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Abstracts of Scientific Reports

Editor: Miloš Rakús

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INTRODUCTION

Currently, more than ever before, it is necessary to inform broad scientific and layman´s society about the results achieved by D. Štúr Institute of Geology in the realisation of scientific-technical and other projects.

To varying degree this task was fulfilled by the yearbook of D. Štúr Institute of Geology, in which brief characterisation of the results attained in particular projects was supplemented by abstracts.

By the decision of the Editorial Board of D. Štúr Institute of Geology the abstracts of reports, which underwent approbations, will be published separately in the edition "Geologické Práce – Správy" in Slovak and English languages.

Actually, this way we continue in our tradition of subediting "Zprávy o geologických výskumoch" published in 1963, 1964 and "Správy o výskumoch Geologického ústavu D. Štúra", being published in 1986, 1989 (within the framework of edition" Regionálna geológia Západných Karpát" No. 21 a 25.

Similar periodicals, informing about the results of previous year´s achievments, are published by a number of geological institutions (e. g. Jahrbuch and Jahres-bericht of the GBA Wien, Principaux resultats scientifiques et technique of the BRGM of France and so on). We feel that Slovak and English abstracts, summarising the results of last year activities, represent a survey of results which will serve to many scientists and to broad public alike. Abstracts will contribute to show a variety of projects of the D. Štúr Institute of Geology and help to spread the latest geological knowledge and information.

Miloš Rakús

Abstracts of Reports for 1993

(All reports underwent opponents approval and represent results of the projects carried out by D. Štúr Institute of Geology). Complete manuscripts of approved reports have been registered in the Archive of the Geological Survey of Slovak Republic

General evaluation of the scientific and research activities for the year 1993 is submitted in the Annual Report. Despite of this every separate project is briefly characterized in the introduction.

Project: GEODYNAMIC EVOLUTION AND DEEP STRUCTURES OF THE WEST CARPATHIANS

Miloš RAKÚS

Idea of the project was outlined when the International Correlation Programme IGCP-198 was successfully completed at the beginning of 90-ties. Absence of a geodynamic model was a limiting factor felt in theoretical and applied research studies as a slow down, when compared with geologically more advanced countries.

All this circumstances caused that within the framework of GÚDŠ the first interim draft was worked out. Later on it was immediately clear that such complex project can be implemented only in close cooperation, on contract basis, with other institutions like the Slovak Academy of Sciences and Faculty of Science of Comenius University.

Due to its complexity the project was divided into two stages:
First stage (1991–1993)
Second stage (1994–1996)
The project was internally divided into two subprojects
– Deep Structures of Slovakia
– Geodynamic Evolution of the West Carpathians

Submitted abstracts represent summarized excerpts of defended final reports being worked out during the first stage of the project in 1993. These abstracts concisely present the most relevant results of study according particular topics. The analytical research study was the main task of this stage. It should serve as a solid base for the second stage to be focused to the geological synthesis of the West Carpathians.

♦ The separation of the Hercynian and Alpine structures in selected areas of the West Carpathians-structural study results of the Inner Carpathians and its interpretation

Jozef HÓK, Ján MADARAS, Peter KOVÁČ

In the first part of the report selected areas of the West Carpathians were evaluated. They cover the Veporic region with adjacent part of the Gemericum and Silicicum, the Lučanska part of the Malá Fatra Mts., the Razdiel part of Tribeč Mts, Hodruša- Štiavnica horst and the southern margin of the Malé Karpaty Mts.

The aim of the report was not to evaluate the West Carpathian crystalline as a whole, but to highlight tectonic evolution of proportionally selected areas of crystalline, defining and veryfing the hercynian structures. The results gained from the selected areas show that the Hercynian tectonics in the West Carpathians had its compression presumably in the E–W direction. From the macrostructural data, which are to our perusal, is difficult to establish the sense and vergence of thrusting. In the south

ern margin of the Malé Karpaty Mts. the existence of two phases of the Hercynian tectonics are indicated. The first stage was compressional, oriented NW–SE according to orientation of asymmetrical folds and strike-slip belts. During the second stage the compression was oriented NE–SW and/or E–W and is indicated by mineral lineation, axial plane cleavage and intersection cleavage. It is believed that the vergence of hercynian thrusting could have been oriented to the SE, like in the West Tatra Mts. This assumption will have to be proved in such areas which have been selected within the framework of the "Geodynamic model". The study of microstructures is also necessary and should continue as a logical step after the first stage of the above mentioned research.

The Alpine tectonics took place in two stages – the compressional with trusting to the N and/or NW resp. and this type of compression is present in the Veporicum and the Tatricum. The compression was followed by the extension being generally oriented in the W–E direction and this is present only in the Veporicum.

The second part of the report contains results of the structural study which are focused to solution of thrusting of the Mesozoic tectonic units of the West Carpathians. In the Slovak Karst area the structures are represented by the north vergent thrust which originated during the Kimerian phase of the Alpine orogeny. Tectonic pattern on the Hungarian side (the area Rudabanya and Bük) is a result of the south vergent thrusting. The Darnó line is a dividing element which, during the geological history was often rejuvenised (overturned position of the Upper Cretaceous at Nekeszeny). From this point of view the Darnó line represents an equivalent of the Insubric line.

♦ Structure of the Hercynian Orogene

Vladimír BEZÁK

For the interpretation of the Hercynian structures of the West Carpathian crystalline a concept of main lithotectonic units has been proposed like in other segments of the European Hercynides. The concepts being accepted so far has taken into account only lithological and metamorphic criteria. The tectonic criteria were considered only to varying degree and/or reflected only the Alpine tectonic pattern and its overprint. The reconstruction was based on the seismical profile 2T. The West Carpathian crystalline complexes were analysed with depth and their correlation is based on the elimination of the Alpine tectonics and according to their similar tectonic and metamorphic evolution. The reconstruction of the Hercynian tectonic pattern was made and three Hercynian lithotectonic units can be discerned with the following superposition:

1. The Upper Unit (gneisso-migmatitic)
2. The Middle Unit (mostly gneiss and mica schist with relicts of low grade metamorphic rocks)
3. The Lower Unit (mostly metamorphics of green schists facies)

The Hercynian granitoides are mainly part of the Upper and the Middle unit. The Upper Unit consists of high grade metamorphics (gneisses and amphibolites) in the Tatra and the Low Tatra Mts. and in the part of the Ľubietová zone of the Veporicum, including the higher pressure relicts, migmatized rocks and granitoids.

The Middle Unit comprises metamorphics (gneisses, mica schists, amphibolites) mostly of the amphibolite facies, which are often extensively diaphtorized together with strongly deformed granitoids. The presence of Lower Paleozoic with the low grade metamorphics is for this unit typical. In the existing erosive level the above mentioned rocks occur mainly in the Veporicum and part of the Tatricum (the Western Tatra Mts., the Považský Inovec Mts. and the Čierna Hora Mts.).

The Lower Unit is represented by low grade metamorphics with the distinctive lithological types in the Kohút zone of the Veporic crystalline (mica schist, phylites, albitized gneisses, metavolcanics, schists with metacarbonates). The position of the unit is relatively subautochthonous with a possibility of correlation to the low grade metamorphics of the Malé Karpaty and the Tribeč Mts. It seems that underlying rocks of the Lower Unit belonged to the southern crystalline basement. The relation to Gemeric complexes will be the aim of the additional studies.

The Hercynian structure is a result of longterm tectonometamorphic events. The proposed concept of the main Hercynian lithotectonic units reflects the effects of the Hercynian collisional stage, generally with the southern vergency. Each unit comprises several subunits with local names. Their mutual correlation and similarity with other segments of the Hercynian orogenic belt should be the aim of further research.

♦ Granitoid rocks of the Tatric unit

Milan KOHÚT

Granitic rocks form numerous plutons in the Tatric zone of the Western Carpathians (W. C.). The majority of the granitoid plutons are metaluminous to peraluminous and are composed of several rock types ranging from tonalite to leucocratic granite. Silica contents of granitic rocks vary in a range of approx. 60–75 wt. %, documenting the increase of alkalinity from the tonalites to the leucogranites. The prevalence of Na_2O over K_2O is common geochemical feature, except of the porphyric granite – "Prašivá" type in which K_2O is exceeding Na_2O. Carpathian granitoids represent low-to high-potassium calk-alkaline series of magmatic rocks (throndhjemite-monzonite series). Biotite is dominant, Fe-Mg mafic mineral and hornblende occurs only rarely in the W. C. granitoids. Accessory minerals (magnetite + allanite and monazite + ilmenite) show in some plutons (Tribeč) antagonism and/or dichotomy, what permits distinguishing two principal granite groups (BROSKA and UHER, 1991; PETRÍK and BROSKA, 1994). The occurrence of mafic microgranular enclaves (MME) in the magnetite-bearing granites and presence of the host (metamorphic) rocks xenolithes in the magnetite/free granites support this dividing in the Western Carpathians. But in some plutons (the Tatry Mts., the Malá Fatra Mts.) one can observe both enclaves and xenoliths side by side. REE are typically LREE enriched in the W. C. granitoids. Chondrite-normalized patterns of the REE exhibit absence or slight negative Eu anomalies and uniform non fractionated distribution trends for various granite types. Initial $^{87}Sr/^{86}Sr$ ratios in the granites are low (0.703–0.708), suggesting a mixed lower crustal and mantle component and/or Rb-poor crustal source (Rb/Sr = 0.1–0.5 for common tonalite-granite types, but for some leucogranites extending from 0.6 to 1.6). The εNd (O) values vary from -4.7 to -6.4 in granitic rocks of the Veľká Fatra Mts. (KOHÚT et al. in prep.) and are comparable with data of LIEW and HOFMANN (1988). Apparent crustal residence ages, being indicated by Nd model age (T = 1.2–1.9 Ga respectively TDM2 = 1.2–1.4 Ga), support authors (l. c.) concept – that the Hercynian Europe comprises mainly recycled proterozoic components with the significant new Paleozoic addition.

All, mainly geochemical, features suggest that the Hercynian granitoids are analogous to VAG (CAG) granites, related to subduction processes. However, during the late Devonian and the early Carboniferous times, metamorphic, sedimentary and structural data rule out this scenario as similar as almost everywhere in Europe and suggest continental collision processes. This collisional processes, with overthrusting of the deep crustal nappes were juxtaposed with crustal reactivation and granitoid production. Field evidence together with P-T-t paths (generally clockwise) suggest in the Tatra Mts. (JANÁK, 1993) tectonic inversion of metamorphism, documented by thrusting of hotter, higher-metamorphosed slab (migmatites, gneisses, amphibolites) over cooler parautochthon (mica schists). Comparable situation is in the Malá Fatra Mts. and in the Nízke Tatry Mts. During the climax of the Hercynian collision tectonic (350–340 Ma) an older igneous material was partially melted in the Western Carpathians. This anatectic granitic rocks inherited VAG geochemical character from older (Caledonian resp. Panafrican–Cadomian?) igneous rocks. Nowadays this granitoids show low degree of magma fractionation and represent common products of the crustal reactivation and remagmatisation.

♦ Granitoids of the Veporic Unit

Igor PETRÍK

The granites of southern Veporic unit, occurring in the Kohút zone were studied by means of geochemistry (REE distribution maps). While the southern body (between Poltár and České Brezovo) shows protracted crystal fractionation, northern granite occurrences (between Krokava and Hladomorná valley) have REE distribution patterns resembling source rock lithology. The same is true for hybrid types. Porphyritic types display monotonous patterns without signs of more extensive fractionation. Leucocratic varieties have highly fractionated patterns although positive Eu anomalies have also been found (Ľ. Hraško, E. Lukáčik).Geochemical maps (1:100 000) were created for concentrations of (1) SiO_2, (2) $Na_2O + K_2O/CaO$ (3) Total Fe as $Fe_20 + TiO_2 + MgO + MnO$. All maps show the southern granitoids as anomalous, most acid and alkali rich (Ľ. Hraško, E. Lukáčik).

Preliminary results of U/Pb datings confirmed the 300 Ma age of the Sihla type tonalite (with upper intercept of 489 + 94 Ma) and suggested a pre-Variscan (Lower Paleozoic) age of the hybrid type (J. MICHALKO et al.).

The investigation in the north-western Veporic Unit was concentrated on the Hrončok type granite. New results show its continuation beyond the main body, mainly between villages of Medveďovo and Krám (Čierny Balog). Smaller occurrences were found in the Veľká Prostredná valley. The Hrončok granite was identified as the A-type, which possibly indicates a post-orogenic stage of the Variscan orogeny (Petrík et al., 1994). Permian age was confirmed by zircon dating (285 Ma, UHER and PUSHKAREV, 1994).

Another significant granitic rocks, the tonalite of Sihla type, was found deformed at the contact with metamorphic rocks in contrast with its main occurrences southward. The Sihla tonalites represent a late orogenic I-type granitoides with equivalents all over Variscan belt (PETRÍK et al., 1994).

The hybrid type, possibly the oldest in the area, seems to show S-type characteristics with Fe-rich, reduced biotites.

Granitoids, forming the porphyritic group, display more or less S-type features and appear to be of different origins.

♦ Introduction to study of migmatites in the SW part of the Veporicum

Pavol SIMAN

The migmatized and high grade metamorphic complexes of the SW part of the Veporicum have been studied. The study was divided into three parts.

In the first part general information about the evolution and genetic models were described. The second part summarises the knowledge about the migmatitization in the Veporicum. The third part is presentation of the study itself in the SW part of the Veporic crystalline. It contains macro and micro-description of migmatites in respect of their petrology and possible solution of the origin of the above mentioned complexes. Mineral associations show polyphased metamorphic evolution with three-four metamorphic events respectively.

The oldest, Pre-hercynian event is characterized by the highest metamorphic conditions and by possible presence of the anatexis. Hercynian tectonometamorphosis took place within the temperature interval 531–592 °C, followed by the emplacement of granitoids.

The Late Hercynian tectonometamorphic event had distinctly allochemic character, influenced by intruding fluids, which originated from granitoids with assimilated parts of crystalline. This event was characterized by temperatures 390–471 °C.

The Alpine tectonometamorphic event is represented by low-grade metamorphism. Their age is still under discussion due to lack of geochronological data from the studied area.

The most difficult problem is caused by retrograde metamorphism, the Late Hercynian or Alpine, because their P-T conditions are very similar. In the submitted work two possibilities of their genetical interpretation are proposed:

– metamorphic differentiation under subsolidus conditions, with local tectonic segregation and/or later addition of magmatic material;

– parcial anatexis of varying degree, which is not yet directly proved;

? (The faults of the N-S direction are seldom. Some faults, being characterized as reverse ones, have a significant component of the lateral movement as well).

♦ The Paleozoic low grade metamorphics of the Tatro-Veporicum

Anna VOZÁROVÁ

The low grade metamorphic complexes has been studied in three areas: a) in the Ďumbier crystalline on the southern slopes of the Nízke Tatry Mts.; b) in Formations of the Janov Grúň and in the Kraklová of the Northern Veporicum; c) in the low grade complexes of the Kohút zone of the South

Veporicum. The main task of this work was to define associations of metamorphic minerals, PT conditions of the regional metamorphism and the character of protolite. This circle of problems, except of the rocks of the Kohút zone, was focused to confirm or reinterpret processes of the progressive low grade regional metamorphics, because only very recently they were considered as diaphtorites.

The object of studies in the Ďumbier crystalline of the Nízke Tatry Mts. were low grade metamorphics described by MOLÁK et al. (1986, 1989) and cartographically shown in geological map of the region Nízke Tatry Mts. at scale 1 : 50 000 (BIELY et al., 1992). SPIŠIAK and PITOŇÁK (1993), analysing the rock sequences, discerned two groups of metamorphics as follows:

1. rocks with structures, textures and mineral composition belonging to the greenschists facies;

2. problematic group of rocks with monotonous composition (Qtz + Mus; Chl + Qtz + Mus), where it is impossible to prove progressive or regressive trend of their metamorphism.

Taking into account that both groups are closely associated with evident relicts of higher grade mineral associations, SPIŠIAK and PITOŇÁK (l. c.) classified them as tectonites (mylonites, blastomylonites) or as retrograde metamorphics. It is quite obvious, that a part of rocks with structural and mineral affinity close to the greenschists facies are present in the form of relicts in the narrow strike-slip zones together with slices of the Lower Triassic quartzites. Because of this the presence of the low grade metamorphics in the Nízke Tatra Mts. is not yet completely rejected. For the final solution of this problem further precise cartographic and structural-petrological studies would be required.

Metamorphics being represented by the Janov Grúň and Kraklová Formations contains mineral associations which with any doubts supports origin connected with progressive metamorphism of the greenschist facies. This interpretation was highlighted by graphite thermometer (ŠENGELIA et al., 1978) and currently supported with data published by (SPIŠIAK et al., 1992; SASSI–VOZÁROVÁ, 1992; KORIKOVSKIJ–MIKO, 1992). According KORIKOVSKIJ–MIKO (1992) critical mineral associations from formations of the Janov Grúň and the Kraklova indicate temperatures T = 350–380 °C and T = 340–350 °C respectively and pressures within the range 3,4–4 kbar (pressures established by methods of MASSON–SCHREYER, 1987), at the geothermal gradient 22 C/km. The pressure conditions studied by the method of SASSI (1972) and GUIDOTTI and SASSI (1976, 1986) show pressures 2–3 kbar with estimated temperatures 350–400 °C at the geothermal gradient of 45 °C/km (SASSI–VOZÁROVÁ, 1992). The results unambiguously support the low pressure type of the regional metamorphism. This does not contradict the results of KORIKOVSKIJ–MIKO (1992), because the author's misinterpretation of the geothermal gradient. Pressures 3–4 kbar established at given temperatures reflects geothermal gradient of about 35–40 °C/km, e. i. very similar data which are close to the boundary of the low pressure and lower-pressure part of the barrowian metamorphism.

The low-grade metamorphic complexes defined by BEZÁK (1982) in the southern part of the Veporicum are named as the Ostrá and Sinec complexes. According to the mineral compatibilities the following metamorphic zones were established between them:

1. the Ostrá complex – almandine zone with PT conditions being transitional between the greenschist and the lower temperature amphibolite facies of the barrowian type, e. i. the beginning of medium grade metamorphism (temperatures above 500 °C, pressures, 4–5 kbar).

2. the Sinec complex – chlorite zone refers to the conditions of greenschists facies of the barrowian type (T = 400–500 °C; P = 4–5 kbar).

The metamorphic structures of the Ostrá complex show signs of the polyphase evolution, what was proved by changes in the chemical composition of the basic metamorphic mineral associations.

♦ Discussion to the metamorphics of the Kohút and Krakľová zone of the Veporicum

Martin KOVÁČIK

The pre-Alpine complexes of metamorphics of the Kohút and Krakľová zone are discerned according to their peculiarities. The peculiarities are observable within the both above mentioned zones, but significant differences are also in the inventory of metamorphics within the framework of every particular zone. Degree of metamorphism is varying from the middle zone of the greenschists facies /(bt)-chl-ms mica schists/ up to the area of the high temperature gneisses and migmatites (presence of sill + kž). Taking into account the Late Variscan retrogression and the Alpine

metamorphism, the porphyroblasts of garnet represent practically the only phase which is characterizing the Variscan regional metamorphism. The present configuration of the metamorphic complexes has a tectonic origin, e. g. in the Krakľová zone HT/LP gneisses indicate overlaying tectonic position in relation to the low grade metamorphics. Despite of very low metamorphism of the Mesozoic envelope of the Krakľová zone, the Alpine metamorphism has reached the biotite isograde providing favourable structural and geochemical conditions were present.

♦ High grade metamorphism and processes of migmatitization

Pavol SIMAN

According to petrological and geochemical studies the metabazites of the Krakľová zone of the Veporicum (South of the river Hron) belong to LA-complex (HOVORKA et al.) and were derived from the magma of the primitive composition. They comprise bodies of metaultramafites, being defined as cumulative products of the lower crust magmatites. According to the above mentioned authors the Tatra metabasites belong to LA-complex as well, but they are anatectically overworked. The authors describe the continental source of the Tatra metasediments (orogene zones, active continental margins and island arcs). Janák showed that in the Tatra Mts. and the Malá Fatra Mts. the tectonometamorphic events had polyphase character. The older one took place in the stability field of kyanite under the conditions of the lower continental crust, with partial anatexis. The younger one is characterized by lower grade conditions, which took place in the middle part of the continental crust with thermal effects of granitic intrusions. The Tatra Mts. crystalline has distinct thrusting. As a result of thrusting the upper gneiss-migmatitic complex is resting on the mica shists, hence, forming a metamorphic inversion. The Malá Fatra crystalline has many common features with the evolution of the upper gneiss-migmatitic unit of the Tatra crystalline.

Siman made an initial study of structure and texture features, mineral associations and geochemistry of migmatites, which indicate very complicated, polyphase and tectonometamorphic events in the SW part of the Kráľová hoľa granitized complex of the Veporicum. During the oldest metamorphic events the protolite probably of the greywacke composition underwent strong ductile deformation and partial anatexis. Further events are represented only by retrograde metamorphism. The author suggests a combined origin of migmatites: partial anatexis of different intensity and subsolidus metamorphic differentiation, later on accompanied with tectonic segregation and further addition of magmatic material.

♦ The Variscan metamorphism in the Gemericum

Anna VOZÁROVÁ

Relics of three variscan terrannes were defined in the Gemericum (VOZÁROVÁ–VOZÁR, 1992, 1993) which differ by their lithology, nature of synsedimentary volcanism, crustal evolution and geothermobarometric conditions of regional metamorphism.

The Gelnica Terrane consists of rock sequences of the Gelnica Group (the Upper Cambrium–the Lower Devonian; SNOPKOVÁ–SNOPKO, 1979) and from the Štós Formation (supposed age the Upper Devonian –the Lower Carboniferous; BAJANÍK et al., 1983).

The pre-Upper Carboniferous age of regional metamorphism is presumed according to continental sediments of the Upper Stefanian–Permian (proven by microflora – PLANDEROVÁ, 1980), which overlay the above mentioned formations. The rock sequences of the Gelnica Terrane were regionally metamorphosed under PT conditions of the lower part of greenschist facies, being proved by critical mineral associations: Mus + Ab in metapelites, Ep + Ch + Act in metabazites. In order to establish the pressure conditions of the Variscan metamorphism in the Gelnica Terrane a method of calculation of b_0 parameter of muskovites (SASSI, 1972; GUIDOTTI–SASSI, 1986; GUIDOTTI–SASSI–BLENCOE, 1989) has been used. The low pressure character of regional metamorphism with narrow temperature interval T = 350–370 °C and pressures 250–300 Mpa were calculated, signalizing relatively high geothermal gradient of the Variscan metamorphic climax 40 °C/km (SASSI–VOZÁROVÁ, 1987; MAZZOLI–VOZÁROVÁ, 1989; VOZÁROVÁ, 1993).

The Rakovec Terrane consists of the rock sequences of the Rakovec Group (? the Devonian) and from the Črmeľ Group and the Ochtiná Formation (both with proved Lower Carboniferous age). The pre-Westphalian age of regional metamorphism was supported by relicts of the metamorphics of the Rakovec and the Črmeľ Groups, in the conglomerates of the Westphalian A-B (ROZLOŽNÍK, 1965; VOZÁROVÁ, 1973). In the Rakovec Terrane the degree of regional metamorphism did not exceed P-T conditions of the lower and middle part of the greenschist facies. This is proved by critical mineral assemblages: Ms + Ab in metapelites, Ep + Chl + Act and Czo + Na-Ca amphiboles in metabazalt volcanoclastics and Cc + Tlc + Mgs /(Dol) in metacarbonates. The determining features of the Rakovec Terrane is the polyphase character of the Variscan metamorphism. The first metamorphic event took place under the P-T conditions of the medium/high pressure greenschists facies, with temperatures 400–450 °C and pressures about 700 Mpa and at geothermal gradient less than 25 °C/km. This is represented by relicts of Na-Ca amphiboles – barroisite (first described by HOVORKA et al., 1988) and by crossites in composition in metabasalts and metabasaltic tuffs of the Rakovec Group (? the Devonian). The second metamorphic event corresponds to the low pressure greenschist facies, with the temperatures 350–430 °C and pressures 200–300 Mpa and the geothermal gradient of 40–45 °C/km. The complexes of the Črmeľ Group and the Ochtiná Formation of Lower Carboniferous age were progressively metamorphosed like this and, at the same time, regressively affected the rock sequences influenced by the first middle-high grade metamorphic event.

The Klátov Terrane is represented by the crystalline rock complex of the amphibolite facies. The regional metamorphism of the Klátov Terrane rock complexes took place under PT conditions of the middle pressure amphibolite facies (T = 520–630 °C; P = 400–600 Mpa; HOVORKA–SPIŠIAK, 1981;

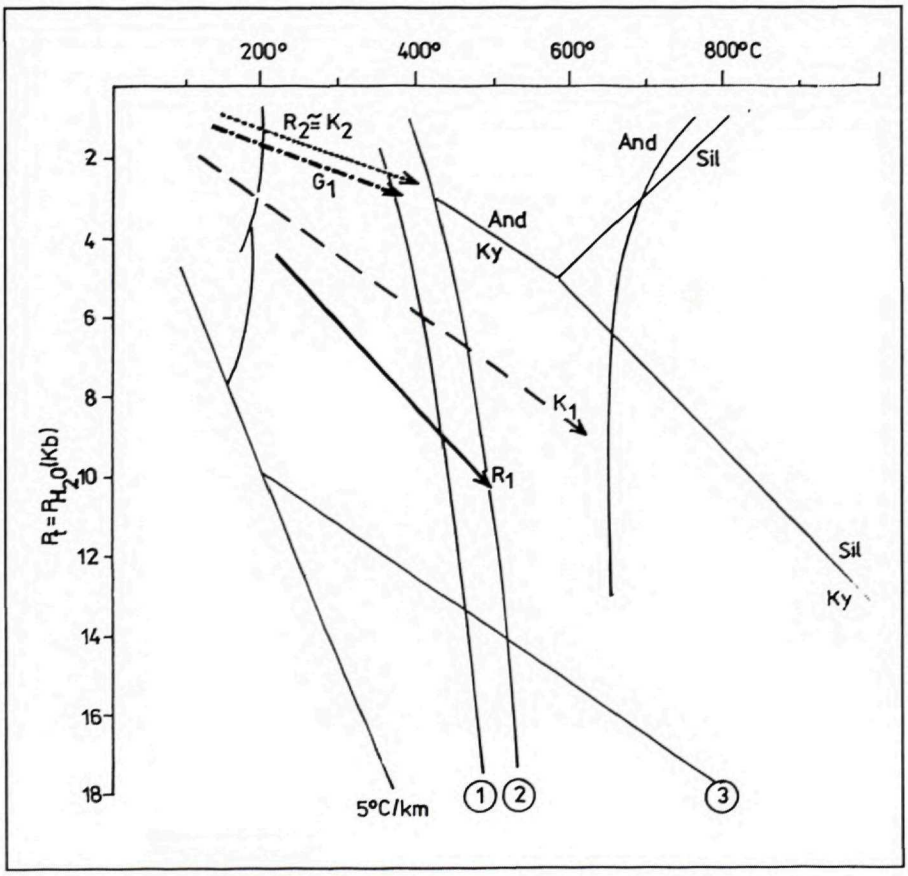


Fig. 1 Metamorphic gradients estimated for Variscan Terranes in the Gemericum
Explanation: K1 – MP amphibolite facies of the Klátov Terrane; R1 – HP greenschist facies of the Rakovec Terrane; R2 ≡ K2 – LP greenschist facies, second metamorphic event in both, the Rakovec and Klátov Terranes; G1 – LP greenschist facies of the Gelnica Terrane.
The length of the arrows shows the temperature range
Curve 1 – dehydration of kaolinite (THOMPSON, 1971), curve 2 – dehydration of pyrophyllite (KERRICK, 1968), curve 3 – stabilization of glaucophane (CARMAN–GILBERT, 1983), Al_2SiO_5 triple point: GREENWOOD (1976)

SPIŠIAK–HOVORKA, 1984; FARYAD, 1986, 1990), while the lower pressure are supposed only by RADVANEC, 1992. The retrograde metamorphism took place under the PT conditions of the low pressure greenschists facies (T = 350–400 °C, P = 200–300 Mpa).

The crustal evolution of the Variscan Terranes in the Gemericum and their metamorphic development is as follows:

I. Gelnica Terrane: a forarc basin associated with an active continental margin – HT/LP greenschists facies.

II. Rakovec Terrane: the first phase – subduction connected to the reverse island arc – LT/HP greenschists facies; the second phase – continental collision connected with HT/LP metamorphism of the greenschists facies; second event corresponds to the retrograde stage in the rock sequences being influenced by the first metamorphic event and the main metamorphic event in the Lower Carboniferous sequences.

III. Klatov Terrane: banded bimodal magmatites of lower magmatites crust origin (HOVORKA et al. 1994; IVAN 1994) presumably the effect of subduction of the midoceanic ridge under the island arc? or the margin of the plate ? – HT/MP amphibolite facies, the younger retrograde phase connected with a continental collision – HT/LP greenschists facies.

♦ Structural and tectonic development of the Veporicum unit

Ján MADARÁS

Within the framework of the project "Geodynamic evolution of the West Carpathians" the problem of structural evolution of the Veporicum was solved separately in two subprojects.

The first subproject dealt with investigations of selected fault systems of the Veporicum. Out of the several significant fault systems, structural kinematical character of the Ľubeník line, the Muráň line, the Pohorelá line and the Mýto faults was studied.

The Ľubeník line, originally a reverse fault, from the Cretaceous period, has acted as a normal fault. It is supposed that it was a result of uplift of the granitoides of the Veporicum.

In the Ľubeník fault area the origin of the Rochovce granitoides was connected with an extension and subsequent intrusion along the E–W oriented shear zone as a result of opening of the pull-apart structure.

The results of structural study show that the Muráň fault was functional already in the Cretaceous period. During the period the fault had a transpressional character and deformation took place under ductile conditions. Another significant fault-thrust system is represented by the Pohorelá line, which can be studied approximately in the length of 40 km. In the area of the current Pohorelá line a distinct older (Paleoalpine) discontinuity is supposed, where a listric plane was derived from the Čertovica and Osrblie line, running in the underneath rocks. The discontinuity with relicts of folded Triassic rauwacks is representing the line where the Kráľova hoľa complex was thrusted on the Hron complex, which was folded as well. From the Middle Cretaceous the Pohorelá line has a character of normal fault. The sinistral horizontal shear along the Pohorelá fault system is related to the paleostrain changes. Such regime can be traced up to the Tertiary and is represented by brittle deformations.

It can be concluded that by the fault analyses of the Veporicum a common Alpine transpressional tectonic regime was proved within the whole area. This was connected with thrusting from S or SE to N or NW being followed by extension which caused that direction of the movement was sinistral. It is assumed that the Muráň fault could inherit older structural plan either. His later functioning is reliably dated only from the Tertiary. According to analyses of the mesoscopic brittle deformations the Muráň fault continued to act as a sinistral – lateral shear also later on. Supposed function of the Muráň fault s. s. as interpreted currently is dated from the Upper Cretaceous – the Eocene, being followed by reactivation during the Neogene – the Middle Badenian. In the Veporicum also transverse faults of NW-SE direction, like the Mýto fault are present. From the course and its relation to the Muráň fault it is obvious that the fault represents a conjugated system which originated in the same strain field, and in the same time. As the Muráň fault system was acting as the sinistral, the Mýto fault is representing a dextral shear. His transtensional character is proved by structures observed in the quarry Zbojská and by the character of the Brezno Paleogene depression and by a relaxed regime of the orogeny. The Tertiary activities of the fault systems is connected with normal faults and with horizontal shearing.

The second part of tectonic and structural research of the Veporicum was including a field mission of structural geologists from GÚDŠ, GÚ SAV, Pr FUK Bratislava, PFUK Praha and BRGM Orleans (France).

The research was based on structural and lithological analyses of about a hundred of outcrops and their systematical sampling for microstructural and petrological study. Preliminary results proves a significant influence of the Cretaceous extensional processes on the basement and its envelope. The extension was accompanied by origin of deformational structures under the conditions of green shist facies. The relicts of older high temperatures Hercynian deformation were defined in the crystalline of the Veporicum as well.

♦ The Pretertiary sequences of the Lučenec basin and the Cerová Hills – explanation notes to the geologic and tectonic map

Dionýz VASS, Michal ELEČKO, Jozef VOZÁR and JÁN BODNÁR

The Pretertiary basement of the Lučenec basin and the Cerová Hills is built by two West Carpathians units: the Veporicum, mainly in its southern part and the Gemericum. South of the Rapovce-Plešivec fault, beneath Tertiary complexes, there are units, which cannot be correlated with any other unit. In the eastern part of the region the Tertiary sequences are underlain by rocks, which belong to the Turnaicum (the Turňa nappe) or to the Silicicum (the Silica nappe), being laterally shifted along the Rapovo-Plešivec fault to the Rapovce village, SE of Lučenec. The Veporicum, the Gemericum and other thrust units which underlay the Tertiary sequences, came to the current tectonic position as a result of the Paleoalpine movements during the Upper Cretaceous. Folding was probably accompanied by granitic intrusions, which are integral part of the underlying sequences as well. The youngest elements of the Pretertiary complexes are represented by erosional remnants of the Upper Cretaceous sediments which are resting upon the Paleoalpine consolidated basement.

The unit situated south of the Rapovce-Plešivec fault came to the present position as a result of lateral shifting during the Tertiary.

The Gemericum is thrusted on the Veporicum along the Lubeník-Margecany tectonic line. The parallel, Hrádok fault, tectonically approaches the South and the North Gemeric units. Tectonic remnants and slices of the Gemericum occur also north of the main thrust at Divin, Podrečany and Lovinobaňa. On the other side. South of the Lubeník-Margecany line, in the basement of the Lučenec basin, the Veporicum is present in the tectonic window, surrounded by the Gemericum (between Hrnčiarske Zálužany and Pinciná). Faults, which disrupt the Pretertiary basement sequences, originated as the post Upper Cretaceous (Senonian). They form two distinct fault systems of the N–S and NE–SW direction. The Fiľakovo-Blh magnetic anomaly as well as doubled belt of magnetic anomalies along the Diósjenö line could be caused by remnants of the oceanic crust, being trapped in the crust as a result of subduction during the Early Paleozoic or even earlier.

Gravimetric and magmatic anomalies are results of magmatic and density inhomogeneties within the pre-Tertiary rocks, respectively, in deeper parts of crust or in the elevated parts of the upper mantle.

♦ Reinterpretation of the basement of the Eastern Slovakian basin and its correlation with the Carpathian units

Jozef VOZÁR, Anna VOZÁROVÁ, Čestmír TOMEK, Miloš RAKÚS, Peter KOVÁČ and Miroslav NOVOTNÝ

The Eastern Slovakian basin is floored by Tertiary - Quaternary filling, underlain by older – Pre-Neogene units, belonging to four tectonic units, three of which are well correlable with the Western Carpathian units. The Pre-Tertiary sequences crop out in two areas- the Humenské vrchy hills in the north and the Zemplínske vrchy hills in the south.

The foundation and development of the Eastern Slovakian basin has been thoroughly described by VASS et al. (1988). Our goal, set within the framework of the project "Deep structure of Slovakia" (1991–1993), was to re-evaluate the hitherto attained information about the basement of this characteristic "pull - apart" type of basin and to present a reinterpretation of its structure and composition of the basement

In agreement with the data acquired so far (FUSÁN et al., 1971, 1987) we presume, that the Veporicum Unit, in broader sense, occurs in the western part of the Eastern Slovakian basin. We correlate it to the Southern Veporicum of the type similar to that, cropping out in the Čierna Hora Mts. and in the Slovenské rudohorie Mts., west of the Ľubeník line. This unit is limited by the faults striking NNE - SSW, whose course can be placed within the Hrušov fault system (sensu VASS et al., 1991). We also expect, that this phenomenon continues southwards, as far as the junction of the Veporicum with the Zemplinicum (extended course of the Hrušov fault belt westward of Byšta).

The Zemplinicum (sensu VOZÁROVÁ and VOZÁR, 1988) is a segment of the Western Carpathians, limited tectonically in the south (in the Hungarian territory) against the Tiszia Unit. To the north and north-east the Zemplinicum is separated tectonically from the Iňačovce - Kričevo Unit in broader sense (?or the so called Ptrukša zone partial unit). This fault strikes NW - SE and dips 35 to 45° to the SW. This contact could be projected into the course of the Trebišov faults (sensu VASS et al., 1981). The proper contact of the Zemplinicum with the Iňačovce - Kričevo Unit (?Ptrukša zone) can also be well shown in the seismic records. We explain this feature as a post-orogenic thrust of the Zemplinicum (eastern vergency), with later down-sliding of this unit as probable repercussion of the Neogene extension of Eastern Slovakian basin (VASS et al., 1988).

The east-vergent thrusting of the Zemplinicum can also be documented by internal structural setting in this unit, as there crops out, at Byšta, its back-part represented by crystalline rocks, while in the eastern part of the unit, near Ladmovce, the front of the nappe structure - represented by the Middle and Upper Triassic rocks occurs. Between the two margins of this, at the surface (the Zemplínske vrchy hills) outcropping unit, a continuous lithological development may be observed, beginning with the Westphalian and ending with the Lower – Middle Triassic. The seismic data indicate, that the Zemplinicum is distinctly separated from its basement by a plane, dipping to the WSW under an angle 25 to 35°, within the depth range from 3.5 km, at the eastern margin, and 7.5 km, at the western margin of the unit. Our interpretation indicates that the underlier of the Zemplinicum represents the Iňačovce - Kričevo Unit, which has also been substantiated by the character and courses of the seismic records.

The question associated with the allocation of the Ptrukša zone, envisaged by Bodnár and KALIČIAK (1993) as a fault- limited and to the north thrusted block of the Zemplinicum, remains still unanswered. These authors confine the Ptrukša area by faults, striking NNE - SSW, which run NE of the Kráľovský Chlmec.

The northern margin of the basin if fringed by distinct NW– SE running structures. It is mainly the Humenné Unit, that covers smaller area at the surface (the Humenské vrchy hills), but the whole structure, which resembles that of the Klippen belt, can well be followed by geophysical methods as far as the Ukrainian territory (see RUDINEC, 1989). The Humenné Unit, considered to be a part of the Krížňa nappe (cfr. MAHEĽ, 1963, 1986, RAKÚS, 1993), is placed steeply to vertically and its contacts with the Iňačovce–Kričevo Unit on one side, but also with the Inner Carpathian Paleogene on northern side, is sharp, steeply dipping toward N, NE (80–90°). The divide with the Iňačovce-Kričevo Unit can well be distinguished in the seismic records. In contrast to the Iňačovce - Kričevo Unit, the Humenné Unit does not display seismic reflectivity.

The underlier of the internal part of the basin proper is represented by a unit defined in the annual report for 1993, and is also described in the earlier reports, based on geophysical data and deep drillings in both Slovakian and Ukrainian territory (SVIRIDENKO, 1976, GRECULA et al., 1981, FUSÁN et al., 1987, VOZÁROVÁ and VOZÁR 1988, RUDINEC 1989, SOTÁK et al., 1993).

According to our petrographic analysis of samples from selected drill holes (documentary material of Maheľ, Kullmanová and Vozár), the following two main rock groups can be distinguished in respect of their lithological composition and the degree of metamorphism:

1. Polymict clastic sediments intersected in the northern part of the Eastern Slovakian plain (Zbudza-1, Lesné-1, Senné-1 drill holes), either non metamorphosed, or only diagenetically lithified. Their texture and structure do not bear any signs of tectonic lineation, crenulation cleavage and tectonic boudinage.

