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Quantitative assessment of generated hydrocarbons in the Prešov Depression (East Slovakian Neogene Basin)

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Abstract: Assessment of hypothetical and speculative hydrocarbon resources in less explored regions is generally based on an analogy to regions with the higher level of exploration. Methodics of calculation of hydrocarbon speculative resources based on the organic geochemistry research of the source rocks of the Prešov Depression is presented as an example.

Key words: organic-geochemical parameters, hydrocarbon generation zones, expulsion, migration, entrapment, hydrocarbon potential evaluation.

Introduction

The hydrocarbon potential evaluation of the Prešov Depression is based mainly on interpretations of organic-geochemical analyses and kinetic modeling of hydrocarbon generation during the geological history (Milička and Pereszlényi, this volume). The aim of this paper is to follow the fate of hydrocarbons during their generation and expulsion from the source rock, migration, and accumulation in traps. For the quantitative assessment of this phenomena we used the method of Waples (1985) based mostly on organic-geochemical parameters.

The results of this method, originally used in American oil industry (e.g. Moshier and Waples, 1985) are expressed in imperial units and only the final calculation is transformed to SI units.

Method

As indicated, one of convenient ways to approach the calculation of hydrocarbon volumes is to divide the process of hydrocarbon accumulation into following phases: generation, expulsion, migration, entrapment and preservation. Waples (1985) proposed the use of the most common organic-geochemical parameters, i.e. the total organic carbon (TOC) content, Rock-Eval pyrolysis yield and maturity as input parameters for the most useful basic hydrocarbon (HC) generation equation as follows:

Volume of HC = (k).(TOC).(HI).(f)

- HC — hydrocarbon volume in million barrels oil/cubic mile of source rock
- k — conversion constant
- TOC — total organic carbon in weight %
- HI — hydrogen index in mg HC/g TOC
- f — fractional conversion (between 0 - completely immature and 1- fully mature organic matter)

The Paleozoic, Mesozoic, Paleogene, Egerian, Eggenburgian, Karpatian and Badenian sediments entered the hydrocarbon generation windows in the Prešov Depression. However, Paleozoic and Upper Badenian sediments do not meet the criteria for source rocks and therefore they are excluded from further calculations. The Paleogene, Egerian, Eggenburgian, Karpatian, Lower and Middle Badenian sediments reached after modeling the early oil and oil generation zone.

In the case of the Prešov Depression following parameters were considered:

a) Conversion constant k = 0.7 (if the source rock is a shale with density of approx. 2300 kg/m^3 and hydrocarbons correspond to oil density of 900 kg/m^3)

b) Average TOC content in source rocks:

Paleogene	1.0 %
Egerian	0.5 %
Eggenburgian	0.5 %
Karpatian	0.9 %
Lower and Middle Badenian	0.5 %

c) Average hydrogene index (HI) of immature organic matter:

