MINERAL AND THERMAL WATERS IN CZECHOSLOVAKIA

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Over 2 000 mineral and thermal water occurences have been registered in Czechoslovakia. These waters of various chemical types are being used in spa resorts and for bottling. Both ways of exploiting these waters have a long tradition. Nowadays, there are 60 spas in the country, visited yearly by 460 000 pacients (the cure usually lasts 3 weeks). About 360 million bottles of mineral water are produced in 22 bottling plants yearly.

Only a small amount of geothermal energy is used in agriculture, pooles and for heating. In Czechoslovakia there are no favourable conditions for geothermal power stations.

Czechoslovakia belongs to two principal Europian geological units. In the west, the Bohemian Massif is part of the Variscan orogenic belt. In the east, the West-Carpathians are the part of apline mountain system. Both units differ not only in their geological age and paleogeography, but also in structural development, geomorphology, magmatic and volcanic history.

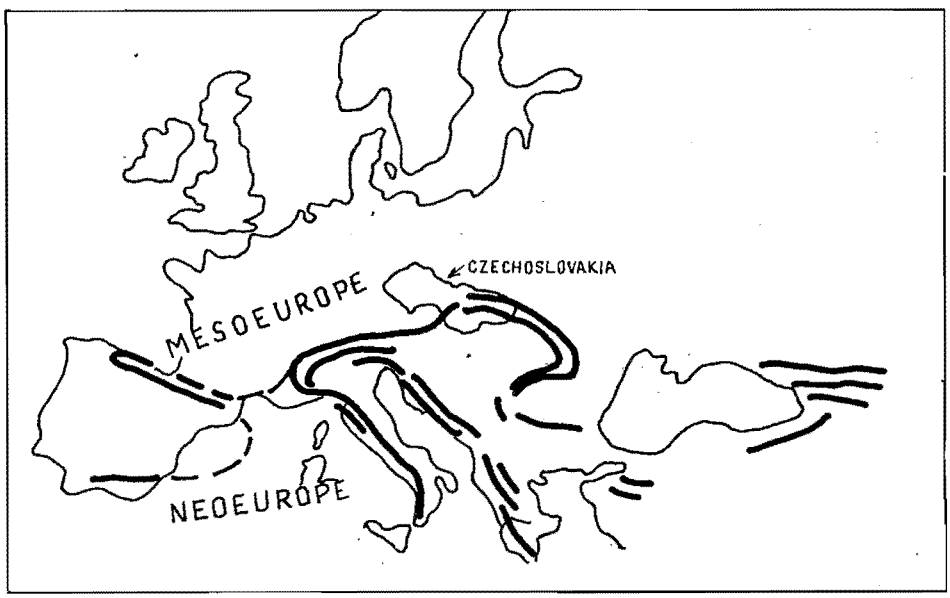

Fig.1. Position of Czechoslovakia in the Europe geological system

The Bohemian Massif has been consolidated during the Variscan orogeny in Late Paleozoic. Consequently, the platform sediments of younger age have been affected only by faulting. A considerable part of this massif is built up by crystalline schists and granitoids. The most intensive young tectonic activity (Saxonic) here took place in Tertiary. The major part of fractured zones is founded on old deep fault tectonics. These are hydrogeologically the most important ascent ways for mineral waters.

In the east, Bohemian Massif adjoints West-Carpathians which from an arc of alpine mountains of Mesozoic and Tertiary age. Their crystalline basement has been built by earlier orogeny. Neogene basins and areas of Tertiary volcanism terminate the geological development of this unit. Mineral waters are relates to all five zones of West-Carpathians, schowing different conditions for their origin. Different are also genetic types of waters and their varied chemistry.

In accordance with the Czechoslovak standard, mineral waters is a ground water exceeding one of the values of the following criteria: 1 $g.l^{-1}$ of total dissolved solids (mineralisation), 1 $g.l^{-1}$ of dissolved CO_2, 1 $mg.l^{-1}$ of titratable sulphur, 5 $mg.l^{-1}$ of Fe^{2+}, 0,7 $mg.l^{-1}$ of As or higher concentrations of F, Cu, Zn, Co, Mo, Li, Sr, Ba, or the radioactivity above 1 350 $Bq.l^{-1}$ The minimal temperature for thermal water is 25 °C. All these waters, as far as their therapautical effects have been proved clinically, are classified as curative waters and are legally protected.

