Slovak Geol. Mag., 11, 4 (2005), 197 – 203

Organic geochemical appraisal of hydrocarbon potential in the Prešov Depression (East Slovakian Neogene Basin)

JÁN MILIČKA[1] and MIROSLAV PERESZLÉNYI[2]

[1]Comenius University, Faculty of Nat. Sci., Dept. Geochemistry, Mlynská dolina, G, 842 15 Bratislava, Slovakia
[2]Euro-Geologic a.s., Tomášikova 26, 821 01 Bratislava

Abstract: Tertiary source rocks quality and kerogen maturity are characterized using Rock-Eval pyrolysis and microphotometry. Hydrocarbon generation zones were evaluated by kinetic modeling calibrated on organic matter maturity parameters. Top of oil generation zone is reached at about 2250 m in the northern part and in a depth range of 800 to 1250 m in the central and southern parts of depression.

Key words: Tertiary, kinetic modeling, maturation zonality, hydrocarbon potential, East Slovakia

Introduction

Tertiary sedimentary basin fill in the Prešov Depression reaches down to a depth of 2700 m in the deepest northern part, in the central part close to the Slanské vrchy Mts. to 2500 m. Mesozoic and Paleozoic complexes of the Veporic Unit build the pre-Tertiary basement in the area between Prešov and Košice and, to the south, the basement is represented by Paleozoic of the Gemeric Unit. Volcanism was active during Eggenburgian to Sarmatian period (Slánske vrchy Mts.) and has influenced actual geothermal conditions in this depression. The temperature at depth of 3000 m is about 100 °C in the northern part and 130 °C in the central part close to volcanics.

The aim of the paper is to present organic geochemistry of source rocks as well as the model of organic matter maturation and hydrocarbon generation using Rock-Eval pyrolysis, microphotometry and kinetic modeling of hydrocarbon generation.

Methods and material studied

Sufficient content of total organic carbon (TOC) in sediments is one of the basic criteria for evaluation of potential hydrocarbon perspect of an area. Most of authors refer worldwide the minimum content of 0.5 weight percent of total organic (disseminated) carbon for potential hydrocarbon source rocks.

In the Prešov Depression more than 280 core samples and 18 surface samples were examined. Most of these samples comes from Tertiary sediments, the rest comes from the Mesozoic and partly Paleozoic basement.

Geological setting

Core samples up to 3200 m from deep wells in the central part of the Prešov Depression as well as from hydrogeological wells in the northwestern and northeastern margins of the depression were examinated (Fig. 1). Few investigated samples are from Čierna hora Mts.

Rock-Eval pyrolysis

Rock-Eval pyrolysis represents a standard method used for rapid evaluation of hydrocarbon (HC) potential, kerogen type and maturity. Principles of the method are described e.g. in Espitalié et al. (1985). This method was applied to investigation of all samples with TOC content over 0.2 %. Approximately 50-100 mg of powdered rock was analysed in Agema Brno on Rock-Eval V apparatus. Following parameters represent direct measured values:

S1: free (volatile) hydrocarbons (HC) in mg HC/g rock
S2: fixed (pyrolytic) HC in mg HC/g rock
Tmax: maximum pyrolysis temperature in °C
From these parameters were calculated:
HI - hydrogen index: (S2/TOC)x100 in mg HC/g TOC
PI - production index: S1/(S1+S2)
GP - genetic potential: (S1+S2) in mg HC/g rock
Results are summarized in Tab.1

Microphotometry

Vitrinite reflectance (Ro) measurements enable evaluating the extent of thermal alteration of sedimentary organic matter. Vitrinite is a macerate of humic coals family and is derived from higher terrestrial plants. During the coalification, vitrinite reflectance increases from 0.25 % at the peat stage to more than 4 % at meta-anthracite stage. In selected samples vitrinite reflectance was measured by the first author in Czech Geological Survey, Branch Brno under standard conditions (Stach et al., 1975): monochromatic non-polarized light (546 nm), oil immersion, photometric field 2x2 μm, Leitz MPV 2. Results are summarized in Tab.1.