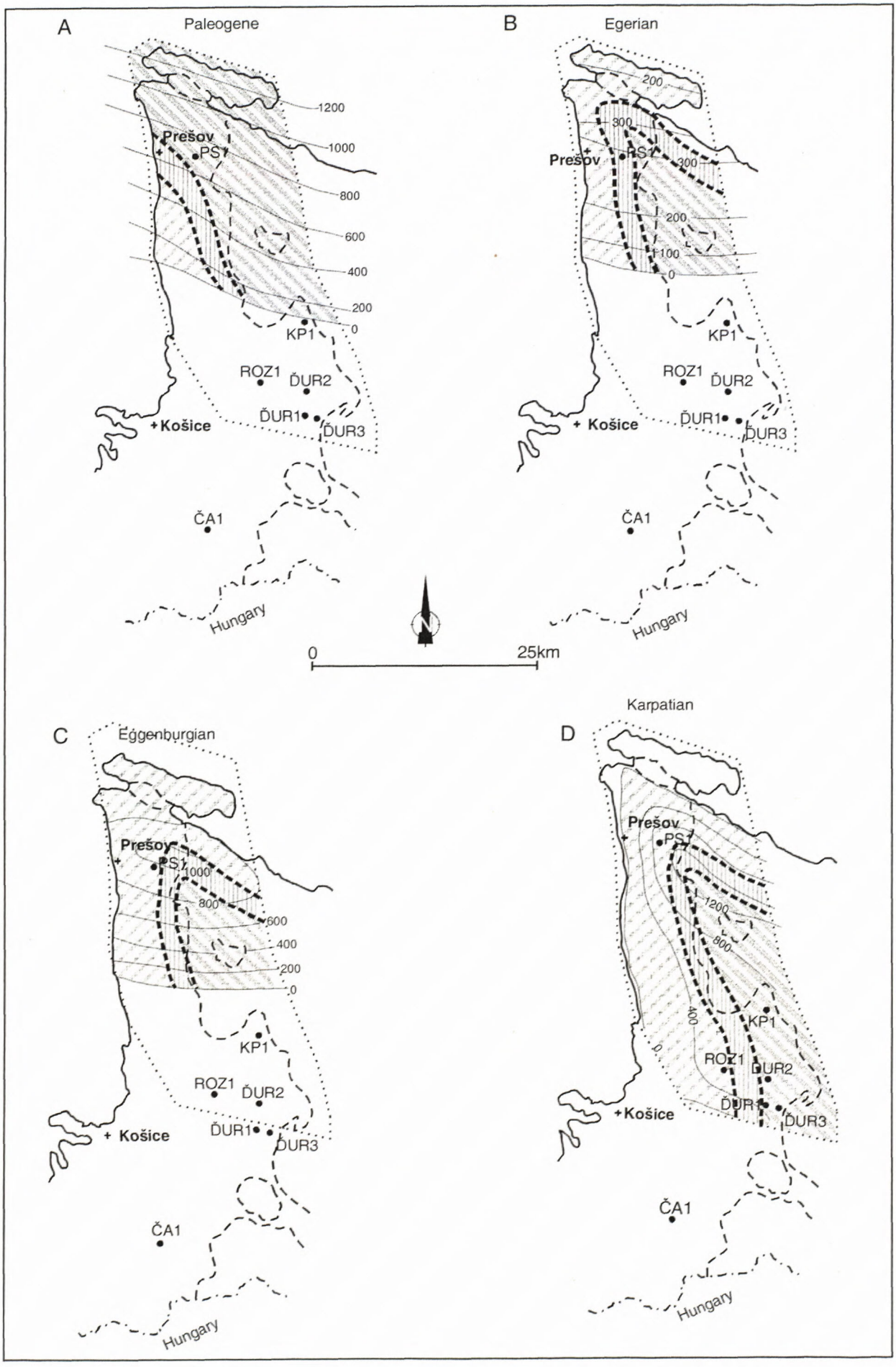
Paleogene	350
Egerian	300
Eggenburgian	300
Karpatian	300
Lower and Middle Badenian	200

d) Fractional conversion (f) for each maturity zone calculated from Fig. 2, i.e. from vitrinite reflectance:

Early oil zone:	*oil* = 0.00;	*gas* = 0.00	Ro = 0.62
Oil zone:	*oil* = 0.75;	*gas* = 0.10	Ro = 1.00

e) Volume of potential source rocks in individual maturity zones from Figs. 1a-e, summarized in Tab. 1.

