reserves of geothermal waters account for 6008 MW_t and their resources for the remaining 600 MW_t (renewable TEP). It is worth mentioning that. because of the distribution of the prospective areas, these energy sources should be regarded as disseminated.

3. PRESENT STATE AND PROSPECTS

In the other 13 prospective areas, geothermal waters have not been verified by wells (Fig. 1 - areas 4, 5, 6, 7, 10, 14, 15, 16, 17, 22, 23, 24, 25). but seven of them (Fig, 1 - areas 4, 5, 10, 16, 17, 21, 23) have been geologically assessed for the purpose of prospecting and exploration for geothermal waters. The evaluation of these areas, based on earlier geological information, results of oil wells and geophysical measurements allowed us to propose wells for geothermal waters in the individual areas.

From 1991 - 1994 the Dionýz Štúr Institute of Geology in Bratislava compiled a geothermal energy atlas of Slovakia, The atlas consists of maps. cross-sections, graphs and diagrams which, along with a text provide a good review of the spatial distribution of the earth's heat (hot dry rock), geothermal waters and TEP in Slovakia. A geothermal map of Slovakia at scale 1:500 000 is ready for printing.

Two wells for geothermal waters are currently being drilled and a third one is being prepared in the Poprad basin (Fig. 1 - area 13). Another geothermal well is being drilled