Source rock study

Pre-Tertiary basement

Mesozoic sediments represent practically all investigated samples from the pre-Tertiary basement. In respect

Slovak Geol. Mag., 11, 4 (2005), 197 – 203

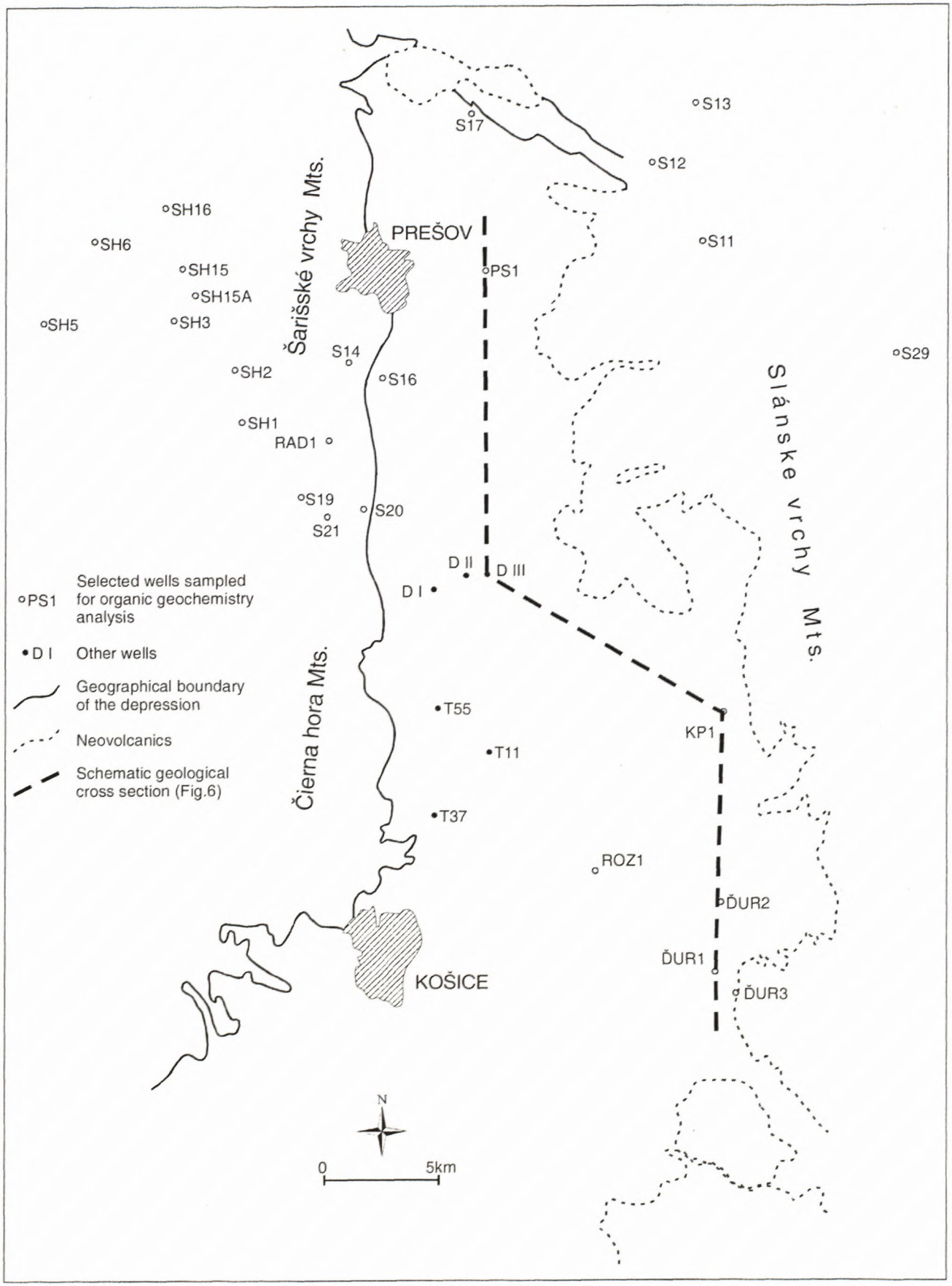

Fig. 1. Prešov Depression - location map of selected wells.