f) The kerogen type considered is the type III-II (terrigenous to mixed), i.e. this kerogen can generate about 25 % oil and 75 % gas (Tissot and Welte, 1984). The oil and gas yield in weight % from average TOC content for particular stratigraphic units is shown in Tab. 2.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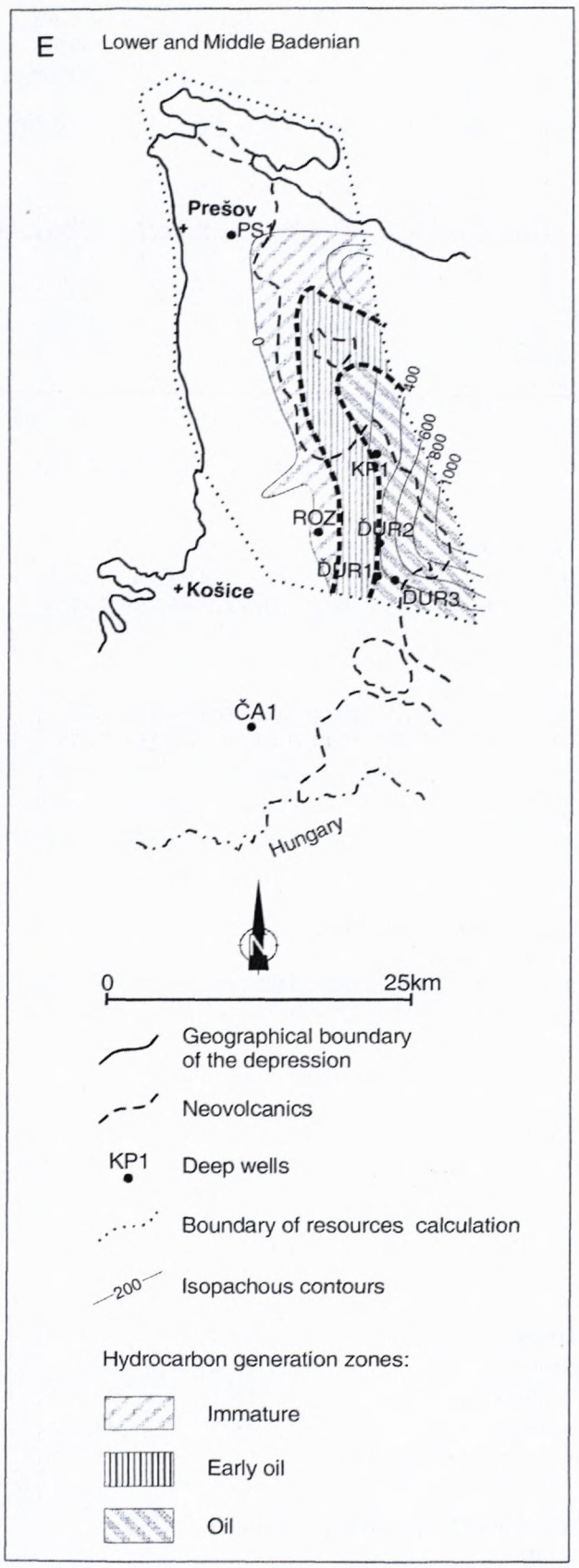