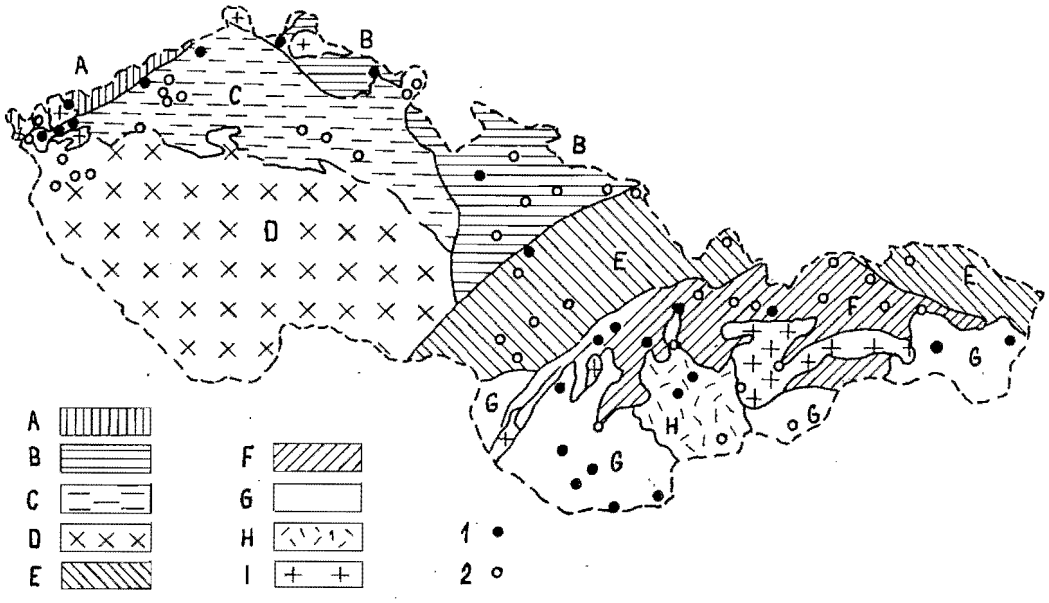

Fig.2 Distribution of mineral and thermal waters in Czechoslovakia
A - Krušné hory - mountain area, B - Sudety mountain area, C - Mesozoic sediments, non folded, D - crystaline shists and granitoids of Southern and Central Bohemia, E - fordeep area, F - Outer Flysh and Klippen Belts, G - Neogene lowlands, H - Tertiary volcanic rocks, I - granit massiffs, 1 - thermal waters, 2 - mineral waters

The mineral and thermal waters in the western part of Czechoslovakia are of complicated origin. Their genesis is often connected with deep fault tectonics and with ascent of postvolcanic CO_2.

The main group of valuable mineral springs occur in the most western corner of the territory. Entirely different types of mineral water circulate within a small area of 50 x 50 km showing relatively equal or similar geology. The most valuable of them are the waters of "Carlsbad - type" ($Na-HCO_3-SO_4-Cl$), oversaturated with CO_2, cold or hot. They have given rise to the most important Czechoslovak spas like Karlovy Vary (Carlsbad), Mariansko Lazne (Marienbad) etc. Another type of mineral water occuring in this area is a thermal water with high radiactivity in Jachymov - spa (up to 13 500 $Bq.l^{-1}$). Mineral waters with low mineralisation but with high content of free CO_2 are used in bottling plants. However, a great number of mineral springs is not exploid at all.

Some mineral waters have been discovered in the neighboring Tertiary basins during mining for brown coal. Mining activity, however, must have been reduced to protect mineral water springs occuring in near spas. This protection shows a long history. The first protection area has been declared and established already in 1761.

Different types of mineral water occuring in the above mentioned area are given on table 1.

The origin of these waters is related to geological conditions and appears to be particularly attributed to deep fault tectonics of the area (affected with an influx of endogenic materials or fluids).

Next large group of mineral springs represent mineral waters high in free CO_2 of Sudetic mountain range. They occur on both sides of the range. Most of them are of low mineralisation, ascending along faults in crystalline shists or granitoids (cf. table 2).

The majority of mineral waters in the West Carpathians is of vadose origin

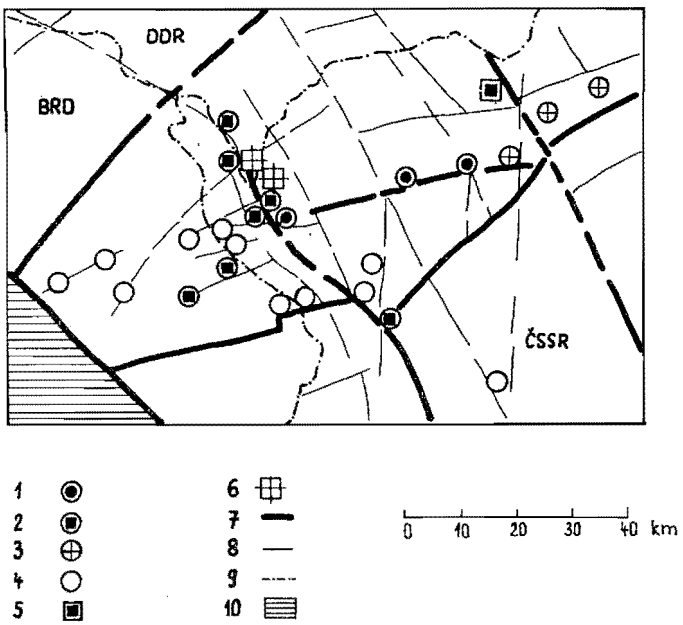

Fig. 3. Accumulation of different types of mineral water in Western Bohemia
1 - thermal water of Carlsbad type, 2 - cold mineral water of Carlsbad type, 3 - mineral water of Na-HCO_3 type, 4 - carbon dioxid water, 5 - radioactive thermal water, 6 - cold radioactive water, 7 - deep fault tectonics, 8 - other faults, 9 -state boundary, 10 - Mesozoic fordeep of Bohemian Massif

and their chemistry is closely related to the mineralogy of host rocks, through which the waters circulate.