Tab.1:Summary of organic-geochemical results based on rock-Eval pyrolysis

Litostratigraphy		TOC	S1	S2	HI	PI	Tmax	Ro	Kerogen
		%	mg/g	mg/g	mg/g		oC	%	type
Lower Sarmatian	Stretava Fm.	0.0X	-	-	-	-	-	n.m.	-
Upper Badenian	Klčov Fm.	0.0X - 0.31	0.0X	0.0X - 0.14	31 - 116	0.08 - 0.19	423-430	0.40 - 0.50	III
Middle Badenian	Vranov Fm.	0.0X - 0.65	0.0X	0.24 - 0.42	36 - 261	0.02 - 0.08	430 - 433	0.43 - 0.65	III
Lower Badenian	Nižný Hhrabovec Fm.	0.0X - 0.97	0.0X - 0.10	0.0X - 1.26	10 - 144	0.0X	435 - 438	0.48	III
Karpatian	Kladzany Fm.	0.0X - 0.23	0.0X	0.0X - 0.28	17 - 121	0.0X	432 - 445	0.89 - 0.92	III
	Teriakovce Fm.	0.0X - 1.39	0.0X - 0.12	0.18 - 4.80	76 - 345	0.0X	426 - 447	0.71 - 1.19	III - (II)
Egenburgian	Čelovce Fm.	0.0X - 0.49	0.0X - 0.07	0.36 - 0.76	124 - 353	0.0X	432 - 437	0.45 - 0.56	III - (II)
	Prešov Fm.	0.0X - 0.70	0.0X - 0.11	0.34 - 1.02	73 - 256	0.0X	430 - 433	0.51 - 0.65	III
Egerian	Solivar Fm.	0.0X - 0.94	0.0X	0.42 - 1.20	55 - 305	0.0X	433 - 436	0.58 - 0.70	III
	Biely Potok Fm.	0.38 - 2.67	0.0X - 0.20	0.20 - 4.66	40 - 181	0.0X	427 - 430	n.m.	III
Paleogene	Zuberec Fm.	0.0X - 4.34	0.0X - 0.15	0.0X - 2.52	14 - 434	0.0X - 0.14	430 - 440	0.59 - 0.69	III - (II)
	Huty Fm.	0.0X - 1.18	0.0X	0.0X - 2.76	66 - 257	0.0X - 0.24	436 - 440	0.57 - 0.68	III
	Borovce Fm.	0.0X - 0.20	0.0X	0.0X	18 - 40	0.0X	~ 440	n.m.	III
Mesozoic		0.00 - 0.40	-	-	-	-	-	2.35 - 3.46	?
Paleozoic		0.50 - 3.20	-	-	-	-	-	4.52 - 4.48	?

Explanations: TOC - total organic carbon (weight %), Rock-Eval pyrolysis parameters - S1, S2 (mg HC/g rock), HI (mg HC/g TOC), PI and Tmax (°C), Ro - vitrinite reflectance (%); n.m. – non measured, Kerogen types - III - terrestrial; III-(II) – terrestrial, possible mixed with marine.

to their minimal TOC content (Tab.1) these samples do not represent potential source rocks at present. Only three core samples from the Paleozoic basement (Čaňa 1 well) reached limit values for potential source rocks (0.50 - 0.65 %). These rocks are metamorphosed to very low grade and in this case, TOC values represent structurally more ordered meta- anthracitic to semi-graphitic carbon (Ro = 4.5 %). TOC content in the core sample from Čaňa 1 well (1132 m) is moreover probably influenced also by solidified bitumen, because of increased S1 pyrolytic value (2.85 mg/g) corresponding to free hydrocarbons content. The same is indicated by increased production index value (PI = 0.52) and low maximum pyrolysis temperature value (Tmax = 415 °C) because of deformed S2 pyrolytic peak corresponding to residual hydrocarbon potential (Espitalié et al., 1985).

Tertiary

Paleogene sediments belong to the basement of the Prešov Depression or outcrop in its surrounding (lithostratigraphy after Gross et al., 1984). The depression fill is of Miocene age (lithostratigraphy after Vass and Čverčko, 1985). More detailed information about geological evolution during Miocene is e.g. in Kováč (2000).

Comparison of TOC values shows that practically 50 % of all investigated Paleogene samples overreach the limit 0.5 % value for potential source rock. These increased values were found mainly in the Zuberec and partly in Huty Fms.