2. A group of very low to low metamorphosed carbonates, carbonatic pelites, locally with basic volcanoclastic material, with distinct signs of tectonic deformation (foliation, crenulation cleavage, isoclinal refolding, boudinaging of laminar carbonatic material).

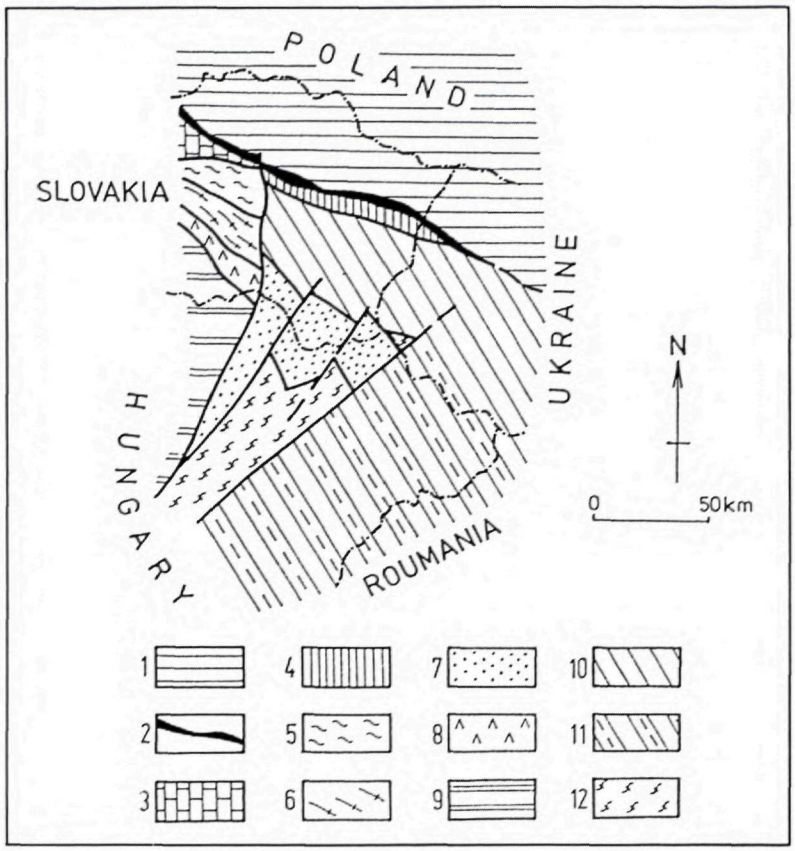


Fig.1. Tectonic Scheme of the pre-Neogene Basement of the East Slovakian Lowland. (Compiled by J. VOZÁR, 1994)
1-2. Outer Carpathian units; 1. Flysh zone, 2. Klippen belt include. Central Carpathian Paleogene; 3.-7. Central Western Carpathians; 3. Hronicum and Krížna nappe, 4. Humenská unit, correlated to Mesozoic of the Krížna nappe, 5. Northern Veporicum, 6. Southern Veporicum, 7. Zemplinicum correlated to Southern Veporicum; 8.-9. Inner Western Carpathians; 8. Northern Gemericum, 9. Southern Gemericum, 10. Units of pre-Neogene basement: Iňačovce-Krichevo zones; 11.-12. Tisza megaunit (acc. HAAS et al. 1995); 11. Flysh zone of the Szolnok, 12. Metamorphites

It is worthwhile to note that the intensity of metamorphism in this compex changes within the range from anchi- to incipient stage of epizone, depending on the intensity of tectonic reworking of rocks.

The first group of sediments (polymict diagenetically compacted sandstone and conglomerate) is, apart from other already mentioned signs, characterized also by abundant clastic carbonatic detritus. The intensity of pre- depositional recrystallization of carbonates is variable, ranging from micrites to coarse grained sparites. The sandstone contains, at the same time, the fragments of low metamorphosed rocks - phyllites, quartzose schists and recrystallized chert. This is why it is right to presume that in composition of this clastic rock there also participated detritus derived from a folded and metamorphosed mobile zone, which is indicated by the character of fragments, probably of Mesozoic age (carbonates, cherts, basic volcanics, metapelites).

The degree of metamorphism of the second group of rocks is defined by critical minerals assemblages, encountered in the metapelitic horizons as well as in the basic metavolcaniclastics.

Following mineral assemblages were found in the discrete rock types and metamorphic stages:

A. very low stage (estimated temperature around 200 - 250 °C and pressure > 5 kb)
   -metapelites: illite + chlorite -+ phengite
   -metamorphosed marls: lawsonite + quartz + dolomite
   -metacarbonates: no reaction between carbonate sediments and siliceous component took place at this alteration stage

B. low degree of metamorphism (estimated temperature of some 350 °C and pressure 5-7 kb)
   -metapelites: sericite + phengite + chlorite + quartz ± paragonite, organic matter, rutile, tourmaline

-metamorphosed marls: phengite/sericite + quartz + chlorite + epidote/zoisite

-basaltic metatuffs: chlorite + albite + actinolite ± sphene, epidote, accompanied by quartz and chlorite

-metacarbonates: Ca-Mg component migrated in the dolomite and calcite; talc formed sporadically (?)

The metamorphic character rounds out the composition of actinolite, which contains relatively high content of Na_2O. This enables to presume that the regional metamorphism of this complex reached medium pressure to high pressure conditions (LAIRD and ALBEE, 1981). Distinct zonality and decreasing content of Na towards the grain margins evidences the change from higher pressure to low pressure metamorphism, provoked either by a rapid rising of the whole complex during the regional metamorphic processes, or was caused by high geothermic gradient, prevailing within the Eastern Slovakian plain and extensional Neogene tectonics.

Very low to low degree of regional metamorphism of the rock complexes underlying the Eastern Slovakian plain were reported by SOTÁK et al. (1993), however, the authors neither paid due attention to the basaltic metavolcaniclastics nor to the composition of mineral assemblages in them, thus, no pressure character of the metamorphism was characterized.

The opinions as to the position, geotectonic development and possible correlations of the Iňačovce Kričevo Unit vary and practically all hitherto known versions to solve this problem have been exhausted. Since we have made a reevaluation of several geophysical methods, including their results, as well as earlier collection of the rock material from drill holes, we suggest the following solution:

a) The Iňačovce - Kričevo Unit is a well reflective entity and the seismic records indicate the existence of subhorizontal or slightly tilted structures. Some sections allow to interpret an existence of a scaly structure, composed of several overlapping horizons.

b) In the deeper horizons of the Pre-Neogene basement there are ultrabasic bodies, interpreted as sources of distinct magnetic anomalies (see GNOJEK, 1990, 1993; GNOJEK et al., 1991, 1993; GNOJEK and VOZÁR, 1993). It is possible that the protrusions of such types of rocks were emplaced into shallower horizons reaching, in the course of formation of the basin, as far as the Neogene sequences.

c) The Iňačovce - Kričevo Unit is a metamorphosed, Post- Eocene subduction sequence. Its regional geologic development and tectonic position is linked with the Szolnok trough structure of Hungary on one hand and with the Kričevo Unit s.s. of Ukraine, on the other. In relation to the Apuseni Mts. and to the Inner Carpathians it may be considered to represent relic of an independent subduction zone. Both, the regional-tectonic links and (mainly) the internal stratigraphic and lithologic filling (compare with FÜLOP and DANK et al., 1987; SZÉPESHÁZY, 1973 and others) speak in favour of correlation of the Iňačovce - Kričevo Unit with the Szolnok trough.

d) It follows from the stated above that we do not acknowledge the opinions of those authors, who interpret the Pre-Neogene basement of the Eastern Slovakian basin as belonging to Penninicum (LEŠKO and VARGA, 1980, MAHEĽ 1981, SOTÁK et al 1993), neither to Zemplinicum in broader sense (FUSÁN et al., 1971; SLÁVIK, 1976), nor it is a unit with affinity to the Eastern Carpathians (SVIRIDENKO, 1976).

♦ Geological project for the "Vadičov" drill hole

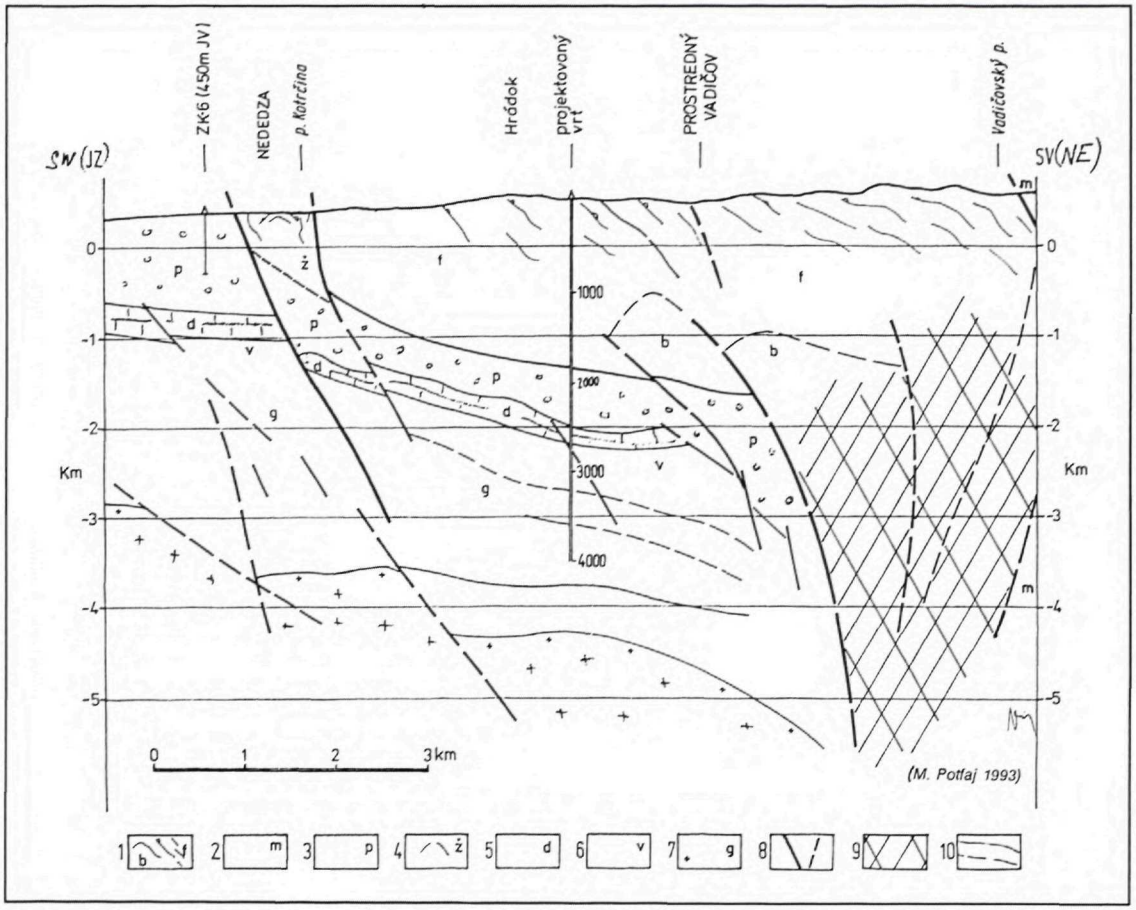
Michal POTFAJ

A structure hitherto unknown within the area of Klippen belt have been indicated east of the town of Žilina by the seismic survey (lines 518/87 and 313/85). Two supplementary reflection seismic sections with higher detectability, labelled 559/92 and 560/92, were shot to specify the structures. The measurements confirmed the occurrence of a distinct seismic reflector beneath the Klippen belt between Zástranie and Belá villages. We assign this feature to the burried block of the Malá Fatra Mts., cropping out at the surface. This reflection surface dips towards north, sinking from - 1km level to -3 km level, with step-wise breaks in its eastern part.

Within this burried block below the Klippen belt there should be a nappe structure similar to that of the Malá Fatra Mts. Provided, there exists a hydraulic connection between the burried block and infiltration area in the Malá Fatra Mts., it may be presumed that this burried block is a highly aquiferous structure and it could then provide considerable water supplies for the Žilina township area. Owing to relatively high geothermal gradient it is probable that waters are heated.

To ascertain this structure a well bas been projected to be drilled in the area between the Kotrčina Lúčka and the Horný Vadičov down to 4000 m, with following presumed section: 0 - 1840 m Klippen belt; - 2720 m Inner Carpathian Paleogene; - 2980 m Choč and Krížna nappes; - 3240 m Malá Fatra Mts. cover "series" with the crystalline rocks underneath.

The well may contribute positively to resolve the water management of the Žilina area.



Geological section of Nededza - Horný Vadičov

1. Klippen belt, s.l.; 2. Magura flysch; 3. Inner Carpathian Paleogene; 4. Žilina Paleogene; 5-6. Mesozoic cover of the Tatricum of Malá Fatra Mts.; 7. crystalline Tatric basement; 8. faults; 9. tectonic zone with distinct disruption of rocks.

♦ Lithology, microfacies and biostratigraphy of radiolarian limestones and radiolarites of the Krížna nappe, Western Carpathians

Milan POLÁK, Anna ONDREJÍČKOVÁ, Ladislav MARTINSKÝ and Eva ŽÁKOVÁ

The report presents the results of lithologic, sedimentologic and biostratigraphic research of the Upper Jurassic radiolarian limestones and radiolarites of the Krížna nappe, Western Carpathians. The study of radiolaria allowed to determine the age of these sediments, basing on direct paleontological methods. The Callovian - Oxfordian - Kimmeridgian ages were established for various tectonic units of the Western Carpathians, mainly however, for the Krížna nappe, in which the radiolaria have been found for the first time.

Interesting, in sedimentological terms, is the confirmation of the presence of distal microturbidites in the upper portions in some of the sections studied.

♦ Sedimentologic-paleogeographic analysis of the Eastern Slovakian basin

Dionýz VASS, Juraj JANOČKO, Stanislav KAROLI, Peter KOVÁČ, and Michal KALIČIAK

A series of reports have been compiled and submitted for approbation within the framework of the theme "Analysis of sedimentary basins and its application for oil and gas exploration in the Western Carpathians".

Juraj Janočko: Development of deposional system of a braided river - Lower Sarmatian, Neogene of the Eastern Slovakian basin.

In stratigraphic terms, the Košice delta is a member (series of beds) of the Stretava group of strata (Lower to Middle Sarmatian). The basin's development and its cyclicity is a result of both, the extra- and the intrabasinal processes. These two processes were running simultaneously, whereby one of them temporarily prevailed over the other only to become later masked by the sediments deposited under a different regime. The Lower Sarmatian was a tectonically active period and it is very probable, that this activity was the main extra-basinal agency active in the formation of the delta.

Based on the fining upward trend of the Košice gravels it can be assumed that the gravels represent a transgressive period. The braided delta developed on a relatively flat surface. Presence of riparian facies, which evolved through reworking of debouchure bars, probably indicates a lesser riverine supply of material and predominance of basinal processes.

Paleocurrent analyses have indicated the south-eastern direction of the main transport of sediments. The presence of andesite cobbles in the central part of the Košice gravels indicates an intermittent supply of material from the north-east, i.e. from the area of Slanské vrchy hills, marked by distinctive volcanic activity during the Sarmatian period. The paleocurrent direction, observed in the riparian sediments, is oblique to the main strike of transport, thus demonstrating an activity of currents along the shore line.

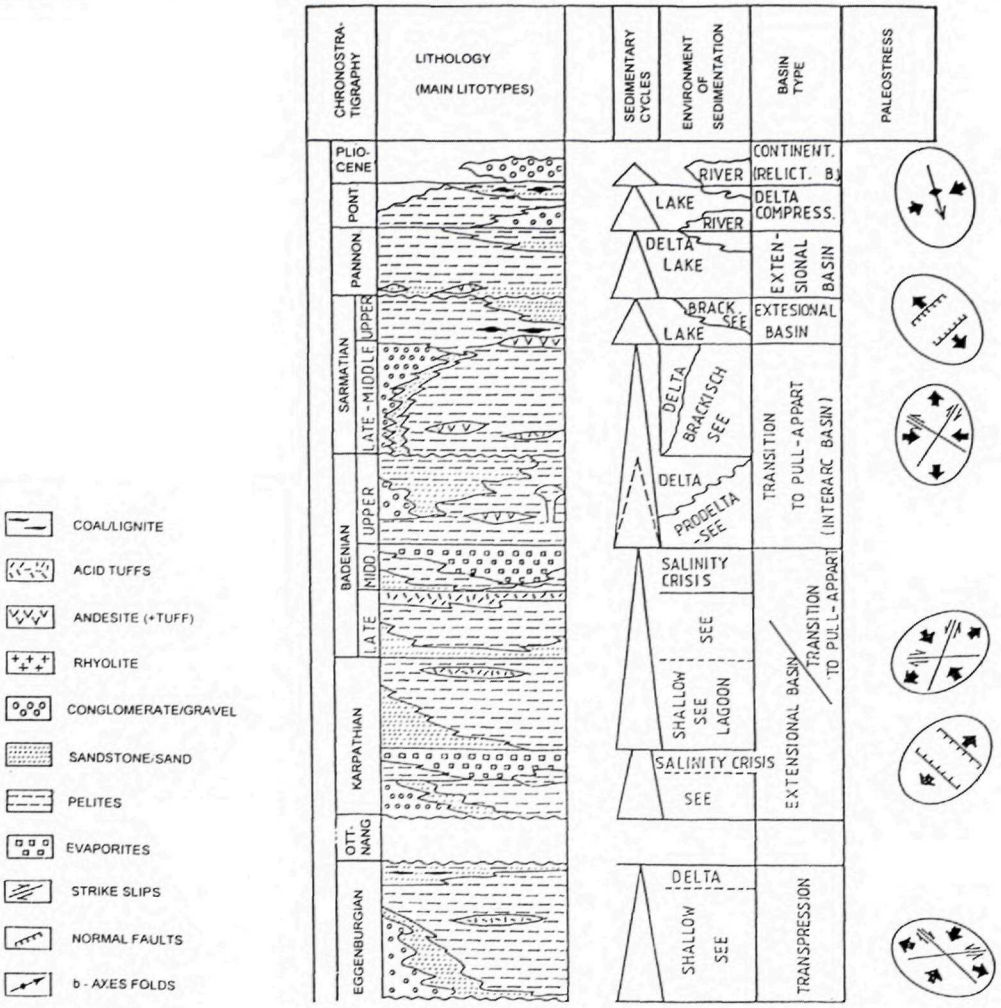
♦ Facial development and sedimentary environment of evaporites in the Eastern Slovakian Neogene basin

Stanislav KAROLI

The Eastern Slovakian Neogene basin is an intramountainous basin with marine development. Two evaporitic groups of beds, with the NaCl predominating, were intersected by drillings in the upper part of its filling. The underlying Solná baňa group of beds of Karpatian age is up to 300 m thick, which had developed within a partly drying out trough, striking NW-SE, and became repeatedly separated from the main sea. The marginal development at the north-western flank of the trough is composed of a mosaics of the main sea sediments, mud flats, and small salt pans. The originally bedded sediments, composed mainly of alternating beds of halite and siliciclastic clays at the base, periodically emerged to form coarse grained collapse breccias due to dissolution of halite by fresh waters. These breccias contain relics of "hipperic" crystals and the process of drying has been resonsible for the formation of evaporites in the upper part of the group of beds. Regular laminae of halite in the pelites, found in several cores drilled within the central part of the basin, represent probably the "hipperic" crystals and beds, which formed due to precipitation at the boundary between water and atmosphere, sinking subsequently to the bottom

The upper salt-bearing group of strata of Middle Badenian age (the Zbudza Formation) occurs within three partial, tectonically disconnected small basins. The thickness of the group of strata does not exceed 200 m. Tens of meters thick beds of halite, intercalatated by clayey sediments, are a typical feature of this group of strata. Halite represents the chevron crystals, displaying usually a vertical arrangement, with irregular disrupted clayey laminae. Such features are typical for a fast growth of halite at the bottom of a shallow water basin.

Both, the facies and the paleogeographic features, illustrate (regardless of the climate) an important role of tectonics played in the formation of the evaporites. While the Karpatian evaporites are of



only local importance, the Middle Badenian evaporites had developed over extensive areas of the Inner and Outer Carpathians. They formed within concluded small satellite basins during the incipient stages of desintegration of the Neogene Paratethys.

♦ Sediments in faces of small deltas in the Eastern Slovakian basin

Juraj JANOČKO

The development of sediments, deposited in the faces of three "small" deltas in the Eastern Slovakian basin, indicates a broad range of sedimentation processes, depending on the morphology of depositional environment, the intensity of material supply, the type of fluvial system supplying the material, the processes which had taken place in the basin as well as on the tectonic development of the investigated area. The fragment and turbidity current facies, present in the delta of the Čelovce group of strata, reflect a steep slope of the delta's face. Extensive presence of planar, diagonally stratified gravels and absence of features, typical for transitory subaerial - subaqueous zone at the face of the Varhaňovce gravel delta, indicates a prograding supply of the material towards the centre of deposition. The development of both the debouchemental beds and the sediments of near-shore zone in the Stretava group of strata demonstrates lower energy of the sedimentary environment, with the material, brought by braided rivers being partly reworked by processes, active in the riparian zone. As several classifications of deltas of similar type came to light recently, as referred to in this study, below we present, for a better orientation, the groupings of deltas under study into some of the published classification schemes:

– HOLMES (1965) (classification based on the characteristics of the drainage system, supplying the material /feeder system/): all three types of deltas belong to the group of "fan deltas".

– ETHERIDGE - WESCOTT (1984) (tectono - physiographic situation): the Čelovce group of strata delta - shelf type ?); deltas in the Klčov and Stretava group of strata - Gilbertian type of delta.

– GALLOWAY (1975) (regime in the area of delta's face): the deltas of the Čelovce and Klčov group of strata belong to the group of deltas with predominant fluvial processes, the Stretava delta belongs to the group of deltas with predominating fluvial and wave-like processes.

– CORNER (1990) (granulometry of deltaic sediments and type of slope of delta's face): deltas of the Čelovce and Klčov group of strata belong to the group of steeply dipping Gilbertian deltas, while the delta of the Stretava group of beds belongs to the group of deltas with smooth slope and development of debouchure beds.

– POSTMA (1990) (type of sediments of the "feeder system", morphology of the basin): the delta of the Čelovce group of strata belongs to the group of Gilbertian deltas, which form on steeply inclined slopes, with great water depth (deep-water deltas), whereas the delta of the Klčov group of strata belongs to the group of "classical" Gilbertian shallow water deltas and the delta of the Stretava group of strata belongs to the group of shallow water deltas (Hjulstrom - type) (Fig. 7).

♦ Tectonic development of the Eastern Slovakian basin during Neogene

Peter KOVÁČ, Dionýz VASS, Stanislav KAROLI and Michal KALIČIAK

The synthesis of measurements of brittle deformation, made on rocks of the Eastern Slovakian basin filling, including the volcanic rocks and the rocks cropping out in immediate surroundings of the basin, elucidated the paleostress features and its changes during the Neogene, i.e. during the period, when the Eastern Slovakian basin has been formed and filled by sedimentary and volcanic rocks. This new information on the palestress, along with extended or new knowledge, respectively, on the mechanism of the filling-in of the basin have shown, that the process of dilation and filling-in of the basin was complicated and incoherent.

The basin started to open during the Eggenburgian period as a relatively narrow basin and formed along the klippen-belt, or near-klippen-belt within the stress field, whose orientation of maximum compression striked NNE-SSW. The basin dilated along the faults, striking NW-SE, with left and right hand slips, along NW-SE striking faults. The sedimentation in the basin have taken place under marine conditions. This incipient basin waned at the close of Eggenburgian time and the sedimentation was terminated by prograding deltas, whose erosive relief is represented by the Čelovce Formation.

The basin began to reopen and to communicate with the main sea during the Karpatian period. In the paleostress field there dominated extension, striking NE-SW, whereas the dilation and the filling-in of the basin was controlled by normal faults, striking NW-SE. During the Karpatian period the activity of these faults decreased. The salinity crisis had occurred in the basin and the evaporites of the Soľná Baňa Formation were formed. The activity of faults was reactivated during the Karpatian period, however, it was compensated by the deposition of sediments, so that more faults striking N-S could be formed under shallow water conditions. These faults were characterized by a distinct normal slip component.

During the Pontian, the subhorizontal compressional component of the stress field, striking ENE-WSW, have taken place. This is evidenced by scanty folds, and can be also seen in the seismic sections, from which the Late Miocene domes can be inferred.

The volcanism, which accompanied the formation and dilation of the basin, was also controlled by the paleostress conditions. The acidic character of volcanism during the Lower Miocene and Lower Badenian indicates a relatively shallower reach of faults, which enabled the magmatic masses to ascend.

The culmination of the volcanic activity is bound to the period of Late Badenian - Middle Sarmatian, when the dilation of the basin of the "pull-apart" type was most intense. The volcanism is predominantly of andesitic character, i.e., it is more basic, compared to the previous period of the basin's opening, which speaks in favour of deeper reach of faults, thus allowing the volcanic materials to ascend.

Geodynamic reasons to explain the formation and activity of faults, as well as the dilation of the basin, may be found in two geodynamic agents: in the subduction of the European platform below the Carpathian-Pannonian block, which provoked a transtensional regime during the development of the basin;

-in the activity of the Pannonian astenolith, the presence of which was accentuated mainly during the transitional period of quieting of the subductional convergence, when the basin dilated under extensional conditions, prompted by ascending Pannonian astenolith.

During the Late Karpatian to Middle Badenian times the direction of extensional component of the stress field did not change, however, the compressional component rotated from a subvertical to subhorizontal position, striking NW-SE. The dilation was again accompanied by the pull-apart mechanism, i.e., the basin became dilated via faults with subhorizontal as well as sub-vertical component, namely via the faults, striking NNE- SSW (left slip) and E-W to ESE-WNW (right slip). It was still during the Badenian time that the dynamics of dilation declined to cause a second salinity crisis and the Zbudza evaporitic formation could develop.

During the Late Badenian to Middle Sarmatian the basin commenced to reopen again under conditions of paleostress field with the maximum compressional component striking ENE-WSW and an extension, striking N-S. It was in this stress field, that the faults with both, the horizontal and the vertical component, played the main role again, whereby the faults striking ESE-WNW had the left and the faults striking NE-SW had the right horizontal component of movement. The deltas, on the other hand, played an important role in filling-in the basin during the Late Badenian (the Klčov, the Sečovce, or the Varhaňovce deltas, respectively) as well as during the Lower Sarmatian (the Košice delta). During the Lower Sarmatian time the speed of sedimentation in the basin culminated, which was obviously related to the tectonic activity along synsedimentary faults.

♦ Lithological and microfacial analysis of Upper Jurassic and Lower Cretaceous formations of the Veľká Fatra Mts. and the Chočské vrchy Mts.

Daniela BOOROVÁ

The aim of this research was to carry out lithological, microfacial and biostratigraphic investigation of the marginal Jurassic-Cretaceous carbonates at the Stankovany locality in the Veľká Fatra Mts., as well as of the Oxfordian-Kimmeridgian sediments of the Lúčky I section in the Chočské vrchy Mts. area. Both localities under study belong to the Zliechov facial area of the Krížna nappe.

The following *Calpionellid* zones have been ascertained within the Jaseniny and the Osnica Formations, of the Stankovany section: the Crassicollaria, with the intermedia subzone and the Calpionella, with the subzones alpina and Remaniella.

The boundary between the Osnica Formation (limestones of Biancone type) and the Jasenina Formation seems to be continuous. The chronostratigraphic boundary between the Jurassic and Cretaceous periods, dated by Calpionellid fauna, runs within the Osnica Formation, some 4,5 m above its base.

In the area under study there prevailed a relatively deep water development and it represents the products of pelagic basinal sedimentation, deposited between the CCD and ACD levels.

Basing on the relation of individual microfossil components the following microfacies were distinguished: the radiolarian and filamentous, at the Lúčky locality and the saccocoman-radiolarian and saccocoman-globochaetan, respectively, in the Jaseniny Formation. Owing to the presence of an index fossil *Stomiosphaera moluccana* WANNER in the Jaseniny Formation there was ascertained the "moluccana" biozone (sensu K. BORZA 1980) indicating the Upper Kimmeridgian age. Streaks, or alignment, respectively (subparallel structure caused by alignment of microfossils) and concentration of allochems in the laminae (laminated textures), as well as streaks or gradational arrangement of individual constituents of the rock (microgradation) have been observed in the Lúčky I section. Such types of sediments can be classified as distal microturbidites.

Because of finding of the Saccocoma sp. in the radiolarian and filamentous facies and the age determination of the radiolarian limestones and radiolarites in the Chočské vrchy Mts. based on loosely separable radiolarite fauna, which corresponds to the Late Callovian - Late Oxfordian (POLÁK

- ONDREJÍČKOVÁ, 1993), the question of first appearance of these planctonic crinoids came to light. At the same time the question arose, as to how to categorize the rock complexes studied into discrete lithological units. This refers mainly to the Jaseniny Formation (saccocoman-aptychan limestones), where several deviations were found in lithological character of rocks from the original definition of the Jaseniny Formation, determined on the reference section at Strážovce (MICHALÍK et al 1990, p. 72). Distinct differences are mainly as regards the bedding of limestones. Besides of shaly limestones there also occur platy, or even layered (locally mottled) limestones. Cherty nodules occur in the lower horizons. The beds of indistinctly nodular limestones, with sporadic cherts, can be seen locally. As a contrary to the type locality, basal part of the formation does not form reddish shaly limestones. This is why I rank conditionally this sedimentary complex into the Jaseniny Formation.
As the lithologic transition is blurred - continuous, the boundary between this and the underlying radiolarite formation was outlined basing merely on microfacial features, determined in the reference section of the Jaseniny Formation.

The Oxfordian-Kimmeridgian rocks in the Lúčky section represent the deep water pelagic facies, whose sedimentation had taken place above the CCD level.

♦ Investigation of basinal and slopy sediments of the Biely Váh succession and paleogeography of the Hronicum Unit

Milan HAVRILA

An essential part of this investigation was a systematic, extensive and detailed field lithological profiling throughout the Hronicum Unit (ANDRUSOV - BYSTRICKÝ - FUSÁN 1973), with the emphasis to study basinal facies of the Biely Váh basin (MAHEĽ 1961).

Basing on application of simple physical-sedimentological criteria (sedimentary structures) and biostratigraphy (conodonts) a new concept of the Hronicum Unit based on identification and analysis of carbonate facies of the Middle to Upper Triassic strata and their position within the basin, has been presented.

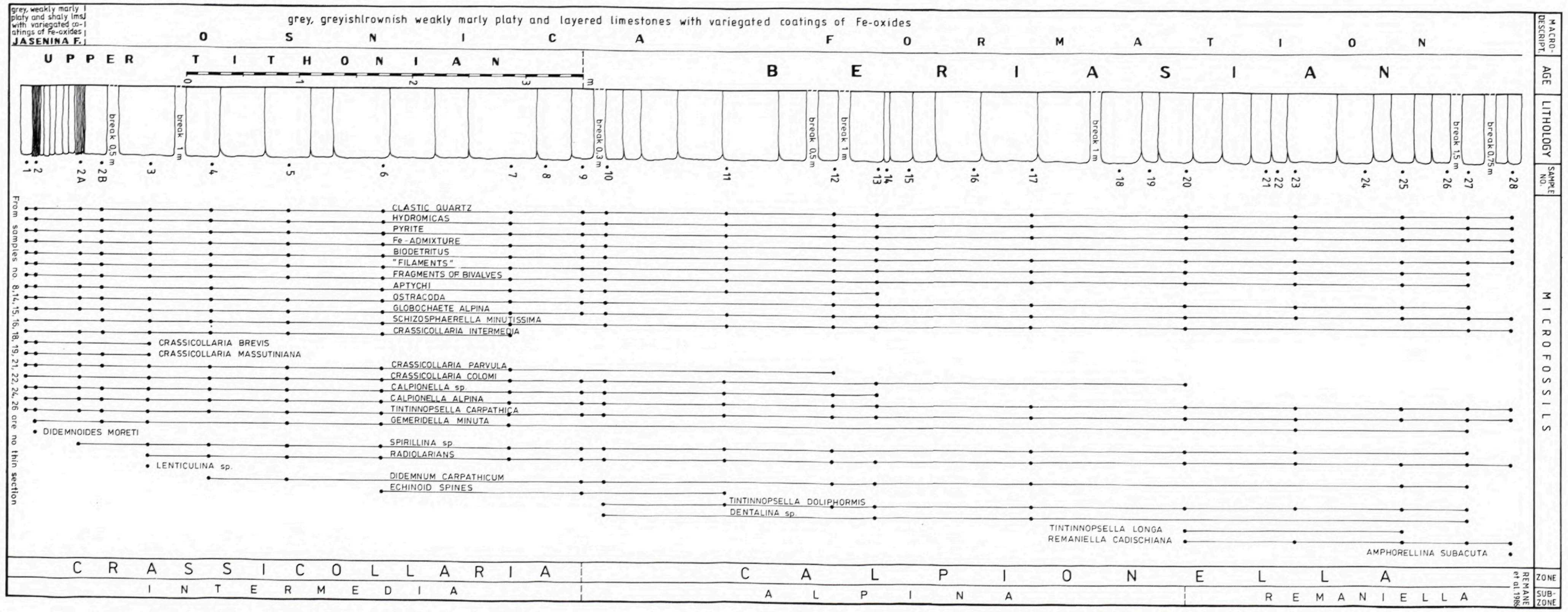
In lithological terms, the determining feature of the Triassic formations is the presence of four lithologic horizons throughout the region of Hronicum: the lower siliciclastic formation (Carboniferous - Lower Triasssic) with the Nižná Boca and Malužiná Formations of the Ipoltica Group (VOZÁROVÁ - VOZÁR 1979), also with the Benkovská and Šuňavská Formation (BIELY 1985), the upper siliciclastic formation (Karnian), represented by the Lunz member (LIPOLD 1863), with a carbonate horizon intercalated between them, differentiated during the Pelsonian - Julian period into two facial areas, which agrees with the hitherto known opinions SPENGLER 1932, ANDRUSOV - BYSTRICKÝ - FUSÁN 1973), the uppermost of the four mentioned horizons is the Hauptdolomite (Upper Triassic).

Establishing turbidite nature of the Cordevolian Raming limestones, which crop out at the divide of the two facial areas, the inclusion of several lithostratigraphic units into them and their apprehension as being the members of Raming limestones (e.g. Göstling limestones, Grafenstein limestones etc., lined up according to proximality) and the study of their distribution (as well as distribution of lagoonal, reef-, slope and basinal facies) within individual nappe bodies allowed to include also the "upper nappes" into the Hronicum Unit, (the Havranica, the Jablonica, the Nedzov and the Strážov nappes), to unveil the structure of the Hronicum Unit and followingly to unwrap the area of its occurrence.

Two basinal regions, invented and delineated within this area, are divided from each other by a carbonate platform - the source of detritus for the Raming limestones. It is presumed, that the number of basins and carbonate plains was even greater and that there existed in fact a system of carbonate platforms and intraplatformal "pull-apart" basins. This indicates an even more complicated paleogeographic situation compared to that, presented by ANDRUSOV, BYSTRICKÝ AND FUSÁN (1973).

The mode of occurrence of the Raming limestones allowed to show the presence of "indentation", i.e. lateral position of traditional facial areas of the Hronicum Unit (the Čierny Váh and the Biely Váh areas).

Furthermore, three basic types of the Hronicum successions were ascertained: the basinal type succession, the carbonate platform succession and the mixed type sussession, which have developed due to progradation of the carbonate platform.



Lithological-microfacial profile
STANKOVANY (CUT OF NAMELESS BROOK)
compiled by: D. BOOROVÁ 1993

Lithological-microfacial profile
LUČKY I (LEFT SIDE OF THE VALLEY)

compiled by: D. BOOROVÁ 1993

purple platy radiolarian, scarcely indistinctly nodular limestones, sometimes with green spots and grey, greyishgreen, greyishpurple siliceous platy, sporadically layered, scarcely cherty limestones with beds of marlstones and a bed of organodetrital limestone

grey, in places indistinctly nodular, platy scarcely layered, sporadically spotted limestones with rare cherts and thin beds of grey marlstones

grey, greyishgreen weakly marly, in places spotted, shaly, platy, scarcely even layered limestones (dominantly in lower horizons sometimes cherty) with beds of grey marlstones and indistinctly nodular sporadically cherty limestones

RUHPOLDING FORMATION

JASENNINA FORMATION

OXFORDIAN

KIMMERIDGIAN

MACRO-DESCRIPTION

AGE

LITHOLOGY

SAMPLE NO.

MICROFOSSILS

- CLASTIC QUARTZ
- HYDROMICAS
- PYRITE
- BIODETRITUS
- RADIOLARIANS
- "FILAMENTS"
- FRAGMENTS OF BIVALVES
- FRAGMENTS OF ECHINODERMS
- SACCOCOMA sp.
- APTYCHI
- SPIRILLINA sp.
- OSTRACODES
- SPONGE SPICULES
- DENTALINA sp.
- AUTHIGENIC QUARTZ
- STOMIOSPHAERA MOLUCCANA
- LENTICULINA sp.
- GLOBOCHAETE ALPINA
- ECHINOID SPINES

The structure of Hronicum Unit has been roughly determined envisaging it as a system of nappes, arranged according to the model of ELISON and SPEED (1989) and following the traditional structural concept of the Western Carpathians (ANDRUSOV - BYSTRICKÝ and FUSÁN, 1973). Thus, the Hronicum Unit consists of the following groups of nappes, which are related, in terms of their lithological filling:

- the lower group of nappes, floored by basinal facies (the Biely Váh facial region in the area of the Biele hory Mts., Dobrá Voda, Strážovské vrchy Mts.),

- group of nappes made of the carbonate platform succession (the Čierny Váh and the Bebrava facial region, within the areas of the Havranica, Jablonica, Nedzov and Strážov nappe, towards east through the Považský Inovec Mts., Tríbeč Mts., Žiar Mts., as far as the Šturec nappe in the Veľká Fatra Mts), - the upper group of nappes, floored by basinal facies (the Biely Váh facial region in the area of the Chočské vrchy Mts., the Western Tatra Mts., the Nízke Tatry Mts. and the Starohorské vrchy Mts.). The fourth group of nappes is made of the Čierny Váh formation.

Establishing turbidite nature for a part of facies of the Biely Váh succession (the Raming and the Partnas formation) implies that they cannot be considered a component of the Reifling formation anymore.

Apart from the palinspastic map of the Hronicum Unit there were also outlined the sedimentary areas for the Farkašovo breccias, the Zámostie limestones, the Schreyeralm and the Raming limestones.

♦ Alpine granitoids - their possible existence within the zone of contact between the Veporicum and Gemericum Units and their role in the structure of the Western Carpathians

Ľubomír HRAŠKO, Anna VOZÁROVÁ, Martin KOVÁČIK, Jozef HÓK, Juraj MICHALKO, Miroslav FILO, Jozef HATÁR, Jozef GREGUŠ, Jarmila ĎURKOVIČOVÁ, Ladislav MARTINSKÝ, Pavol SIMAN, Magda SLÁDKOVÁ, Viera WIEGEROVÁ and Tomáš GREGOR

The existence of Paleo-Alpine magmatic activity and its extent has been ascertained in the zone of contact between the Veporicum and Gemericum Units, roughly in the area between Poltár and Rejdová villages. In particular the granitoids of the following types were addressed in this study: the Rochovce type, the Rimavica complex type, the Kohút massif type and the Turčok type. Furthermore, manifestations of their contact effects, and of younger deformational-recrystallization processes have been investigated. The Rochovce granite has been submited to special isotopic-geochronological examination.