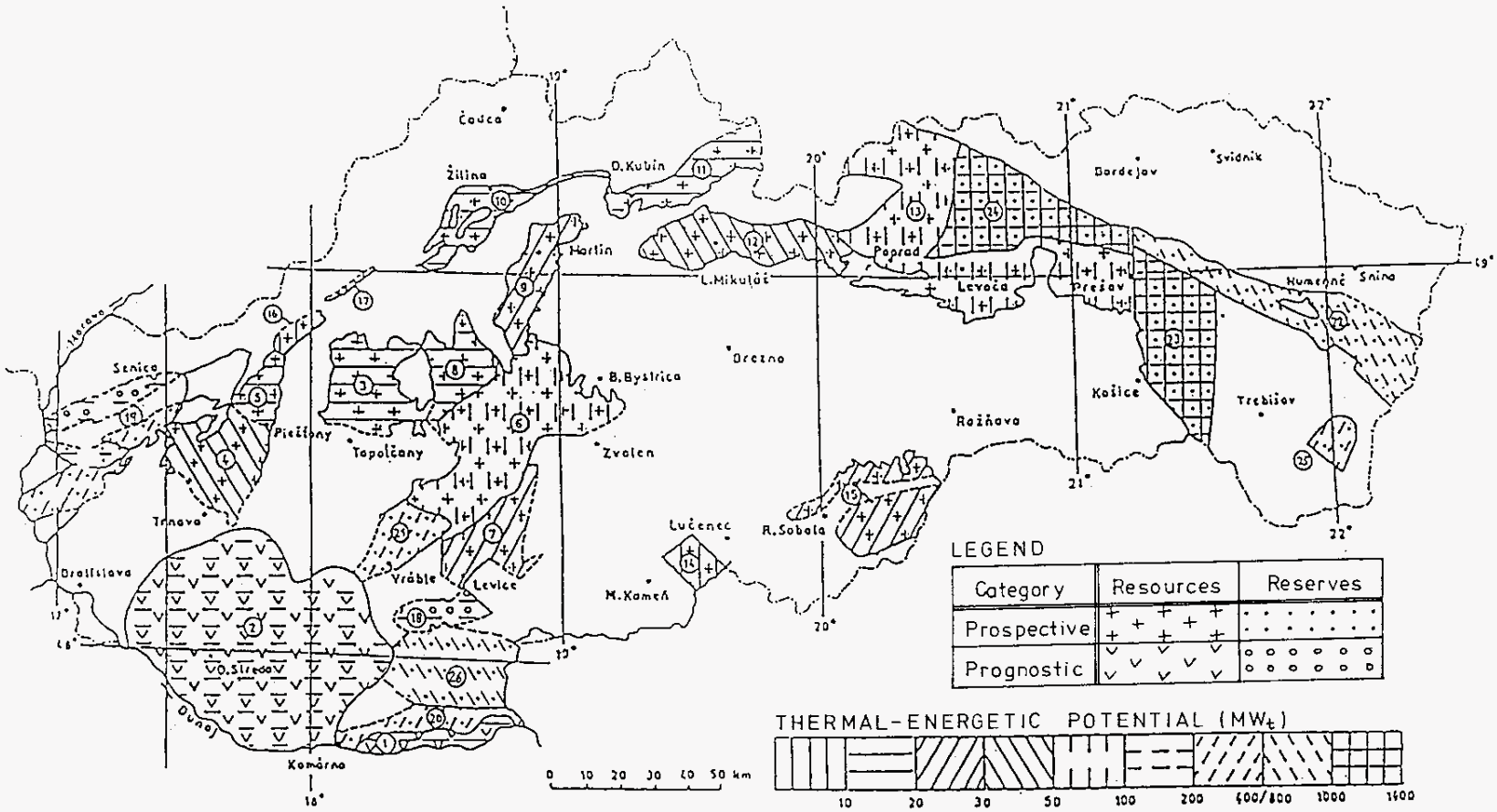

Fig. 1 Map of prospective geothermal water areas or structures in Slovakia and their thermal-energetic potential (Remšík and Fendek, 1994).

1 - Komárno high block, 2 - Central depression of the Danube Basin , 3 - Bánovce basin, 4 - Trnava bay, 5 - Piešťany bay, 6 - Central Slovakian neovolcanics (NW part), 7 - Central Slovakian neovolcanics (SE part), 8 - Upper Nitra basin, 9 - Turiec basin, 10 - Žilina basin, 11 - Skorušina Mts., 12 - Liptov basin, 13 - Levoča basin (Wand S part), 14 - Horné Strháre-Trenč graben, 15 - Rimava basin, 16 - Trenčín basin, 17 - Ilava basin, 18 - Levice block, 19 - Vienna basin, 20 - Komárno marginal block, 21 - Komjatice depression, 22 - Humenský chrbát Mts., 23 - Košice basin, 24 - Levoča basin (N part), 25 - Beša-Čičarovce structure, 26 - Dubník depression

Tab. 1 Distribution of low- to high-temperature geothermal waters (RemSik and Fendek 1994)

Type and temperature of geothermal waters	Defined geothermal water structure of area	Number of geothermal water structures and areas
Low-temperature T < 100 °C	Komárno high block, Central depression of the Danube basin, Bánovce basin, Trnava bay, Piešťany bay, Central Slovakian neovolcanics (NW part), Central Slovakian neovolcanics (SE part), Upper Nitra basin, Turiec basin, Žilina basin, Skorušina Mts., Liplov basin, LevoEa basin (W + S pari), Horn6 Strháre - Trenč graben, Rimava basin, Trenčín basin, Ilava basin, Levice block, Komárno marginal black, Vienna basin, Komjalice depression, LevoEa basin (N part), Humenský chrbát Mts., KoSice basin, BeSa - Čičarovce Structure. Dubnik deoression	*26*
Medium-temperature T = 100 - 150 °C	Beša-Čičarovce structure, Central depression of the Danube basin, KoSice basin, Humenský chrbát Mts., LevoEa basin (N part), Liptov basin, Turiec basin, Central Slovakian neovolcanics (NW part), Bánovce basin, Žilina basin, Ilava basin, Trenčín basin, Piešťany bay, Trnava bay, Vienna basin. Komhrno marginal block	16
High-temperature T > 150 °C	Beša-Čičarovce structure, Žiar basin (part of Central Slovakian neovolcanics - NW part), Košice basin, Vienna basin, Central depression of the Danube basin	5

in the Žilina basin (Fig. 1 - area 10). Two geothermal stations based on earlier wells are under construction: in the Danube basin central depression (2) at Galanta and in Levice block (18) at Podhájska (reinjection).