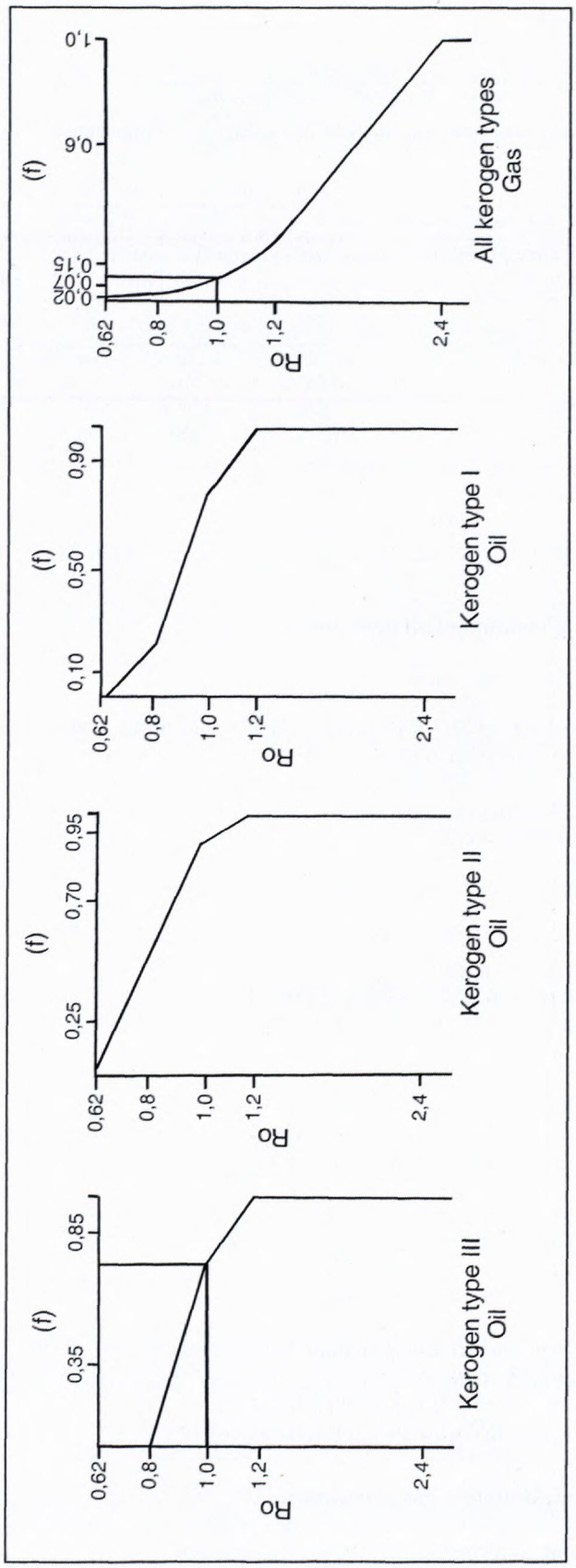

Fig. 1a - calculation of the source rock volume in Paleogene (without Egerian), b - calculation of the source rock volume in Egerian, c - calculation of the source rock volume in Eggenburgian, d - calculation of the source rock volume in Karpatian, e - calculation of the source rock volume in Lower and Middle Badenian.

Fig. 2. Relationship between Ro values and fractional conversion (f) of three main groups of kerogene to oil and gas (after Waples, 1985).

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Table 1.

		Paleogene	Egerian	Eggenburgian	Karpatian	Lower and Middle Badenian
Total vol. of sediments (km^3)		332.5	70	175	390	100
volume of sediments in maturity zones	immature	50	30	110	235	27.5
	early	20	15	15	20	10
	oil	262.5	25	50	135	62.5
% of potential source rocks		25	20	20	10	10
volume of sediments in productive maturity zones	early	5	3	3	2	1
	oil	65.625	5	10	13.5	6.25

Table 2.

	wt. % of TOC	wt. % of oil	wt. % of gas
Paleogene	1.0	0.250	0.750
Egerian	0.5	0.125	0.375
Eggenburgian	0.5	0.125	0.375
Karpatian	0.9	0.225	0.675
Upper and Middle Badenian	0.5	0.125	0.375

Calculation of oil generation

General formula:

Volume of HC = (k).(TOC).(HI).(f) in million barrels of oil/cubic mile of source rock

Paleogene
Maturity stage:
early: 0.7 x 0.25 x 350 x 0 = 0
oil: 0.7 x 0.25 x 350 x 0.75 = 45.9375

Egerian
Maturity stage:
early: 0.7 x 0.125 x 300 x 0 = 0
oil: 0.7 x 0.125 x 300 x 0.75 = 19.6875

Eggenburgian
Maturity stage:
early: 0.7 x 0.125 x 300 x 0 = 0
oil: 0.7 x 0.125 x 300 x 0.75 = 19.6875

Karpatian
Maturity stage:
early: 0.7 x 0.225 x 300 x 0 = 0
oil: 0.7 x 0.225 x 300x 0.75 = 35.4375

Lower and Middle Badenian
Maturity stage:
early: 0.7 x 0.125 x 200 x 0 = 0
oil: 0.7 x 0.125 x 200 x 0.75 = 13.125

Calculation of gas generation

General formula:

Volume of HC = (k).(TOC).(HI).(f).(a)

(a) - conversion constant (conversion of gas volume to oil equivalent); if we want to obtain the volume of gas in billions of cubic feet per cubic mile of source rock, constant (a) = 6.

Paleogene
Maturity stage:
early: 0.7 x 0.75 x 350 x 0.02 x 6 = 22.05 = 3.675 oil equivalent
oil: 0.7 x 0.75 x 350 x 0.10 x 6 = 110.25 = 18.375

Egerian
Maturity stage:
early: 0.7 x 0.375 x 300 x 0.02 x 6 = 9.45 = 1.575
oil: 0.7 x 0.375 x 300 x 0.10 x 6 = 47.25 = 7.875

Eggenburgian
Maturity stage:
early: 0.7 x 0.375 x 300 x 0.02 x 6 = 9.45 = 1.575
oil: 0.7 x 0.375 x 300 x 0.10 x 5 = 47.25 = 7.875

Karpatian
Maturity stage:
early: 0.7 x 0.675 x 300 x 0.02 x 2 x 6 = 17.01 = 2.835
oil: 0.7 x 0.675 x 300 x 0.10 x 6 = 85.05 = 14.175

Lower and Middle Badenian
Maturity stage:
early: 0.7 x 0.375 x 200 x 0.02 x 6 = 6.3 = 1.05
oil: 0.7 x 0.375 x 200 x 0.10 x 6 = 31.5 = 5.25

Calculation of total hydrocarbon generation

The amount of total hydrocarbons (oil and gas, the gas volume is expressed in oil equivalent) in million barrels per cubic mile of source rock is shown in Tab. 3.

Table 3.