The research of contact-metamorphic metasedimentary sequences, found at the junction with the complex of Rimavica granitoid have shown that these rocks are affected by at least three metamorphic processes: pre-contact, contact and a younger Alpine metamorphism. The Alpine contact metamorphism is bound exclusively to the contact effects of the Rochovce granitoide body.

Granitoids: Basing on the field, petrologic and previous geochemical data we distinguish the following older types of granitoids: the "Dubovo" granitoide (Poltár-Zlatno area), granitoids in the Klenovec complex, granitoids in the Krokava- Hladomorná dolina belt as well as various types of predominantly porphyric, deformed and recrystallized granitoids, cropping out within the Kohút massif. Isotopic-geochronological data, deformation and recrystallization of these granitoids, which increase towards NE and the manifestations of Alpine deformations speak against their Alpine age. The K/Ar model dating of minerals, yielding predominantly the ages around 90 Ma., do not represent the real age of rocks, but the age of the youngest, most intense thermic-metamorphic events, which affected the granitoids of the Rimavica complex. A better retention of the older radiogenic Ar in minerals in the SW part of the area further proves the increasing intensity of alterations towards E, or NE, respectively.

A part of aplites and pegmatites, which are younger relative to the previously mentioned types, are of uncertain age, however, they may still be best associated with the closing development of the previous types. Cretaceous age of these youngest differentiates is also contradicted by the model age records of the coarse grained muscovites, extracted from the pegmatites and aplites (around 150-170 mil.y.), which should, owing to the deformation of rocks, signify a probable repercussion of younger deformational phases, with incomplete resetting of K/Ar geochronometer and not the real age of rocks. In the NE part of the area these youngest granitoide differentiates display the effects of deformational-recrystallizational processes, thus allowing to date these aplitic-pegmatitic derivatives prior to Alpine metamorphic events.

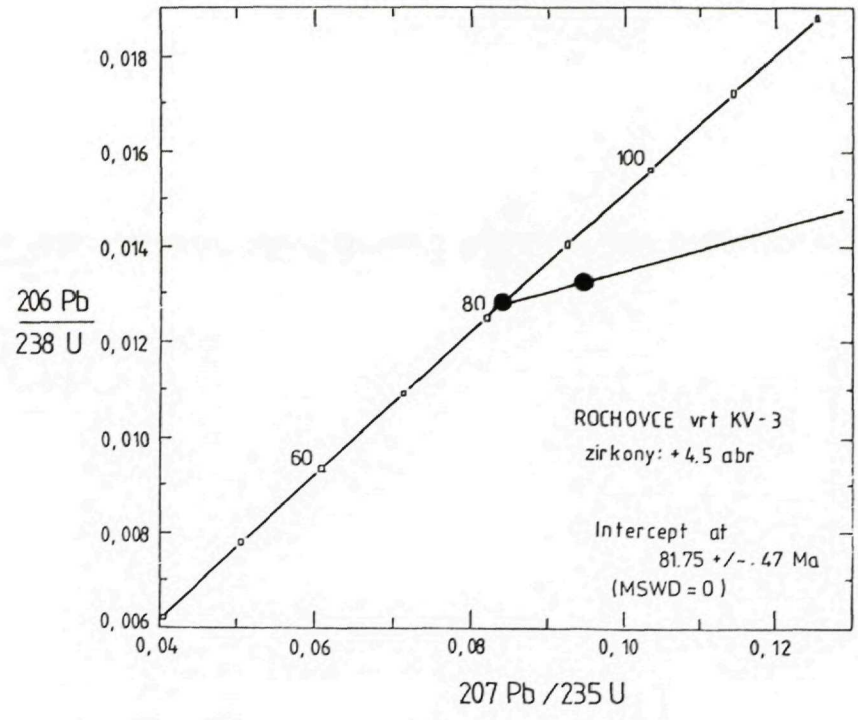


Fig. 1 Position of measured zircons on the concordia diagram

The structural and petrological research lead us to the conclusion that the granitoids of Rimavica complex were affected by both the compressional and the extensional Alpine deformation.

1. A more intense deformation and recrystallization of granitoide rocks appears first in the Rimavica granitoide complex in the area of Krokava and it is coaxial with the deformation, exhibited within the contact-metamorphic rocks. Extreme manifestation of such deformation is obvious within the Kohút massif. This stage can be identified with the thrusting of surficial nappes. The compression had been oriented toward N or NW, respectively. This stage manifests itself throughout the area by thrusts of granitoide complexes over the units, which crop out northwards. In the western part of the region (the Sinec massif area, the Dubovo massif) this process took place in a more irregular form in folding processes within narrow zones, associated with retrograde alteration of both the metamorphics and the granitoids. Transitions into horizontal displacements mark a continuation of the deformational process.

2. Relatively less intense deformation (low temperature) is characteristic for the E part. It is marked mainly by the deformation, whereas the recrystallization is negligible. It reflects the extensional conditions with slips towards E or S, respectively. It is this extension that we consider important in terms of the intrusion of the I. phase of the Rochovce granite (approx. 81 Ma., based on the zircon dating, the Pb/U ages are practically concordant). The extensional stage is evident throughout the region. We cannot exclude that also the manifestations of hydrothermal activity along the shear zones in the southwestern part of the area (Sinec-Dubovo) indicate an existence of an abyssal magmatic body of Alpine age.

This stage is also well evidenced by published Ar/Ar datings and K/Ar model ages of biotites and muscovites from E limits of the Kohút zone as well as from regions, lying northwards of the Muráň Mesozoic on one hand and by dating of the Rochovce body proper, on the other.

The Rochovce granites of the Ist phase crystallized under extensional conditions, whereas the granites of the IInd phase were emplaced during the final stage of Upper Cretaceous movements, in the course of horizontal movements within the basement, which possibly took place due to an uplift, caused by tectonic denudation processes.

Based on the results of geochemical and petrographic features and structural research in the surroundings of the Rochovce intrusion, its Ist phase has many features in common with a postorogenic granite. The magma source was of crustal/mantle nature (indicated by Nd/Sm isotopic characteristics and mixed enclave populations) and originated in considerable depths. The relation of Nd/Sm isotopes indicates that the crustal material, which shares the composition of the source, had an old, complicated crustal history.

During a tectonic relaxation stage (some 80-85 Ma ago) the conditions were established for melting reaction to occur as well as for ascension of magma and emplacement of granite. In adition, thermal effect of the underlying mantle have obviously taken place. Contact effects of the granitoide upon presumed Lower Triassic sequences of the Foederata unit also speaks against the concept of the Late Paleozoic age of this granite.

The body of Turčok granite, wedged-in tectonically between the Gelnica and the Ochtiná Formation, displays the features of a post-orogene to anorogene body, with anomalous properties. Its age is probably Permian.

♦ Geodynamic development in the regions of Slovakia during Upper Pliocene and Quaternary

Juraj MAGLAY, Vladimír BAŇACKÝ, Rudolf HALOUZKA, Ján HORNIŠ and Ján PRISTAŠ

Presented report is a synthesis of all available data related to the dynamics of young geological processes in the selected regions of Slovakia. On the basis of observed differences between absolute and relative heights, depths and thicknesses of correlated and dated sediments the authors evaluate the degree of differentiation, the rate and the stages of vertical movements of discrete morphostructures. They also pay due attention to the tectonogenesis, sedimentogenesis, paleogeographic and geomorphologic development.

The report is intentionally divided into three independent scopes, each representing a specific range of problems and, at the same time, a specific model for geodynamic development of the Carpathian intramontainous basins, with the emphasis to the marginal basinal lowlands. Due to technical reasons the topics to solve are only targeted to most representative regions. Preparation of an overall review of the geodynamic situation of the Western Carpathians is planned to take effect during the second stage of this research.

In the first part of this report the author (V. Baňacký) refers to the geodynamics of the Eastern Slovakian and Borská nížina lowlands during a younger neotectonic stage and compares the two lowlands. He concludes that a complicated tectonic regime, which took place during a short Quaternary period did not cease, but, to the contrary, it was evidently more distinct and closely related to the Pre-Quaternary regime.

The second part of the report deals with the geodynamic development of the Váh River valley, stretching from the Púchov water gap down to its debouchure, during the time spanning from the Rhodanian tectonic phase to Holocene. The authors (J. Horniš, J. Maglay, J. Pristaš) distinguish three basic types of morphostructures in the area: 1. the morphostructures of the Middle Váh River basins with distinct positive movement tendency (from Upper Pliocene some 120-150 m). 2. Morphostructures of the Trnava and Nitra uplands with alternating, or but slightly positive tectonic activity. 3. Morphostructures of the Danubian plain with unequivocal predominance of negative tectonic movements (since Upper Pliocene, -500 m).

Unlike in previous parts of this report, in the third part the author (R. Halouzka) deals with the Quaternary geodynamics of selected basins and valleys of the Slovakian Carpathians. In this context he also refers in detail to the paleohydrography and subdivides discrete morphostructures. Of the wide range of the reported data the most remarkable are those determining the record values of 400 - 600 m of movements of the Vysoké Tatry Mts. versus the Popradská kotlina basin and 250 m between the correlated sediments of the Zvolenská kotlina basin.

♦ Seismic section G-1

Jozef VOZÁR, Čestmír TOMEK, Anna VOZÁROVÁ, Ján MELLO and Ján IVANIČKA

A seismic section G-1 has been realized in 1992 in the eastern part of the Spišsko-gemerské rudohorie Mts., along a more than 50 km long line, conecting the Janík (a village next to the Slovak-Hungarian frontier) - Hačava - Smolnícka Huta - Slovinky - Krompachy. The realization of this project, coordinated by the GÚDŠ Bratislava, was subject of a competition, which resulted in the Geocomplex, a.s., the Uranpres, š. p and the ELGI Budapest being selected to carry out the project entitled: Geodynamic development and deep structure of the Western Carpathians,. The measurements proper were made by the ELGI Budapest, using a 144 channel telemetric apparatus MDS-16. It was, in fact, the first telemetric measurement made (August 1992) in the then ČSFR. Technical parameters of the measurements were as follows: number of channels - 144, pace 50 m, number of geophones in a group - 16, length of a group 50 m, registration time - 20 sec., total length of stretch 7200 m, number of drill holes 218, distance between holes 200 m, with possible additional explosions, depth of holes in the Turnianska kotlina basin - 25-30 m, in its upper part - 13-18 m, nominal overlapping 12-18 m. The evaluation and supervision of seismic works have been carried out by the consulting company KAPPA, s.r.o. Brno.

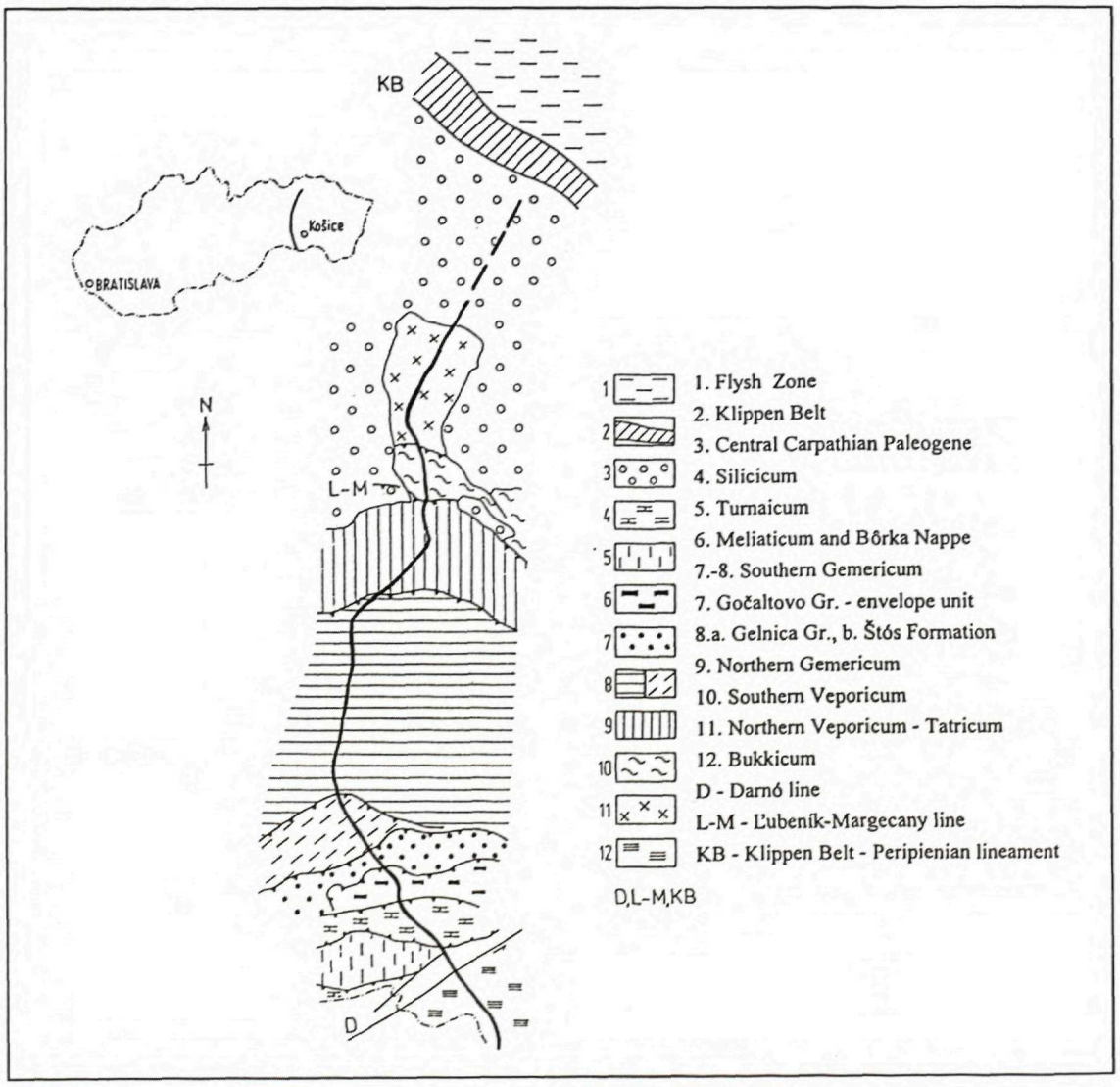
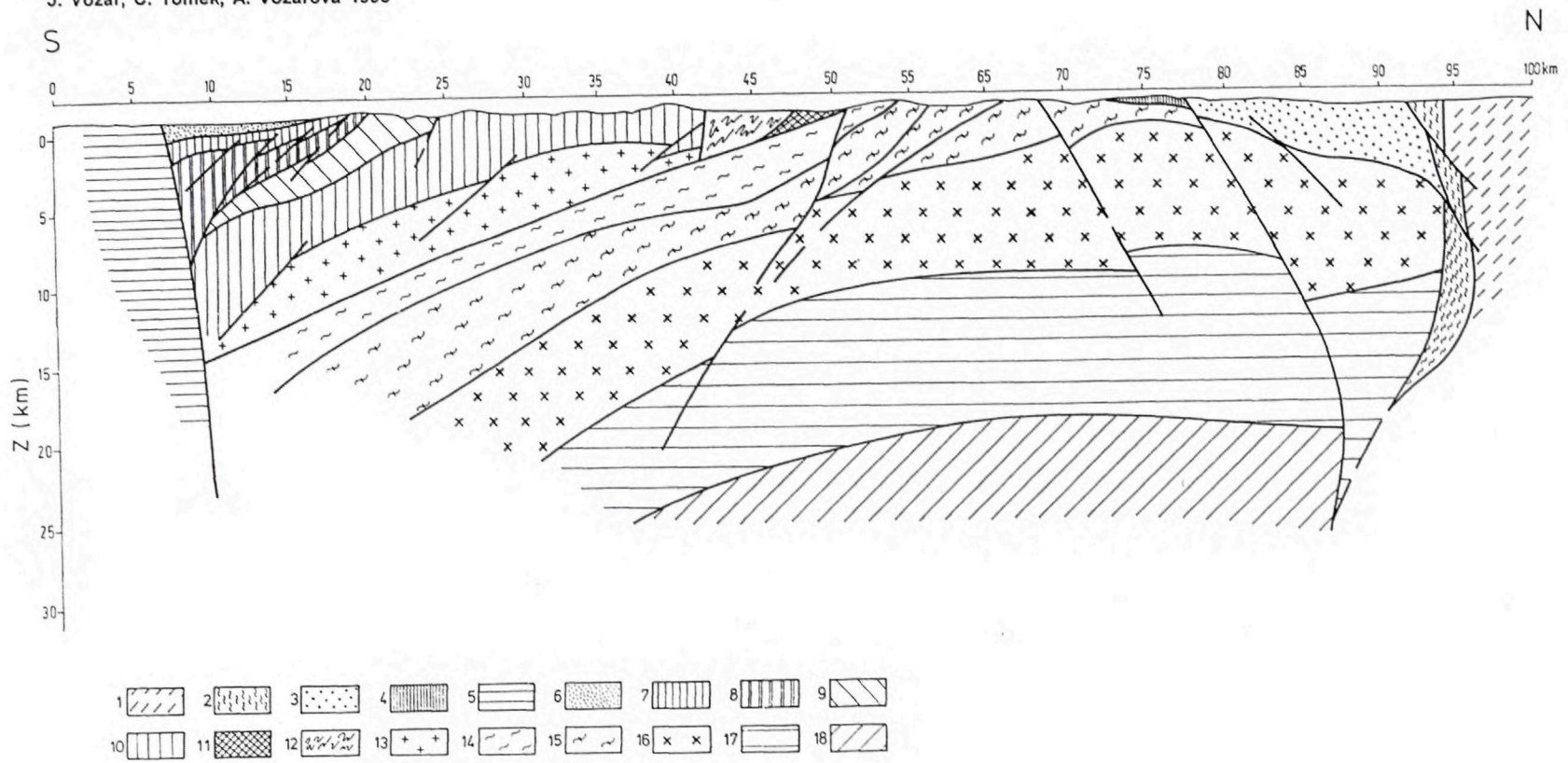


Fig. 1 Deep seismic profile G: Geological scheme and profile-line.

DEEP SEISMIC PROFILE G: Geological interpretation

J. Vozár, Č. Tomek, A. Vozárová 1995



1.-2. Outer Western Carpathians: 1. Flysh Zone; 2. Klippen Belt; 3. Central Carpathian Paleogene; 4. Hronicum; 5. Bukkicum; 6. Silicicum, Turnaicum; 7. Bôrka Nappe; 8. Meliaticum; 9.-10. Southern Gemericum: 9. Štós Formation and envelope unit of the Southern Gemericum; 10. Formations of the Gelnica Group; 11.-12. Northern Gemericum: 11. Envelope unit of the Northern Gemericum - Dobšiná and Krompachy Groups; 12. Rakovec and Klátov Groups; 13. ?Middle-?Upper Cretaceous granitoids intrusion; 14. Southern Veporicum; 15. Northern Veporicum; 16. Tatricum; 17. Southern Penninicum; 18. ?Middle Penninicum

The first results, reported in December 1992 by the ELGI, have shown very promising technical findings along the whole length of the section. The follow-up detailed evaluation of the section confirmed excellent quality of obtained seismic data. In the first stage the standard processing has been made, while in the second a special method to prepare coloured versions of the time - sections, the so called Hilbert transformation, has been made. A total of three deep section variants at 6 sec., 12 sec.,and up to 20 sec. were made.

The results of processing of data into the time -sections, which include the migrations, show an extraordinary reflectivity of the whole crust along the section. Furthermore, an unique result has been achieved thanks to selection of suitable registration distances, showing the reflectivity of the mantle. This is the second reported case worldwide of registering the mantle reflectivity, achieved within anorogenic zone. The MOHO discontinuity has been detected in the southern part of the section at 10 sec., i. e. at a depth of some 30 to 32 km, whereas in the northern part of the section, the crust and mantle boundary have been disconnected due to reflexes, plunging from the crust in the N to S direction.

In geological terms the most important result is finding, in the upper part of the crust, of transparent and indistinct (due to small amplitude) zones, interpreted as granitoide bodies, intruded into the Alpine structures. A distinct reflection, indicated below this zone, has been interpreted as the thrust of the Gemericum Unit "en bloc" over the southern part of the Veporicum Unit. Southwards dipping reflexes, which mirror the Alpine structures, predominate throughout the crust. At the presumed contact of the Rakovec Group with the Gelnica Group in northern part of the section, the remnants of Variscan structure, dipping to the N, can be interpreted. Tectonic contact of the Štós Formation with the Gelnica Group, which dips to the south, can be distinguished in the Gemeric part of the section. From the southern part of the section the position of Meliata Group and the Silica and Turňa nappes can be interpreted, which will undoubtedly contribute to understanding of the Kimerian orogeny.

An extensive crustal and mantle suture zone, dipping under an angle of 30° towards S occurs below the Gemericum Unit and Southern Veporicum. We interpret this feature as a remnant of continental Upper Cretaceous collision, which involved the Northern Veporicum, Tatricum and very probably the Penninicum, too. The section labelled G-1/2, which continues northwards as far as the Branisko Mts., has been realized in 1993, following the realization of older deep sections, continuing up to the Klippen belt (Lipany - Bardejov). This will help to complete the second Transcarpathian deep seismic section made in Slovakia.

♦ Palinspastic reconstruction of the Mesozoicum in the Western Carpathians

Miloš RAKÚS

The main paleogeographic Mesozoic domains have been defined in the territory of the Western Carpathians and the adjoining parts of stable Europe.

Furthermore, presented are the paleogeographic maps for six Mesozoic periods: Norian, Pliensbachian, Callovian, Tithonian Barremian and Albian and a new variant of the palinspastic position of the Meliaticum as well as ultrameliatic position of the Silicicum Unit.

This new variant has been realized in accordance with the new paleomagnetic and structural researches realized within the Inner Carpathians.

The Western Carpathians represent a polyphase mountainous system, composed of regional - tectonic units, which formed during the Upper Jurassic to Tertiary convergences. This longlasting (more than 130 Ma), but discontinuous convergent trend resulted in a formation of a mountainous range, in which mostly only fragments of sedimentary basins have remained preserved. Tectonic reduction of original spaces may have been so extensive as to cause complete detachment of the superficial nappes from their basement (the Hronicum nappes, the Outer Flysch Belt).

Another example of extreme reduction of a sedimentary area is the Klippen belt. Its present day form - mega-boudinage - is a result of mainly Tertiary collision of the southern European margin with the block of the Central Western Carpathians.

In addition to the above mentioned phenomena there also occur great shears, accompanied by horizontal strike slips as well as by rotations of blocks. From the stated above it follows that the construction of paleogeographic maps should pose a number of intricate problems.

Beginning of the Mesozoic sedimentary cycle is characterized by two types of contact with the underlying Late Paleozoic: while there exists a distinct disconformity in the Tatro-Veporicum on one hand, a conformable contact can be observed in the areas of Hronicum and Silicicum Units, on the other.

Both, the composition of clastics and the sedimentary character allow to consider the presence of deltaic - estuarian conditions with occassional aeolian activity. A Lower Triassic sedimentary wedge overlapped the entire Tatro-Veporic region and its partial extension over the Hronicum area cannot be excluded. However, supplies of other type of material, originating from a destructed back-arc volcanism, has also been observed here (VOZÁROVÁ and VOZÁR 1993).

The situation in the Silicicum Unit differs in that the Lower Triassic development includes many clastics, originating from the acid volcanics (FEJDIOVÁ in VOZÁROVÁ, 1993).

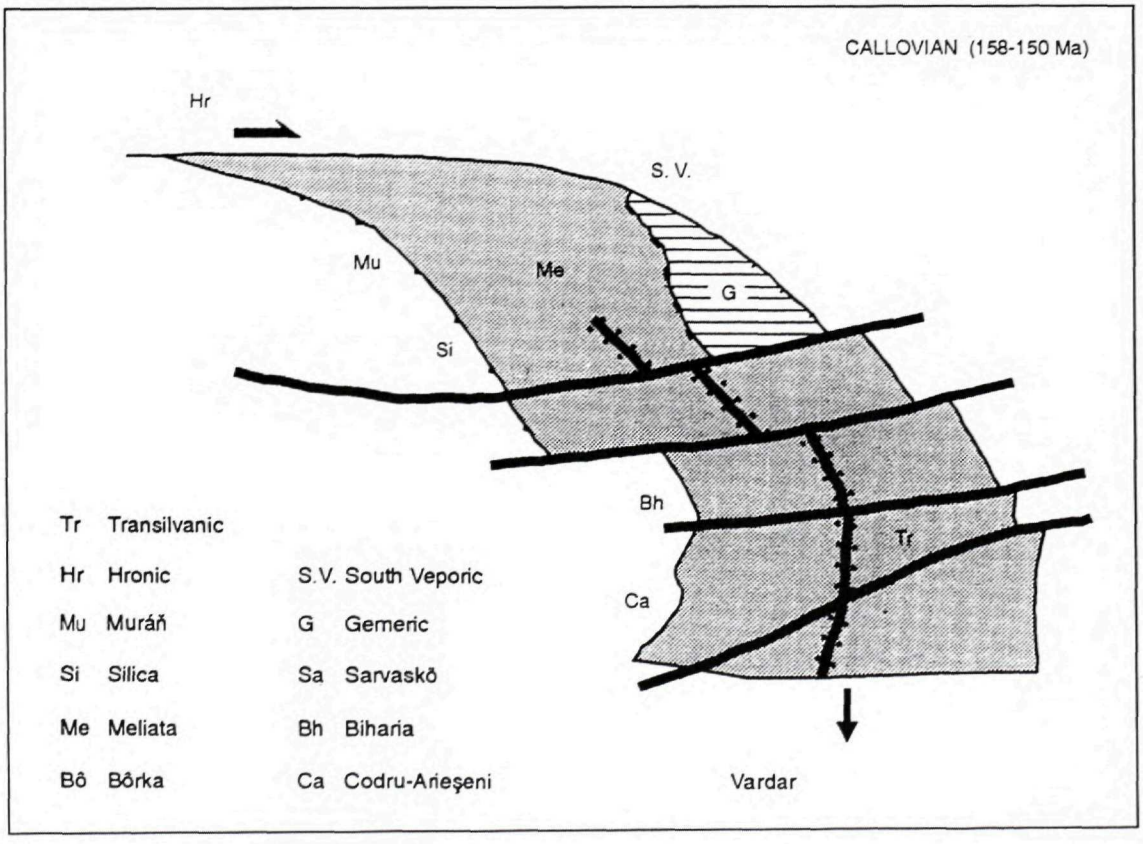
The Middle Triassic period is characterized by carbonate sedimentation in all zones. During the Pelsonian and Ilyrian the hitherto homogeneous carbonate platform was divided into intra- platformal basins with relatively deeper-water sedimentation.

A new extensional domain starts to open within the innermost zones - the forthcoming Meliaticum, which communicated with the Transylvanian, or Vardarian ocean respectively, at the Upper Triassic - Lower Jurassic boundary. This domain ceased to exist during the Upper Jurassic due to expansion of the Penninic ocean. The subducting Meliatic microplate dragged the portions of its own sedimentary filling into the conditions of HP - LT metamorphism.

The closure of the Meliaticum domain, which resulted in a far reaching reconstruction of paleogeographic scenario, had also taken place within the Silicicum Unit. The structuralization and probable cessation of the sedimentation processes occurred here after Tithonian period.

During the Lower Cretaceous times the areas, occupied by the Silicicum, have already formed a nappe system, with obducted Meliaticum in its underlier.

During the Albian times new changes have taken place. The Silicicum Unit, the southern Veporicum and the Hronicum Units were already without sedimentation and formed elevations, projecting over surrounding country. The sedimentation axis migrated outwards, into the Klape basin,



which was then situated between the Klippen belt and the frontal part of the Manín zone. The supply directions within the Klapy basin indicate that the source area must have been southwards of the Klape basin (MARSCHALKO 1986).

The axis of Upper Cretaceous sedimentation was shifted into the Pieniny Klippen-belt and into the Outer Flysch, giving the way to formation of mighty prisms of flysch sediments.

♦ Beginning of the Mesozoic sedimentary cycle

Anna VOZÁROVÁ and Oľga FEJDIOVÁ

The facial association and the sedimentary model have been established basing on following studies:

- detailed analysis of the discrete lithotypes,
- sedimentary structures and sedimentary features,
- cyclic development and cycle types,
- mineralogical composition of sediments,
- the assemblage of heavy minerals and rare findings of micro- and macro-fauna.

The following facial associations and sedimentary environments were defined:

1. clastic facies of the "red beds" type, associated with the sub-environments of alluvial flood plains, ephemeral lakes, associated with distributary channels of alluvial fans and inland sabkhas, or playas and tronas,

2. alluvial flood plains prograding towards litoral part of the siliciclastic shoreline, with distributary channels of small deltas, with sandstone bars and shallow coastal lagoons,

3. clastic facies of the "red-beds" type prograding into arid sabkha - lagoonal and near shore environments with occassional connections with the open sea, and/or with the carbonate shelf,

4. association of evaporitic arid coasts with the so called "deep water" model of sedimentary basin, i.e., with the slope- like and basinal evaporitic facies, developing within tectonically established basins separated from the open sea by a tectonically active horst, with a mobile basin floor.

As far as the relation of the Lower Triassic formations to their basement is concerned the following regions could be distinguished:

1. regions with a distinct discordance and discontinued sedimentation;

2. zone of clastic sedimentation with gradual transition from the underlying Upper Permian sediments;

3. zones of clastic sedimentation, which are gradually, replaced by evaporitic formations of Permo-Triassic age.

We redefine the Lúžna Formation as a Lower Triassic sequence for the entire area of occurrence of the Lower Triassic sediments in the following units: Tatricum, Northern and Southern Veporicum and Zemplinicum, including sandstone-shaly and shaly-evaporitic horizons. The title: Benkovský potok Formation, invented previously by Biely (in SAMUEL et al 1985) to name the Lower Triassic sequences of the Hronicum Unit, was sustained.

We consider that the evaporitic and variegated "red bed" sequences of the northern Gemericum constitute a part of the Novoveská Huta Formation, (the name assigned previously by BAJANÍK et al. 1981); their lithostratigraphy has been described in detail by VOZÁROVA and VOZÁR (1988).

In the Southern Veporicum the upper part of the Štítnik Formation spans stratigraphically from the Upper Permian to the Lower Triassic.

The Lower Triassic sequence of the Silicicum, which is the only unit, whose age was well established by biostratigraphical findings (Kampilian-Lower Anisian), cannot be compared with any of the above described Lower Triassic sequences.

The petrotectonic parameters of the sandstones of the Lower Triassic sequences indicate two main source areas: 1. a tectonically activated basement and 2. a recycled orogeny.

The continental provenance is a characteristic feature of the Lúžna Formation. The source from a recycled orogeny influences the composition of sandstones in the Northern and Southern Gemericum and in the innermost tectonic units. A dissected magmatic island is a possible source of material for the Lower Triassic sandstones of the Hronicum Unit.

The sandstones of the Silicicum Unit represent a particular group of sediments. The proportion of plagioclases and fragments of volcanic detritus is so high in them as to show an affinity to a volcanic arc source (FEJDIOVÁ in FEJDIOVÁ & SALAJ, 1994).

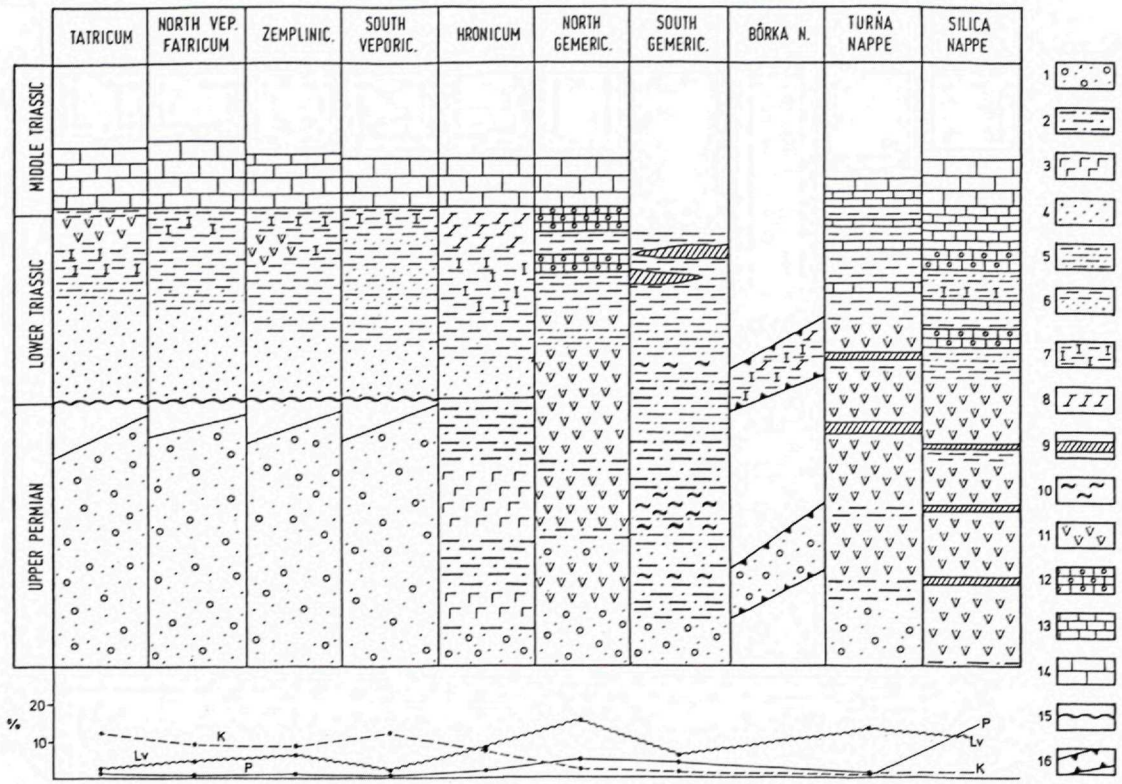


Fig.1 Distribution scheme of main Permian-Lower Triassic lithofacies with expression of mutual relations among different tectonic units of the Western Carpathians (compiled by A. VOZÁROVÁ). Accompanying diagramme shows the contents of basic components in sandstones.
1 - Upper Permian coarse clastic facies of "red-beds type; 2 - sandstone - shaly facies associated with Upper Permian "red-beds", 3 - andesite - basalt volcanics of Hronic Unit; 4 - mineralogically mature mostly continental Lower Triassic clastic sediments of alluvial flood plain; 5 - sandstone - shaly facies deposited in sabcha-lagoonal andnear shore environment; 6 - sandstones alternating with shales; 7 - shales with nodules or lenses of anhydrites; 8 - dolomitic shales, laminae of dolomites alternating with shales; 9 - dolomites, dolomitic limestones; 10 - shales and finegrained sandstones with small lenses of albitolites, phosphorites and phosphatic sandstones; 11 - massive gypsum, anhydrites with horizons of evaporitic breccias; 12 - calcarenites, oolitic limestones; 13 - marly limestones; 14 - shallow water dolomites, limestones; 15 - unconformity; 16 - thrust nappe boundary.

♦ Reconstruction and paleogeography of the Late Paleozoic basins of the Western Carpathians

Anna VOZÁROVÁ and Jozef VOZÁR

We characterize the development of Late Paleozoic basins of the Western Carpathians as follows:

1. The Carboniferous - Permian basins of the Western Carpathians, formed as temporal and spatial consequences of collisional events of the Variscan Orogeny

2. The distribution of Carboniferous - Permian basins in time and their lithofacial character of their filling document a south-vergent polarity of the Variscan Orogeny in the Western Carpathians.

3. As far as the polarity of Variscan Orogeny is concerned the Carboniferous - Permian basins formed in three zones, which differ from each other in both, the type of crust and their position. These are:

a) The Tatro-Veporic Domain, which comprises the terranes belonging to the upper continental plate with the maximum manifestations of magmatism and metamorphism, associated with the convergent subductional regime. In the recent Alpine structure the Tatric superterrane, together with the Kohút and the Ipoltica terranes, represent relics of this continental plate, which also contained, apart from probable fragments of a Pre-Cambrian crust, the elements of converging margins, it means the remnants of magmatic arcs, or eventually back - arc basins, associated with the Variscan Orogeny. Within this innermost zone of the Variscan Orogeny there formed only continental Upper Carboniferous - Permian basins, associated with transpressional-transtensional regime.

b) The Spiš superterrane, composed of the Klátov and the Rakovec terranes, which represent different relics of plates with oceanic to transitional crust. The sedimentary basins generated within this zone reflect the progression of Variscan collision. This relic of a Variscan suture is composed of tectonically squeezed scales of subducted oceanic crust and probably also includes a destructed island arc and remnants of collisional and post-collisional Carboniferous-Permian basins. The latter are represented by deep- to shallow marine Post-Bretonian intrasutural basins as well as by a shallow sea Post-Sudetian peripheral basin. They are disconformably overlapped by a Post-Asturian continental molasse.

c) The Gelnica terrane represents a relic of a for-arc basin filling associated with the ensialic magmatic arc at an active continental margin. On this background the Post-Asturian continental basin formed there under conditions of transform, shearing related, rifting regime. It is very probable that the Gelnica terrane was lateraly connected with a flysch trough, of which the relics were found as a tectonic outlier in the drill hole BRU-1 and may be correlated with the occurrences in the Szendrö Mts. If this presumption is correct, then the Middle Carboniferous trough, represented by the Turiec Formation and the Szendrö Phyllite Formation was associated with the subductional regime. The closure of this basin was connected with the Asturian movements and the subducted crust was probably totally destroyed. In palinspastic terms, this zone is linked directly with the Southern Alpine-Dinaride flysch zone, whose bonds with the lagoonal-shallow sea formations of the African plate's passive margin, are evident.

4. Basing on the findings of relics of the Carboniferous- Permian basin fillings in the Western Carpathians the following two temporally different zones of the continental collision were identified:

a) Internal - Bretonian-Sudetian (relics of the Spiš superterrane within the Alpine unit of the Northern Gemericum and intracontinental basins in the Tatro-Veporic Domain);

b) Outer - Asturian (the Gelnica terrane and associated outliers of the Middle Carboniferous flysch in southern Slovakia and northern Hungary).

Both sutures represented zones of extension and space reduction during the Alpine Orogeny. It was mainly the Asturian suture that represented a zone of maximum extension and rifting, which resulted in formation of the northern branch of forthcoming Vardar ocean.

♦ Characteristics of Permian volcanics based on zircon typology

Igor BROSKA, Pavol UHER and Jozef VOZÁR

The results of typological examination of zircons from the Permian volcanics and their pyroclastics of rhyolitic to dacitic composition indicate that the following differences exist in the character of volcanicsm in the areas under study:

1. a polyphase character of Permian rhyolitic volcanism was ascertained. The synsedimentary volcanism was of subalkaline to alkaline nature.

2. The zircons found in the northern Veporicum indicate a lower temperature calc - alkaline trend of Permian volcanism.

3. The zircons from both the northern and southern Veporicum indicate the crystallization under conditions of high temperature alkaline environment.