Quantitative distribution of TOC content within Neogene basin fill was interpreted separately for Middle and Lower Miocene sediments (Tab. 1). Considerable numbers of Neogene samples mostly from Ďurkov area do not contain any organic carbon. This is most probably caused by an increased presence of volcaniclastic material in these sediments. Origin and type of kerogen are one of very important characteristics that directly influenced the hydrocarbon generative potential. Quality of organic matter was evaluated mainly on the basis of HI, Tmax and S2 parameters (Figs. 2 and 3). Terrestrial kerogen type (III) is dominant for the Tertiary sediments, but in Lower Miocene and Paleogene sediments can be locally found also mixed terrestrial marine kerogen type (HI over 300mg/g; Fig. 2). The maximum residual source potential of Middle Miocene sediments is about 1 kg hydrocarbons per tone of rock, in Lower Miocene and Paleogene sediments it is to 5 kg HC/t of rock.

Model of catagenic zonality

Kerogen maturity and actual burial depth are the most important factors for evaluation of active hydrocarbons generation. Depth related to the organic matter maturation is interpreted mainly by vitrinite reflectance (Ro) and partly also by maximum pyrolytic temperature (Tmax) measurements.

Pre-Tertiary basement

Vitrinite reflectance values (Tab. 1, Fig. 4) measured in cores and surface samples give the evidence about exhausted kerogen from the viewpoint of potential hydrocarbon generation. These rocks were exposed to a weak

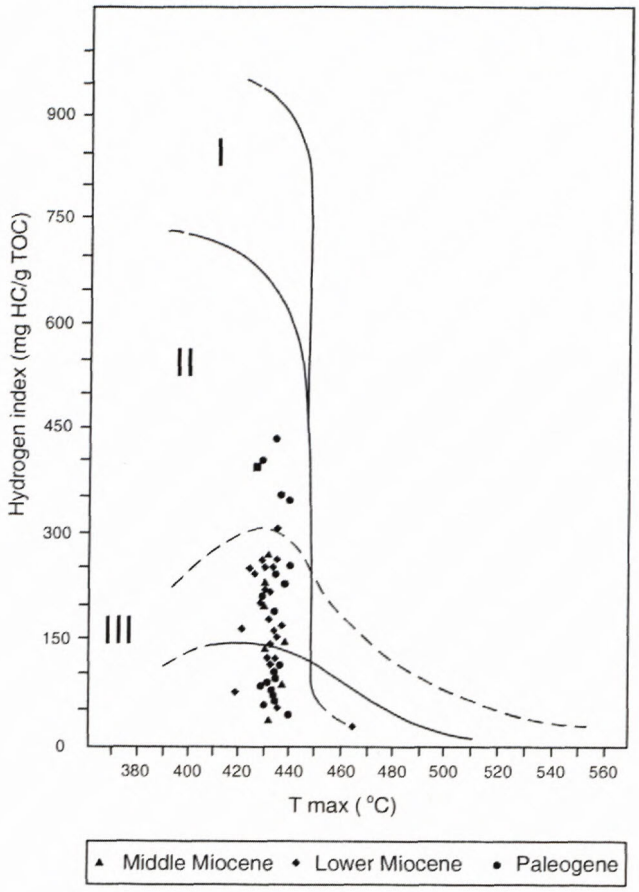

Fig. 2. HI - Tmax diagram indicating kerogen type in Tertiary sediments

maturity of Paleogene sediments depending upon burial depth and corresponding geothermal gradient was observed. The early oil generation zone is reached in this region at depth approximately of 2400 m while in the western elevated margins of the Prešov Depression this zone lies at the surface or in shallow depth below the surface. This, at present passive generation zone was reached in different depth and geothermal conditions than is found at present.

Trend of the organic matter maturity increase in Neogene sediments corresponds to present geothermal conditions in the Prešov depression that is from this point of view considerable heterogenous. Relatively "coolest" part after steady state temperature measurements (Král et al., 1985) is the area near Prešov. On the other hand the eastern part of the depression close to Slanské vrchy Mts. (Ďurkov 1, 2, 3 and Kecerovské Pekľany 1 wells) is an area with increased geothermal gradient (l.c.). Actual kerogen maturity reflects very well the thermal exposition of organic matter in different parts of the depression (Fig. 4).