Among the boundary between the Bohemian Massif and Carpathians lies a fordeep area. The mineral water originate here due to leaching processes, which are often affected by CO_2 ascent. Similar conditions are thought in adjacent areas i.e. Outer Flysh and Klippen Belt (cf. table 3).

The Inner Carpathian zone appears to be the largest and most varied spring area. The abundance of mineral water resulted from the presence of excelent rock collectors (Carbonates of Mesozoic age), a fold structure of Mesozoic formations, young faults and Neogene volcanism.

The last West Carpathians area are Neogene Lowlands, consisting of about 5 000 m of young marine sediments. Characteristic mineral waters here are Na-Cl brines.

Mineral waters in West Carpathians are often altered by ion exchange and by mixing of water of different types (cf. table 4).

The mean value of heat flow within Czechoslovakia is 71,1 mWm^{-2} (Standard deviation is 22,1 mWm^{-2}). In spite of great differences in geology of the territory (Meso-Europe in the west and Neo-Europe in the east) the regional values of heat flow are actually equal. Local values, however, due to the structure and geology show great deviations. Relatively lowest values have been recorded in the southern and central parts of Bohemian Massif, where the earth crust is thought to be about 40 km thick (50 - 60 mWm^{-2}). The heat flow is increasing towards the margin of the Bohemian Massif, particularly in places with deep fault tectonics. In these places where the earth crust is reduced and tectonic activity increased, the heat flow shows higher values (70 - 90 mWm^{-2}).

The heat flow is alsou increasing along the contact of the Bohemian Massif with the Carpathians and toward the inner part of the Carpathian arc. However, even here we deal with low temperature, but with thermal water with high quantity. These waters occur in relatively shalow depth. The Central depression of

of the Danube basin and some intermountain depressions appear to be permissing. The first boreholes in these areas to depth of 2,5 km have met thermal waters having up to 110°C and an active outflow of about 10 $l.s^{-1}$. The mineralisation shows Na-Cl-HCO_3 type, T.D.S. about 6 $g.l^{-1}$. These waters are mainly used in holidays resorts and for agriculture.

Table 1

Locality	T.D.S. $mg.l^{-1}$	Na	Ca	Mg	HCO_3	SO_4	Cl	CO_2 $mg.l^{-1}$	T °C	radioaktiv. $Bq.l^{-1}$
					mval%					
Carlsbad	6416	88,7	7,6	0,1	40,1	39,9	19,8	395	73	81
Sokolov basin	10397	41,0	38,7	19,7	35,0	44,3	25,3	720	56	-
Cheb basin	11905	31,2	47,2	24,0	44,2	38,2	17,5	3000	35	-
Cheb basin	133000	97,1	1,1	1,1	1,2	56,9	42,0	-	36	-
Franzensbad	22801	83,0	7,9	3,5	16,2	62,7	21,1	1109	13	129
Marienbád	10683	80,0	8,0	6,7	28,2	51,1	20,8	2508	10	13
Jáchymov	598	74,2	14,8	6,7	93,0	4,1	2,7	-	34	9694
Kyselka	1767	61,5	17,0	12,0	96,8	1,5	1,6	2463	11	-

Table 2

Poděbrady	4511	59,1	23,2	13,6	75,5	2,9	21,4	2661	12	-
Vratislavice	1284	61,3	27,8	5,6	94,5	3,7	1,8	2641	9	-
Janské lázně	327	15,9	70,5	11,9	93,4	5,1	1,5	8	30	-
Velké Losiny	206	95,5	2,7	0,5	51,5	22,8	11,8	-	54	-
Teplice n.B.	1770	2,0	78,6	19,3	95,4	1,2	1,8	1800	22	-

Table 3

Luhačovice	13764	87,0	4,0	1,4	56,0	0,1	44,0	2150	14	13
Nosice	3208	80,4	10,4	5,3	92,9	0,8	6,0	831	11	-
Bardejov	9555	82,6	8,4	3,4	77,1	0,2	22,6	2535	11	-
Orav. Polhora	41646	92,7	3,5	1,8	1,4	-	98,2	313	7	-

Table 4

Piešťany	1407	20,3	59,6	17,5	21,2	60,4	17,2	151	67	-
Bojnice	661	7,0	56,6	34,2	79,8	18,5	1,2	34	25	-
Sklen.Teplice	2500	2,6	71,2	23,2	15,0	64,6	0,2	288	52	-
Číž	13793	92,4	2,6	3,2	5,6	-	94,0	55	11	-
Dun. Streda	7329	95,9	1,0	0,2	32,7	0,8	66,1	158	90	-