4. The acidic ignimbritic extrusions, found in the Stephanian-Permian sequences of the Zemplinicum, contain zircons whose typology suggests to calc-alkaline to subalkaline trends, with higher I.A and I.T parameters.

5. The zircons in rhyolites near Telgárt (Silicicum Unit?) have a typologically distinct alkaline and high temperature character.

The alkaline, high temperature character of zircons in the rhyolites of Silicicum, Veporicum and Tatricum Units indicates that the origin of rhyolite magmas should be sought in the deeper portions of the continental crust.

The presence of calc-alkaline, sub-alkaline to alkaline acidic volcanism, spanning in the Western Carpathians times from the Permian to Lower Triassic, indicates a transformation of geotectonic regime from an early molasse (calc-alkaline to subalkaline intermediary - acidic members of the Lower to Middle Permian) to a post-orogeny stage of consolidation, accompanied by alkaline magmatism (Upper Permian - Lower Triassic), (cf. BONIN, 1990).

♦ Composition of Carboniferous sandstones of the Gemericum Unit

Anna VOZÁROVÁ

A petrofacial method has been applied to reconstruct the development of the Late Paleozoic sedimentary basins of the Western Carpathians. The analysis of sandstone petrofacies was based on their spatial and temporal distribution. 296 analyses of modal composition of Late Paleozoic sandstones (VOZÁROVÁ - VOZÁR 1988; VOZÁROVÁ 1990) were used.

A petrographical analysis of the Ochtiná and the western part of the Hámor Formation metasandstones confirmed that both clastic groups have shared a common source of clastic material. Apart from quartz the clastic grains include feldspars and rock fragments as the main components. In spite of low grade metamorphism all metasandstones are characterized by predominance of fragments over the grains of clastic feldspars. Among the feldspars the plagioclase rock fragments distinctly prevail over the alkaline felspars. The metasedimentary fragments represent a majority among identified rock fragments, while the volcaniclastic fragments are less widespread.

According to abundant literary data, such composition of sandstones can be derived from a recycled orogenic source. The term recycled orogeny is meant to refer to the following source areas: a) subduction complex, b) collisional suture belt, c) back-arc, reversed thrust fold belt (DICKINSON - SUCZEK 1979; DICKINSON - VALLONI 1980; DICKINSON 1982, SUCZEK - INGERSOLL 1985 and others).

On the basis of their composition and provenance, the sandstones of the Ochtiná and Hámor Formation can be termed quartzolithic petrofacies (defined by DICKINSON et al 1986), characterized by low contents of feldspars and granitoid rock fragments, high content of metasedimentary and sedimentary detritus and variable content of poly- and monocrystalline quartz.

The observed data confirm, that the source area was situated within a Variscan suture of collisional type, as already inferred from the analyses of sandstones of the Rudňany and the eastern part of the Hámor Formations.

Finding of an identic source for sandstones of both the Ochtiná and Hámor Formations from the type region reject those tectonic interpetations, which question either pertinence of the Ochtiná Formation to the Gemericum Unit. Distinct difference in the composition of detritus in the Upper Carboniferous sandstone of the Hronicum Unit on one hand and sandstones of the Hámor Formation on the other, eliminates their visualization as members of the same sedimentation area (MAHEL'S concept, 1986, considering the function of the Hámor Formation as a root zone for the Choč nappe).

♦ Isotope composition of oxygen and carbon in Lower and Upper Carboniferous carbonates of the Gemericum Unit

Jarmila ĎURKOVIČOVÁ, Anna VOZÁROVÁ, Ivan REPČOK, Ivan RÚČKA, A. KOVÁŘOVÁ, Emília HARČOVÁ and Elígia FERENČÍKOVÁ

We have analysed the isotopic composition of oxygen and carbon in some of the well geologically and petrographically characterized carbonates of the Gemericum Unit. The following rocks have

been analysed: limestones from the Zlatník Formation, limestones, dolomites and magnesites of the Ochtiná Formation and limestones and magnesites of the Črmeľ Group. An additional set of samples has been processesed with the aim to correlate the results: limestones of the Silica Nappe, limestones and dolomites of the Foederata Group from the G-37 drill hole, limestones and dolomites from the DRŽ-1 drill hole, limestones and dolomites of the Dúbrava Beds, limestones from the BRU-1 drill hole,

Distinct differences in isotopic composition of oxygen in the series limestone - dolomite - magnesite can be observed in the Ochtiná Formation. The isotopic composition values correspond to the degree of metamorphism, the age of sediments and to shallow sedimentary environment.

On the basis of isotopic composition of C and O in magnesites and paleothermometric investigation, two types of solutions took part in the formation of magnesites:

a) solutions, whose $\delta^{18}O$ = - 1.7 to + 1.5 per mille is close to the composition of the sea water (for coarse grained magnesites with decrepitation temperature 140-180 °C);

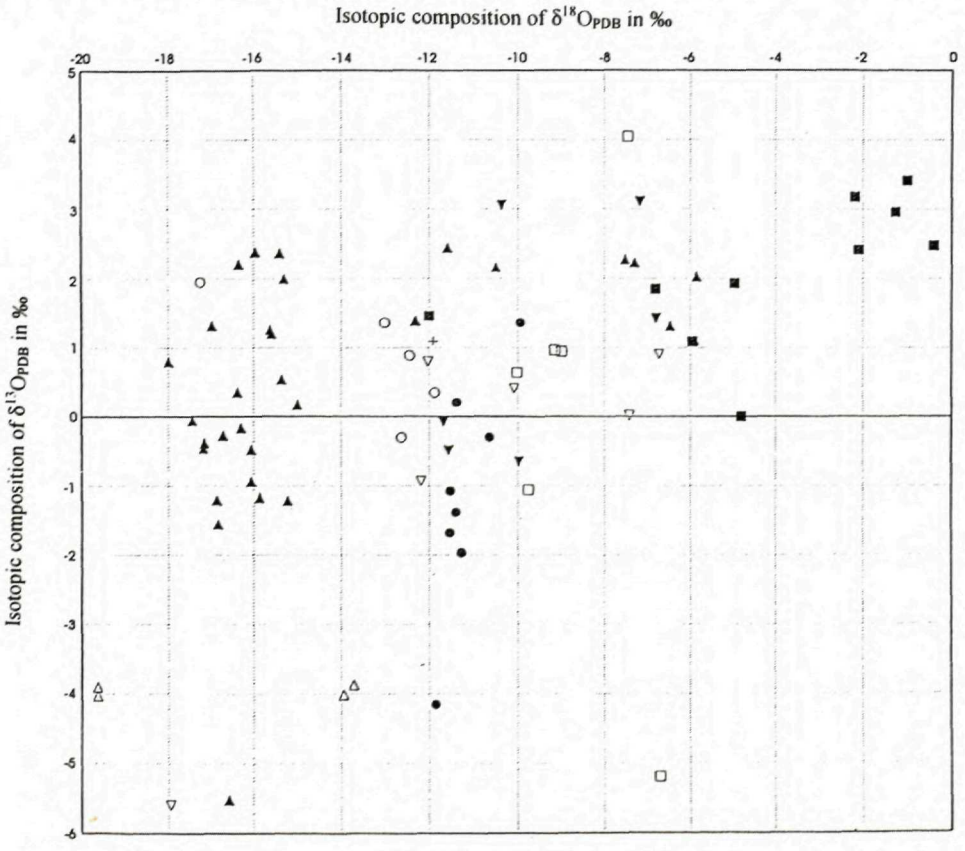
b) solutions with isotopic composition ranging from $\delta^{18}O$ - 8 to -4.5 per mille, in which the influence of meteoric waters is evident).

A different isotopic composition of carbon - i.e. increased content of light isotope, was recorded in rocks of the Črmeľ Group. However, owing to limited number of analysed samples we cannot take these values for quite representative.

The set of rocks from the BRU-1 drill hole comes from a carbonate olistostrome of Carboniferous age. It is illustrated by small differences in isotopic composition of oxygen and its increased values in relation to the Ochtiná Formation.

The values of $\delta^{18}O$ and $\delta^{13}C$ for the Zlatník Formation are nearly equal to those carbonates, present in the BRU-1 drill hole. They represent the shallow water organodetritic limestones, affected by but very low degree of metamorphism.

A distinct group of samples exemplify the carbonates from the Dúbrava beds. Their oxygen isotopic composition ranges from -12 to - 6 per mille, while the variation in isotopic composition of



■ Mesozoic of Turňa and Silica Nappe as well as eastern part of Bôrka Nappe
□ G-37 Dobšiná Hámor, ▼ DRŽ-1 Jelšava Form, ∇ Dúbrava Beds,
● BRU-1 Turiec Formation, ○ Zlatník Formation, ▲ Ochtiná Formation, Δ Črmeľ Group

carbon is but small. These rocks were metamorphosed under conditions of the upper part of the green schist facies. However, their oxygen isotopic composition is higher compared to that of the slightly metamorphosed rocks of the Zlatník Formation. The isotopic composition of oxygen in some of the samples from the Dúbrava beds approaches that of the metamorphosed Mesozoic complexes of the Bôrka nappe (Medzev - Šugov, Bôrka). This may indicate an affinity of the Dúbrava Beds to the metamorphosed Mesozoic of the Bôrka nappe.

Thus, application of isotopic research enabled us to distinguish reliably the rocks affected by different degrees of metamorphism (the Silica, Bôrka and Turňa nappes, the Foederata Group) as well as various sedimentation conditions (marine, shallow water, or hypersaline).

♦ Relation of basins at the contact of Outer and Inner Carpathians

Michal POTFAJ, Tibor ĎURKOVIČ, Milan KOHÚT, Jarmila RAKOVÁ and Ondrej SAMUEL

Based on a lithostratigraphic and facial analysis of the stratigraphic sequence, the Biele Karpaty Unit could be excluded from the group of the Magura nappes and sequences and redefined as an independent lithofacial and tectonic unit. The Biele Karpaty Unit is neither a facial, nor a tectonic equivalent of the Oravská Magura (or Krynica) Unit, but, in paleogeographic terms, it represents a more internal structural and facial element, compared to those of the Magura Units.

The Biele Karpaty Unit is composed of two sequences: the more western Hluk group and the eastern Vlára group. The Vlára group is almost exclusively restricted to the Javorina nappe structure. The Hluk group displays a certain affinity to the Magura sequences (increased contents of siliciclastic material), the Vlára group, in turn, contains mixed carbonate-siliciclastic sequences. In the composition of the Vlára group clastics a considerable proportion represents the dolomite. Their source remains enigmatic.

Facial features of the Vlára group indicate a progradational trend, whereas the older formations are sediments of the lower/middle fan and the younger display the features of the upper part of middle fan. Facial equivalent of the Lopeník formation, in a proximal position, are the Jarmuta beds, while the equilvalent of the Rajkovec Formation, in the apical zone of the fan, are the Proč beds. Their petrographical composition, as well as their age, coincide and the corresponding facies are not in a contradiction. The size of missing connecting space is estimated to range from 5 to 30 km.

An area which should be formed by marginal facies, and should fringe the Eocene "Orava cordillera" is missing at the northern margin of the Inner Carpathian Paleogene. It had a character of an elevated, linear source, with shallow litoral carbonate shelf margin.

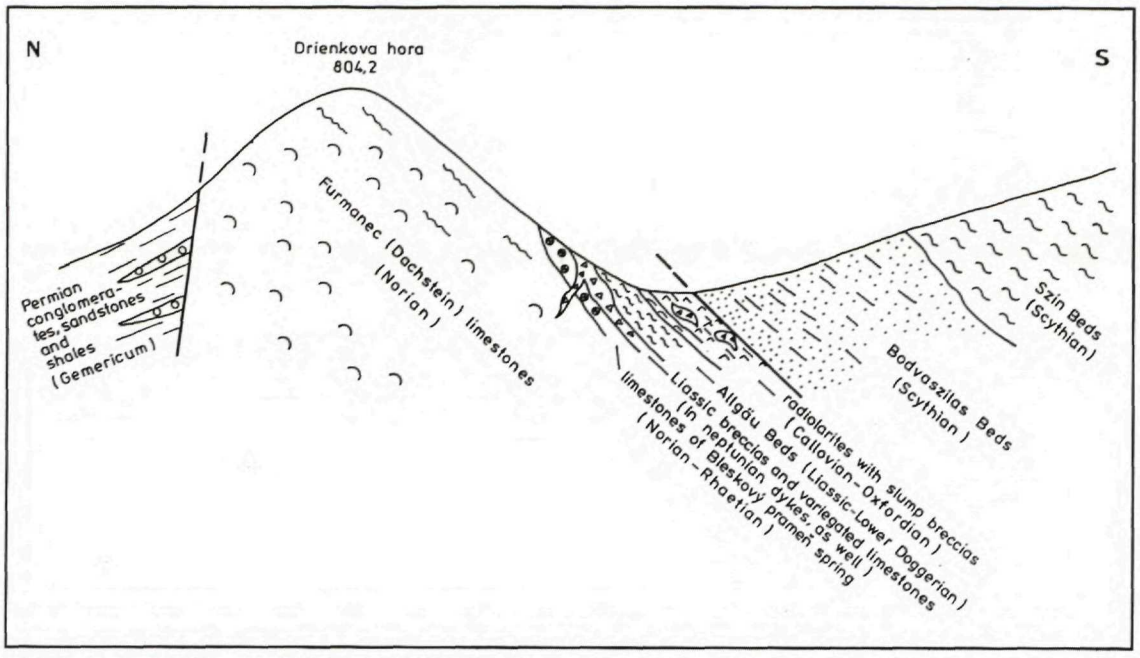
The communication of the Biele Karpaty Mts. and the Klippen belt area during the Sennonian time is interpreted as linking the Javorina and Rajkov member with the Jarmuta and Proč beds, respectively, in the Pieniny section of the Klippen belt. However, the evidence is missing to link it farther south of the Klippen belt. Communication between the Magura and the Inner Carpathian regions at the break between Eocene and Oligocene in the western section does not seem probable.

On the basis of facial and tectonic reconstructions a theory of a sinistral movement along both sides of the Klippen belt has been pronounced. The magnitude of slip at the outer side has been estimated to reach some 100 km, while the calculated velocity of movement during the period Middle Oligocene - Early Miocene was 1 cm/y.

Meliaticum - geological development, position and relation to surrounding units

Ján MELLO

Because the questions related to the Meliaticum and neighbouring units ended in a blind alley, which should be due to sustaining the view that the Silica nappe originated from a sedimentation area situated more north relative to actual Meliaticum, this report tests a concept of its possible provenance in a southern shelf.



Geological cross-section of Drienkova Hora Mt. near Drnava (Upper Jurassic Duplex in Silica Nappe) J. MELLO, 1993 (not to scale)

This concept agrees with the structural record of RICOU (1986) and HÓK - KOVÁČ (1993) stating that both the Silica and Turna nappes moved towards N and NW. This concept is also supported by the entire structure with northern vergency, which was confirmed by seismic measurememnts along the section G-1 (VOZÁR et al 1993).

In such case it is needless to consider an improbable gravitational sliding of the Silica nappe towards south, followed by its repeated thrusting towards north. We have no evidence for this, nor the time would be sufficient to open an oceanic realm and to close it repeatedly again, which would have to take place in a relatively short time span between the Pelsonian and Lower Oxfordian; this is evidenced by Pelsonian fissure fillings within the Meliaticum and the youngest beds (radiolarites) in the Drienková hora hill duplex near Drnava.

As demonstrated at several localities, the superposition of tectonic units in the area is following (from downside up): Gemericum, Bôrka nappe/Meliaticum, Tornaicum and Silica nappe. Should we base our palinspastic reconstruction on the above mentioned structural observations, it would be logical to expect the arrangement of the units in the same order, from north to south.

The data on Meliaticum in the Eastern Alps (MANDL - ONDREJÍČKOVÁ 1991) as well as correlations of the Mürzalpine and Schneeberg nappes with the "Süd-Rudabánya (KOZUR-MOSTLER 1992) indicate that the situation is in both areas very analogous: In Western Carpathians and in Alps alike the units, originating from the slope and shelf south of Meliatikum, were thrusted aloft the Meliaticum. The correlation proposed by KOZUR and MOSTLER (1991) should, however, be amended in that the Mürzalpine and Schneeberg napes are facially almost identic with the Stratená, Muráň and Silica nappes, this correlation being known since long time ago and nobody questions it (most recently referred to e.g. by TOLLMANN 1988). This correlation confirms the newest results of geological mapping carried out in both areas.

However, this concept also poses problems, which can be summarized in the following three points:

1. If the Silica nappe originates from the area south of Meliaticum, then the Choč nappe should also originate there (related and contiguous facies). This is, in turn, closely related to the Krížna nappe, as they both have common Lunz beds facies, the Hauptdolomit and eventually also the Carpathian Keuper. The explanation has been proposed by RAKÚS (1993).

2. Problem of facial polarity: it is well known that most of the basinal facies are found at the southern margin of the Silica nappe in spite of the fact that, if it were in agreement with this models rather the carbonate platform facies should be present there. One way to explain this is that the car

bonate platform facies were thrusted in a form of higher nappes (duplexes) farther north, whereas the basinal ones remained behind. Facial relations within the framework of individual bodies will have to be studied in detail.

3. Supply of clastic material into the Meliaticum and the Turna nappes during the Karnian times should have been from the south, but it could not be possible through the Silica nappe, which is absolutely free of clastic admixture.

Another particular problem to be solved is associated with the interpretation of the Jaklovce Meliaticum. This is bound to the Črmeľ zone, or to the root-scar respectively, which delineates the thrust between the latter and the Rakovec zone. This zone disappears (wedges out, it is cut away, or dips downwards) in the area of Kluknava - Krompachy. However, it is possible that it has, or had a more thorough continuation underneath the Paleogene of the Hornád basin, as it supplied abundant material into the Upper Cretaceous conglomerates at the Dobšinská ľadová jaskyňa ice cave (HOVORKA et al 1990). This indicates, that the Meliata "ocean" could have had several branches and stages as was e.g. the case in the Vardar ocean in the Helenides. Discrete oceanic branches (belts) could have been separated by slopes, or "microcontinents". The Spišsko gemerské rudohorie ore mountains could have been one of them. This scenario also suggests RAKÚS (1993) in his palinspastic reconstruction.

Project: HYDROGEOLOGIC RESEARCH OF SLOVAKIA

Vladimír HANZEL

This project has been implemented during 1991 - 1993. It is divided into the following 4 partial projects: 01 - Hydrogeologic research of selected regions of Slovakia; 02 - Basic hydrogeological maps at a scale 1:50 000; 03 - Methods of assessment of hydrogeologic parameters for regional prognoses and optimization of utilization of ground waters and 04 - Isotopic research to establish the origin of ground waters.

Complex hydrogeologic evaluation with the delineation of hydrogeologic structures, quantification of prognostic exploitable resources of groundwaters, amounting to 513 $l.s^{-1}$, the evaluation of quality of groundwaters and their protection from the polution, were made within the framework of the project 01 in the regions of Malé Karpaty, Biele Karpaty and Spišská Magura Mts.

The work on the project 02 resulted in completion and acceptance of a unified method for the construction of hydrogeologic maps at a scale 1: 50 000. In agreement with this method nine hydrogeologic maps at a scale 1: 50 000, along with the explanations, were constructed for the regions of Záhorská nížina lowland - northern part, the Chvojnica pahorkatina hills, the Hornonitrianska kotlina basin and Vtáčnik Mts., the Kriváňska Malá Fatra, the Zvolenská kotlina basin, the Breznianska kotlina basin, the Levočské vrchy hills, the Branisko Mts. and the Šarišská vrchovina highlands.

Contructed hydrogeological maps present the informations on principles of the development of ground waters, on the geometry of aquifers and their filtration parameters, on character of ascension of the ground waters and their utilization. The maps will serve a indispensable background for water management organizations, for rational use and preservation of the ground waters, for the regional planning and location of various waste disposals.

Project 03 is methodologically conceived. 5 topics were resolved within the framework of this project, with the objective to work out a method of appraisal of the hydraulic parameters and application of the methods for optimization of ground water usage, the assessment of structural-hydrogeological function of the Triassic rocks of the Krížna nappe in the Veľká Fatra and to correlate the lineal data of remote sensing of the Earth with some of the hydrogeological features.

Realization of this project resulted in: Proposal of optimal complex of direct and indirect methods to assess hydraulic parameters of rocks for regional prognostication; work out and application of methods for optimal use of ground waters and appraisal of methods in terms of ecology, selecting of 42 prognostic localities to be checked for optimal use of ground waters; based on hydrogeological balance, combined with application of hydrogeochemical and isotopic methods, a structural-hydrogeological scheme of the rocks of Krížna nappe of the Veľká Fatra Mts. was constructed, which represents actual aspect of the circulation of ground waters, because the thorough knowledge of circuits represents essential entry information to assess the conditions of their preservation; analytical interpretation of the relations of lineament courses, identified from various sources of remote sensing of the Earth and from the geological map, new concepts of the distribution of fault zones in the drainage basin of the Hnilec River in Volovské vrchy hills, were made.

Project 4 has been conceived to contribute in implementation of the previous projects. It deals with the wide range of problems related to the provenance and genesis, with infiltration, accumalation-transporting and exsurgence regions, with various genetic types of waters, their mutual relation and effects. Based on gauging study and the isotopic composition of oxygen in waters and sulphate sulfur, the origin of ground waters as well as correlations among the discrete sources of waters in the Veľká Fatra, the Pezinské vrchy hills, the Levočské vrchy hills and the Oravice and origin of geothermal waters in the Liptovská kotlina basin, the Central depression and the Komárno high block were made.

The results achieved within the framework of this project represent general contribution, which stems from its wide applicability in various projects and needs of the society. Economic contributions of the project are as follows: delineation of the water management prognostic regions, quantificationof the prognostic exploitable sources of groundwaters and construction of the hydrogeological map at a scale 1:50 000 with explanations for 9 regions. The results attained in the projects 03 and 04 are mostly scientific contributions.

The entire project comprises a total of 19 completed and succesfully approved final reports.

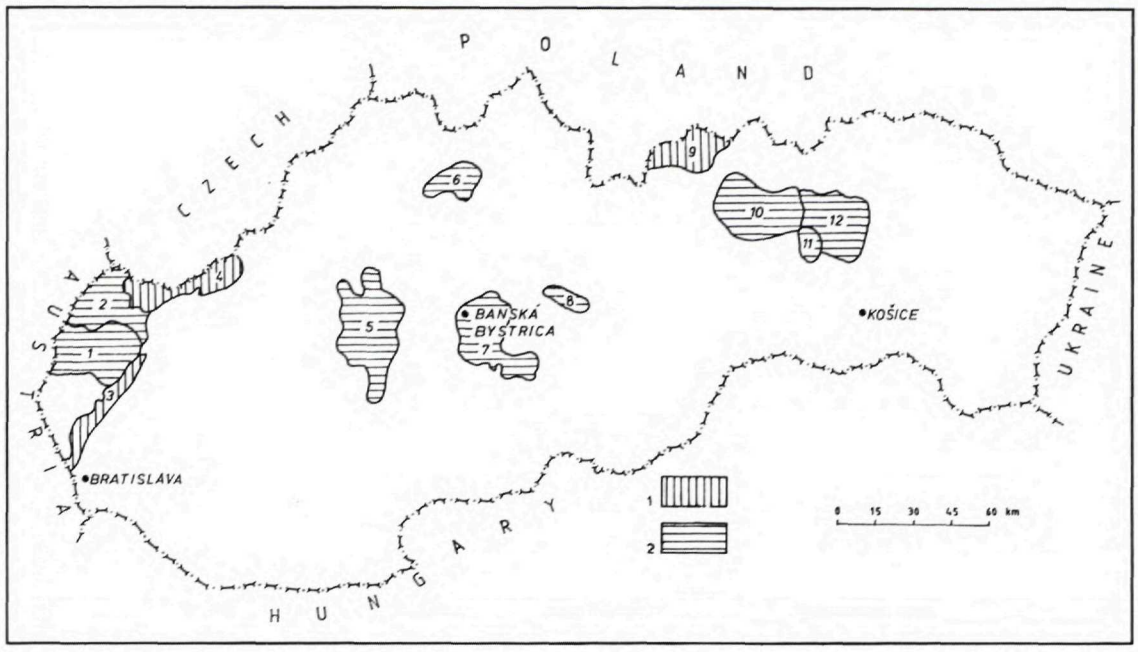


Fig. 1 Map of investigated regions

Explanations: 1) Regions with completed hydrogeological research, 2) Regions covered by hydrogeological mapping at a scale 1:50 000

Titles of regions: 1. Záhorská nížina basin - northern part, 2. Chvojnická pahorkatina - upland, 3. Devínske and Pezinské Karpaty Mts., 4. Biele Karpaty Mts., 5. Horná Nitra, 6. Krivánska Fatra Mts., 7. Zvolenská kotlina basin, 8. Brezninanska kotlina basin, 9. Spišská Magura Mts. 10. Levočské vrchy hills, 11. Branisko Mts., 12. Šarišská vrchovina highland

♦ Ground waters on western slopes of the Devín and Pezinok Carpathians

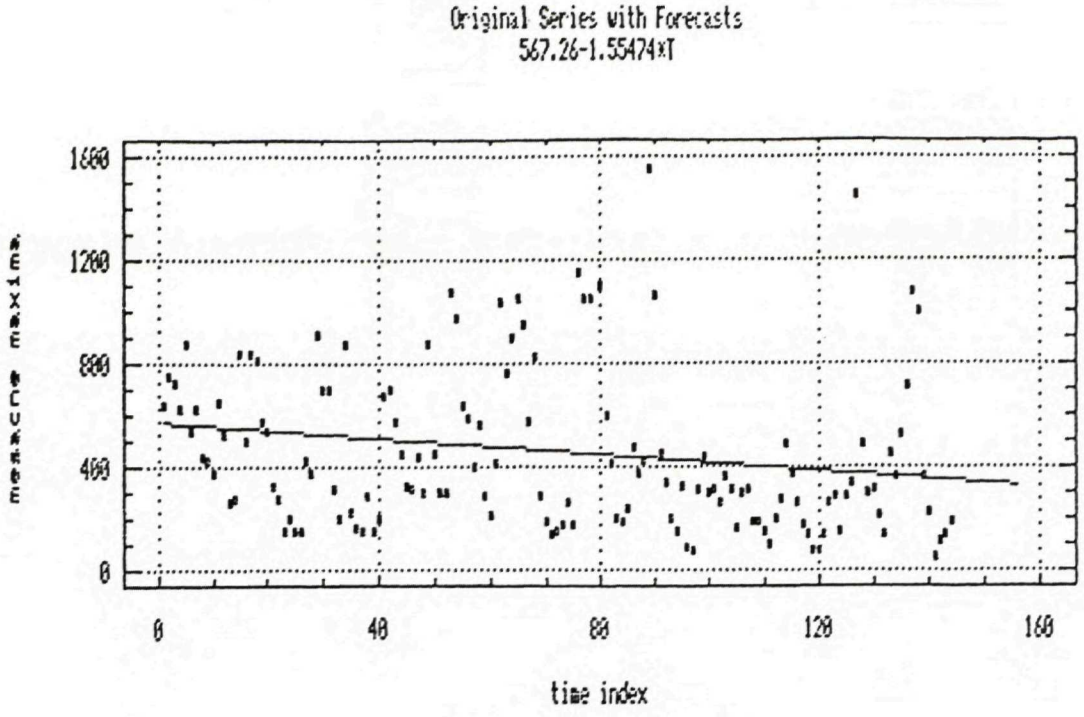
Vladimír HANZEL, Kamil VRANA and Svetlana ČIMBOROVÁ

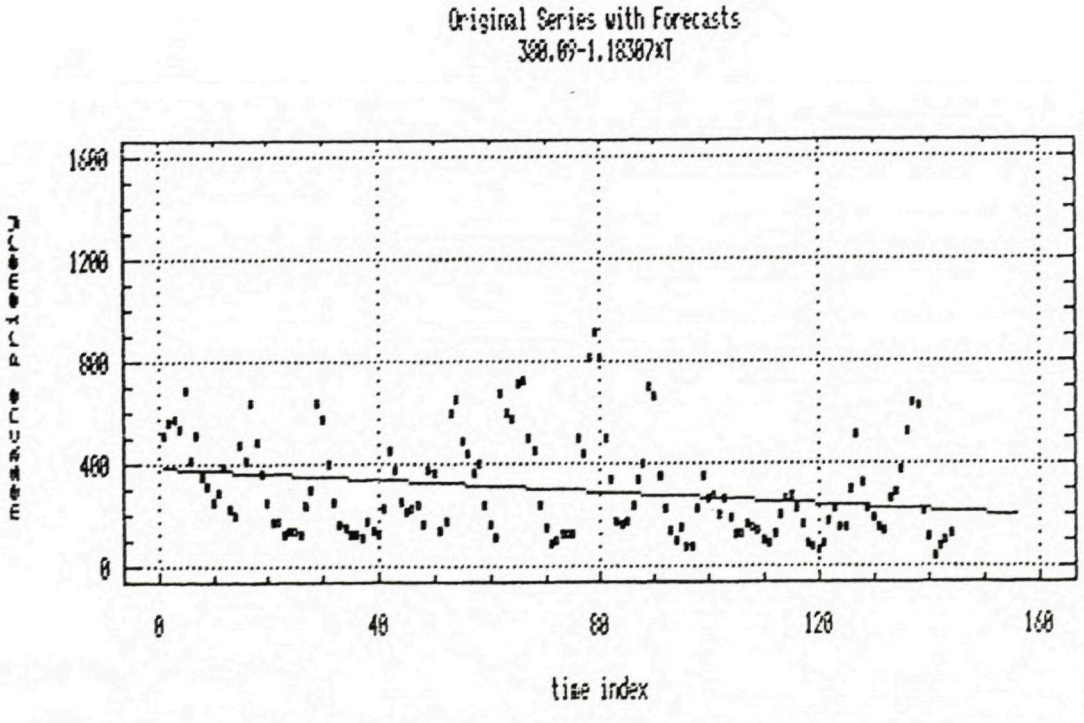
Based on geologic structure, three hydrogeological complexes were distinguished in the region. Crystalline hydrogeological complex, represented by the metamorphites and granitoids, drained predominantly by yield of springs up to 0.1 $l.s^{-1}$. Mean run-off of the ground waters from granitoids was 3.4 $l.s^{-1}.km^{-2}$ in 1992. Mineralization varies from 110 to 350.l^{-1}.

The second hydrogeologic complex is represented by Jurassic sediments of the Tatricum Unit with sporadic occurrence of Triassic carbonates. Liassic limestone of the Borinka unit is the most important aquifer in the region. The most yielding springs in the region are the Pajštún exsurgence with the yield from 9.0 to 871.0 $l.s^{-1}$ and the Limbach exsurgence with the yield from 0.0 to 203.6 $l. s^{-1}$. Mean run-off of groundwaters from the Borinka unit hydrogeologic structure was 6.8 $l^{-1}.s^{-1}.km^{-2}$ in 1992. Groundwaters are maily of the Ca-HCO_3 type, containing 350 to 600 $mg.l^{-1}$ of mineralization.

Hydrogeologic complex of the Neogene and Quaternary sediments is deficient in springs. Drill holes ascertained the sources of ground waters with yields from 0.13 to 12.1 $l.s^{-1}$ in the Neogene sands, gravels and conglomerates of the Malé Karpaty block region. Compared to waters in the Mesozoic, these have higher mean mineral content - 680 mg $.l^{-1}$. Yields of the drill holes within Quaternary sediments range from 0.2 to 33.0 $l.s^{-1}$. From the hydrogeologic point of view the Devínska Nová Ves terrace is the most important.

Trend analysis of the run-off waters from the Stupavský potok creek drainage, which drains Borinka unit structure, has shown that during 1981 - 1992 the run-off of underground waters decreased for 39 to 45 % (Fig. 1a, 1b) .

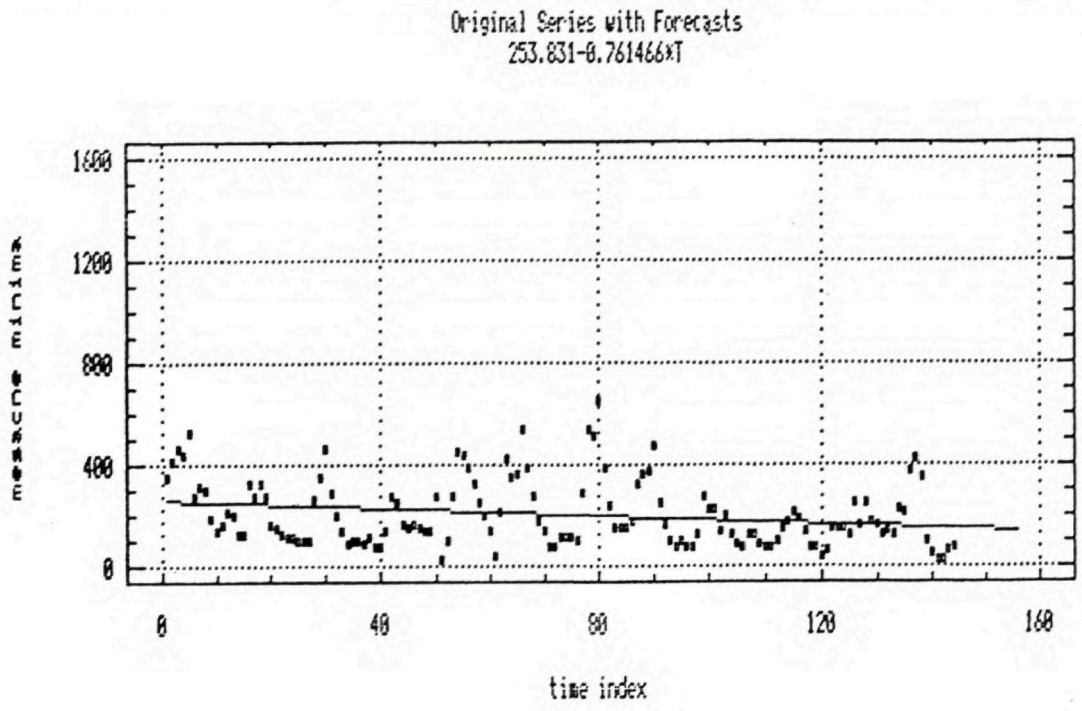




Water budget evaluation of the Borinka structure in 1992 has shown that some 39.0 $l.s.^{-1}$ of groundwater has been lost to Neogene sediments of the adjoining part of the Záhorská nížina lowland and to the Neogene basement.

455.5 $l.s^{-1}$ of the prognostic reserves of groundwaters have been appraised. Based on the gauging observations of springs with yields exceeding 1.0 $l.s^{-1}$, 213.7 $l.s^{-1}$ of the above quantity were documented groundwater sources, 83.0 $l.s^{-1}$, coming from drill holes, all totalling 296.6 $l.s^{-1}$ of documented groundwater sources.

From the water management point of view, the important chemical components meet the criteria of the ČS norm 75 7111, the nitrates only being increased due to sheet-wash of infiltrating waters through forest soil.



5120 Borinka – Stupavský potok 1981-1992

Data: mesačné maxima					Percent: 100
Forecast summary	M.E.	M.S.E.	M.A.E.	M.A.P.E.	M.P.E.
567.26–55474*T	0.00000	111875	243.332	87.4956	-62.65993

Data: mesačné maxima					
Forecast summary	M.E.	M.S.E.	M.A.E.	M.A.P.E.	M.P.E.
380.09–1.18307	0.00000	35197.9	151.521	76.7235	-49.9394

Data: mesačné maxima					
Forecast summary	M.E.	M.S.E.	M.A.E.	M.A.P.E.	M.P.E.
253.831–0.761466*T	0.00000	15593.8	100.558	80.9611	-54.1915

Fig. 1 Trend analysis of the run-off waters from the Stupavský potok creek

Based on the geological structure, the results of geophysical measurements and water budget evaluation it has been presumed, that a part of grounwaters of the Borinka structure as well as from the Devínska Kobyla is being lost to Neogene sediments of the adjoining SW part of the Záhorská nížina lowland. Gauging observation of the Jelšovec spring, as well as the results of structural drill hole DNV-1 (Devínska Nová Ves), which intersected Mesozoic limestones in the footwall of Neogene sediments, however do not enable to assume that a portion of waters has been contributed from affluents along the faults from the basement, from the Mesozoic carbonates.

According to hydrogeologic evaluation, several water management prognostic areas have been delineated in the region. These are as follows: central part of the Prepadlé valley, verified by the PKH^{-1} drill hole, tectonic contact of the Borinka Unit with Neogene in the Stupavský potok valley W of the Borinka village and in the Vápeničný potok valley, verified by the drill holes PKH-2 (Borinka) and MKZ^{-1} (Vápeničný potok), as well as the area of Devínska Nová Ves terrace. However, this area is even more interesting in terms of presumed aquisitions of the geothermal waters.

♦ Hydrogeological research of Spišská Magura

Ján JETEL, Ján NEMČOK and Ján TKÁČ

Hydrogeological research of the Spišská Magura gave a thorough picture of hydrogeological features within the Innercarpathian Paleogene of the region under study. This region represents a hydrogeological massif with the groundwater circuit, concentrated predominantly in the subsurficial zone, reaching the average depth of 20 - 50 m. Positive correlation exists between the mean permeability and the proportion of sandstones in the assayed section of the drill hole. However, maximum permeability and discharge are bound to tectonically dependent fault belts, usually detached from lithology.

55 sites of concentrated groundwater circuits in 30 sections 65.4 m long were identified by means of geophysical research (symmetric resistance survey, induced polarization). 4 hydrogeological research wells, drilled down to 150 - 200 m through the Šambron beds, situated according to the geophysical interpretations, brought explicit knowledge on the hydraulic parameters of rocks and hydrogeochemical characteristics. The SMJ-1 Veľká Lesná well intersected disturbed sandstones and conglomerates of the Šambron beds, with the weir of sulfuric mineral water with the content of mineralization amounting between 0.69 and 0.81 $g.l^{-1}$, containing 7.0 - 11.4 $mg.l^{-1}$ H_2S (steady exploitable yield 5 $l.s^{-1}$, with possible temporary consumption of 8 - 9 $l.^{-1}$. The SMJ-3 well at Strážany produced a potable water source with the yield of 1 $l.s^{-1}$. The SMJ-4 well at Veľká Franková is a source of sulfuric mineral water with the content of mineralization between 0.53 and 0.65 $g.l^{-1}$, containing 2.1 $mg.l^{-1}$ H_2S (weir 0.2 $l.s^{-1}$, permanent pumping 1.0 $l.s^{-1}$.

Complex evaluation of hydrogeologic testing data from previous as well as fresh wells resulted in interpreting the spatial distribution of hydraulic parameters of the Paleogene rocks. Discharge of the bed (valley) category, which characterizes the depressional parts of the area is, at its best, represented by the discharge coefficient values T = 1.10-4 - 5.10-4 $m^2.s^{-1}$, the most common range being however T = 4.10-5 - 1.10-4 $m^2.s^{-1}$. The average values of the filtration coefficient in the best permeable, the most surficial parts of the subsurficial zone ranges betwen k = 1.10-5 - 3.10-5 $m^2.s^{-1}$, the majority of average values within the subsurficial zone of Paleogene being in the range k = 3.10-7 - 1.10-5 $m^2.s^{-1}$. Average permeability of the subsurficial zone is 2 to 3 times higher within the sandstone lithofacies (Biely potok group of strata) than in Šambron beds.