Principal zones of hydrocarbon generation were determined using mathematical models (Fig. 5). Calculated maturity parameters in all modelled wells were compared to measured (mainly vitrinite reflectance).

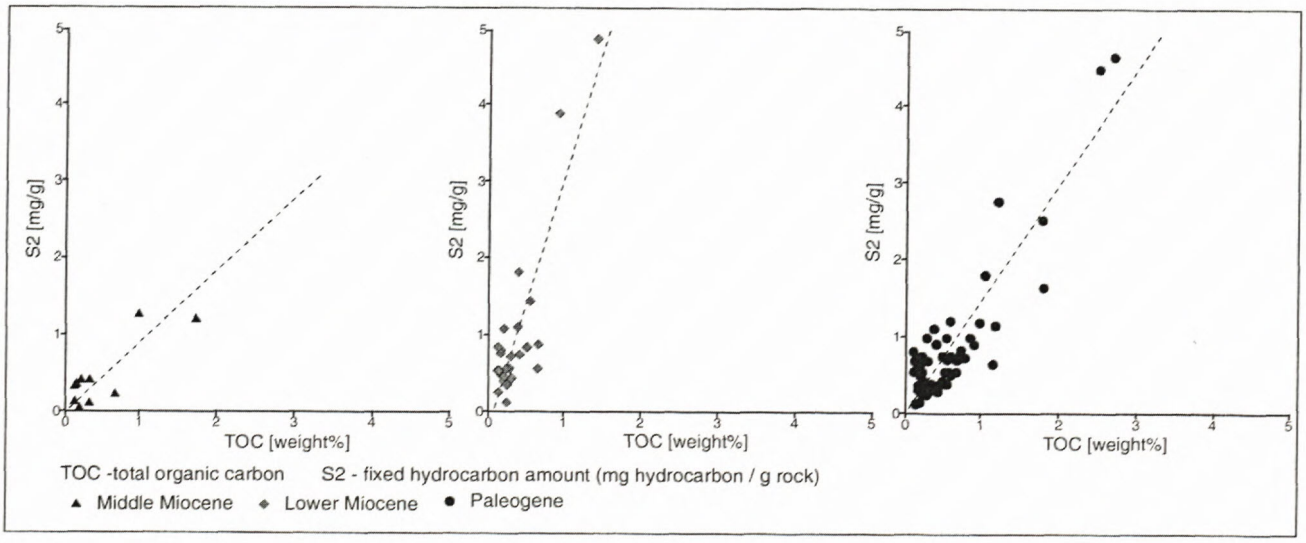

Fig. 3. Tertiary source rocks characteristics based on Rock-Eval pyrolysis

regional metamorphosis. Corresponding depth and geothermal conditions in relation to actual kerogen maturity give no real chance for an active hydrocarbon generation. In other words the pre-Tertiary basement is at present in a passive maturation zone.

Tertiary

Maturity stage of Paleogene sediments depends upon a geotectonic position in the studied depression. In the Prešov area a continual increase of the organic matter

Based on mathematical modelling, map of hydrocarbon generation zones in selected Neogene sedimentary levels for kerogen type III were constructed. Resulting hydrocarbon generation zones in north-south cross section are presented in Fig. 6.

Conclusions

Paleogene (Huty and partly Zuberec Fms.) and Lower Miocene (Teriakovce Fm.) sediments include fairly good