A good chance to capture geolhermal-energy may also be found in those areas where geothermal waters have not yet been verified by wells. Particularly promising are seven areas (4, 5, 10, 16, 17, 21, 23) where geological evaluation realistically suggests new sources of geothermal energy. The most promising of them is the KoSice basin (23) where medium- and high-temperature Sources of geothermal energy suitable for electricity generation (25 - 30 MW_e) can be captured (Remšík, 1993a). At a depth 2500 - 3000 m there are walers at 115 - 165 "C. The Dionýz Štúr Institute of Geology is actively anempting to verify geothermal waters in the KoSice basin and has compiled a geological project including a 3000 m deep pilot well (RemHik and Fendek, 1992). The well is currently being planned.

There exist further possible sources of geothermal energy in Slovakia as geothermal waters are widely distributed here. In addition to the above facts, it is worth mentioning that the 26 defined prospective areas cover more than a quarter (27 %) of Slovakia's territory.

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Tab. 2 Results of geothermal uells drilled in 1971 - 1994 in Slovakia (Remšík and Fendek, 1994)

Structure	Number of geother-mal wells	Drilling period	Aquifers	Oepth of perforated intervals (m)	Discharge (l/s)	Uater temperature (°C)	neat power (MW_t)	T.D.S. (g/l)	Chemical type of waters (over 20 eq. % of 100 % ion sun total)
Komárno block	6	1972-1990	Triassic dolomites, limestones, Neogene sands. conglomerates	77-1761	5.5-70.0	20.0-56.0	0.12-7.33	0.7-90.0	Ca-Mg-HCO_3-SO_4 Na-Cl mixed type
Central depression	34	1971-1990	Neogene sands. sand-stones, conglomera-tes	276-2487	0.3-25.0	23.0-91.5	0.13-6.80	0.5-8.3	Na-HCO_3 Na-HCO_3-Cl Na-Cl
Dubník depression	2	1989-1990	Badenian sandstones, conglomerates	745-1905	1.5-15.0 *	52.0-75.0	0.25-2.40	10.0-30.0	Na-Cl Na-SO_4-Cl
Levice block	2	1973-1986	Badenian clastics, Triassic dolomites	995-1740	28.0-53.0	69.0-80.0	6.30-14.42	19.2-19.6	Na-Cl
Komjatice depression	'1	1989	Pannonian sands, sandstones	1509-1700	12.0	78.0	2.50	20.1	Na-Ca-Cl-HCO_3
Bánovce basin	2	1984-1985	Triassic dolomites	1512-2025	2.0-17,0*	40.0-55.0	0.33- 1.78	0.7-6.0	Na-HCO_3-SO_4 Ca-Mg-HCO_3
Vienna basin	2	1982-1984	Triassic dolomites, limestones	1242-2570	12.0-25.0	73.0- 78.0	2.91-6.59	6.8-10.9	Na-Ca-Cl-SO_4 Na-Cl
Upper Nitra basin	1	1979-1980	Triassic limestones, dolomites	1677-1851	26.0	66.0	4.85	0.93	Ca-Na-Mg-HCO_3-SO_4
Liptov basin	4	1976-1991	Triassic dolomites, limestones	1315-2486	6.0-31.0	32.0-62.0	0.43-5.89	0.5-4.8	Ca-Mg-HCO_3-SO_4 Ca-Mg-HCO_3

Structure area	Number of geother-mal wells	Drilling period	Aquifers	Depth of perforated intervals (m)	Discharge (l/s)	Uater temperature (°C)	Heat pover (MW_t)	T.D.S. (g/l)	Chemical type of waters (over 20 eq. % of 100 % ion sun total)
Levoca basin	3	1981-1994	Triassic dolomites	835-1983	20.0-33.0	46.0-59.0	2.58-6.08	3.0-4.0	$Ca-Mg-HCO_3-SO_4$
Skorusina Mts.	1	1990-1991	Triassic dolomites	950-1565	100.0	54.0	16.3	1.2	$Ca-Mg-HCO_3-SO_4$
Turiec basin	1	1989-1990		2461**					
Ilava basin	1	1989-1990		1761**					
Eastern Slovakian basin	1	1973		1001**					