Predominance of sandstone has favourable effects upon the average permeability only in cases of low representation of claystones and aleurolites (up to 25 %). In case of higher proportion of these lithotypes unequivocally, no further reduction of the average permeability dependent upon decreasing representation of sandstones in the examined section of the well, was found.

Exponential decrease of average permeability of Paleogene rocks in relation to depth is considerably faster close to the surface (down to some 20 m) than at greater depths. Thus, between the depths of 20 - 100 m, the average value of the coefficient of filtration is being reduced within each 10 m interval to 80 % of its initial value and between the depths of 0 - 20 m the average permeability drops to 22 % of its initial value. Expected values of effective (progressive) velocity of groundwater within the subsurficial zone in the major part of the region range roughly between 0.1 - 0.2 $m.d^{-1}$, whereas within the uppermost part of the subsurficial zone they can reach even 2 - 7 $m.d^{-1}$.

Groundwater chemistry is reflected in vertical hydrogeological zonality. Waters of descending springs and the upper part of subsurficial zone belong to the subzone CII and contain 0.19 to 0.54 $g.l^{-1}$; they represent usually the types CIIIa, or CII, molal subfacies C-Ca-Mg and correspond, according to the Gazda's classification, to the basic Ca-Mg-HCO_3 type. Besides of waters of the CI subzone with mineralization 0.41 - 0.55 $g.l^{-1}$, the waters of the "deeper" subzone CI, with mineralization 0.58 - 0.93 $g.l^{-1}$, corresponding to the basic type Na-HCO_3, in the C-Na-Cl, or C-Na-Mg subfacies, also occur in the deeper parts of the subsurficial zone. Waters of the CI subzone, with mineralization 0.58 - 1.39 $g.l^{-1}$, of the basic type Na-HCO_3 and usually in the C-Na-Cl subfacies, are thus typical for the deeper portions of Paleogene, below the subsurficial zone. They often display elevated contents of the amonia ions, hydrogen sulphide and organic matter. Predominance of Mg and Ca is typical for Na-HCO_3 waters.

From the biennial gauge monitoring of the flows, measured at 4 sites, the inferred average value of specific underground run-off amounted to 3.66 $l.s^{-1}$ $.km^2$. Within the monitored time span between

1992 - 1993, the average specific run-off of groundwaters ranged in discrete monitored drainage areas between 1.90 - 5.34 $l.s^{-1}.km^2$ (with the maximum in Osturňa creek). Abundance of underground run-off from the total of the precipitation may be estimated at 15 - 19 % in the Osturňa creek drainage system, 12 - 15 % in the Rieka (Staroveská dolina valley) and 6 - 9 % in the Toporský and Lesniansky creeks drainage systems.

Groundwater natural resources of the whole region (399 km^2) were quantified at 1460 $l.s^{-1}$. Prognostically exploitable amount of groundwater in the area floored by Paleogene in the Spišská Magura (without the Ružbachy Mesozoic) was estimated at 94 $l.s^{-1}$ and in the adjoining section of the Dunajec alluvium at 31 $l.s^{-1}$, i.e. totaling to 125 $l.s^{-1}$ of groundwater, exploitable as potable water. Groundwater quality usually meets the criteria of the ČSN 75 7111 norm (with occasional surpassing of the limiting contents of ammonia ions, Mn and Fe). Contents of nitrates are generally low.

♦ Hydrogeological research of SW slopes of Biele Karpaty Mts.

Anna ČECHOVÁ and Sylvia KÚŠIKOVÁ

Based on geological structure of the southwestern part of the Biele Karpaty Mts., three hydrogeological complexes can be distinguished.

Due to small extent of aquifers (Crinoid, organodetritic and Orbitoid limestones), the Mesozoic hydrogeologic complex produces predominantly but springs with yields of less than 0.1 $l.s^{-1}$. Springs yielding more than 1 $l.s^{-1}$, are scarce.

Within the Cretaceous and Paleogene hydrogeological complexes of the Biele Karpaty Mts. Unit, the subsurficial weathering zone is an aquifer. Fissure-, or strata-bound springs have little yields, seldom exceeding 1 $l.s^{-1}$.

Average specific run-off, ascertained by regime observations of surficial streams, amount in the Svodník group of strata to 1.3 l. $s^{-1}./km^{-2}$, whereas in the Javorina beds to 3.23 $l.s^{-1}./km^{-2}$.

Fluvial sediments of greater confluences of the Váh River and their proluvial cones, floored by well permeable gravel sediments are the most important from the hydrogeological complex of Neogene and Quaternary sediments. Neogene sedimets are represented in the area under study only marginally.

3 hydrogeological wells were drilled within the framework of hydrogeological research programme. The Drietoma hydrogeological well $BKČ^{-1}$ contributed to the knowledge of hydrogeological parameters of the Drietoma group of strata. Maximum pumped yield was 0.91 $l.s^{-1}$, at 41.5 m draw-down T = 6.01.10-5 $m^2.s^{-1}$. The BKČ-2 well was drilled in the Kysuce succession of the Klippen belt and the pumping tests demonstrated unsuitability of this rock complex for the exploitation of larger amounts of groundwater. Calculated discharge is 2.56.10-6 $m^2.s^{-1}$. The BKČ-3 well, which intersected the Javorina group of beds, was checked by a pumping test at the depth of 100 m. 1.67 $l.s^{-1}$ of groundwater was pumped, with a drow down of 42.6 m.

Total of 806 l. s^{-1} of prognostic resources of groundwaters were calculated in the evaluated area. Based on gauging observation of the springs and groundwaters from the wells, 108 l. s^{-1} of documented resources were calculated in the area.

This water management prognostic region may be divided into areas, floored by the sediments of the Javorina group of strata, with predominance of sandstones and the Klippen belt region, floored by Crinoid and sandy limestones and fluvial plains of greater confluences of the Váh River (Súčianka, Drietomica and Bošáčka). No great yields (up to some 2 $l.s^{-1}$) can be expected from hydrogeological wells, drilled in the Klippen belt and Flysch belt.

Biele Karpaty region, floored mainly by the Biely potok Unit and Klippen belt flysch groups of strata, are characterized by the groundwaters of shallow circuit. The majority of groundwaters of the flysch groups of beds are of the calcium - hydrogencarbonate type, with various representation of S_2 (SO_4) component, dependent on oxidation of sulfidic sulfur, which originates mainly from pyrite. Groundwaters of the flysch groups of beds are of carbonatogenic type. The last mentioned type is characteristic for deeper circuits (BKČ-1,2,3 wells at depth of 150 m). Mineralization in groundwaters of the shallow circuit ranges from 467.0 to 744.0 mg. l^{-1}. Waters from the wells contain increased mineralization - some 810 mg . l^{-1}. The wells located in the Quaternary sediments provide mainly waters with insignificant A_2 component, supplemented by S_1 and S_2 components. S_1 component is the main indicator of partially anthropogeneous contamination.

Groundwaters of the Klippen belt Mesozoic have characteristic Ca-HCO_3, or Ca-Mg-HCO_3 type of chemistry respectively, the (A_2 component ranging from 52.55 to 90.09 mval %), thus they are carbonatogenetic groundwaters. Mineralization in these waters ranges between 500 and 700 $mg.l^{-1}$, with the highest values in the wells influenced by secondary contamination.

Quality of groundwaters is good, with some exemptions, including waters from the wells, sunk in Quaternary sediments, less so in the Svodník group of beds, comprised in a group of anthropogenically influenced groundwaters. It is mainly for their increased contents of NO_3, that these waters do not meet the ČSN 75 7111 criteria for drinking water.

♦ Explanations to hydrogeologic map of the Záhorská nížina basin

František ČECH and Vladimír ZVÁČ

Hydrogeologic map of the northern part of the Borská nížina basin and the explanations, were made during 1992 - 1993 by the Department of groundwaters of the Faculty of Science, the Comenius University in Bratislava. This map features following hydrogeologic regions of the Borská nížina basin: Q 003 - Quaternary of the Myjava, Q 004 - Quaternary of the Morava in the Brodské - Vysoká pri Morave section, Q 005 - Neogene of the central part of the Borská nížina basin, Q - 006 - Quaternary and Neogene of the northeastern part of the Borská nížina basin and Q - 007 - Quaternary and Neogene of the near-carpathian southern and southeastern parts of the Borská nížina basin. Table 1 summarizes the data from 158 documentation points.

Sediment	Discharge ($m^2 s^{-1}$)	Standard deviation σY	Number of entries for σY(n)
N_k	$T_Y = 1.53 . 10^{-4}$	0.81	5
N_b	$T_v = 1.15 . 10^{-4}$	0.56	5
N_s	$T_v = 3.47 . 10^{-4}$	–	2
N_p	$T = 2.34 . 10^{-4}$	$3.25 . 10^{-4}$	30
N_{pt}	$T = 4.10 . 10^{-3}$	0.473	15
pQ	$T = 2.67 . 10^{-3}$	–	–
fQ	$T_Y = 1.74 . 10^{-3}$	0.275	8
eQ	$T = 1.27 . 10^{-3}$	0.38	30

Nk - sandy clays, sands, claystones, sandstones. Average number of aquifers: 3
Nb - sandy clays, with intercalations of coarse grained sands and gravels
Ns - marls, marly clays, sand beds
Np - lagoonal sediments, marly and coaly clays with frequent intercalations of sands and lignite Np - variegated clays, sands, gravels, coaly seamlets
pQ - sandy gravels, occassionally boulder-bearing, often clay- bearing (alluvial cones)
fQ - fluvial sediments and alluviums
eQ - aeolian sands
Ty - data on permeability, ascertained according to standard correlation methods (geometrical mean)
T - "strictly" determined data are the results of discrete hydrodynamic tests on existing wells, sy - standard deviation calculated from the data from Geofond.
n - number of data used for calcultion of parameters.

It follows from the stated above that the Borinská nížina basin is hydrogeologically defined by Quaternary and Neogene sediments (in the investigated area Karpatian to Pannonian; under the general title of Pannonian all the Pliocene sediments are probably included).

We divide the groundwater circuit into the following types:

- shallow circuit of the groundwater with distinct calcium - bicarbonate type of chemistry; deeper and deep seated sandy Neogene aquifers are characteristically natrium - bicarbonate, natrium - chloride - bicarbonate and natrium - chloride type of groundwaters.

In respect of the ČSN 75 7111 norm we can contend that increased contents of anorganic matter (Fe, Mn, NH4+) indicate the existence of anoxic environment within the Neogene and Quaternary basin fillings.

♦ Explanations to hydrogeologic map of Chvojnica pahorkatina upland at a scale 1:50 000

Anna ČECHOVÁ and Silvia KÚŠIKOVÁ

Chvojnica pahorkatina upland is floored by Neogene sediments, which are generally overlapped by Quaternary sediments. The most important aquifers are fluvial sediments of the Morava, Myjava, Teplica and Chvojica Rivers.

Flysch sediments of the Svodník group of beds of the Biele Karpaty Unit, charaterized by the fissure permeability, enter marginally the northern parts of the region. An aquifer in these sediments is the subsurficial zone of looseness of the rock massif (down to some 30 m). Subsurficial run-off from these sediments amounting to 1.28 $l,s^{-1}.km^2$, was assessed during 1981-1990 using the method of Kille. The yields of springs seldom exceed 0.1 $l.s^{-1}$. They frequently exsiccate during the dry seasons. Neogene and Quaternary hydrogeologic complexes were evaluated using mainly the archival data from the Geofond, these being, however, supplemented by reevaluation and documentation of 266 hydrogeologic wells and statistical evaluation of hydrogeologic parameters: discharge coefficient T, permeability coefficient K and correlative hydrogeologic parameters of discharge index Y and permeability Z. Discrete lithostratigraphic entireties of the Neogene and Quaternary sediments, characterized by calculation, estimation, or analogy, were furnished with intervals of average permeability values.

From the hydrogeological point of view the clays in the Neogene rock complexes represent impermeable horizons and render the attributes of an aquiclude, whereas the beds, or intercalations of the sandstones and gravels have intergranular permeability and the sandstone groups of beds display the fissure or fissure- intergranular permeability and form the aquifers. Deep-seated sandstone beds have characteristically confined groundwater body. Due to their spatial situation the dewatering of Neogene sediments is limited to small number of springs. The springs are mostly of barrier-, or eventually fissure type, with shallow circuit. Deeper circuits are characteristic for hydrogen sulfide springs (e.g. the Smrdáky spa).

Groundwaters of the fluvial sediments are hydraulically contiguous with the water level matching the surficial streams. Formation of the groundwater reserves is shared by both permeating surficial and slope waters and infiltrating precipitation, including the infiltration during high water levels in the river, the former predominating over the later.

Considerable part of groundwaters in the Chvojnica pahorkatina upland have been formed under the conditions of shallow circuit, from relatively well permeable Quaternary groups of beds. Besides, groundwaters of relatively deeper circuit, genetically associated with the Neogene basin filling, also occur here. According to the genetic classification of groundwaters (GAZDA, 1974), the groundwaters under study belong to petrogenic and fluviogenic types. Relatively great volume of groundwater has been influenced by the anthropogenetic polution.

Following water types were found in the area: carbonatogenic, carbonate - sulphatogenic and sulphatogenic (proluvial, deluvial sediments), silicatogenic, silicate - sulfidogenic (aeolian sands, terrace sediments of the Morava River). Carbonate - hydrosilicatogenic waters occur in the Neogene basement, in deeper circuits. Calcium - magnesium - hydrogen-carbonatic and calcium - hydrogencarbonatic types of chemistry, eventually with increased S_2SO_4 component, predominate in those groundwaters with shallower circuit. Calcium - hydrogencarbonatic natrium - calcium - hydrogen-carbonatic transitional types, with characteristic occurrence in the Neogene groups of beds, are less widespread. Anthropogenic factors cause obliteration and shift to transitional and mixed types of chemistry. Mineralization in waters ranges between 200 - 1 200 mg/l. A characteristic feature of waters of the Morava and Myjava River's alluvial plains are high contents of iron and manganese, which complicate, in terms of the water management, their utilization.

♦ Explanations to hydrogeologic map of the Horná Nitra region at a scale 1:50 000

Ondrej FRANKO, Eugen KULLMAN, Ladislav MELIORIS and Kamil VRANA

Hydrogeologic attributes of rocks from the Paleozoic through Quaternary have been evaluated in the region. In Paleozoic domain the granites and granitoids and their alluvia are characterized by mean value of specific run-off of 4.94 $l.s^{-1}.km^2$. Paragneisses and migmatites display lower mean values of the specific run-off ranging from 1.5 to 3.0 $l.s^{-1}. km^2$.

Malá Magura and Ráztočno Mesozoic cover sequences are floored predominantly by less water-bearing Jurassic and Cretaceous groups of beds. Žiar succession is exceptional by occurrence of water-bearing Triassic sandstones and dolomites of considerable surficial extent. The Krížna nappe groups of strata comprise discrete areas of various hydrogeologic importance. Due to their drainage function, the Triassic limestones and dolomites are the chief aquifers within the northern part of the region, whereas in the other portions (Nitrianske Rudno - Hradište area and eastern part of the area investigated, north of Handlová), their hydrogeological import is insignificant. Of utmost hydrogeological significance are the exceedingly water- bearing Triassic carbonates of the Choč nappe.

High groundwater specific run-offs, amounting to (8.4 - 10.0 $l.s^{-1} . km^2$), were documented within the Mesozoic of the northern part of the region under study. Besides of high groundwater specific run-offs from the water-bearing Triassic limestones and dolomites (10.0 - 14.0 $l.s^{-1}. km^2$), high groundwater specific run-offs were also found in the less permeable or impermeable groups of beds (6.9 - 10.6 $l.s^{-1} .km^2$).

Groundwater specific run-offs were calculated for the area north of the Nitrica River to 8.6 $l.s^{-1} .km^2$) and for the area south of the Nitrica River to 6.6 $l.s^{-1} .km^2$); these areas belong to the Triassic carbonates, which crop out in the Mesozoic in the southwestern part of the area under study (between Nitrianske Rudno - Hradište and Zemianske Kostoľany).

Of particular hydrogeologic importance are the Nitrica River alluviums, combined with the underlying Triassic water-bearing carbonates. The Mesozoic divides the Nitrica alluvium in its surficial and subsurficial zones into two parts and forms an important drain for groundwaters of the Triassic carbonates. Based on the results gleaned from the extensive network of wells (36), high discharge coefficient (Ty), reaching the average values in discrete parts of the alluvium between $2.29.10^{-3}$ and $1.1.10^{-2}$, with small variability level in individual parts of the alluvium (S = 0.15 - 0.35), was documented. From the quantitative point of view, the Nitrica alluvium combined with adjoining Mesozoic carbonates, is one of the most significant source area of the investigated region. Apart from their exploitation, important unexploited, concealed entries of groundwaters exist actually in this region.

Groundwater specific run-offs from the Triassic carbonates in the area north of Handlová, floored by the Mesozoic rocks, were calculated for carbonates of the Ráztočno group of strata and amount to 11.8 $l.s^{-1} .km^2$, while in the Krížna nappe they amount to 11.0 $l.s^{-1} .km^2$ and in the Choč nappe to 10.2 $l.s^{-1} .km^2$.

Basal clastics (carbonatic conglomerates, breccias, sandstones) of the Innercarpathian Paleogene are characterized by the average value of the discharge coefficient Ty = 6.99. 10-5 $m^2 .s^{-1}$ and by standard deviation s = 0.3, whereas the flyschoid Paleogene (claystones, alternations of claystones and sandstones) by Ty = 9.85. 10^{-6} $m^2 .s^{-1}$ and s = 0.50, and the "sandstone Paleogene" by Ty = 1.10. 10^{-4} $m^2 .s^{-1}$ and s = 0.40 - 0.60.

The Čausa (Schlier-Eggenburgian), Handlová and Nováky (coal) group of beds and the Koš clays (Badenien-Sarmatian) are aquicludes with T < 1.10^{-6} $m^2 .s^{-1}$, and q <1.5 $l.s^{-1}$ km^2. Volcanic rocks of the Vtáčnik are divided into 3 complexes: k1 - faulted andesites of the Vtáčnik Formation with the average specific underground run-off q = 7-10 $l.s^{-1} .km^2$; k_2 - slightly faulted andesites of various formations with q = 4-5 $l.s^{-1} .km^2$ and k_3 - slightly faulted volcaniclastics and rocks affected by secondary alterations with q = 3-4 $l.s^{-1} .km^2$. The Lehota (Badenian - Sarmatian) and Lelovce (Pontian) group of strata (gravels, sands, clays) lie in the Nitra valley superposed one over the other (the Vtáčnik Formation is missing) and constitute one entirety. To the north of Prievidza, the Upper

part of this entirety is characterized by an average value of the discharge coefficient Ty = 3.63. 10^{-4} m^2 $.s^{-1}$ and standard deviation s = 0.36, whereas in the Prievidza town by Ty = 2.29. 10^{-3} m^2 $.s^{-1}$ and s = 0.36 and to the south of Prievidza by Ty = 2.29. 10^{-4} m^2 $.s^{-1}$ and s = 0.52. The hydrogeologic environment, both north and inside Prievidza, is strongly inhomogeneous, whereas south of Prievidza it is still considerably inhomogeneous.

The Quaternary Pleistocene - Holocene proluvial sediments (alluvial cones of Vtáčnik) between Prievidza and Bystričany are characterized by the average value of the discharge coefficient Ty = 3.63. 10^{-4} m^2 $.s^{-1}$ and standard deviation s = 0.36, thus, they are referred to in terms of medium transmissivity and remarkably inhomogeneous environment. Pleistocene - Holocene fluvial sediments of the Nitra River, between the Nitrianske Pravno and Čereňany, are characterized by the average value of the discharge coefficient Ty = 1.0 - 1.58.10^{-3} m^2 $.s^{-1}$ and standard deviation s = 0.16 - 0.36. The Holocene proluvial sediments of the Handlovka in Prievidza (alluvial cone), have high transmissivity (Ty = 4.57.10^{-4} $m^2.s^{-1}$), however, the rock environment is considerably inhomogeneous (s = 0.62). The same sediments of the Bystrá creek have medium transmissivity (Ty = 4.57 .10^{-4} m^2 $.s^{-1}$), whereas the environment is very inhomogeneous (s = 0.84). The Holocene fluvial sediments of the Handlovka have also medium transmissivity (Ty = 2.23 .10^{-4} m^2 $.s^{-1}$) and the environment is inhomogeneous (s = 0.29).

♦ Explanations to hydrogeologic map of the Krivánska Fatra region at a scale 1:50 000

Vladimír HANZEL, Viera ŠALAGOVÁ, and Kamil VRANA

Hydrogeologic situation of the Krivánska Fatra reflect variegated and complicated geological structure of the region, emphasized by morphological diversity and climatic zonality of the mountain range.

Crystalline rocks are composed of granitoids and form a hydrogeological entirety in the southern part of the Krivánska Fatra, occupying 38 % of the whole expanse of the mountain.

It is being predominantly dewatered by the talus springs, or by the migration into surficial streams through the zone of tectonic disturbance, weathering and relieve of the massif. High values of the groundwater specific run-off (in average 11.2 $l.s^{-1}.km^{-2}$) show that the zone has good accumulating capacity, augmented in some drainage systems by extensive Quaternary cover.

Specific conditions for the circuit and accumulation of the groundwater in the Krivánska Fatra are in the areas of distinct tectonic disruption at sites of preferred migration through the fault zones. Such conditions prevail in the Suchie near Šútovo, where there were documented artesian waters with the weir of 8.24 and 5.88 $l.s^{-1}$, respectively, at the collars of the wells (Fig. 1). Springs yielding more than 0.5 t $l.s^{-1}$ are also bound to the zones of tectonic disruption.

Mesozoic hydrogeological complex is composed of variegated group of rocks, differing by various degree of water-bearing. The Lower Triassic, Jurassic and Cretaceous shaly and marly rocks represent the aquicludes. Limestones, dolomites (Middle and Upper Triassic Jurassic) and quartzites (Lower Triassic) are the aquifers with various permeability, depending on the degree of tectonic disturbance and karstification.

Mesozoic is represented by three tectonic units - the cover sequence, the Krížna and the Choč nappes.

The cover sequence forms at the northern side of the mountain, the hydrogeological host structures for the karstic - fissure to karstic type groundwaters from the Middle and Upper Triassic limestones and dolomites.

Due to intense tectonic disruption and spatial extension the Lower Triassic quartzite group of beds forms quite favourable environment for the accumulation of groundwaters, supplied through infiltrations from the precipitation, or by passage of waters from the crystalline rocks. The average groundwater specific run-off is 8.3 $l.s^{-1}.km^{-2}$.

Overlying carbonate group of beds of the cover sequence forms three hydrogeological structures - the Suchý and Belianska dolina valley, the Veľký Kriváň and the Kykule structure.

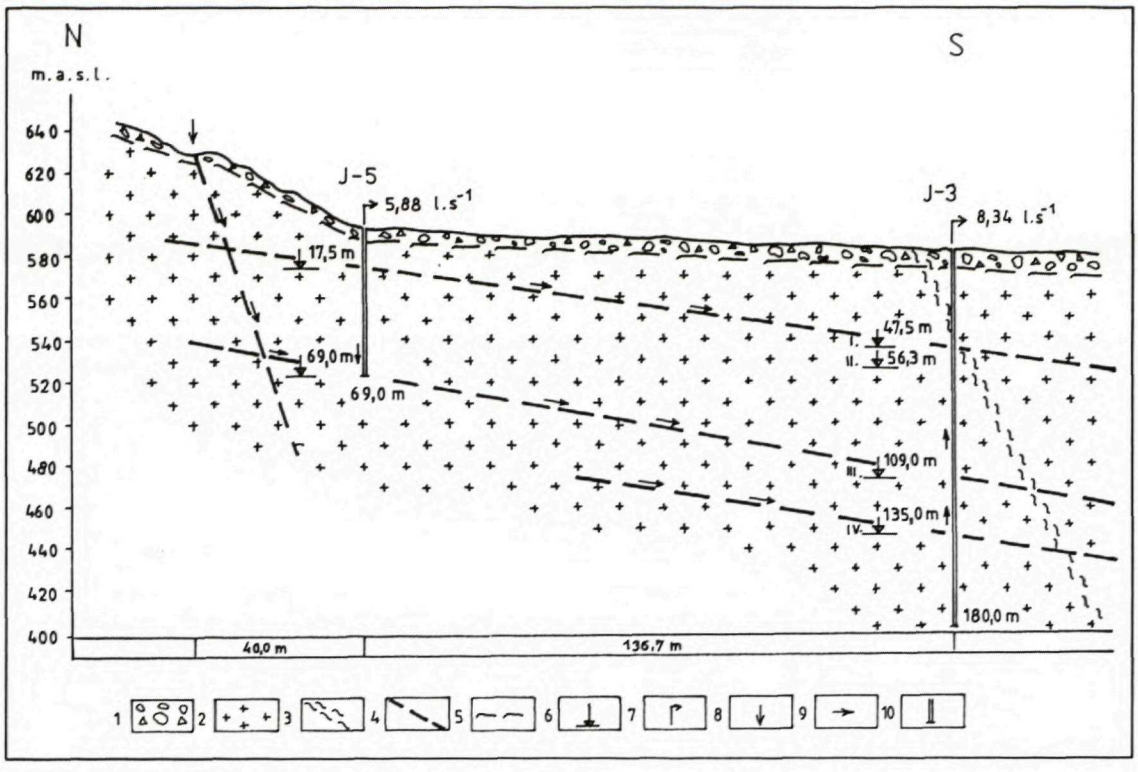


Fig. 1 Hydrogeological blueprint section through wells in the Šútovo
1 – gravels, sands; 2 – granodiorites; 3 – mylonitic zone; 4 – fault zones; 5 – boundary of Quaternary; 6 – horizon tapped; 7 – weir of well; 8 – losses from surficial stream; 9 – strike of groundwater flow; 10 – well

The hydrogeological structure - Suchý and Belianska dolina valley extends over 10.12 km^2 and forms a synclinal feature. Three partial structures can be defined within this structure. The partial structure of Stratenec and the partial structure of Malý Kriváň have typically a karstic circuit, with dewatering along preferred karstic paths in the Kukurišov and Belá 1 exsurgence. The partial structure of Prostá is being dewatered by karstic - fissure type springs (the Belá 2, 3 springs).

Hydrogeological structure - of the Veľký Kriváň, extending over 3.75 km^2, is formed by Triassic carbonates, Lower Triassic quartzites and a hydrogeologically infavourable Keuper group of beds, flooring the central part of the structure. This structure is being dewatered by the karstic exsurgence of Krivánska Rizňa, yield 13.8 - 1500.0 l.s^{-1}. km^{-2}).

Special position in the cover sequence ocupies the hydrogeological structure of Kykule in the area Bystrička - Párnica. It is being dewatered by passage along tectonic lines into the Orava, or Zázrivka Rivers, respectively, (indicated by geophysical measurements).

The Krížna nappe is the most extensive tectonic unit, occupying 60 % of the region, floored by the Mesozoic. Triassic limestone and dolomite group of strata and quite favourable Jurassic carbonates are mostly widespread in the eastern part of the region in the Lysica structure, extending over 18.5 km2 (KULLMAN 1976). This structure is dewatered by direct passing of the groundwaters into the Zázrivka River and into Teplica 1 and 2 springs. Increased temperature of the groundwaters as well as high contents of sulphates indicate the deeper circuit of groundwaters due to complicated structure of the Lučivná and Lysica digitation (POLÁK, 1979).

The Malá and Veľká Bránica structure is another hydrogeological structure of the Krížna nappe, made predominantly of Jurassic rocks. This structure is being dewatered by a line of springs, or by passing of groundwaters into the surficial streams, respectively.

The Choč nappe forms three discrete hydrogeological structures: the Boboty - Sokolie and Veľký Rozsutec and a small structure in the Šútovo region.

The Boboty - Sokolie hydrogeological structure has the largest extent. It is located in a narrow belt, extending over 8.63 km^2 and dipping steeply below the Paleogene filling of the Varín - Terchová

salient of the Žilina basin. Dewatering takes place mainly by concealed passage of waters into the Dierový potok or Vrátňanka creek, or into Quaternary talus.

The Veľký Rozsutec structure is dewatered by concealed passage into Quaternary talus and by concentrated exsurgence of the Kremeniny. Hydrogeological structure made of carbonates in the Šútovo area, stretching over 3.0 km^2, is only being dewatered by hidden passages of waters into the Váh River.

Specific run-off of water from the Triassic limestones and dolomites is in average 16.6 $l.s^{-1}.km^2$, from the Jurassic limestones it is 8.2 $l.s^{-1}$.km2 and from Cretaceous limestones and sandstones - 4.2 $l.s^{-1}.km^2$.

Fluvial sediments of the Váh River in the Krpeľany - Sučany, area as well as the sediments of the Orava River in the area of Istebné - Párnica, are both important aquifers, yielding 2.0 to 50.0 $l.s^{-1}$ from the wells, with predominantly high transmissivity.

Most of the groundwaters of the Krivánska Fatra meet the criteria of the ČSN norm for potable waters, however, groundwaters of the Párnica area do not meet this criteria due to increased concentrations of sulphates.

Polution sources at the marginal parts of the region do not jeopardize directly the quality of groundwaters, which come from the Mesozoic carbonates. Quality of waters can only be at risk indirectly, through precipitation.

♦ Explanations to hydrogeologic map of the Zvolenská kotlina basin at a scale 1:50 000

Vavrinec BÖHM, Ladislav ŠKVARKA, Katarína HYÁNKOVÁ, Miriam FENDEKOVÁ, Peter MALÍK and Zlatica ŽENIŠOVÁ

Folowing hydrogeological complexes were established in the area:

1. Crystalline rocks cropping out between the Lieskovec and the Zolná villages. The chief aquifer in the granitoids is a subsurficial zone of weathering and loosening of rocks. The average discharge, amouting to $T = 3.10^{-5} - 1.10^{-4}$ m^2/s, was estimated basing on analogy with the other regions, floored by crystalline rocks.

2. Mesozoic groundwaters are bound mainly to carbonates, which crop out in the northern part of the basin. The limestones display karstic - fissure discharge in contrast to dolomites,in which the fissure permeability prevails. The circuit is faster in limestones. The transmissivity values are: $T = 1.05.10^{-4}$ m^2/s and $k = 1.53.10^{-6}$ m/s.

Upper Triassic, Jurassic and Cretaceous variegated limestones, marly limestones and shales form an inhomogeneous aquifer with predominantly fissure permeability. Claystone and marlstone beds with low permeability, or nonpermeable, govern the movement of grounwater in the structure. The average transmissivity estimated in analogy to the other areas amounts to $T = 1.10^{-4}$ m^2/s to 3.10^{-4} m^2/s.

Neogene rocks are represented by variegated series of lithofacial types of volcanic breccias, tuffitic sandstones, claystones and andesite flows. Frequent alteration of more or less permeable beds, lying mainly in horizontal position, results in irregular water-bearing of discrete beds, locally with confined horizons. The weathering crust of andesites, reaching the depth of 30 - 50 m, influences their water-bearing. Besides, tectonic faults and fissures play also an important hydrogeological role in the andesite bodies. Transmissivity in these rocks was calculated basing on the evaluation of 8 wells. Geometrical mean is $T = 1.40.10^{-4}$ m^2/s. Volcanisedimentary rocks with the predominant sedimentary component (tuffites and clays) are characterized by geometric mean $T = 3.7.10^{-5}$ m^2/s and $k = 3.05. 10^{-6}$ m/s. Volcanisedimentary rocks with predominant volcaniclastics (agglomeratis tuffs, tuffites) have $T = 1.97.10^{-4}$ m^2/s and $k = 1.17.10^{-5}$ m/s.

Lacustrine - fluvial sediments of the Hron Formation - Pliocene gravels and sands are characterized by intergranular permeability, $T = 3.86.10^{-4}$ m^2/s and $k = 5.26.10^{-5}$ m/s.

4. Quaternary sediments. Remnants of the terrace benches at various levels of limited extent and given position represent only insignificant accumulations of groundwaters, supplied predominantly by

precipitation. To the contrary, sediments of the lower terrace benches and of the lowest Hron River terrace are in direct hydraulic contiguity with the surficial stream.

As regards the values of hydraulic parameters, the majority of the Hron alluvium can be ranked as the highest discharge class, with the T values greater than $3.0.10^{-3}$ m^2/s (Kremnička - Rakytovce, surroundings of Budča and Sliač - Veľká Lúka sections).

The Hron River section in the Zvolen region and fluvial sediments of the Slatina in the Zvolen region are characterized by decreased transmissivity, $T = 8.77.10^{-4}$ m^2/s and $k = 2.37.10^{-4}$ m/s.

Variegated lithofacial composition of the rocks reflects itself in physical and chemical properties of groundwaters. Great range of mineralization (89 mg/l - 2239 mg/l) can be found here as well as gas saturation by carbon dioxide. The highest mineralization values fall to the groundwaters influenced by the deep-seated sulphate waters and to waters saturated by carbon dioxide. According to predominating ions, the Ca-Mg-HCO_3, or eventually the Ca-Mg-HCO_3-SO_4 type revails. The majority of groundwaters contain aggressive carbon dioxide (max. 85 mg/l).

Groundwaters of the Neovolcanics are peculiar by high content of silicic acid (max. 93 mg/l). Carbon dioxide is always present in these rocks and stipulates their aggressive properties. Na-HCO_3 component is typical in the silicates, in waters of the deep circuits.

Volcanisedimentary complex, which forms the basin filling, is distinguished by waters of variegated chemical composition and different mineralization. Although containing but low mineralization, the waters of the Pliocene and Quaternary gravels contain relatively high contents of Na, Cl, NO_3 and SO_4 and are great deal influenced by the secondary agents.

Strongly contaminated waters were found in the surroundings of the Sliač airport and Vlkanová (oil matter, carbohydrates, chlorinated derivatives of the alifatic and aromatic carbohydrates, PCB and increased concentrations of metals).

♦ Explanations to hydrogeologic map of the Breznianska kotlina basin at a scale 1:50 000

Vavrinec BÖHM, Kvetoslava HYÁNKOVÁ and Miriam FENDEKOVÁ

Metamorphic rocks occupy most of the basin. They underlay both the basin basement and its slopes. They are composed of phyllites, schists, paragneisses, amphibolites and migmatites of the Krakľová zone of the Hron complex. These rocks are pervaded by fissures and rocks, which become progressively more congested towards the depth. Specific run-off from this unit is 2 $l/s/km^2$.

Biotitic granodiorites and migmatites (Kráľova hoľa zone) crop out in a small area, at the SE margin of the Brezno basin. Absence of shaly beds and disruption of rocks causes their better water-bearing. This was supported by higher yields of the springs as well as the structural drill hole at the Pohronská Polhora (KV-1). Specific run-off was evaluated using our measurements and a correlation was made with similar areas. Determined value is 3 - 5 $l/s/km^2$.

Mesozoic rocks at the SE and NW sides of the basin occupy small area only(1 - 3 km^2). In terms of lithofacies, the shales and quartzites predominate, whereas carbonate rocks are less widespread. They are of little hydrogeological importance.

The main filling of the Brezno basin form Paleogene sediments of both, fresh and marine descent (Paleocene - Lower Oligocene). Heterogeneous complex of sediments, conglomerates, sandstones, sandy clays and claystone beds do not constitute favourable conditions to form aquifers, with possible accumulation and circuit of the groundwater. No yielding springs are found in this area. As a contrary, Paleogene sediments act as an impermeable basement for the Quaternary groups of beds and the springs at their contacts are but low yielding and unsteady.

Neovolcanics (Badenien - Sarmatian) are represented by intrusive bodies of autometamorphic andesites and their porphyries, which intrude the crystalline massifs in the area of the Fabova hoľa. Epiclastics of the volcanisedimentary group of beds are found at the S side of the basin (Hájna hora massif). Fissure permeability of these rocks is augmented by porosity permeability within the zone of weathering. The springs in this region do not reach the yield of 1 l/s.

Quaternary sediments are relatively most water-bearing. We refer to deluvial as well as proluvial sediments, with frequent occurrence of springs yielding up to 1 $l.s^{-1}$, however, their regime is unsteady and depends from precipitation.

Fluvial sediments occur in the Hron and Rohozná valleys, within the terraces and the alluvial plain. They reach the thickness of 2 to 6 m. Water-bearing of the fluvial sediments is weak. The yield from wells ranges from 0.02 to 0.7 l/s, Kf is of the order of 10-5 to 10-6 m/s. Groundwater level lies, in average, 1 - 4 m below the surface (Hron). In case of Rohozná the above values are even lower.

Groundwaters of the Pre-Mesozoic, Mesozoic, Tertiary and Quaternary occur within the basin. This refers to infiltrated precipitation waters with shallow circuit, in hydrogeochemically little active rocks, which manifests itself in relatively low total mineralization - 55 - 444 mg/l and in the presence of aggressive carbon dioxide, mostly in amounts exceeding 20 mg/l and the maximum of 54 mg/l. Practically, the only waters in which the carbon dioxide is missing are those from Mesozoic carbonates. Waters that lack any secondary influence are predominantly of the Ca-Mg-HCO_3 and Ca-HCO_3 type. Waters migrating through neovolcanics contain high contents of the silicic acid, with the maximum of 60 mg/l, while those, migrating through the crystalline rocks contain 20 mg/l H_2CO_3, whereby the contents of mineralization is about the same in both. Increased concentrations of alumina were observed in waters from the Neogene volcanics.

Waters of the deeper circuits are more mineralized. The highest contents of mineralization was found in the deep circulating waters in Paleogene, which also show indications of marinogenic mineralization. These waters also contain Na-HCO_3 component and eventually Na-Cl component too, whereas the mineralization increases up to 1080 mg/l and the type of water changes to Na- HCO_3-Cl type. The presence of NH^{4+}, Mn and Fe indicates an anoxic environment.

Low temperature, low KNK 4,5 values, Ca+Mg, increased concentrations of Mn, Fe, NH_4 and eventually Al are the most frequent problems, menacing the norms for potable water.

♦ Explanations to hydrogeologic map of the Levočské vrchy at a scale 1:50 000

Michal ZAKOVIČ, Dušan BODIŠ and Kamil LOPAŠOVSKÝ

Sediments of the Inner-Carpathian Paleogene with prevalent Bielopotocké (sandstone-bearing) group of beds take their share in the structure of the Levočské vrchy region. The other lithostratigraphic members crop out only in its marginal parts. Quaternary sediments fill the alluvial plains of discrete larger streams.

Due to their lithological composition, the Paleogene sediments display mostly fissure permeability.

Predominant part of the springs is bound to faults, formed due to the action of surficial agents, resulting in the thick scree covers with good filtering attributes. The most important groundwater developing process within the Levočské vrchy region is the infiltration of atmospheric precipitation, or infiltration of surficial waters into the rock environment. The run-off of the groundwaters, which formed this way, takes place more or less conformably with the surface, through a subsurficial zone reaching the depth of 30 to 50 m. It is being dewatered by means of talus- fissure springs, or by scattered transfer into Quaternary alluviums and surficial streams.

Concentrated dewatering via springs takes place in several regions, the most important being those in the wider area of Toryska, with the total run-off amounting to 15.5 l/s and scattered transfer into the surficial streams, totalling 69 l/s.