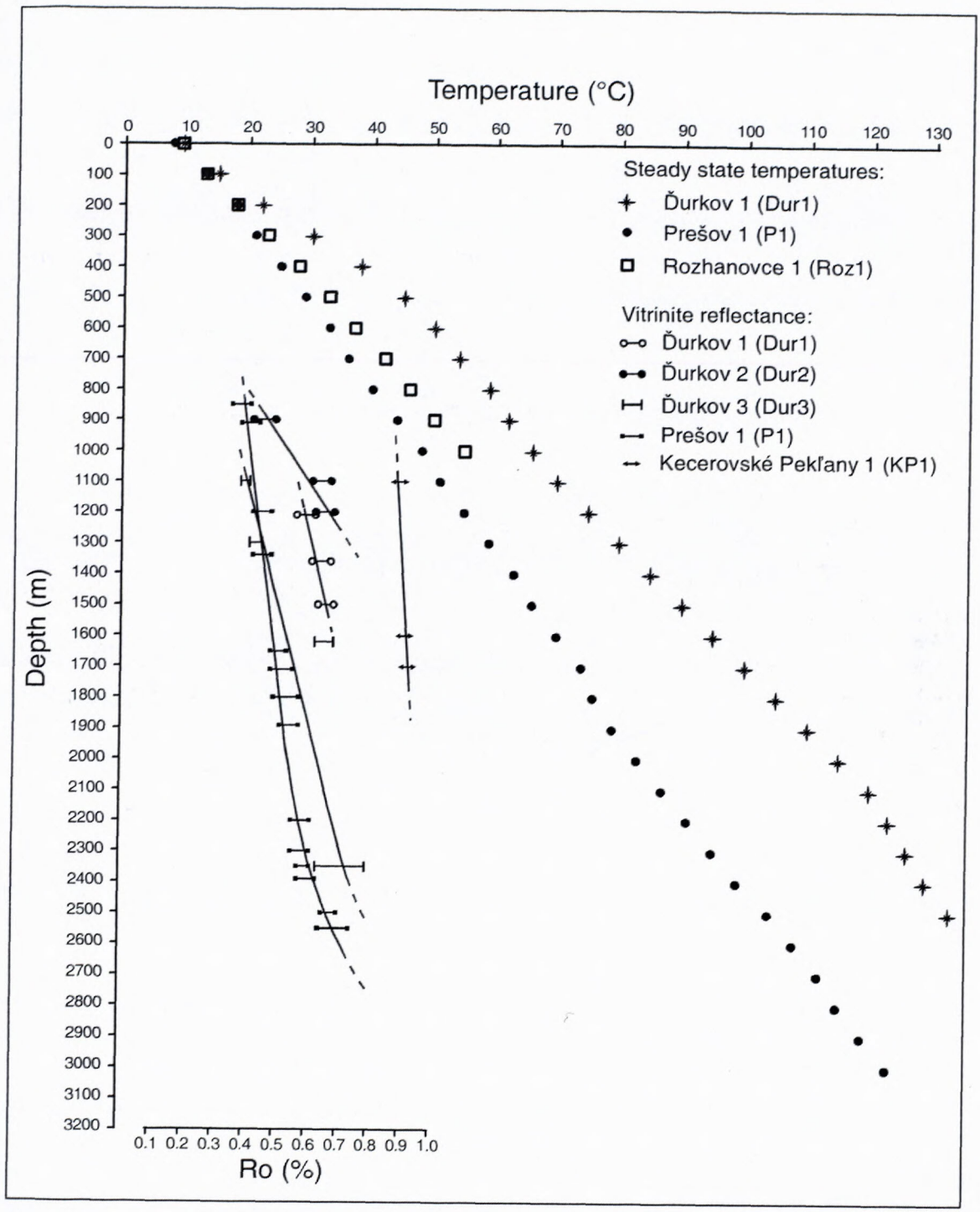

Fig. 4. Steady state temperatures and vitrinite reflectance in selected wells

source rock intervals locally with mixed terrestrial and algal kerogen.

Organic matter maturity in Neogene increases continuously with depth in the northern part and is strongly influenced by increased geothermal gradient close to neovolcanics (Slanské vrchy Mts.).

Top of early oil generation zone is in the northern part reached at depth of approximately 2000 m in Oligocene-Miocene sediments. Southward, near Kecerevské Pekľany lies this zone at depth of 1000 m (Middle to Lower Badenien), then ascends to 600 m below the surface (Upper Badenien) towards the KP 1 well and sinks slowly to depth of approximately 900 m near the Ďurkov 1 well.

Top of the main oil generation zone practically lies approximately 250 m deeper below the early oil zone. This zone involved Oligocene-Miocene and Paleogene sediments in the northern part of the Prešov Depression (e.g. the Prešov 1 well), while Upper and Middle Badenian and Karpatian sediments in the southern part, in Kecerovské Pekľany and Ďurkov area.