Wider area of the Tichý Potok village is another region with concentrated exsurgence of groundwater. Several springs, yielding 1.3 - 16.3 l/s, exsurge here. Larger degree of dewatering of the Bielopotocké group of beds takes place in the area of Levočská Dolina village, too. Most of the groundwaters concentrates in the Peklisko (Q = 2.0 - 12.6 l/s) and Smrdiace mláky (1.7 - 8.0 l/s) springs. At the northern side of the mountain, there are concentrated ascensions to the surface at the Jakubianka valley, the Koláčkovský potok and the Lomnické rieky creeks. Their yields range

from 1.8 to 12 l/s. The majority of streams are found in the valley headwaters, mainly at places, where the sandstones form thicker weathering crust. Due to its greater proportion of clayey component, the western part of the Levočské vrchy, but mostly its marinal side, is less water-bearing in the sandstone group of beds. The springs' yields range from 0.1 to 0.5 l/s.

Scattered passages of groundwaters into surficial streams, important from the water management point of view, were ascertained in the Torysa River, between the Torysky - Nižné Repáše villages, in the Slavkovský potok and its left hand tributary - Dolina, in the Jakubianka and Holumnický potok creeks, between the Ihľany and Jurské villages.

In conclusion it can be stated that the Paleogene sediments show great run-off fluctuation. In the course of a hydrologic year the maxima of run-offs are reached during the spring months when the snows are melting, whereas the minimum run-offs take place during the winter months. Decrease from the maximum down to the minimum is relatively fast. The 15 year average specific run-off from the Bielopotocké group of beds amounts to 2.54 l/s/km^2.

Evaluation of hydraulic parameters of the Bielopotocké group of beds was made, using the correlating hydrogeological parameters - transmissivity index (Y), permeability index (Z), discharge coefficient (T) and hydraulic conductivity coefficient (k). 25 entries from 25 wells were available. Calculated results are shown in the following table.

Hydraulic parameters of the Bielopotocké group of beds:

Group of beds	n	R (Y)	Md (Y)	M (Y)	s (Y)
Bielopotocké	25	3.93–6.4	5.4	5.33	0.57
		R (Z)	Md (Z)	M (Z)	s (z)
		2.6–4.8	3.7	3.6	0.55
		R (T) m^2/s	Md (T) $m^{2/s}$	G (T) m^2/s	transmissivity class
		$1.5.\ 10^{-5}$–$4.4\ .\ 10^{-3}$	$4.4\ .\ 10^{-4}$	$3.8\ .\ 10^{-4}$	III.c
		R (k) m/s	Md (k) m/s	G (k) m/s	permeability class
		$7.6\ .\ 10^{-7}$–$1.2.10^{-4}$	$8.9\ 10^{-6}$	$1.7\ .\ 10^{-5}$	IV.c

R (Y), R (Z), R (T), R (k): range of assessed values;
Md (Y), Md (Z), Md (T), Md (k): median
? (Y), M (Z): arithmetic mean; G (T), G (k): geometric mean;
s (y), s (z): standard deviation; n – number of entries

Fluvial sediments of discrete rivers, namely gravely-sandy fillings of the Torysa, Slavkovský potok, Levočský potok, Poprad and Jakubianka river beds, are the second significant aquifer in the Levočské vrchy hills. The highest transmissivity of the water-bearing beds were found in a section of the Torysa River (between Brezovica and Tichý Potok villages, T = $9.2\ .\ 10^{-3}\ m^2\ .\ s^{-1}$) and in a section of the Poprad River (between Forbasy and Stará Ľubovňa villages, T = $6.3\ .\ 10^{-3} m^2\ .\ s^{-1}$). The lowest discharge values were found in the fluvial sediments of the Poprad River (between Podolinec and the Lomnička creek, T = $2.4\ .\ 10^{-3} m^2.\ s^{-1}$.

Besides of common groundwaters, mineral waters also occur in the Levočské vrchy hills. They are of carbonatic (Forbasy, Nová Ľubovňa - spa and Poľanovce) and hydrogen sulphidic (Jakubany, Ľubica and Levoča valley) type. A hydrogeological well was drilled down to 176.1 m at the Nová Ľubovňa - spa locality. Mineral water, yielding 11.4 l/s, with the temperature of 9 °C, the mineralization content of 1694.7 mg/l and the content of CO_2 - 1768.8 mg/l was intersected between 98 - 110 m. This water is of Mg-Ca-HCO_3 type.

Chemical composition of groundwaters of the Levočské vrchy hills is a result of both geogene and anthropogene factors, under various conditions of the hydrogeological cycle. Geogene factors are relatively monotonous and the formation of chemical composition of grounwaters takes place predominantly in the sandstones. In the groundaters, exsurging from springs, the total mineralization ranges from 104.5 to 966.8 mg/l. They are calcium- hydrogen-carbonatic, or calcium-sulphate and mixed types, respectively. Total mineralization in the groundwaters ranges from 221.5 to 1088.1 mg/l; they are of the basic natrium- hydrogencarbonatic, or calcium-hydrogen-carbonatic chemical type.

♦ Explanations to hydrogeologic map of Branisko Mts. at a scale 1:50 000

Peter MALÍK and Tomáš LÁNCZOS

Hydrogeologic map of the Branisko Mts. at a scale 1:50 000 was constructed in accordance with the method, that takes the account on the discharge of aquifers, located closest to the surface (MALÍK - JETEL 1991). It depicts the mountain area (Fig. 1), covering 88.9 sq. km and besides, it includes a list of documented springs (totalling 338) and wells (totalling 93).

Hydrogeological importance of the Lower Triassic quartzites as a well faulted aquifer, competent to conduct and accumulate large amounts of groundwaters, was acknowledged during the construction of the map. Lower Triassic quartzites form east-west striking, 200 to 2 000 m wide, elongated belts within both essential tectonic units of the Branisko Mts. They occupy an area of 8.63 sq.km, (i.e. 10 % of the extent of the mountains).

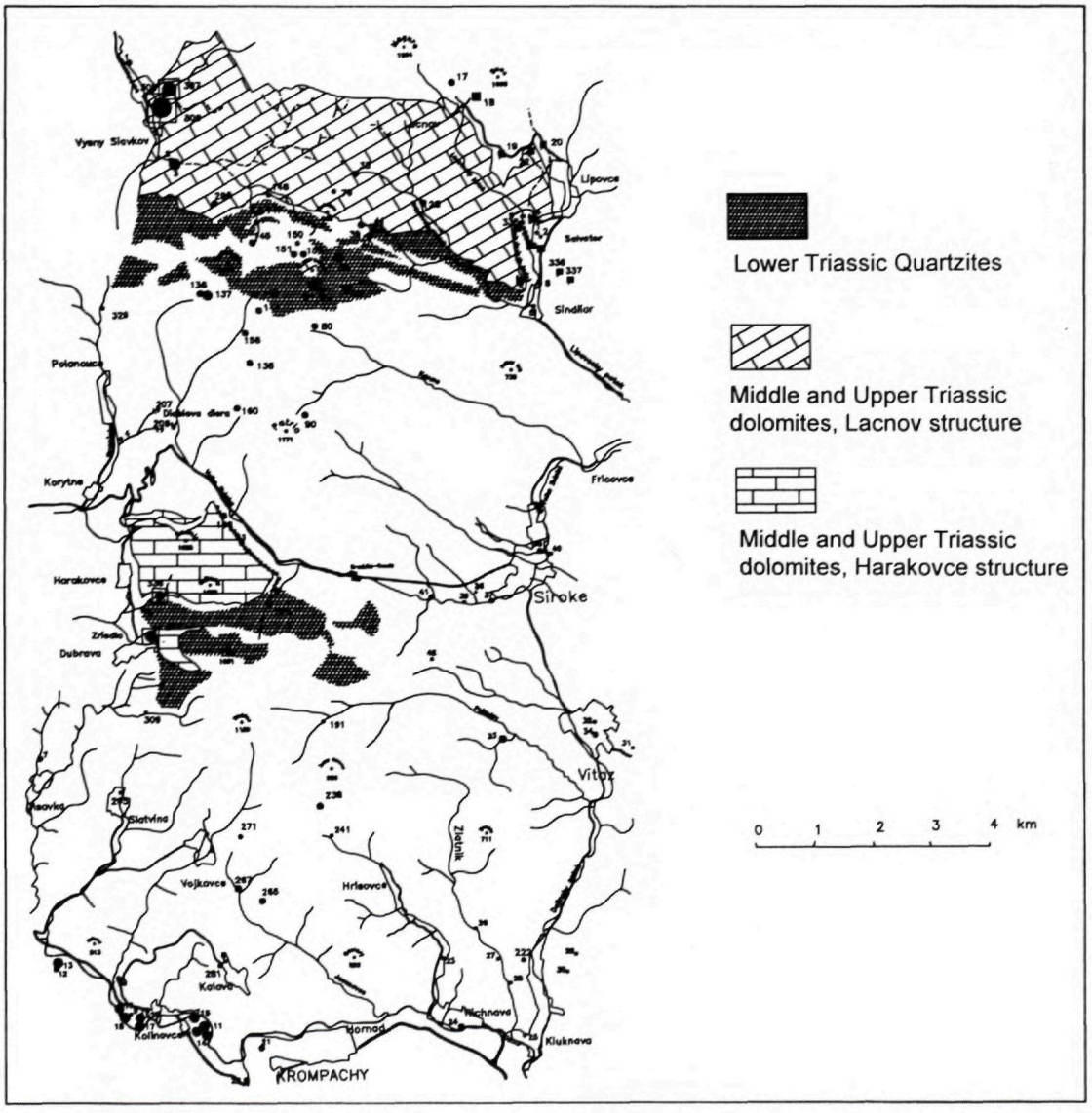


Fig. 1 Main hydrogeological units in Branisko Mts.

Their hydrogeological significance is not only supported by the high average yields of the sources springing from quartzitic host rocks (1.16 $l.s^{-1}$) and the specific run-off of these springs, reaching 3.98 $l.s^{-1}.km^{-2}$, but also by the fact that these sources are located at the very margin of the quartzitic rock complex, i.e. in the fashion known to occur in karstic carbonatic structures. Our oppinion is that the "Žriedlo" source, springing in the Dúbrava village, also originates in these rocks.

As the area of potential infiltrating region of the Žriedlo spring - adjoining block of dolomites, covering 0.35 sq.km, is too small, considering the average yield of the spring 7.61 $l.s^{-1}$ and the water acquires certain features typical for silicatogenic waters, e.g. very low specific electric conductivity (306 $uS.cm^{-1}$) and total dissolved solids (273 $mg.l^{-1}$), relatively high value of the relation r(Na+K)/(Ca+Mg) (0.053) and high concentration of Li (0.05 $mg.l^{-1}$), both, the yield and the water temperature are very steady.

In terms of potable water, however, the Middle and Upper Triassic dolomites and limestones are in the Branisko Mts. the most complicated, and at the same time, the most important aquifers. They are found in two significant hydrogeologic structures, each of them having different geological position and resulting manner of circulation of groundwaters.

The Lačnov hydrogeologic structure is represented almost exclusively by dolomites and covers an area of 15.51 sq km of the out cropping carbonatic rocks. Their average altitude is 721.66 m above sea level. Detected average specific run-off of grounwaters reaches 9.76 $l.s^{-1}$.sq km. Total average amount of the groundwater run-off soared up to 151.41 $l.s^{-1}$ during hydrogeological years 1973 - 1974.

Given amount of run-off was probably facilitated by additional drainage of a more extensive unit, as compared to the area of the mentioned structure. South adjoining Permian and crystalline rocks contribute by 9.91 $l.s^{-1}$ to the structure via surficial streams, whereas north adjoining Paleogene sediments contribute by 4.24 $l.s^{-1}$. However, this amount, exceeding actually ascertained calculated value, is probably still too low to cover the whole surplus of 45.8 $l.s^{-1}$. Chemical composition of the "Hlavný" spring, containing increased chlorides and alcalies typical for the groundwater circuit in the Paleogene sediments, also indicates possible drainage from Paleogene sediments flooring the area north of outcropping carbonates of the Lačnov hydrogeological structure. Presence of mineral waters of Salvator exsurgence area at Lipovce on the other side of the syncline manifests the percolation through Paleogene sediments with resulting formation of mineralized waters.

Harakovce hydrogeologic structure occupies only 3.05 sq. km of the area of outcropping carbonates. Its geological position is slightly elevated, (having average altitude of 821.70 m above the sea level), nevertheless, it forms but a shallow "caping" on the predominantly Permian, or Lower Triassic basement.

Although the specific groundwater run-off value of the Harakovce hydrogeologic structure is 6.97 $l.s^{-1}.km^{-2}$, it corresponds to precipitation and effective infiltration, confirming the fact, that hydrologic budget of the Harakovce hydrogeologic structure is balanced.

Tracing tests at the "Diablova diera" swallow – hole have shown that direct hydraulic connection exists between karstified metamorphosed limestones of plausible Jurassic age and their dolomitic footwall, with slightly permeable Permian sandstones and shales cropping out here at the main ridge of the Branisko Mts. Dye-tracing tests confirmed that the point of issue of waters is on the other (western) side, via springs NE of the Poľanovce village (FILO, 1992).

♦ Explanations to hydrogeologic map of the Šarišská vrchovina highland at a scale 1:50 000

Michal ZAKOVIČ, Dušan BODIŠ and Kamil LOPAŠOVSKÝ

Geological structure of the Šarišská vrchovina highland region is made of sediments of the Innercarpathian Paleogene, with predominating Bilopotocké (sandstone-bearing) group of strata. The remaining lithostratigraphical members crop out in their marginal parts. Quaternary sediments fill the alluvial plains of discrete larger streams. Hydrogeological situation of the Šarišská vrchovina highland reflects itself in prevailing geological-tectonic an climatic situation. Paleogene sediments display mainly faulted permeability. It is bound to faults formed by endogenetic agents on one hand

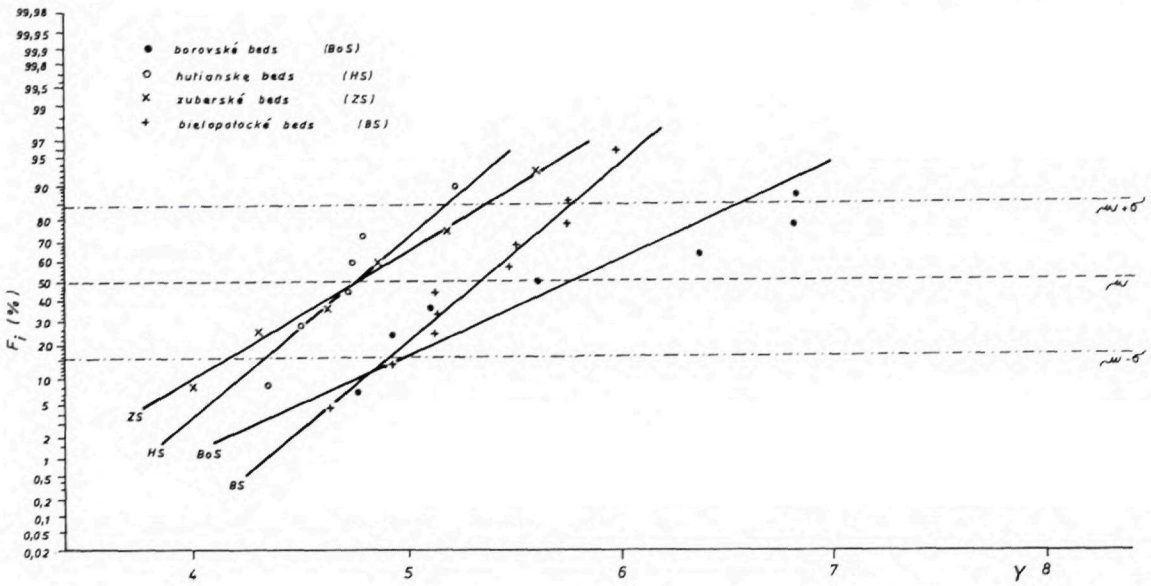


Fig. 1 Quantile diagram of distribution of discharge index "Y" in the Paleogene sediments of the Šarišská vrchovina highland

and by exogenetic agents, on the other. Predominant number of the springs is bound to faults, generated by the action of exogenetic agents, as a result of formation of thick scree covers with good filtration properties.

Infiltration of atmospheric precipitation, or surficial waters into the rock environment is the main source of groundwater in the Šarišská vrchovina highland. The chief aquifer in the region floored by the Paleogene sediments is a subsurficial zone, represented by weathering crust and relieve. The dewatering is effected by means of scree fault-bound springs, or by scattered transfer into the Quaternary alluviums and surficial streams.

Concentrated dewatering in the form of springs takes place in the area floored by the Borovské and Bielopotocké group of strata. The Borovské group of strata crops out in the southern part of the highland, forming, along with carbonates of the Čierna hora, or the Branisko Mts., common hydrogeologic structures. It is being dewatered by a string of barrier springs situated at the contact with the Huty group of beds. Their yields range from 4.6 to 56.0 l/s.

The overlying Huty beds are characterized by fissure type of permeability, bound to subsurficial zone. The yields of springs vary around 0.2 l/s. The Zuberec group of beds represents a similar hydrogeologic structure.

The Bielopotocké group of strata is characterized by a variegated lithology. It is represented by conglomerates, sandstones and claystones. Groundwater circuit in the later group of beds takes place predominantly within the subsurficial zone, or within the zones affected by faulted tectonics. The springs yielding up to 0.5 - 1.0 l/s are bound to the subsurficial zone. Springs associated with the fault zones, mainly in the area of Renčišov and Uzovské Pekľany, have greater yields (2 - 5 l/s).

Evaluation of the hydraulic parameters of individual lithofacies in the Paleogene was made from the results of processing of correlating hydrogeological parameters - the discharge index (Y), the permeability index (Z), discharge coefficient (T) and fitration coefficient (k) (see the Table).

Group of beds	R_2(T) m^2/s	Md (T) m^2/s	G (T) m^2/s	Transmissivity class
Bielopotocké	$7.07 . 10^{-5}$–$1.95. 10^{-3}$	$3.8 . 10^{-4}$	$3.89. 10^{-4}$	III.c
Zuberec	$1.45 . 10^{-5}$–$5.75\ 10^{-4}$	$8.91 . 10^{-5}$	$8.32. 10^{-5}$	IV.d
Huty	$3.34\ 10^{-5}$–$2.43 . 10^{-4}$	$7.67 . 10^{-5}$	$7.50 . 10^{-5}$	IV.c
Borové	$1.23 . 10^{-4}$–$1.44 . 10^{-2}$	$8.51 . 10^{-4}$	$1.26 . 10^{-3}$	II.d

R(T) - range of ascertained values Md(T) -median

B(T) - geometrical mean

The second significant aquifer in the Šarišská vrchovina highland are fluvial sediments of the Torysa, the Slavkovský potok and the Svinka Rivers. The greatest transmissivity of the of the bed filling aquifer were found in the section of the Torysa between Krivany and Sabinov (average value $T = 1.08.10^{-2}$ m^2/s). The lowest transmissivity values in the fluvial sediments were detected in the section Prešov - Drienovská Nová Ves ($T = 1.22.10^{-2}$ m^2/s).

Besides of common waters, mineral waters also occur in the Šarišská vrchovina highland. Two types of mineral water are known: carbonatic and hydrogen monosulphide type. The most important locality of carbonatic waters, bound to the marginal Šindliar fault, is found between the Lipovce and Šindliar. Their infiltration area are Triassic carbonates of the Branisko Mts. Remaining carbonatic waters are bound to the faults striking NW - SE, or N - S, respectively. These waters come from the Paleogene sediments and are CO_2 gas saturated from the basement.

Groundwaters of the Paleogene of the Šarišská vrchovina highland are predominantly of Ca-Mg-HCO_3 type, exceeding frequently (compared to norm for potable water) the Fe, Mn, NH_4 and NO_3 parameters.

♦ Assessment of hydraulic parameters of rocks for regional prognostication

Ján JETEL

Critical analysis of the actual state of art of the method to assess the hydraulic parameters of rocks, with succeeding development and refinement of selected direct and indirect methods, designed for regional prognostication purposes, led to the realization of a proposal for optimal complex of methods to appraise the permeability and the discharge. In applying the direct methods - i.e. in assessing the data from hydrodynamic tests in the wells, it is optimal to use proposed combination of the interpreting methods of transient groundwater flow with assessment of approximate logarithmic parameters, which enable to control the accuracy of the interpetation of data on transient flow. To achieve a concept on regional regularities in vertical distribution of the permeability, it is necessary to implement a refined method for the assessment of permeability from the water pressure test data. It is derived from an application of Jacob's and Lochman's formula for transient flow maintaining constant increase of pressure. To complete information on the regional permeability and discharge characteristics, which refers mainly to the hilly terrains without data from hydrogeological wells, it is practical to apply indirect methods to assess the permeability and the discharge. Evaluation of practical experience in applying the indirect methods in the regions with various attributes resulted in accomplishment of refined variants of indirect estimation of the regional characteristics of the bedding and slope discharge, from the data on the underground run-off and indirect assessment of average permeability and discharge of the subsurficial zone, as well as from the results of correlation of hydrochemical and geomorphometric features of descending springs.

Implementation of proposed complex of methods will permit to achieve representative regional characteristics of the permeability and discharge, with optimal employment of existing data, including archival documentation of previous works; it will eliminate common errors of any order in assessing the values of geohydraulic parameters and will enhance the effectivity of works, designed as regional prognostication and optimization of exploitation and protection of the groundwater sources.

♦ Spatially differentiated regional characteristics of hydraulic parameters of rocks in discrete types of terrain

Ján JETEL

Analysis of specific conditions in the discrete hydrogeological-structural types of terrain, as far as optimal expression of regional characteristics of the hydraulic parameters is concerned, has been made. The objective was to define those regional characteristics, which are effective for discrete types of both,

theoretical and practical (technical) applications and to propose the procedures to infer such characteristics.

Common mathematical-statistical characteristics of the distribution of values of approximative parameters and corresponding strictly hydraulically defined parameters describe satisfactorily the spatial distribution of geohydraulic parameters in reservoirs of stratified waters in intergranular and fissure aquifers. It is expedient to use geostatistical procedures (kriging, semivariograms). Tectonically dependent fissure zones are exhibited as the positive anomalies, or even the extreme maxima.

Within the hydrogeological massifs it is necessary to modify the general regional characteristics in terms of spatial disuniformity and to differentiate them according to their position in the field relief. Besides of common indicators, the real quantification of the formula of exponential decrease of average permeability with the depth becomes an essential parameter characterizing the spatial distribution of hydraulic parameters.

Extreme hydraulic inhomogegity in karstified rock complexes inevitably results in applying different manner of implementation of regional geohydraulic characteristics. Their classical application would lead to fictitious values with no real meaning.

Permeability coefficient represent here only auxiliary integral characteristic of a given real section (well, cross section). Spatial disuniformity is, in this case, associated with distinct hierarchization of mutually diverse hydraulic communications. The density of information is not sufficient for a representative quantification of extremely inhomogeneous karstic fissure-bearing environment; the importance of indirect run-off, budgetary and flow-measurement characteristics increases in such cases.

A proposition has been made to deduce the discrete hydrogeologically-structurally differentiated characteristics for each of the three considered types of terrains, with an outline of their applicability for various kinds of use. Owing to distinct abyssal decrease of average permeability in the subsurficial zone in the terrains of hydrogeological massif type it is necessary to distinguish 4 determined categories of discharge and to do consistent separation of sections with the slope discharge from those of the bedding (valey) category.

Since in the calculations of exploitable amount of the well systems in the valleys mainly the bedding discharge and the discharge from the fissure zones are applied, the evaluation of natural resources of groundwater and underground run-off must first take into accout the slope discharge, which is usually an order lower.

The regional statistical processing of data on the permeability and discharge (mainly in terrains of the stratified reservoir type and hydrogeologic massifs) must result, apart from other things, in acquisition of the values of geometrical and harmonic average of investigated parameters, which are basic for the inference of virtually important effective values of these parameters. In real application the estimation of effective values will be corrected by modelling, which is the highest stage of regional evaluation.

♦ Optimization of exploitation of groundwaters from karstic - fissure type hydrogeological structures with the objective to delineate perspective regions

Eugen KULLMAN

Realized thematic project was envisaged to initiate a wider conceived programme for optimal exploitation of the karstic - fissure type waters by combined use of groundwater sources, with seasonal exploitation of accumulated groundwater sources in springs adjacent to hydrogeological structures.

The first chapter of this project refers, in theoretical terms to the essential principles terms of solution, as well as factors, influencing the choice of suitable sites and adjoining parts of the hydrogeologic structures and the selection of suitable localities for investigation.

Following theoretical analysis of problems this project also analyses the problem concerned with optimal use of groundwaters and with safeguarding the ecological run-off and protection against

quantitative devastation of groundwaters in the hydrogeologic stuctures. It also displays authentic cases of non optimal capture of a portion of karstic- fissure springs by actually used methods of tapping and options to utilize the groundwaters from these sources.

Essential part of the solution is an appraisal of possibilitities for a broader application of this form of effective use of karstic-fissure type groundwaters in Slovakia by selecting of perspective localities. Suggested locality proposal includes a synthesis of to date knowledge of discrete sources, as well as other criteria, such as importance of the source, range of yields, depth of groundwater circuit and assumption of important accumulated reserves of groundwater. In selecting the prognostic localities a particular attention was paid to groundwaters with deeper circuits (more than 100 m), as potentially more suitable localities, to be used as technical water sources.

The carried out evaluation has shown a notable perspective for enhancing the exploitability of karstic-fissure type of waters in Slovakia by combined utilization of sources and accumulated sources of groundwaters.

♦ Structural-hydrogeological analysis of carbonates of Krížna nappe of the Veľká Fatra Mts.

Peter MALÍK, Juraj MICHALKO and Stanislav RAPANT

Basing on preliminary hydrologic budget, gauging observations, isotopic composition of oxygen of waters and analyses of isotopic composition of sulphate sulphur dissolved in groundwater we have addressed the genesis of groundwaters bound to both, the Triassic carbonate cover and to the Krížna nappe of the Veľká Fatra, as well as to correlations among discrete sources.

Within the framework of application of isotopic methods we have calculated the degree of dependance, the correlation between the average isotopic composition of oxygen and the above -sea-level-altitude of infiltration regions of individual sources:

$$\delta^{18}O = -0.0097\ H - 9.975$$

The above result enabled us to either exclude, or to confirm the potential infiltration regions of several important, used, or observed, sources. At the same time, due to high degree of fluctuation of isotopic composition of oxygen and increased content of heavier isotope in the average isotopic composition of 9 samples, we have found, or confirmed, respectively, the previous circulation of water in surficial streams at the Havranovo (Belá - Dulice) and Lazce (Necpaly) springs.

Basing on isotopic analyses of sulphates, diluted in the spring groundwater, we have suggested the contact with Lower Triassic gypsum-bearing shales of waters from several springs.

Dilution of sulphates from the Keuperian shales plausibly enhances the contents of sulphates in the spring waters at Nižné Krátko, Teplô - Pod parohami and Štubne.

Potential infiltration regions of several springs were delineated by means of provisional hydrogeological budget, combined with hydrogeochemical and isotopic methods - infiltration area of the "Hradská" spring in the Podhradie village in the northeastern part of the mountain was assigned to limestones and dolomites of the cover unit in the area of the Prieložnica triangulation point. In spite of the fact that the "Jazierce" source in Ružomberok - Biely potok springs within the domain of the Krížna nappe dolomites, it was assigned to the cover unit, located in the area of the Maďarová - Pulčíkovo triangulation point. Applying common evaluation critria, the groundwater of the "Bukovina" spring, an important water source of the Ružomberok town, may also originate from the same area. Probable communication with the surfical waters of an important water source, the "Lazce" at Martin was found, which not only applies to so far considered sites in the upper part of the Belianska dolina valley, but also to the nearby Necpaly creek, running in immediate surroundings of the spring. Communication with the surficial waters has been also ascertained in case of other less important springs (Havranovo, Pri starej priehrade, Hričov).

We presume, that the infitration area of groundwaters exsurging in three highest situated sources of the assembly water supply pipeline (Jergaly, Štubne and Generál Čunderlík) is located in the outcropping cover carbonates (the Bukovec syncline), in the Krížna nappe, between Motyčky, Hanesy and Donovaly, as well as in the area of the southern slopes of Motyčkova hoľa and Zvolen

triangulation point, (gradual disappearance of surficial streams in an area of 12.59 sq.km and finally, in the area north of the Váh - Hron groundwater divide, covering an area of approximately 6.8 sq.km. Thus, we presume the migration of groundwaters beneath the geomorphologic groundwater divide. In respect to surroundings their drainage function is associated with the augmentation of discharge amount along the stream.

Besides, the hydrometric works contributed to the knowledge of important transfers of groundwaters into surficial stream in the area of the Hradská dolina valley at the Podhradie village, in the surroundings of the Jazierce spring as well as in lower part of the Ľubochnianska dolina valley and in Harmanecký potok creek, in the Dolný Harmanec area.

These transfers could be intercepted by drillings as new, valuable, groundwater sources.

♦ Correlation of linear RS data with some hydrogeological characteristics

Peter MALÍK, Juraj MICHALKO, and Stanislav RAPANT

Correlation has been made between the location of natural exsurgences of groundwaters and the courses of lineaments, identified in multispectral, photogrammetric panchromatic and 2.5 cm radar photographs "SLAR" of the Hnilec River drainage system. The location of natural exsurgences was correlated the same way with the courses of fault zones, identified by geological mapping. It was found out that, independently from the kind of source photograph to identify lineaments, the most frequent in the Hnilec River drainage are the lineaments striking 51-60° and 151-160°. However, the majority of geologically mapped fault zones have the most frequent ranges 0-10° and 171-180°.

1761 springs (MALÍK, 1990) have been documented during previous research in the area of 510 sq. km, floored almost exclusively by Lower Paleozoic epimetamorphoesd rocks. Correlation between the lineaments and the springs has been made using geographical information system IDRISI, which enabled to construct envelope areas around the lineaments, with the limits at the distances of 50, 100 and 150 m. This was followed by an inter-correlation of the cumulated yield of the springs among the groups of lineaments inside the envelope area, distinguished by interpretation of panchromatic, multispectral and radar photographs (and faults). Number of springs, found inside the envelope areas, have also been correlated. As regards the cumulated yields and numbers of springs inside the envelope areas, at the distances of up to 50 m, 100 m and 150 m from the lineaments, the most successful appeared to be the identification of the fault zones from multispectral photographs, made by the airborne MKF-6 camera at a scale 1:50 000.

The same method was used to compare mutually the directional intervals between the lineaments, ranging 10° each. Directional ranges 51-60° and 151-160° had the most frequent representation and, at the same time, the highest "absolute" values of cumulated yield and number of springs. Division by size of the area of cover domain made in an attempt to achieve the "relative" values independent from the frequency of occurrences of lineaments caused that the hydrogeological import of lineaments with directional ranges 71°-120° became more conspicuous. Obviously, these are the most open ways for groundwater circuits, manifesting themselves by increased concentration of springs within the unit area of the cover domain of the lineament, as well as greater total run-off of groundwaters from springs in this area. However, lineaments with directional ranges 71°-120° are parallel to the boundaries of geological units, thus, they are difficult to identify by both geological mapping and remote sensing methods. West-eastern direction of these, geologically well exposed lineaments, agrees with the direction perpendicular to the last regional field of stretching extension, associated with the subduction of the flysch belt basement the beneath the Western Carpathians during the Upper Sarmatian - Pliocene period.

♦ Isotopic research to study genesis of the groundwaters

Jarmila ĎURKOVIČOVÁ, Ivan RÚČKA, Anna KOVÁŘOVÁ, Peter MALÍK and Juraj MICHALKO

Hydrogenetic research carried out in Slovakia using light stable isotopes (H, O, S) was intended to resolve several problems, associated with waters of various genetic types. Isotopic composition (O partly H too) of the cumulated monthly precipitation at seven precipitation measuring stations of the

SHMÚ (Bratislava - Koliba, Chopok, Liesek, Milhostov, Mochovce, Stará Lesná and Topoľníky). This research extended the previous works and enabled to fulfill a quinquennial string of observations. Temporal and spatial variations in the distribution of isotopes in precipitation are in agreement with the complicated climatic and geographic conditions of Slovakia. Average quinquennial values of $\delta^{18}O$ range between -8.18 (Bratislava) to -9.85 permil (Chopok) the "lightest" months being December and January, whereas the greatest representation of the heavy isotope renders the precipitation during summer months (May - July).

As regards the surficial streams, systematic long term observations (from 1982 on in monthly intervals) of the isotopic composition of waters of the Danube (from 1993 in a fortnight's intervals) and Morava Rivers have been made. Variations of values, as well as progress in changes of $\delta^{18}O$ in time have been found to be caused by different nature of both rivers. Our results are in good agreement with the results of analogic research testing both rivers, made by Austrian colleagues. One shot collection of samples from surficial streams has been made (in April 1992) in Slovakia (73 samples), which should characterize their isotopic composition during the spring period of melting snows. The results have been correlated with those measured in 1982 (l.c.), as well as with the quinquennial average values of precipitation at seven precipitation measuring stations. The values are compatible with the climatic, geographic and hydrologic conditions.

Isotopic features of waters, bound to hydrogeologic structures in Triassic carbonates of the Veľká Fatra region, were investigated. Isotopic composition of waters in 30 springs and a brook has been monitored in approximately two month intervals during the period - December 1991 - July 1993 (altogether 9 collections) and isotopic composition of sulphate sulphur has also been measured. Degree of dependence of the average isotopic composition of oxygen upon the average altitude of the infiltration areas of discrete sources has been calculated, this calculation being the basis for the discrimination of certain potential infiltration areas for particular sources.

We have ascertained the δ34 S values in the springs dewatering the structures, which lack sea sulphate (e.g. Harmanec Veľký Tunel). We have confirmed the assumption that some δ34 S values of sulphate sulphur of the water sulphate may well be explained by mixing of sulphur with individual isotopic composition, from different sources in various directions, whereas the isotopically heavy component is represented by sulphur coming from the Scythian evaporites and the light sulphur isotope, on the other hand, belongs to the background.

The origin and the correlation between discrete water sources was appraised basing on monthly monitoring of isotopic composition of oxygen in waters (June 1992 to May 1993) in the area of Pezinok and Devín Carpathians and in a collection from nine water sources, one sulphate sulphur sample each. The results are compatible with those achieved by hydrogeologic and hydrogeochemic research in the region.

The data on isotopic composition of oxygen in selected sources from the Levočské vrchy highland contributed to understanding of their origin and correlations. The results of research do not contradict the assumptions, that waters from the Torysa River increase the run-off of the springs in broader region of the Toryska and Tichý Potok villages, however, this assumption could not be ascertained unequivocally.

Data on the isotopic composition of oxygen and sulphur in waters in the wider area of Oravice contributed to understanding of their origin and correlation. We visualize the origin of water sources as a result of recent local precipitation. This research rendered the hypothesis, demanding marine sulphate of Keuperian age as a source of suphatic sulphur in some water sources, doubtful.

Isotopic research contributed to the information on genesis of geothermal waters in the Liptovská kotlina basin and certified the assumptions that water in the GTM-1 well in Marcelová has a marine descent. Sulphate, originating in the Upper Devonian sea, has been postulated as a source of sulphatic sulphur in water from this well.

Monitoring of isotopic composition of daily precipitation at Chopok as well as daily sampling of the Bystrianka creek in Tále contributed to precise the local precipitation-run-off model.

Project: GEOTHERMAL ENERGY OF SLOVAKIA

♦ Atlas of geothermal energy of Slovakia

Marián FENDEK and Anton REMŠÍK

The objective of this project was to understand the spatial distribution of geothermal energy in delineated regions by means of geothermal waters and temperature of dry rocks.

The project is intended to construct geothermal maps and sections at various levels at a scale 1:200 000 as well as larger regions and territorial maps of Slovakia at a scale 1:1000 000.

In addition to the later maps, the following maps will also be issued: thematic geothermal map, maps of thermal flow, map of reserves, map of saturation indexes, map of saved combustibles and map of reduced emissions. Maps of technological properties and liquidation of thermally used geothermal waters will become part and parcel of the maps covering the delineated regions. Tables, diagrams, figures, sections and explanations will also be appended to the maps. The project will ultimately result in the issue of a printed atlas.

The works, commenced in 1991 - 1992, continued in 1993 by realization of the Liptovská kotlina, Bánovská kotlina and Turčianska kotlina basins, Trnava and Piešťany embayment, Trenčianska and Ilavská kotlina basin, Žilinská kotlina basin, Skorušinské vrchy and Hornonitrianska kotlina basin (GÚDŠ, VVNP, Geocomplex).

Collection of samples for isotopic analysis (^{14}C, O, D and S) has been continued. Samples were collected in the Malé Krškany, Kalinčiakovo, Santovka, Slatina, H. Túrovce, Dudince, Cerovo, Piešťany, Bánovce n/Bebravou, M. a V. Bielice, Chalmová, Laskár, Bojnice, Rajecké Teplice, Liptovská Štiavnica, Liptovské Sliače, Lúčky, Kalameny, Bešeňová, Liptovský Ján, Stráňavy, Višňové, Peklina and Kamenná Poruba.(GÚDŠ, Faculty of Science, Department of Nuclear Physics).

Made by the Geocomplex, the report entitled "Geothermal energy of the Liptovská kotlina basin", which presents a reinterpretation of earlier geophysical measurements, has been approved within the framework of this project.

♦ Geothermal energy of Liptovská kotlina basin

Anton REMŠÍK, Marián FENDEK, Miroslav KRÁL, Dušan BODIŠ and Juraj MICHALKO

Present report is a synthesis of the geologic, geophysical, hydrogeologic and geochemical data and the information, achieved during the exploration and research of geothermal waters in the Liptovská kotlina basin. Based on the results of four geothermal research wells, drilled down to 1987 - 2500 m, as well as on other research, or exploration wells respectively, the following features have been evaluated: geological structure, geothermic situation, occurrence, distribution and chemical composition of geothermal waters, pressure conditions, hydraulic parameters of aquifers and thermal-energetic potential of the geothermal energy (renewable resource).

The Liptovská kotlina basin represents an intramontaneous depression filled by some 100 m (at Bešeňová) to 1700 m (at Liptovská Mara) thick Paleogene sediments. The Paleogene basement has a ragged relief, its morphostructures (elevations and depressions being underlain by the Choč and Krížna Nappes. The geothermal field activity varies considerably, with the geothermal gradient ranging from 18 to 32 °C/km and the density of global thermic current being 44 - 77 mW/m^2, out of which the lowest values of the above parameters characterize the eastern (Kokava depression) and the southern part of the depression.

Convective heat transfer takes place in both, the Kokava depression (negative anomaly) and the Bešeňová elevation (positive anomaly).

Existence of one, or up to three hydrogeothermal structures in vertical sense are considered within the underlying Paleogene, in a deeper nappe structure of the basin, where there are geothermal

waters bound mainly to Triassic dolomites and limestones (further referred to as carbonates) of the Choč and Krížna Nappe, and presumably, to the Tatricum cover unit as well. The above mentioned are open (with infiltration, accumulation and exsurgence areas developed) or semi-open (exsurgence area is missing) hydrogeologic structures. Approximate thickness of the Triassic carbonate aquifers ranges from 300 to 1200 m. In the Liptovská kotlina basin, in the underlier of the Paleogene there occur geothermal waters at depth of 500 to 5 000 m heated to 20 - 150 °C (low to medium tempered sources). The chemical composition of waters has shown that they are mainly of the Ca-Mg-$HCO_3(SO_4)$-$SO_4(HCO_3)$ and Ca-Mg-HCO_3 types, respectively, with the content of mineralization amounting to 0.4 - 5.0 g/l. The CO_2 gas predominates.

The Triassic carbonates, tested within the interval between 1255 to 2500 m, are characterized by the absolute transmissivity coefficient ranging from Tp = $2.4.10^{-12}$ to 1.10^{-10} m^3 and permeability coefficient Kp = $3.8.10^{-14}$ - $9.1.10^{-13}$ m^3. The Triassic carbonates were classified into three groups of absolute transmissivity and permeability, with indicated decreasing trend of the values from east to west.

Piezometric level of geothermal waters varies from 591.6 m. above sea level (the Vyšný Sliač area) to 690.8 m a.s.l (the Liptovská Kokava area), the point of gas evasion in geothermal waters, including the areas of Lúčky, Liptovský Ján and excluding the well FGL-1, occurs at depth between 50 m (BJ-101) and 225 m (ZGL-2/A).

Prognostic thermal - energetic potential of the geothermic energy of the Liptovská kotlina natural resources, ascertained by means of distributional parametric model, represents 34.302 Mw, out of which 14.038 Mw has already been proved by drillings (84 l/s of water with temperatures ranging from 32 to 62 °C), whereas remaining 20.264 MW are still awaiting for confirmation.

Project: DANREG PROGRAM

♦ Danube Region Environmental Geology Program

Ján HORNIŠ

Realization of the DANREG project continued in 1993 in accordance with the memoranda exchanged among the GÚDŠ Bratislava, the MÁFI Budapest and the GBA Vienna, with Hungarian and Slovak geophysical institutes (ELGI and GEOCOMPLEX a.s.) taking part as well. The objective of this international DANREG program is to construct a set of unified and compatible geological and geophysical maps and studies from the Danube region within the triangle Vienna - Bratislava - Budapest.

The works carried out within the framework of this project were effected in two levels. At the national level, the works were oriented at gathering of information for the construction of discrete geological maps. Systematic sorting out and reevaluation of existing background and documentation have been made to fulfill this goal. These data have been updated by the results of a new field geological and geophysical research. Intense co-operation between the GÚDŠ and the GEOCOMPLEX, the two bearers accountable for the project to the Ministry of the Environment of the Slovak Republic, enabled to utilize the newest knowledge, achieved by the geophysical research applied in order to construct geologic maps and, on the other hand, the data attained by geological research, applied to facilitate the construction and interpretation of the geophysical maps.

At the international level, the works were focused at completion of common methodological principles used in construction of discrete maps. Meetings of the working groups were organized, which included short field excursions and regular gatherings of the co-ordinating commitee of the program. Due to demanding process of construction of common maps the works were divided in two stages. In accord with the agreed principles the first stage includes the construction of provisional versions of discrete maps with the scope that their correlation and final adjustments would result in definite versions of the maps.

Following provisional versions of maps were constructed and commissionally approved in 1993 at the GÚDŠ: Surficial geological map, Map of Pre-tertiary basement, Tectonic map and Engineering-

geological map (see abstracts). The process of construction of definite versions of the Surficial geological map, the Lithogenetic map, the Map of thicknesses of Quaternary sediments and the Map of lithofacies and thicknesses of the Pannonian through Pliocene sediments, has continued at the same time. Provisional versions of the remaining types of maps were prepared, however, the most advanced are preparations of the Map of environmental hazards and the background for the "Study of water quality".

GÚDŠ employees take an active part in the completion and interpretation of geophysical maps, approved commisionally in 1993 within the framework of geophysical part of the DANREG project.

♦ Surficial map of Danube Region at a scale 1:50 000

Ján PRISTAŠ, Ján HORNIŠ, Rudolf HALOUZKA, Juraj MAGLAY, Vlastimil KONEČNÝ, Jaroslav LEXA, Alexander NAGY, Dionýz VASS and Jozef VOZÁR

Presented map is a basic map of the whole set of maps of the DANREG program. At the same time, it is the first geological map of the whole delineated Danube Region at a scale 1:50 000, constructed in accord with the agreed method. Complex evaluation of the existing maps and documentation data, including the interpretation of new geophysical measurements, have been applied in the construction of the map. Completion of the map required a reambulation of large parts of the region as well as new mapping of the following regional entireties: southern part of the Trnavská and Nitrianska pahorkatina highlands, left banks of the Malý Dunaj and maily the confluence areas of the Váh and Malý Dunaj (Vážsky Dunaj) and neovolcanic part of the Ipeľská pahorkatina highland and the Burda Mts. Construction of the map was based on explanations, accepted mutually by the workers of the DSIG Bratislava, the MAFI Budapest and the GBA Vienna. It depicts the structure and correlation of the Quaternary and Pre-Quaternary geologic units in terms of their lithology, origin, stratigraphy, paleogeographic development and, in case of Pre-Quaternary units, relation to lithologic-stratigraphic, or tectonic units, respectively. The most important elements of the surficial, mainly young tectonics, are particularly accentuated.

♦ Map of Pre-tertiary basement at a scale 1:200 000

Jozef VOZÁR, Peter DŽUPPA, Jozef HÓK, Jozef SALAJ, Ján ŠEFARA and Dionýz VASS

This map, constructed in accordance with the criteria, accepted by the participants of the DANREG program, i.e. the GBA Vienna, the MÁFI Budapest and the GÚDŠ Bratislava, displays the actual state of knowledge of the Pre-Tertiary basement. Delineated Units of the Hungarian Central Mountains are separated in the north from the Central Western Carpathian Units by the Rába - Hurbanovo fault belt. This is a new concept to explain the function of the Rába line and the Hurbanovo fault. The units within the Gabčíkovo depression, which displays all the features typical for a "pull-apart" basin, are delineated different way. Within the frame of this space the low metamorphosed volcanic and sedimentary sequences correlate well with the metamorphics of the Mihalyi phyllite formation, as well as with the Paleozoic at Graz. The metamorphics and basic to ultrabasic rocks are considered to occur in the central part of the Gabčíkovo depression and are correlable to the problematic Penninic zone of the Western Carpathians. In the eastern part of the region, the Southern and Northern Veporicum are delineated, with a distinct differentiation of the two zones. This division refers to both, the crystalline rocks and the cover sequences. The Veporicum, as an entirety, is overlain by the Hronicum nappe and by the Mesozoic nappe, correlable to Silicicum. The Tatricum, in a wider sense, is divided in the map into three groups: The Malé Karpaty Mts., the Považský Inovec Mts. and the Tribeč Mts. The cover sequences, which occur within the Tatricum Unit, are delineated at the surface, as well as inferred in the underlier. There is a separately delineated area in the region of the Považský Inovec and Tríbeč, underlain mainly by Permian and to a lesser extent by Triassic of the Hronicum nappes (the Malužiná formation. Of the whole Malužiná formation, the Permian basalts display the most distinct magnetic anomality. Continuation of the cover sequences of the Tatricum

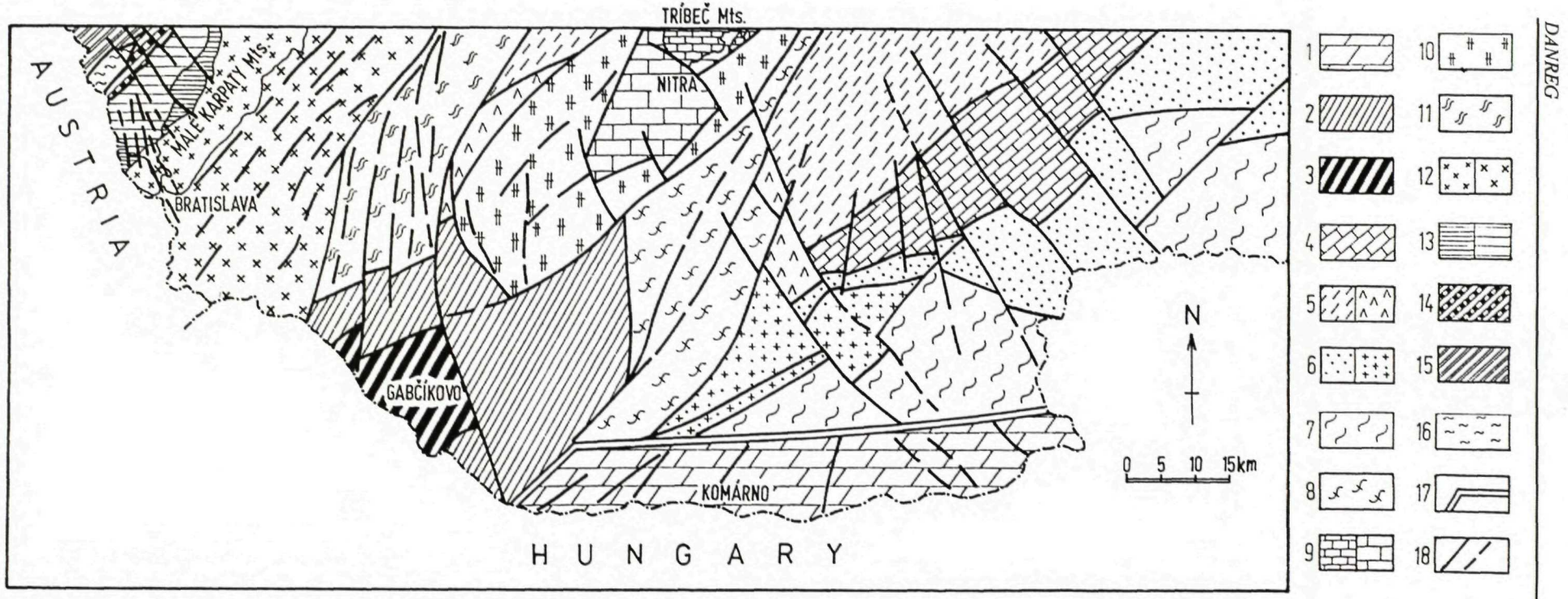


FIG. 1 MAP OF PRE-TERTIARY BASEMENT OF THE DANUBE REGION ON THE TERRITORY OF SLOVAK REPUBLIK (Compiled by: J. VOZÁR, 1994)

1. Units of the Hungarian Central Mountains - prevailingly Mesozoic; 2.-3. Units in the Gabčíkovo depression area; 2. Undivided Paleozoic metasediments and metavolcanic - Mihalyi Formation; 3. Ultrabasic rocks - ?basic metamorphic rocks correlated with the Penninic zone; 4.-5. Units of the Inner and Central Western Carpathians; 4. nappes of the Silicicum - prevailingly Triassic; 5. nappes of the Hronicum - prevailingly Permian: a) sediments; b) volcanics-basalts, andesites; 6.-7. Units of the Southern Veporicum; 6a. Late Paleozoic - Mesozoic envelope sequences; Revúca Gr. - Rimava and Slatviná Frms. correlated with Ipoly complex in Hungary; 6b. Inferred occurrences of the Southern Veporic, Early and Late Paleozoic with penetrations of Alpine granitoids (contact thermic metamorphism); 7. Early Paleozoic, prevailingly metamorphites with local occurrences of the envelope sequences (Late Paleozoic: Slatviná and Rimava Frms; Mesozoic: Tuhár development); 8.-13. Units of the Northern Veporicum and Tatricum; *Northern Veporicum:* 8. Group of Rázdiel massif - Early Paleozoic (metasediments, metavolcanics, mica schists, partly volcanics of the Skýcov and Slopňa Frms.); Mesozoic - prevailingly Triassic; 9.-12. *Tatricum:* Group of the Tribeč Mts.; 9.-Undivide Mesozoic - envelope sequence (prevailingly Triassic) of the Tribeč Mts.; Mesozoic partial nappe units overlying it (Krížna nappe) - a) at the surface; b) in the Pre-Tertiary basement; 10. Early Paleozoic: crystalline rocks, prevailingly granitoids of the Zobor massif (Tribeč Mts.); *Group of the Považský Inovec Mts.* 11. Early Paleozoic: crystalline rocks, mainly granitoids; *Group of the Malé Karpaty Mts.:* 12. Early Paleozoic: granitoids (Bratislava and Modra massifs), metamorphitc (metasediments and metavolcanics of Pezinok - Pernek and Harmónia Frms.); 13. Envelope unit of the Malé Karpaty Mts.: Devín sequence - Mesozoic, partly Permian; Borinka sequence - Mesozoic; a) at the surface; b) in the Pre-Neogene basement; *Nappe units in the basement of the Vienna basin - Slovak part:* 14.-15. Western Carpathian units, 14. Mesozoic of the Vysoká nappe, 15. Mesozoic of the Hronicum nappes, 16. Eastern Alps - Paleozoic of the Grauwacken Zone, 17. Raba - Hurbanovo fault-zone, 18. Significant faults, faults, strike-slip faults, inferred faults.

of Malé Karpaty Mts. including the Vysoká nappe, into the area of Pre-Tertiary basement, is found within the Vienna basin (its south-eastern part only). Contact of the Vysoká nappe with the Paleozoic of the Grauwacken-zone is tectonic (a fault). Continuation of the "Grauwackenzone" is contiguous from the Austrian territory, but wedges out towards the north-east. The area underlain by higher nappes of the Malé and Biele Karpaty continues into the basement of the Vienna basin and they appear in a synthesized form in the map, covering only a small area.

♦ Tectonic map of Pre-Tertiary basement at a scale 1:200 000

Michal ELEČKO, Dionýz VASS and Ján HÓK

In this map, constructed using a common legend with the Hungarian and Austrian partners, there are portrayed tectonic units mainly - the Tatricum, the Hronicum and the Veporicum, i.e. the units that crop as windows out from beneath the younger units. The Tertiary sediments have been divided into Hungarian Paleogene, Lower Miocene, Upper Miocene (Pannonian) and Upper Miocene to Pliocene (Pontian - Dakian and Rumanian). The faults, disrupting the region under study, were also time - scaled into Mesoalpine, i.e. the Paleogene and the Neoalpine, divided into the Lower Miocene (Eggenburgian - Karpatian) with the Middle Miocene to Pliocene (Badenien - Pliocene) members. If possible, each fault has the sense of its movement shown (downslip or transcurrent). One of the most important fault lines - the Hurbanovo line - has the repeated movements marked, distinguishing their age and sense as well.

♦ Engineering geological map of Pre-tertiary basement at a scale 1:100 000

Miloš KOVÁČIK, Pavel LIŠČÁK, Mária KOVÁČIKOVÁ and Helena TKÁČOVÁ

Engineering geological regional map at a scale 1:100 000 with explanations has been completed during 1992-1993. Surficial geological map at a scale 1:50 000 (PRISTAŠ et al 1993) has been used as a geological background. Total of 23 engineering-geological areas were delineated in the map according to genetic division (marked by symbols). Lithologic composition of areas (altogether 9 lithotypes) is symbolized in colours. Besides of these, there are following data in the map: - tectonics, neotectonics, exogene geodynamic features (slope deformations, erosional features, karst, loess sagging), hydrogeologic data, sites of raw material exploitation and waste disposal. These data are expressed in the map using the marks (point- or line-type). Method of realization and explanations were prepared in collaboration with the Hungarian and Austrian partners (dr. P. Scharek, dr. T. Tullner, dr. G Schäffer). The method of construction of this map corresponds to that used in the maps of this kind and the scale in this country. Bilingual (Slovak and English) explanations are pending the approbation.

Project: MINERAL RESOURCES OF SLOVAKIA

Dušan ONAČILA

The project involves research activities carried out in order to understand the genesis and to assess mineral resources in Slovakia with the aim to stimulate their exploitation and protection. It is composed of six partial projects devoted to more or less indeependent problems:

1. Metallogenetic model and mineral resources in the central zone of the Štiavnica stratovolcano. Partial project includes compilation of a detailed geological map, petrology of the Štiavnica stratovolcano, structural analysis, mineralogical/isotopic studies and metallogenetic

modelling of magnetite skarn, porphyry/skarn Cu, disseminated/stockwork base metal and vein type epithermal mineralizations, and finally resource assessment using all available data and GIS techniques.

2. Metallogeny of polymetallic mineralizations in the Western Carpathian Neogene volcanics. Partial project has been completed earlier and its result in the form of metallogenetical model for intrusion related disseminated/stockwork base metal mineralizations published.

3. Genetic models and localization of ore deposits in the contact zone of the Veporicum and Gemericum Units. Investigations carried out within the frame of the Partial Project include structural analysis, lithogeochemical studies of rock units, mineralogical studies of mineral occurences, reinterpretation of geophysical data, metallogenetic modelling and regional resource assessment.

4. Raw material potential of carbonaceous formations. This partial project has been concluded by a final report, evaluating the mineral resources potential of carbonaceous formations of major units of Slovakia in terms of their metallogeny, oil- and gas-bearing potential and nontraditional use.

5. Regional mineral resources assessment maps (scale 1:50 000 or 1:100 000). Regional mineral resources assessment, including compilation of maps, has been carried out in the regions Biele Karpaty, Slanské vrchy and Košická kotlina - south and Slovenské Rudohorie - west. Methodological aspects have been addressed too.

6. Isotopic research of selected ore deposits and mineralizations of the Western Carpatians. The research carried out within the framework of this theme is closely related to the above mentioned projects. The leaders of partial projects co-ordinated submission of suitable samples required for application of isotopic methods. Intense isotopic analytical work has been made on a set of sulfidic and sulphate samples from the Štiavnica - Hodruša ore field with accessible thermometric data. The studies of gas and fluid inclusions found in silicified zones and Mesozoic complexes of the Bukovec and the isotopic and thermometric research into the Pb-Zn mineralization in the surroundings of Čavoj have also been made.

♦ Raw material potential of carbonaceous formations of Slovakia

Bohumil MOLÁK, Augustín BEGAN, Alfonz BUJNOVSKÝ, Tibor ĎURKOVIČ, Michal ELEČKO, Milan GARGULÁK, Pavol GRECULA, Jozef HÓK, Miloslav KHUN, Juraj KNÉSL, Oto MIKO, Milan POLÁK, Miroslav PULEC, Martin RADVANEC, Igor ROJKOVIČ, Zuzana SIRÁŇOVÁ Miroslav SLAVKAY, Laurenc SNOPKO, Pavlína SNOPKOVÁ, Viera ŠIRÁŇOVÁ, Ján TURAN, Lýdia TURANOVÁ and Anna VOZÁROVÁ

This report is composed of two themes, in which the raw material potentiality of black shales, in terms of metal-bearing, oil-bearing and non-traditional use, is evaluated. Besides, it brings new informations on the paleoenvironment of the black shales, applicable in geodynamic modelling of the Western Carpathians.

Contributions to the sub-theme on black shales of the Gemericum include the paleoenvironmental modelling, the geochemical characteristics of black shales and their role in the metallogeny. Black shales and lydites supplied a portion of metallic element balance and the CO_2 into metamorphic fluids, which prompted the precipitation of the vein-type siderite - sulfidic mineralization, within the suitable structures.

Black shales of the Slovinky - Gelnica ore field could be of prognostic interest, since the majority of metal elements in them are contained in anomalous amounts, compared to the SDO-1 standard. Black shales of the Sb - belt are enriched in the Sb. Estimation of prognostic resources, bound to this belt, gave 16 Kt of ore @ 1.5 per cent, however, a revaluation is necessary to meet the criteria of the new classification.

Compared to the Gemeric Unit, the Lower Paleozoic of the Veporicum Unit is generally higher metamorphosed, with lesser occurrence of black shales. The black shales of the Janov grúň formation deserve attention, due to their contents of up to 1.4 g/t of gold, whereas the black shales in the area of Čierny Balog are scheelite-bearing.

Within the core mountains of the Fatric - Tatric Belt, the graphitic schists in the Tatricum Unit of the Nízke Tatry Mts., were investigated. Graphitic schists crop out in the belt between Bukovec and Medzibrod and represent a productive zone of the Sb - Au mineralization, containing 750 Kt of ores @ 0.84 per cent Sb and 1.55 g/t Au (MICHÁLEK et al 1988). This mineralization may be of prognostic interest in the future. Dark or gray problematic rocks, occurring in continuation of the W - Au mineralization near Jasenie locally contain anomalous amounts of W, Sb, As and Au (up to 2.4 g/t). Average contents of graphite in nebulites at the Štefan adit has been estimated to 1 wt. per cent, however the extent of its occurrence is not known to date.

Of some prospecting interest are anomalous contents of vanadium (up to 1600 ppm), found in the Rhaetian black shales of the Kössen beds in the Bystrý potok of the Veľká Fatra Mts.

In agreement with the previous investigations, which ascertained up to 6000 ppm of V and up to 1.45 ppm Au in black shales of the Pezinok - Pernek crystalline in the Malé Karpaty Mts., these results could be supported by new studies and confirmed possible economic resources.

High contents of Pt and Au occur in the Jurassic dark shales and clayey limestones intersected in the drill hole PKH - 25 at Borinka. In case of Pt the increase reaches 60 - times and in case of Au 5 - times relative to the SDO - 1 standard. Association of these metals with kerogen is suspected. Black shales are manganiferous and findings of new lenses, or seams, cannot be excluded.

Mn - mineralized lenses, localized within the black shales of the Branisko Mts. contain up to 22 per cent of Mn, however, due to their small extents they are probably of no prognostic interest.

Au - mineralization of possible Carlin-type was found in the area of Remata in the Žiar Mts. Black shales here are the most perspective horizon, containing up to 1 g/t Au.

The sub-theme on the Hronicum Unit describes the lithologic, sedimentologic and metamorphic conditions of the black shales. U - mineralization, associated with organic matter, which occurs in the Permian of the Kozie chrbty Mts., has been described in detail. This mineralization is of prognostic importance.

Occurrence of flaky graphite at Kokava nad Rimavicou village yields the average content of 5.4 per cent of graphite in the ore. The length of prognostic area reaches some 2 km and prognostic resources were estimated at 2 000 t of good quality graphite.

Large areas floored by the Kössen beds of the Krížna nappe within the Mesozoic domains of the Tatricum, Fatricum and Hronicum have shown increased contents of organic substances. The boundaries between individual nappes appear to be suitable environment for migration of carbohydrates.

An important prognostic resource of oil-bearing shales is located at Drienovec village in the Slovak karst.

In the Flysch belt, the most perspective beds in terms of oil-bearing are the menilite beds of the Dukla - Bukovec flysch, the Zuberec and Huty beds of the Orava Paleogene and the Zuberec group of beds of the Poprad and Hornád kotlina basins. Contents of Corg and Cbit are comparable to the world-wide perspective oil-bearing sediments.

An occurrence of alginite, intersected in the maar structure at Pinciná, is interesting from the prognostic point of view. Alginites are a potential source of fertilizing materials. This maar structure is now subject to exploration with the aim to evaluate the reserves.

The results of study of black shales, occurring in various stratigraphic horizons and tectonic units have shown, that there occur in several areas increased contents of trace elements, or organic matter. Therefore, recommendations were put forward to continue with the research at selected sites within the framework of future projects of the DSIG.

Following targets with the occurrence of black shales were proposed for further research:

1. Slovinky - Gelnica ore field
2. Sb - Au ore belt in the Nízke Tatry
3. Au and V mineralized zones in the Malé Karpaty Mts.
4. Increased contents of Pt and Au at Borinka in Malé Karpaty Mts.
5. Au at Remata
6. Graphite at Kokava nad Rimavicou
7. Carbohydrates at the nappe boundaries, Veľká Fatra Mts.
8. Menilite beds of the Dukla - Bukovec Flysch; Zuberec and Huty beds: carbohydrate potential
9. Alginites - fertilization of the agricultural soils

♦ Regional map of mineral deposits and resource assessment Slovenské rudohorie Ore mountains-West, eastern part (1:100 000)

Miroslav SLAVKAY, Jozef BEŇKA, Milan GARGULÁK, M. ARDOVÁ, Miroslav FILO, I. KUČERA and Ján MIKUŠKA

Apart from few ore deposits assigned to the Caledonian and Variscan stage, we attribute the majority of ore deposits, found within the Veporic metallogenetic zone, to the Middle or Upper Cretaceous period (SLAVKAY and PETRO, 1993). They are mostly represented by the siderite and tungsten-molybdenum ore formations. The Upper Alpine stage is represented by polymetallic formation, associated with the Miocene volcanic activity.

Out of the above mentioned deposits 70 are metallic and 68 nonmetallic deposits and/or occurrences. Various genetic, morphologic and raw material types are described: metamorphogenic deposits (Revúca-Dolinkovský potok, pyrite-pyrhotite), magmatic (Revúca-Hiak, granite), hydrothermal-metasomatic (Dúbrava massif, magnesite), veiny and veiny-impregnational (Čuntava-Samuel, Hg), stockwork-impregnational in the endo- and exo-contact of the granite (Rochovce, W-Mo), infiltrational (Muráň-Paseky, Fe), residual (Ochtiná-Hrádok, Fe) and sedimentary (Tisovec, limestone).

We have classified the prognostic resources in the P1 and P2 categories.

Metallic ores: Cu, Au± Fe -P2 5 285 kt; Au - P2 210 kt; Pb, Zn, Ag, Au± Cu - P2 1 910 kt; W - P1 3 790 kt, P2 - 31 220 kt; Mo - P1 10 507 kt, P2 - 86 564 kt; W, Mo - P2 - 20 000 kt; Sb, Au - P2 - 420 kt; Hg, Au - P2 220 kt. Nonmetallic materials: construction stone - P1 65 250 000 m^3, P2 247 000 000 m^3; sands - P1 10 300 000 m^3, P2 200 000 000 m^3; limestone - P1 100 000 kt; dolomites - P1 38 400 000 m^3, P2 10 000 000 m^3; brick clays - P2 1200 000 m^3; magnesite - P1 80 950 kt, P2 - 10 000 kt; soapstone - P1 5 130 kt, P2 - 265 kt; graphite - P1 900 kt, P2 - 600 kt; decorative stones - P2 20 000 m^3.

Estimated prognostic reserves of the raw materials are actually of no economic interest. The following nonmetallic ore materials attract attention at present: magnesite, soapstone, construction stone, (mined actually), flaky graphite (non traditional material), cement manufacture materials, high quality limestones and dolomites for smelting purposes.

Attained results offer a general review of the raw material base in the region under study.

♦ Regional map of mineral deposits and resource assessment - Biele Karpaty Mts.

Michal STOLÁR, Augustín BEGAN and Michal POTFAJ

The map of deposits and prognoses of raw materials of the Biele Karpaty Mts., introduced in a simplified geological setting, depicts the occurrences and deposits of raw materials as well as prognostic areas of occurrence of discrete types of raw materials.

Although the region does not belong to important mineral resource areas within the Western Carpathian territory, its heterogenic geologic structure and complicated geological development induced the formation and accumulation of a whole string of raw materials. Of the prime importance are the cement manufacture materials and the constructing stones. However, the Quaternary accumulations of gravels in the Váh valley and loess sediments, suitable for brick manufacture, are also significant.

Complicated geologic development of the area had been a reflection of a deep seated basement structure and resulted in the formation of extensive structures, favourable for hydrocarbon accumulations. The metallic ore materials are represented by the only manganese ore occurrence at the Lednické Rovne.

Cement manufacture raw materials are mined at present at the Horné Sŕnie deposit. The deposits at Krivoklát and Babiná were subject to exploration, too. Since the other potential resources of the cement manufacture raw materials lay within the Biele Karpaty Protection Area, we do not evaluate their prognostic resources.

The prognostic area of gravels and gravel-sands (alluvial sediments) stretches along the whole course of the Váh River.

We have delineated altogether four prognostic areas with the total volume of raw material amounting to some 60 mil.t. in the P3 category.

The stone materials are the raw materials that occur in considerable quantities, however, their quality does not always meet the required criteria (flysch belt region and rocks of the Klippen belt).

16 localities, which include the rocks of the Klippen belt and, to a lesser extent, the flysch rocks, were delineated as prognostic resource areas for stones and stone materials. The total volume of prognostic resources was estimated at 225 mil. m^3 in the P3 category.

The brick manufacture materials have not been mined in the region. Brick clay quarries were mined out during earlier times and abandoned, thus the brick manufacture was halted.

We consider the Drietoma (Hrozenkov) elevation, located within the Paleozoic as well as Mesozoic formations of the Biela Voda area, perspective in terms of occurrence of oil and natural gas.

The Drietoma (Hrozenkov) elevation forms an elongated tectonic unit, running parallel to, and in front of the face of the Klippen belt.

Since some 40 % of the interpreted elevation belong to the Czech territory, prognostic resources of the natural gas, bound to the Slovak part of the Drietoma (Hrozenkov) elevation, are reduced to 40 mil. m^3.

♦ Regional map of mineral deposits and resource assessment of the southern part of Slanské vrchy hills and Košická kotlina basin at a scale 1:50 000

Michal KALIČIAK, Ján BODNÁR and A. DUBÉCIOVÁ

Southern part of the Slanské vrchy hills and Košická kotlina basin is not a significant mining region.

Apart from a magnesite deposit located in the NW part of the Košice township, the deposits of gravel-sands, construction stones, brick manufacture materials and bentonite have been mined sporadically. Less important, and actually out of work, are the occurrences of pottery raw materials, perlite and energetic raw materials - lignite and natural gas.

Metallic ores do not represent industrially exploitable deposits so far. The only known occurrences and manifestations of epigenetic metallic ore mineralization are associated, both genetically and structurally, with the Neogene volcanism. A direct structural link with the central volcanic zones and their close surroundings is an essential sign of metallogenetic processes. An insignificant polymetallic mineralization was found within the central volcanic zone of the Bogota stratovolcano (DIVINEC et al 1989) and an interesting occurrence of noble metal (Au, Ag) mineralization at the Byšta (BAČO, 1989). An occurrence of hydrothermal-explosive breccias, with indications of Au, Ag (Sb, Zn, Pb) mineralization is genetically bound to a type of hot water springs exsurging outside the root inflow zone of the volcanic structure.

The nonmetallic ore materials are recently exploited in the region. The deposits of construction stone and stone for crushing are located within the neovolcanic rock of the Slanské vrchy hills, most of them lying directly within the volcanic bodies - lava flows and extrusions. The deposits of gravels and gravely sands are either bound to the detritic Neogene sediments, or to the proluvial and fluvial Quaternary sediments, which mostly lay in the bed fillings of larger rivers (Hornád, Torysa, Olšava).

The brick manufacture materials are either in the Neogene pelitic sedimentary facies, or, and mainly, in the Quaternary aeolian sediments - loess, loessy loam or deluvial loam. The raw materials, exploitable in the pottery industry, are bound to the pelitic clayey - aleuritic sediments of the Sečovce group of beds, in the soutwestern part of the Košická kotlina basin. An occurrence of perlite is bound to the peripheral part of a rhyolite extrusive body north-west of the Byšta village, as well as to the redeposited rhyolitic volcaniclastic bentonite deposits (Kuzmice, Lastovce). The most important,

from the economic point of view, is the magnesite deposit in Košice, located in the Upper Carboniferous Ochtiná group of beds.

The energetic raw materials are represented by lignitic coal, found in thin seams in the Upper Sarmatian and Pannonian pelitic sediments near the Svidnica and Dargov villages and by an occurrence of natural gas in the drill hole Albínov-4.

Based on prognostic factors and prognostic geologic and geophysical criteria, the areas with potential presence of metallic ore raw materials (with high, medium or low degree of reliance) and perspective areas of occurrence of the construction stone, gravel and gravely sands, brick and pottery manufacture materials were delineated in the map.

♦ Geochemical model of porphyry copper mineralizations in central zone of the Štiavnica stratovolcano

Karol MARSINA, Jaroslav LEXA, Vlastimil KONEČNÝ, Eva ŽÁKOVÁ,
Viera HOJSTRIČOVÁ, Patrik KONEČNÝ, Štefan KÁČER and Otto ORLICKÝ

This report summarizes to date knowledge on the geological structure and the development of alterations in the skarn- porphyry copper bodies at Zlatno and Šementlov in the central zone of the Štiavnica stratovolcano and is supplemented by some new findings. Based on the results of detailed petrographic and mineralogic investigation of alterations in the samples from exploration drill holes of the "V" series, a new model of vertical alteration zonality at the Šementlov body is presented here by Dr. V. Konečný, CSc., Dr. V. Hojstričová, CSc. and Dr. E. Žáková, CSc. Authors delineated the following 8 zones of alteration (from higher to lower thermal ones): 1. chloritic-actinolitic zone, 2. skarnization zone, 3. biotitization zone, 4.albitic- epidotic zone, 5. phyllitic zone, 6. argillitic zone, 7. zeolitic zone and 8.propylitic zone.

Most attention has been paid to the lithogeochemical investigation of the third dimension of two explored bodies, while the evaluation of the distribution of 25 macro- and microelements in 467 rock samples, collected from ten exploration drillholes of the "R" (Zlatno) and "V" (Šementlov) series, was also highlighted. Based on the calculation of basic mathematical- statistic characteristics for the established sets, a considerable disagreement in the distribution of several elements was found in the above two objects. This disagreement arises mainly from the contrasting geochemical environment of the two localities, which is predominantly due to the divergent development of hydrothermal alterations. This refers mainly to dominant development of the phyllic zone at Šementlov (to which the maximum contents of Mo, Sn, Ag - mineralization, Si - silicificaton, Al - clayey minerals, K and Rb - sericitization the minimum contents of Ca, Sr, Na, Fe, Mg, Mn and Zn due to hydrothermal desintegration of plagioclases and Fe-Mg minerals are bound) and its absence at Zlatno.

The report also includes the results of petrologic (Dr. P. Konečný) and special geophysical research into the intrusive rocks of both objects.

Provisional results of petrographic and petrologic studies of the least altered parts of both the Zlatno and Šementlov intrusive complexes, enabled to assume that the two intrusions of the granodiorite porphyry had a common magma development (path of plagioclase crystallization, presence of enclaves etc.) as well as separation and ascension into hypoabyssal levels in a form of stock intrusions with complicated systems of dykes in their apical parts, that followed this process.

Special geophysical research of intrusive rocks has been oriented at the measurement, in the samples, of magnetic susceptibility changes due to heat. Four Fe - oxides, or Fe - sulfides, namely magnetite, hematite, pyrite and chalcopyrite were identified and analysed quantitatively.

Summary of the results of all used research methods, supplemented by the literary data, resulted in putting up the concluding chapter entitled "Model of skarn-porphyry copper mineralization of the Štiavnické vrchy hills", in which the above mineralizations are referred to as transitional types between the "monzonite" and the "diorite" model.

♦ Sulphur isotopes in sulfides from Hodruša - Štiavnica ore district

Ivan REPČOK, Karol ELIÁŠ, Jarmila ĎURKOVIČOVÁ, Elígia FERENČÍKOVÁ, Anna KOVÁŘOVÁ and Ivan RÚČKA

The part I. of the report includes a set of 578 sulphur isotopic analyses of the sulfide minerals (pyrite, sphalerite, chalcopyrite and galena) from the Hodruša - Štiavnica ore district, with all the available localizing and metallogenetic characteristics. In several cases however, the information on periods, mineral assemblages, paragenetic and successive relations is missing. Lack of such information constrains, or prevents at all the interpretation of the isotopic analysis. Isotopic temperatures for 243 sulfide pairs were calculated, and 70 out of these were further checked by TVI decrepitation analyses. Many of these data were published for the first time. Isotopic data were arranged according to the discrete veins and the PIS mineralization and were processed statistically, with the references given to the basic parameters, such as: number of analyses, average, median, modus, maximum and minimum values, including the distribution histograms. Vertical distribution of the sulphur isotopes discrete sulfides in the main veins and the PIS mineralizations has been plotted in diagrams. Report includes predetermined conditions to interpret isotopic temperatures necessary for the assessment of cogenetic relations of the coexisting sulfides.

The redox isotopic exchange reactions between the solid and the fluid phases during the ore-forming processes. These reactions are referred to by appropriate formulas. The regression analysis was used in processing the isotopic composition of data on the coexisting sulfides pairs from discrete veins in order to calculate presumed composition of sulphur isotopes in the original fluids. Apart from the basic assemblage of isotopic analyses, the report also includes suggestions for further possible applications, not only for a given area, but also for the other ore districts, other minerals and other isotopes (O, H, C). To date results of isotopic investigations in Slovakia suggest, that they are important not only in the field of science, but also in practical applications, such as exploration, exploitation and utilization and preservation of raw materials.

♦ Fluid inclusions in silicified zones of the Bukovec Mesozoic complexes

E. JULÉNYOVÁ

The part II of the report deals with the results of study of fluid inclusions in order to assess the character of the hydrothermal system, which provoked the development of silicified zones within the Bukovec carbonate complexes. Hydrothermal fluids with the average salinity of approx. 2.4 wt % NaCl eq. caused the silicification of the carbonate precursor in two temperature intervals: 220-240 °C and 150-180 °C. Statistical evaluation of the measured values of salinity and temperature indicates a moderately increasing trend of the fluid concentration from north to south. In contrast, the crystallization temperatures display a reverse trend. Based on the attained results we can assume, that mentioned trends were influenced by a hypothetic granite intrusion, which intruded the subvolcanic level of the Štiavnica stratovolcano (intersected in the drill hole ST-5).

♦ Isotopic and thermometric investigation of Pb-Zn mineralization in surroundings of Čavoj

Ivan REPČOK, Elígia FERENČÍKOVÁ, Karol ELIÁŠ, Ivan RÚČKA, Anna KOVÁŘOVÁ, Magdaléna SLÁDKOVÁ and Viera WIEGEROVÁ

The part III. of the report is an update of the existing isotopic information on the Pb-Zn mineralization in the surroundings of Čavoj. New isotopic analyses of oxygen and carbon in calcites from

the Čavoj, Baniská and Geschenk localities rendered the following range of δ delta values: $\delta^{13}C_{PDB}$ from -5.44 to -8.97 ‰ and $\delta\ ^{18}O_{SMOW}$ from 14.68 to 20.48 ‰.

Their TVI decrepitation temperatures ranged from 300 to 330 °C. Proposed isotopic composition of oxygen in the initial fluid ranged in the calcites between 10.6 and 15.5 ‰. According to given data it is possible to presume, that the calcites under study are of abyssal provenance and they were formed under unusually high temperatures, ranging from 300 to 330 °C. The $\delta\ ^{34}S$ value of -1.33 and TVI decrepitation temperature of 330 to 340 °C, too high in respect to the known data, were found in galena from pegmatite. Muscovite from this pegmatite gave an K/Ar age of 383-7 Ma. This age is in good agreement with the previous Rb/Sr datings made in this area. The study of undulatory extinction of quartz substantiated this age in several samples. Undulatory extinction of a carbonate, found in a vein together with inclusions of granitoide, suggests relatively high age of formation of this carbonate (350±50 mil.a).

Project: RESEARCH INTO GEOLOGICAL FACTORS OF THE ENVIRONMENT

Alena KLUKANOVÁ

The intent of the Project "Research into geological factors of the environment" was to resolve the actual problems related to the development and preservation of the environment of the Slovak territory, during the period 1991 to 1995. It has been formerly divided into 3 independent partial projects:

01: Geochemical atlas and geochemical-ecological mapping of the Slovak territory at a scale 1:200 000.

Term of realization: 1991-1995

02: Set of regional maps of geological factors of the environment.

Term of realization: 1991-1993

03: Engineering-geological research for optimal exploitation of the country and protection of the environment

Term of realization: 1991-1992

The partial project 03 represented a continuation of the former departmental research project R-52- 547-204 (realized from 1.1.1989),the solution of which has been formally and organizationally terminated in 1992 (excluding the final report, submitted and approved in the first half of 1993).

A substantial part of the solution of the ZP-547-008 project was further continued in 1993 in the project 01 (Geochemical atlas) and completed by the project 02 (Set of maps at a scale 1:50 000).