In respect to present burial depth, geothermal gradient and uplifting parts of the depression are hydrocarbon

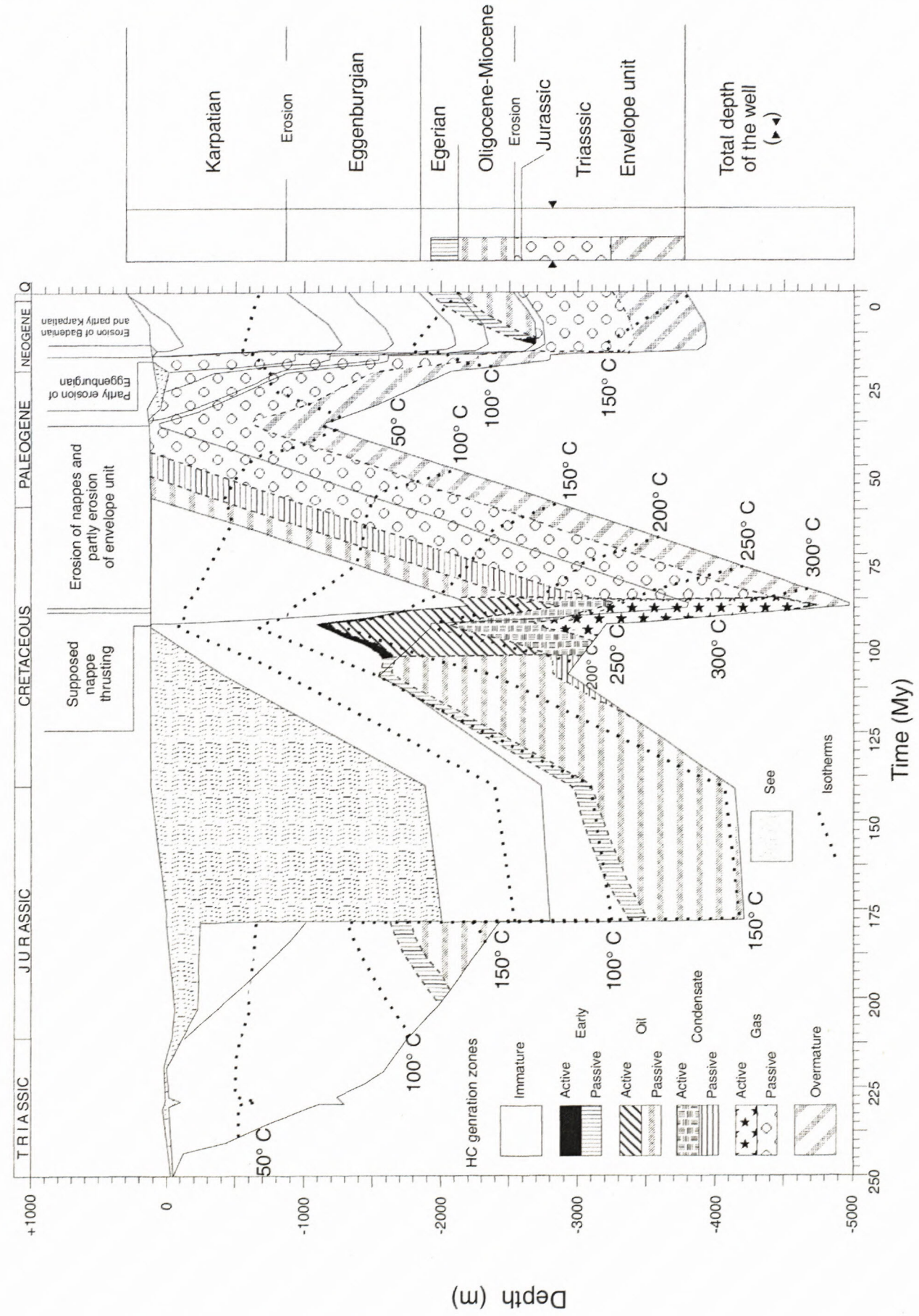

Fig. 5. Burial history and hydrocarbon generation zones in the Prešov 1 well.

generation zones passive in most area. Active generation could be expected only in the deepest buried Paleogene sediments near the Prešov 1 well area.

Acknowledgement

The work was supported by the Slovak Grant Agency VEGA, grant No. 1/1031/04.

References

Espitalié J., Deroo G. & Marquis M., 1986: La pyrolyse Rock Eval et ses applications. Partie I. Rev. Inst. Franc. Pétr., 40, 5, 563-579

Gross P., Köhler E. & Samuel O., 1984: Nové litostratigrafické členenie vnútrokarpatského paleogénu. Geol. Práce, Správy 81, Bratislava, 103-117

Král M., Lizoň I. & Jančí J., 1985: Geotermický výskum SSR. MS, archív Geocomplex a.s. Bratislava

Kováč M., 2000: Geodynamický, paleogeografický a štruktúrny vývoj karpatsko-panónskeho regiónu v miocéne: Nový pohľad na neogénne panvy Slovenska. VEDA, SAV, 202

Stach E., Mackowski M. T., Teichmüller M., Taylor G. H., Chandra T. & Teichmüller R. 1975: Textbook of coal petrology. 2nd ed., Gebr. Borntraeger, Berlin - Stuttgart, 428.

Vass D & Čverčko J., 1985: Litostratigrafické jednotky neogénu východoslovenskej nížiny. Geologické práce, Správy, 82, 111-121.

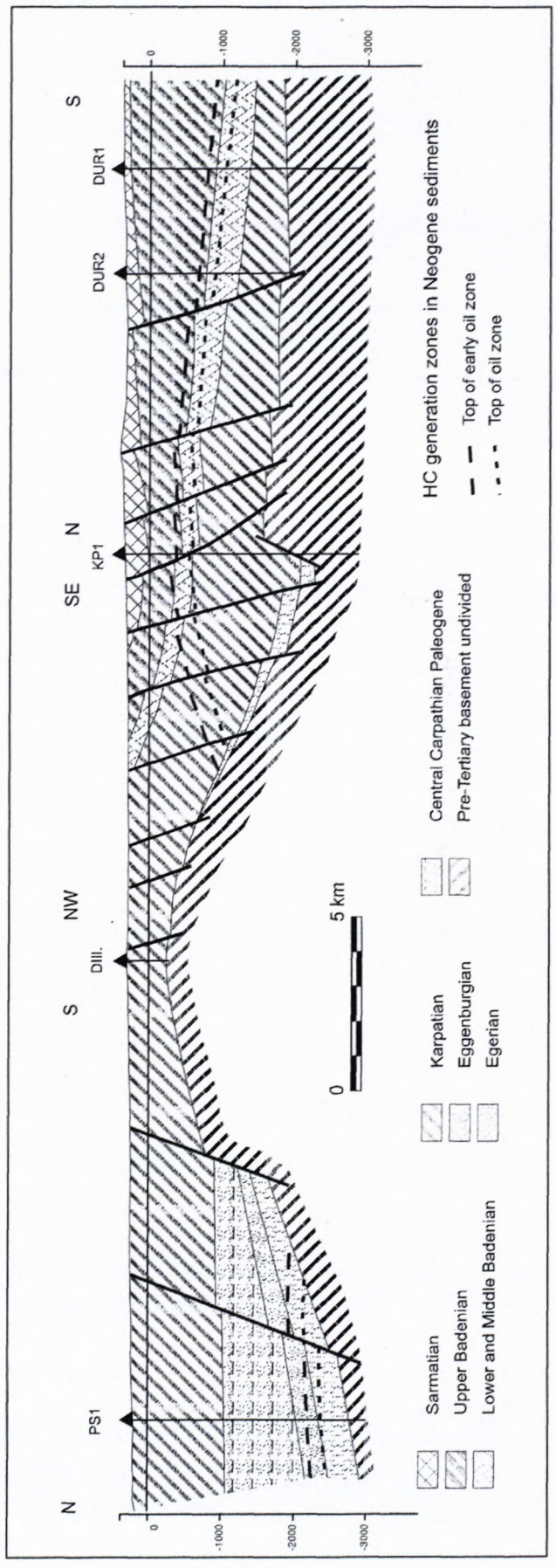

Fig. 6. Zones of hydrocarbon generation in schematic N - S geological cross-section