Partial project 01: Geochemical atlas and geochemical-ecological mapping of the Slovak territory at a scale 1:200 000

♦ Geochemical atlas, Banská Bystrica sheet

Kamil VRANA, Silvester PRAMUKA, Stanislav RAPANT, Juraj ČURLÍK, B. MAŇKOVSKÁ, and I. DANIEL

Partial project is divided into 6 stages of realization (stream sediments, groundwaters, rocks, forestry biomass, soils and radioactivity of the region) co-ordinated by the GÚDŠ.

Following main projected targets have been achieved during the given stage of realization:

-Collection of field samples (1991-1993). Due to lack of funds the soil geochemistry sampling did not start prior to 1992. It follows from the results attained so far that the term, delineated to conclude the activities i.e. 1995, will not be endangered provided there is a sufficient fiscal credit to cover the costs.

-Concept of a method to assess individual elements. It is assumed that the methods will be available after the completion of the project. Assessment of fluorine in the forestry biomass poses a problem. The analytical check-up has shown that geochemical results are comparable to those, obtained within the framework of similar projects at analogous institutions abroad. Thus, (as far as the distribution and concentration of chemical elements - regional geochemistry is concerned) Slovakia may be included in the international program to participate in preparation of the geochemical background.

-Preparation of the software for computerization, realization of the databases and map backgrounds, compatible with the foreign geochemical background. However, during the time ahead it will be necessary to concentrate to mastering effectively the processing of the enormous quantity of data within the whole scope of a geochemical atlas, along with the preparation of editing business.

Current results from discrete geochemical themes have confirmed that the regional geochemical results are of great importance, not only in terms of the geologic, but also of subsequent environmentalistic interpretations.

Partial project 02: Set of regional maps of geofactors of the environment at a scale 1:50 000

Igor MODLITBA and Miloš KOVÁČIK

This partial project, aimed at the construction of newly conceived maps, has been realized during 1991 - 1993:

- geochemical reactivity of rocks
- natural water quality
- geochemical - environmental map (stream sediments)
- pedologic map
- regional radioactivity (two sheets)
- engineering-geological map (three sheets)

covering 6 regions of Slovakia:

- Horná Nitra (GÚDŠ)
- Nízke Tatry (GÚDŠ)
- Hornádska kotlina basin and eastern part of the Slovak Ore Mountains (GP SNV)
- Košická kotlina basin and Slanské vrchy hills (GP SNV)
- Malá Fatra Mts. and a part of adjoining basins (INGEO Žilina)
- Žiarska kotlina basin and the area of Banská Štiavnica (GEOS Bratislava)

GÚDŠ has been appointed institution to realize the first two regions, as indicated in the above review and besides, it sustained the co-ordination of work, in terms of the methodology, in other regions.

♦ Set of regional maps of geofactors of the environment at a scale 1:50 000 – Horná Nitra region

Miloš KOVÁČIK, Karol MARSINA, Kamil VRANA, Jozef HATÁR, Helena SMOLÁROVÁ, Peter ČÍŽEK and Ján ČURLÍK

This final report presents the results of geological - environmental mapping in the Horná Nitra region. The whole region mapped belongs administratively to the Prievidza county. The mapping was realized within the following partial areas of the map sheets at a scale 1:50 000: 35-22, 35-24, 35-42, 36-11, 36-13, 36-31; altogether 800 sq.km were mapped.

The aim of this exercise was to construct a set of maps, based on regional geological maps, which would represent the geological factors of the environment. Following set of geoenvironmental maps at a scale 1:50 000 was completed during 1991- 1993:

a) map of geochemical reactivity of rocks (Project leader: K.MARSINA)

b) natural water quality (Project leader: K.VRANA

c) geochemical - ecological map (Project leader: J. HATÁR)

d) map of natural radioactivity of the region (Project leaders: P. ČÍŽEK, H. SMOLÁROVÁ - Uranpres, Spišská Nová Ves)

e) pedological map (Project leader:Ján ČURLÍK, VÚPÚ Bratislava)

f) set of engineering-geological maps (Project leader: M.KOVÁČIK).

a) The map displays a review of the element and chemical compound distribution in the rocks, which is essential for the formation of soils and chemistry of circulating waters. Resulting map shows the classification of rocks from very reactive - carbonates, to very low reactive - (majority of non carbonatic rocks).

b) The main objective was to express in the map the quality of ground- and precipitation waters, including the location and evaluation of anthropogenetic influences. Contamination in the surface streams comes from both, the municipal and the agricultural realm, however, in the section of Nitra River off the Prievidza township, from the industrial sphere, too. The greatest concentrations of precipitation (snow) polution were found in the surroundings of Zemianske Kostoľany and Nováky. The so called concentration types of polution were found in the groundwaters (mainly in the alluvium between the Prievidza and Nováky - Zemianske Kostoľany townships) with concentrations of Fe, Mn, sulphates, nitrates, chlorides and organic compounds, surpassing the limiting values.

c) The geochemical-ecological map (map of alluvial geochemistry) displays the distribution of elements in the alluvial sediments, dependent from natural and anthropogenic influences. High anomality of some detrimental elements (As, Hg, Ba, B), as well as organic substances were found in the surroundings of Nováky - Zemianske Kostoľany townships (chemical manufacture, electric power plant) however, anomalies of geogene type have also been traced.

d) A set of natural radioactivity maps (radioactive potassium uranium, thorium and radon) show the occurrences of radioactive elements in the region. Their concentration does not exceed general values in our natural conditions. In terms of the radon hazard, we rank this region into the medium category. Increased contents occur within the tectonic fault zones.

e) The soil map shows the distribution of soil types in the region. Fluvisols, albic luvisols and planosols belong to the most productive soils in the region.

Due to the region's morphology, soil erosion poses a serious problems. Erosion hazard index of the region reaches 14.5%.

f) The engineering geological maps provide an information on the most significant geological factors (geotechnical properties of rocks and soils, geodynamic events, geologic, hydrogeologic and tectonic features), which considerably influence, be it negatively or positively, the environment. In terms of engineering geology (slope stability), we consider the region between Handlová and Prievidza the most problematic.

♦ Map of geochemical reactivity of rocks; the Horná Nitra region

Karol MARSINA

The report consists of the Map of geochemical reactivity of rocks of the above region, a concise explanations and a database.

The map provides a basic review of the element and chemical component distribution in the rock basement, which plays conclusive role in formation of the soil cover as well as in shaping the chemistry of circulating waters. Geological boundaries, redrawn from the regional geologic map and were purposedly simplified. Based on calculated values of the alkalinity coefficient - X_{alk} and some other criteria, discrete rock types were distinguished in the map by a colour according to the degree of reactivity, grading from blue (very reactive rocks - carbonates), through the shades of red, amber, yellow and green (medium reactive rocks - most of magmatic and metamorphic rocks) to

the shades of brown and grey (low reactivity rocks - most of non-carbonate sediments). Anomalous distributions of elements are also plotted in the map.

A database consisting of geologic, petrographic and analytical data from 174 samples represents an important part of the report.

As the map is fully digitized it represents an "electronic medium" and facilitates immediate editing of the data, according to changing needs and intentions.

♦ Map of natural water quality, the Horná Nitra region

Kamil VRANA

The report is composed of a written text and an appended map entitled "Map of natural water quality, the Horná Nitra region at a scale 1:50 000". A database of hydrochemical data is attached to the map.

The hydrogeochemical research was directed at the assessment of groundwaters, surface and precipitation waters in the Horná Nitra region. The map, appended with explanations, displays the genetic groups of waters, the qualitative groups of surface and subsurface waters and the distribution of compounds (supplementary marks and additional maps). A total of 436 chemical analyses of waters, out of which 259 were underground waters, 123 surface waters and 31 snows, were included in the evaluation.

Following are the measured parameters, assessed elements, or components, respectively: Tv, pH, conductivity, or O_2, respectively, neutralizing capacity, oxidability, fluorine, chlorine, NO_2, NO_3, HPO_4, Na, K, Mg, Ca, Fe, Mn, Zn, Cu, Cd, Cr, Hg, As, Se, Tl, Sb, Al and, to a limited degree, organic compounds.

Achieved results have shown that the natural conditions, under which the chemical composition of waters within the Horná Nitra region have formed are, to a considerable degree, modified by secondary influences, manifesting themselves in certain parts of the region by concentrated type of water polution which is consequence of combined influences of the industry, agricultural activities and municipal polution, and includes high concentrations of nitrates, chlorides, sulphates, organic pollutants, iron and manganese in both, the surficial and groundwaters. Atmospheric contamination (e.g. arsenic) was also documented by means of detailed investigation of the chemical composition of snows.

♦ Geochemical-ecological map of the Horná Nitra Region

Jozef HATÁR and Ján GREGUŠ

Since 1991 the research project entitled "Geological factors of the Environment", co-ordinated by the GÚDŠ Bratislava, has been in effect in the Slovak Republic. A Geochemical Atlas at a scale 1:1 000 000, based on the stream sediment sampling, has been made within the framework of this research. This project is methodologically and substantially compatible with the geochemical mapping programs, carried out in other European countries. The partial studies entail the regional geochemical-ecological maps at a scale 1:50 000. The sampling density applied in the actual drainage systems, in both the dry regions and in the seasonal streams, was 1 sample per 2 sq.km in case of the atlas preparation program and 1 sample per 1-1.5 sq.km in case of the regional map preparation. The weight of a sample is 2-3 kg, and the fractions below 0.125 mm mesh are submitted to analysis.

The distribution of 34 elements (Al, As, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Fe, Ga, Hg, K, Li, Mg, Mn, Na, Ni, P, Pb, Rb, Sb, Se, Sn, Sr, Ti, V, W, Y, Zn and Zr) is investigated. The following analytical methods are applied: ICP, ICP-OES, H-AAS, XRF-p and AAS.

The main goal of this exercise is to acquire as authentic a representation as possible of the provenance of the elements under study, which may basically represent two sources:

- natural (geologic) sources
- anthropogenic (civilization) sources

A due attention is payed not only to the inhabited regions (villages, towns), but also to the industrial units, exploitation and agricultural activities and to the related waste disposal.

The region's morphology is ragged the lowland being fringed by the Vtáčnik, Žiar, Strážovské vrchy and Malá Magura Mts. A dense drainage system is developed with a good hydrogeologic situation; the mean sampling density was 1 sample per 1.3 sq.km.

The results

569 collected samples yielded some 20 000 analytical data, evaluated statistically in two levels:

a) all data as a set with each element separately

b) all monoelemental data separated in 6 sets according to the geologic environment (Quaternary, Neogene-Paleogene, Neogene volcanics, Mesozoic, gneisses + migmatites, granites).

The frequency parameters for 10 to 11 classes were calculated from the sets of individual elements, representing a background for the construction of monoelemental maps. Method of construction was prepared in the Geofond Computer Centre in Bratislava. The regional map at a scale 1:50 000 was segmented into a square cell network, each square covering 2.5x2.5 mm (corresponding to an area of 125x125 m). The value of each cell was calculated basing on 8 adjacent samples, taken in a circle with the diameter of 5 km. Each analysis was weighted by means of a relation 1/D2 (D - distance of the sample site from the centre of calculated cell). A condition is sustained that the nearest sample does not exceed the distance of 4 km and the most distant one 5 km from the centre of calculated cell. The formulae used for the calculation are following: a)

A- element value at a real point, D- distance of the point from the centre of calculated cell, R- value of calculated cell;

The second calculation level consists of local smoothing of each calculated value by means of a moving average through 9 neighbouring cells b) weighted according to the relation 1-D2/Dmax.

D- distance of a square in the net from the centre of the cell R5, which should be smoothed.

Dmax- distance of squares from the centre of the R5 cell, multiplied by 1.1 so that the value of above mentioned cells will not be equal to 0.

The areal distribution of 34 elements is primarily influenced by overall geologic structure and active geological processes, thus, we speak in terms of natural (geologic) sources.

The anthropogenic sources in the region under study have their own specific features, namely:

- mining and processing of brown coal
- chemical production - township affliction and agricultural production, small scale municipal production and services and associated waste management.

The former two are the chief sources with the risk factors that afflict the environment of the Horná Nitra.

Besides of the monoelemental mosaics, the resulting "Geochemical- ecology map" includes a map of 10 most toxic elements, which are plotted, although, not necessarily contained, in distinctly anomalous concentrations. These are: As, B, Ba, Be, Cd, Hg, Pb, Se, V and Zn.

Geochemical level of knowledge - a new knowledge on the geologic development, expressed regionally, such as magmatism and petrology, hydrothermal ore forming processes and distribution of secondary aureoles of the elements investigated in streams and their sedimets.

Ecological level of knowledge - (in this case the distribution of toxic and detrimental elements) is a dominant motif of the project "Geological factors of the Environment".

Both natural and anthropogenic factors are involved. From the ecologic point of view the most important anomaly extends along the upper course of the Nitra River, from the Koš village through Nováky, Zemianske Kostoľany up to the limit of the region and we presume that it continues further along its course.

Increased contents of As, B, Ba, Hg, Se and Zn are observed.

a) coaly slimes (tailings) - a product of washing of the excavated brown coal and the wash-outs of the dust emissions from the Cígeľ, Koš and Nováky plants. An alluvial sediment with a high content of such slime contains As (50-250 ppm).

b) fly ash produced by combustion of brown coal in the Electric Power Station in the town of Nováky, As (230 ppm), B (160 ppm), increased contents of Ga, Sr, Rb, Li, Ni and V. It is distributed

from the plant chimney stack and numerous waste dumps, during transportation and production of the shaped bricks and their destruction during the construction activities. It reaches the drainage system by means of the sheet-wash.

The increased content of Zn and Se in this area is obviously linked with these two sources.

c) lime slimes from the Chemical Works of Nováky (large tailing dam next to the Nitra River) contain Hg (108 ppm), Ba (20490 ppm) and o a lesser extent Cu, Sr. These elements are washed out from the dam into the Nitra River.

The smaller anomalies are of local importance only. This also refers to the metallic elements from the natural sources. They indicate some other types of mineralization. Their occurrence may either be correlated with the already known ore mineralizations, or they deserve further investigation and verification.

♦ Set of engineering geological maps of the environment: the Horná Nitra region

Miloš KOVÁČIK, Vlasta JÁNOVÁ, Martin ONDRÁŠIK, Pavol LIŠČÁK, Igor MODLITBA, Ľubica IGLÁROVÁ, Mária KOVÁČIKOVÁ, Gustáv GABAUER and Alena KLUKANOVÁ

This partial final report presents the results of engineering-geological mapping of the Horná Nitra region (parts of topographic map sheets, at a scale 1:50 000, Nos. 35-22, 35-24, 35-42, 36-11, 36-13, 36-31). The area mapped covers approx.800 sq.km.

Following engineering-geological maps were constructed:

a) Map of engineering-geological zoning (M. Kováčik, Ľ. Iglárová)

b) Map of relative susceptibility to slope deformations (M. Kováčik).

c) Map of weathering resistance of rocks (V. Jánová)

d) Map of rock susceptibility to erosion (M. Ondrášik)

e) Map of ultimate bearing capacity of foundation soils (P. Liščák, I. Modlitba)

f) Map of important geological factors (V. Jánová)

The discussions held to resolve the contents and the method of engineering-geological mapping resulted in an agreement that: the maps a), b) and f) are the so called "compulsory" maps, i.e. they must be constructed for all the regions mapped within the framework of the Project ZP-547-008 entitled "Set of engineering-geological maps of the environment", while the remaining maps c),d) and e) should be constructed to verify the methods used to preparate the special engineering-geological maps. These maps document and evaluate the selected geological and technical factors of the environment (weathering, erosion and ultimate bearing capacity of the foundation soils in the region). All maps are supplemented by a written text section, as well as by concise characteristics of the selected regions in the form of tables.

Archival data deposited in the Geofond Archive in Bratislava were processed and an extensive field mapping and sampling has been done during 1992-1993 within the framework of this project. 80 engineering-geological bore holes were drilled down to 10-20 m and the results were used as a background for the map a), as well as for the other maps ("Map of geochemical reactivity of rocks", "Geological map", "Map of ultimate bearing of foundation soils"). The laboratory tests of physico - mechanical properties of soils were carried out at the GÚDŠ Bratislava and the Geohyco Bratislava. A total of 1889 of various tests have been made (moisture - 473 measurements, granularity - 432 measurements, bulk density - 69 measurements, specific density - 65 measurements, Atterberg's fluidity and plasticity limits - 445 measurements each, contents of carbonates - 103 measurements, compressibility - 28 measurements and triaxial test neodvodnena - 28 measurements).

Constructed engineering-geological maps at a scale 1:50 000 represent a synthetic set of maps, which display the most significant geofactors responsible for substantially negative effects upon the environment of the Horná Nitra region.

The objective for the construction of engineering-geological maps was to inform, either in graphic, or written form, about the engineering-geological situation of the Horná Nitra region and

about the most important geodynamic phenomena and geologic factors. In respect of the exploitation of the region, these may act as geologic potentials, or barriers, influencing the utilization of the natural environment.

The above maps, along with the other geoenvironmental maps constructed within the framework of the project, will stand for a theoretical background made in order to understand the actual state of abiotic part of the environment in the Horná Nitra region and to design the compensation measures to alleviate the conditions in the region.

♦ Set of regional maps of geofactors of the environment at a scale 1:50 000 – Nízke Tatry Mts. region

Milan LOBÍK, Štefan KÁČER, Stanislav RAPANT, Dušan BODIŠ, Helena SMOLÁROVÁ, Peter ČÍŽEK and Ján ČURLÍK

Final report presents the results of complex geological- environmental mapping. In terms of regional management the mapped area belongs to the Banská Bystrica, Liptovský Mikuláš and Poprad counties. The mapping has been realized within the areas of following map sheets 1:50 000: 26-34, 26-43, 26-44, 27-33, 36-12, 36-21, 36-22, 37-11, 36-14, 36-23, 35-24 and 37-13; the mapped area stretches over some 2 200 sq.km.

Concise characterization of the region in terms of natural features and technogenic conditions (inhabitation, industry, agriculture, forestry) is given in the final report.

The objective of the realization of this set of six types of maps was to characterize recent state of the environment and interaction of the environment with the anthropogenic activities.

Constructed maps:

a) map of geochemical reactivity of rocks
b) natural water quality
c) geochemical - ecological map
d) map of natural radioactivity of the region
e) pedological map
f) set of engineering-geological maps (map of engineering geological zoning, map of relative slope deformation ability, map of important geological factors).

a) The map displays a review of the element and chemical compound distribution in the rocks, essential for the formation of soils and chemistry of circulating waters. Resulting map shows the classification of rocks ranging from the very reactive carbonates, to the very low reactive - (majority of non carbonatic rocks). The map also displays all the anomalous contents of chemical elements within given rock environment.

b) The main objective was to express in the map the quality of ground- and precipitation waters, including the location and evaluation of the anthropogenetic influences. The contamination in surface streams is lower compared to the other regions and comes from municipal and agricultural sphere, whereas in the upper course of the Hron River, in the surroundings of Podbrezová township where there are greatest concentrations of the precipitation (snow) polution, it comes from the industrial sphere.

c) Geochemical-ecological map (map of alluvial geochemistry) displays the distribution of elements in the alluvial sediments, which depends from natural and anthropogenic influences.

Increased anomality of some detrimental elements was also found in the mentioned area (iron smelters) as well as in the surroundings of Ružomberok (paper manufacture).

d) A set of natural radioactivity maps (radioactive potassium uranium, thorium and radon) display the occurrences of radioactive elements in the region. Their concentration does not exceed the range of values in our natural conditions. In terms of the radon hazard, we rank this region into the category of low hazard. Inreased content of radon occurs within the tectonic fault zones however, the extents are too small.

e) The soil map shows the distribution of soil types in the region. Soils of the 3rd and 4th bonity should be regarded as the best quality (fluvisols and planisols). Due to the region's morphology the soil erosion poses serious problems.

f) The engineering geological maps provide an information on the most significant geological factors (geotechnical properties of rocks and soils, geodynamic events, geologic, hydrogeologic and tectonic features), which considerably influence, be it negatively or positively, the environment.

♦ Map of geochemical reactivity of rocks; the Nízke Tatry region

Štefan KÁČER

The report consists of the Map of geochemical reactivity of rocks of the above region, concise explanations and the database.

The map provides a basic review of the element and chemical component distribution in the rock basement. Regional geological map at a scale 1:50 000 has been used as a background for construction of this map.

Based on calculated values of the alkalinity coefficient - X_{alk} and some other criteria, discrete rock types were distinguished in the map by a colour.

Anomalous distributions of elements are also plotted in the map.

A database consisting of geologic, petrographic and analytical data from 709 samples represents an important part of the report.

The map is fully digitized.

♦ Map of natural water quality, the Nízke Tatry Mts. region

Stanislav RAPANT

The report evaluates the results of chemical composition and the qualitative properties of natural waters of the Nízke Tatry Mts. Qualitative properties of both, groundwaters and surface waters are evaluated in a synthetic fashion and expressed in the map by an appropriate colour. Chemical composition of the precipitation waters is demonstrated, using examples of selected components, in the attached supplementary maps.

The qualitative properties of natural waters in this region are relatively very good. More than 80 % of the Nízke Tatry Mts. region has been ranked as A1 and A2 - the best two water quality classes. The remaining part of the region, characterized by worse qualitative properties of waters, may be roughly divided in two halves, one being influenced by anthropogenic, and the other by geogenic factors. Most of the areas influenced by anthropogenic factors are alluvial plains of the Hron and Váh Rivers. The areas affected by geogene influences are those, with the occurrence of known mineralizations in the surroundings of Jasenie, Dúbrava and Magurka, characterized by the above-the-limit increases of the heavy metals in both, the underground and the surface waters.

♦ Geochemical - ecological map, the Nízke Tatry Mts. region

Dušan BODIŠ

The objective of geochemical - ecological mapping of alluvial sediments in the Nízke Tatry Mts. region was to:

1. find out the distribution of ecologically critical (harmful) elements/compounds and to display them in the map,

2. carry out a special geochemical-ecological mapping within the restricted area of the Hron River drainage.

According to granulometric analysis, the alluvial sediments of the Nízke Tatry Mts. region belong to the group of sands and aleuritic sands, which is due to their being formed predominantly in mountainous landscape. The contents of humic matter range from 2.42 to 20.68 %. The mineral composition is influenced by both, the country rock and the character of weathering processes. As a typical feature of the Nízke Tatry Mts., the distribution of analysed elements may partly be influenced by the rock environment, but, the main influence comes from the present metallic ore formations and assemblages.

Based on special geochemical mapping of alluvial sediments and carried out experiments it can be stated that 88 % of As and 100 % of Sb in the surface stream water occur in the form of ions or complexes in the solution, respectively, which means that, bearing in mind their concentration and areal extent, they can enter in a soluble form also the sources of potable water in the anomalous area,. The source of Sb in the alluvial sediments, as well as in the surficial streams, can be identified according to variations in its solubility, i.e. according to character of bonds in the solid phase.

No organic compounds such as PCB-s were identified in the "confined" Hron River drainage, however, the total amounts of aromates (in the Dubová and Šifrová dolina valley) and the PAU (in the lower part of the course below Brezno) are increased.

As regards the areal distribution and the degree of concentration, the As, Pb and Cd are the most ecologically critical elements in the Nízke Tatry Mts. region and represent a real high level of polution of the environment. All the metallic/compound anomalies are of geogenic-anthropogenic, or anthropogenic origin, respectively.

The results (map, information system, database) should serve as a background for further appraisal and evaluation of the environmental effects upon the people and the biota of the Nízke Tatry Mts. region.

♦ Set of engineering-geological maps of the environment: the Nízke Tatry region

Milan LOBÍK, Mikuláš KRIPPEL, Ľubica IGLÁROVÁ, Ingrid VANČÍKOVÁ, Martin ONDRÁŠIK, Vlasta JÁNOVÁ, Pavol LIŠČÁK, Igor MODLITBA, Alena. KLUKANOVÁ and Gustáv GABAUER

This partial final report presents the results of engineering-geological mapping of the Nízke Tatry region (parts of topographic map sheets, at a scale 1:50 000, Nos. 35-22, 35-24, 35-42, 36-11, 36-13, 36-31). The area mapped covers approx.800 sq.km.

Within the framework of the national research project entitled: "Geological factors of the Environment" and a subproject "Set of engineering-geological maps of the environment, the Nízke Tatry region at a scale 1:50 000", the following engineering- geological maps were constructed:

- map of engineering-geological zoning
- map of relative susceptibility to slope deformations
- map of important geological factors
- map of rock susceptibility to erosion
- map of weathering resistance of rocks
- map of ultimate bearing capacity of foundation soils.

The first three of the above mentioned maps belong to the so called compulsory, while the others to non compulsory, or recommended maps.

Map of engineering-geological zoning displays the basic information on the engineering-geological situation in the area under study. It contains the hydrogeological data, the data on geodynamic features and the documentation marks. The explanations with characteristic normative values and the engineering-geological properties are appended to the map. The map provides a first hand information on the conditions, or possibilities, respectively, of the building foundation, the dump disposal and the constructing materials.

Map of relative susceptibility to slope deformations is a special map of engineering-geological zoning. The whole area is divided into following three regions: nonstable, circumstantially stable and stable, distinguished in the map by the traffic light colours. The regions are evaluated in respect of the slope stability, selecting the regions with similar susceptibility to the development of slope movements. We distinguish in the map the five basic rock types of Pre-Quaternary basement (solid

rocks, semi-solid rocks, alternation of solid and semi-solid rocks, gravely - sandy sediments and fine grained sediments) and the four types of cover units (fragmentary rocks, gravely - sandy soils, fine grained soils), which results in a delineation of the sub-regions bound to geologic structures. The delineated regions and sub-regions are furnished with tables and texts.

Map of important geological factors - it is a multi-purpose map, yielding a basic information for the decision making on the optimal use of the country, especially its abiotic component. Map synthesizes the data on: the deposits of raw materials, suitability of geological basement for waste disposal, agricultural soil quality, slope stability, ultimate bearing capacity of foundation soils, scourings, karstification, seismicity, drainage inundation areas, undermined areas, tectonic faults and others. The map should serve as one of the important backgrounds for selection of suitable building sites, for proposing the type of building constructions, the type of suitable foundations, the location of various types of waste disposals etc.

Map of weathering resistance of rocks is a prognostic analytical map made to indicate the hazards constrained to the short-term and long-term impacts upon the rocks of different ability to resist the effects of the exogenic agents. The rocks with different resistance to weathering are divided into three categories - the weathering resistant, the medium weathering resistant and the slightly weathering resistant rocks. Following are the basic criteria to classify the rocks: resistance to pressure, persistence of rocks and the degree of disruption.

The map is supplemented by explanation tables, which contain a summary of data on the delineated regions and sub-regions, on the geologic structure of the region, on the morphology, on the sensitivity of rocks to the contact with water, the character of their weathering under natural conditions as well as the data forecasting the development of weathering processes within the open excavation pits and cuts, their suitability for building foundation and the use as constructing material.

Map of rock susceptibility to erosion displays the segmentation of the region into three areas, distinguished by traffic light colours - an area of rocks resistant to erosion (green), an area of rocks relatively resistant to erosion (amber) and an area of rocks non-resistant to erosion (red). The regions are further divided into sub-regions, according to their strength: solid rocks, semi-solid rocks and earths. The sub-regions are further distinguished by tint or, if the boundary cannot be delineated, by a hachure. Explanations and tables, appended to the map, give an analysis of the present state of art and prognosis for possible generation and development of acute erosion due to the manmade impact, as well as the estimated time of natural sanation. Map of ultimate bearing capacity of foundation soils is a supplementary map to the geologic map at a scale 1:50 000 and to the engineering-geological zoning. It evaluates the foundation soils in terms of the building foundation norm ČSN 73 1001.

The geological map of the Nízke Tatry Mts. region, constructed by BIELY et al. (1992) and the topographic map of Slovakia at a scale 1:50 000, were the two essential and the most important backgrounds for construction of the above described set of maps.

Besides of the study of archival data stored in the Geofond and the other institution's archives, the results of field and technical works were also taken into account in construction of the maps. In processing the physico-mechanical properties of soils and rocks the data on 521 pits were taken from the Geofond archive, whereas their selection depended from the complexity of assays, the density of exploration grid and the quality of laboratory results. 100 core drill holes, reaching the total meterage of 1230 m, were drilled with the objective to intersect the whole thickness of Quaternary sediments. The physico-mechanical properties of soils and rocks were also assessed. The drill hole material was also used to investigate the trace elements, as well as to resolve the petrological and stratigraphical questions. 28 water samples were also collected to find out the degree of their aggressivity.

Partial project 03: Engineering geological research on optimal use of the country - final report for a partial project

Igor MODLITBA, Ľubica IGLÁROVÁ, Vlasta JÁNOVÁ, Alena KLUKANOVÁ,
Mária KOVÁČIKOVÁ, Mikuláš KRIPPEL, Ľubomír PETRO, Zoltán SPIŠÁK and Ingrid VANČÍKOVÁ

This is a progress report of the partial project "Engineering geological research for optimal use of the country and the environment", included in the national research project entitled "Research of geological factors of the environment" No. ZP 547 008, for the period from 1. January 1991

to 31 December 1992. The report correlates the planned versus the real state of solution, its formal content, the achieved results, the expenditures during discrete stages and other data.

The greatest contribution of this activity is the possibility of immediate application of predominant part of achieved results in the constructing practice.

Realization of partial projects has been done within the framework of following nine formal stages:

Stage 01: "Engineering geological properties of rocks in the Východoslovenská nížina basin". The objective was to systematically study the defined lithofacial rock types in terms of their engineering geological properties, and mainly the relation to their origin, depth of occurrence and collection of samples, the relation between physical and mechanical properties, as well as to the microstructure of the rocks under study.

Stage 02: Automatized storage, classification and processing of the rock property data - it dealt with the problems of updating of the existing database of the physical and mechanical data so that the automatized classification of the data sets based on geologic features, such as the origin, the stratigraphy etc., could be made.

Stage 03: Monitoring of the relation between the fabrics and their physico-mechanical properties - the structures of individual defined lithofacial soil types of the Východoslovenská nížina basin and other areas were evaluated in order to use them as a supporting program to solve discrete stages within the framework of this project.

Stage 04: Engineering-geological maps of the environmental geofactors - it solved setting up of the methodic procedures used in mapping of geological factors of the environment at a scale 1:50 000. A method was invented for selected geological factors and tested in the Košická and Turčianska kotlina regions and in the surroundings of Bardejov.

Stage 05: Basic engineering geological maps at a scale 1:10 000 - the realization was targeted at:

a) edition of an engineering geological map album showing the regions of Košice and Prešov, including a monography on engineering geological properties in given regions.

b) construction of six sheets (at a scale 1:10 000) of basic engineering geological maps of the south-western part of the Košice urbanization region - the Moldava nad Bodvou area.

c) Construction of four sheets (1:10 000) of engineering geological maps of the Bardejov area, for use in applied urbanization planning and protection of the environment within greater areal wholes.

Stage 06 : Registration of the slope deformations - the objective was to update the slope deformation register by means of exploration, mapping and documentation of landslides, mainly in the areas of flysch uplands and highlands, intramontaneous basins and volcanic ranges.

Stage 07: Prognosis of formation and development of slope deformation - it dealt with the creation of areal and long-term monitoring system at the slope deformation sites, with the aim to establish a prognostic servis to report the activation of the slope movements in the whole territory of Slovakia. Monitoring stations were set at 11 localities. They possess the instruments for geodetical measuring using the precise levelling and tachymetry, to monitor changes in drill hole inclinations, surface stress etc.

Stage 08: Engineering geological evaluation of the waste disposal basements - the objective was to register the solid municipal waste disposals in the area of the Podunajská nížina lowland (the Dunajská Streda and its broader surroundings) and selection of areas with favourable geological structure in terms of waste disposal. Based on the request of the SHMÚ, the registered area was extended, during the realization, by the Žitný ostrov island - Protected water area.

♦ Engineering-geological properties of rocks in the Východoslovenská nížina basin

Igor MODLITBA, Ľubica IGLÁROVÁ, Pavol LIŠČÁK, Richard MIKA, Mirko MATYS, Erika POLAŠČINOVÁ, Ingrid VANČÍKOVÁ and Alena KLUKANOVÁ

Engineering geological properties of rocks in the region have been evaluated within the framework of the partial project entitled "Engineering geological research for optimal use of the country and the environment" and its sub-project "Engineering geological properties of rocks in the Výcho-

doslovenská nížina basin", which were included in the national research project "Research of geological factors of the environment". The objective of this evaluation was to describe the essential qualitative and quantitative features of selected physical and mechanical properties of rocks, which depend on genetic and lithologic homogeneity of the defined rock types, as well as on their structure and stratigraphic classification. The intention of the realization was to acquire orientative, or eventually computable regionally relevant engineering geological values, whose application would have a higher degree of authenticity, compared to the normative values.

To achieve the outlined goal, a "classical" method, composed of the following tasks, was implemented:

-compilation of basic literature dealing with the results of geological research in given area. The works of BAŇACKÝ et al (1987,1988) were an essential source of information,

-evaluation of archival engineering geological research reports,

-drilling of special engineering geological bore-holes and penetration holes down to 15 m, designed to collect soil/earth samples,

-laboratory and field assessment of selected physical and mechanical properties of rocks and their mathematical- statistic processing,

-final evaluation of the results and realization of the final report.

Attained results are evaluated using histograms, graphic correlations and their mathematical definition. The statistical results are shown in separate tables and referred to in the text.

Characterization of the internal structure of rocks and its relation to the engineering geological properties, studied by means of a scanning microscope, has also been described.

The report represents a complex evaluation of homogeneous engineering geological types, in terms of their physical and mechanical properties. We presume that acquired results will provide desired assistance to the building designers and engineering geologists in their efforts to solve geotechnical problems.

♦ Map of suitability of the region for waste disposal and registration of waste dumping grounds in the Dunajská Streda county

Igor MODLITBA, Mária KOVÁČIKOVÁ, Tomáš LANCZOS and Matilda BEZÚCHOVÁ

First part of the report evaluates the Dunajská Streda area in respect of the basement suitability for construction of the waste dumping grounds. A crucial role in selected geological environment and in legislation play: protected water management areas and groundwater sources, protected natural areas, protected forests, structural arrangement of the rock environment in respect to degree of groundwater hazard, geodynamic features and hydrogeological characteristics. Specific factors and their evaluation are portrayed in the documentation maps. Resulting evaluation is illustrated in the Map of area evaluation using traffic light colours. When generally disagreeable condition for instalment of the dumping grounds (very high groundwater hazard in the area) are considered, the whole region is ranked as unsuitable. This ranking is not meant to bar absolutely the waste disposal, it only stresses the importance of organized dumping grounds, which should ensure the protection of the environment from polution.

The second part of the report represents the registration of dumping grounds during the period 1989-1991. The registered dumpings are plotted in the topographic maps at a scale 1:10 000.

Total of 161 duping grounds were registered in the area of the Dunajská Streda county. The following 5 sites were selected for detailed hydrogeochemical monitoring: Jelka, Veľké Úľany, Gabčíkovo - mesto, Gabčíkovo - Tuňog and Horný Bar-Šurany. Testing wells were drilled at the above sites and the samples of groundwater, clay, earth-gas and waste material were collected. These samples were analysed for the contents of organic and anorganic matter and probable provenance of these matter has also been determined. Comparison of the results with the existing norms and regulations for groundwater evaluation facilitated to assess the degree of polution of the environment (probability) and subsequently, to advise further measures to be taken to solve this inappropriate situation.

A corollary to this report is an independent report which evaluates the results of organic compound analyses in groundwaters in the surroundings of the dumps.

♦ Construction of a demonstration sheet of Geochemical atlas;

Kamil VRANA

The project: "Geochemical atlas" is conceived to compile a geochemical atlas of monoelemental maps showing the contents of chemical elements in the alluvial sediments, groundwaters, rocks, soils and forestry biomass and the radioactivity of the territory of Slovakia (1991 - 1995).

The progress report informs about the state of realization of the project and present the Banská Bystrica sheet No. 36 as an example of a concept of methodic procedures and the software to process the data.

In accordance with the concept of the project the whole scope of geochemical study has been evaluated as follows:

a) alluvial sediment geochemistry
b) groundwaters geochemistry
c) rock geochemistry
d) soil geochemistry
e) forest biomass geochemistry
f) radioactivity of the region

The d, e and f parts are presented as discrete partial reports, prepared by co-operating, institutions, co-ordinated by the GÚDŠ Bratislava and by the Section of geologic research and exploration of the Ministry of the Environment.

In addition following two issues, comprised in the main project, were presented in the form of discrete reports:

-preparation of superstructural interpretations
-analytical procedure check up

Following goals have been achieved at this stage of realization:

- Completion of the sample collection, excepting the soil geochemistry (1991-1993).
- Completion of the method to assess individual elements - the final method will be presented after the termination of the project.
- Computerization, production of a software to process the data and the map backgrounds, compatible with international geochemical databases (backgrounds).

The results in progress have demonstrated that the geochemical results of regional character are of great significance.

♦ Partial monitoring system of geological factors of the environment

Alena KLUKANOVÁ, Mikuláš KRIPPEL, Martin ONDRÁŠIK, Vlasta JÁNOVÁ, Mária KOVÁČIKOVÁ, Miroslav HRAŠNA, Vladimír LETKO, Mirko MATYS, Ján VLČKO, Michal LUKAJ, Ľubica IGLÁROVÁ, Ľubomír PETRO, Erika POLAŠČINOVÁ, Zoltán SPIŠÁK, Anton MATEJČEK, Rudolf HOLZER, Peter WÁGNER, Anna HYÁNKOVÁ, Dušan JADROŇ, Egon FUSSGANGER, Ján OTEPKA and Dušan GRMAN

The development of ecological monitoring and information systems is one of the cornerstones for the realization of an environmental policy. These systems should be envisaged as another tool to warrant the protection and formation of the environment. It should serve as a background in decision making, as regards the activities and perspective intentions in the field of the environment. Partial monitoring system of the geological factors of the environment is intentionally targeted at those geological factors and such forms of reports, which are suitable as the entry data to resolve the problems of preservation of the environment and optimal utilization of the country's geopotential. In selecting

the geofactors important in terms of monitoring we have paid due attention to the so called geological hazards, i.e. natural, or anthropogenic geological harmful processes that jeopardize the environment, including man, as an ultimate consequence.

The partial monitoring system of geological factors is composed of the following nine independent subsystems:

1. Landslides and other slope deformations
2. Erosion processes
3. Weathering processes
4. Monitoring of collapse in foundation soil
5. Monitoring of influence of mining upon the environment
6. Changes in anhtropogenic sediments (dumps and tailings)
7. Stability of rock massifs underlying the historical objects
8. exploration and documentation of covered anthropogenic sediments
9. Tectonic and seismic activity of the region

The effects of specific geological processes activated by either natural or anthropogenic factors are a characteristic feature of the discrete sub-systems.

Referring to the results of the first stage of realization, presented report describes the following topics:

- Selection of localities for monitoring.
- Evaluation of geologic, geomorphologic, climatic and hydrogeologic conditions at the monitored localities.
- Definition of technical conditions for construction of monitoring stations.
- Definition of possibilities of automatic accumulation of measured data.
- Selection of most suitable measuring systems.
- Definition of frequency of data acquisition.
- Precision of monitoring method in respect of discrete geologic factors.

The only real measurements were made within the framework of the slope deformation monitoring as a continuation of the previous project ZP 542 008 903.

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