	Maturity stage	
	Early oil	oil
Paleogene	3.675	64.3125
Egerian	1.575	27.625
Eggenburgian	1.575	27.5625
Karpatian	2.835	49.6125
Upper and Middle Badenian	1.050	18.3750

Expulsion of hydrocarbons during the primary migration

A threshold value of about 50 million barrels of hydrocarbons (oil or oil equivalent) had to be generated from the source rock, before any expulsion could occur. This threshold value was in the Prešov Depression not reached during the early oil zone in any stratigraphic

formation i.e., the expulsion practically did not occur except the biogenic gas. In main oil generation zone expulsion occurred only in the case of Paleogene and Karpatian source rocks. The expulsion efficiency from potential source rock near threshold value is assumed to be 50 % for oil and 80 % for gas.

General formula:

Volume of hydrocarbons expelled = (A).(B)

(A) - volume of hydrocarbons generated in million barrels per cubic mile

(B) - expulsion efficiency

Paleogene - oil generation zone

Oil: 45.9375 x 0.50 = 22.96875
Gas: 18.375 x 0.80 = 14.7

Karpatian - oil generation zone

Oil: 35.4375 x 0.50 = 17.71875
Gas: 14.175 x 0.80 = 11.34

Secondary migration and accumulation efficiency

Proposed general secondary migration and accumulation efficiency ranges from 10 to 20 %. Regarding the fact that sediments in the Prešov Depression are within most area in relict maturation stage, to considerable extent tectonically disturbed and often "deteriorated" by volcaniclastics, we used the low efficiency value, i.e. 10 %.

General formula:

Volume of HC accumulated = volume of HC expelled x 0.1 in million barrels per cubic mile of source rock

Paleogene - oil generation zone

Oil: 22.96875 x 0.1 = 2.296875
Gas: 14.7 x 0.1 = 1.47

Karpatian - oil generation zone

Oil: 17.71875 x 0.1 = 1.771875
Gas: 11.34 x 0.1= 1.134

Converted into SI units it corresponds:

Paleogene - oil generation zone

Oil: 0,0876092 mil.m^3/km^3
Gas: 0,0560699 mil.m^3/km^3

Karpatian - oil generation zone

Oil: 0,0675843 mil.m^3/km^3
Gas: 0,0432539 mil.m^3/km^3

Total source volume

General formula:
Total source volume = volume of accumulated HC (in million m^3/km^3) x volume of potential source rocks (km^3).

Paleogene - oil generation zone

Oil: 0.0876092 x 65.625 = 5.7493538
Gas (oil equivalent): 0.0560699 x 65.625 = 3.6795872

Karpatian - oil generation zone

Oil: 0.0675843 x 13.5 = 0.9123881
Gas (oil equivalent): 0.0432539 x 13.5 = 0.5839277

Volume of oil is expressed in millions of cubic meters and volume of gas in billions of cubic meters.

Geological resources in total are as follows:

Σ Oil: 6.6617419 million m^3, i.e. 5.9955677 million ton
Σ Gas: 4.2635149 billion m^3

Conclusion

Presented calculated values represent the approximation of all hydrocarbons potentially generated, migrated and trapped for the whole area of the Prešov Depression. Parameters used for this calculation may of course locally vary - positively or negatively, depending upon the level of geological exploration. Assessment of quantity and quality of speculative (P2) resources is based mostly on analogues to similar, more detailed explored areas. We consider presented genetic-quantitative method, supported by the real analytic data, being not only an assessment but already the calculation. Geological processes involved in hydrocarbon generation, migration and accumulation are considered in this calculation.

From this viewpoint the applied method of speculative resources calculation seems to be universally applicable in hydrocarbon exploration of any area.

Maximum 50 % of hypothetical and speculative resources could generally be converted into the economically interesting reserves using exploration works. In the case of the Prešov Depression it would mean approx. 2.13 billion m^3 of gas and 2.45 million tons of oil.

Using average recoverability coefficient 0.7 for gas and 0.2 for oil it would represent recoverable reserves approx. 1.5 billion m^3 of gas and 490 thousand tons of oil.

We can state, based on above values that the Prešov Depression is an area with the low prospect for exploration of oil and gas fields.

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References

Milička J. & Pereszlényi M., 2005: Organic matter study of the Tertiary sediments in the Prešov Depression (Transcarpathian Basin, Eastern Slovakia). Slovak Geological Magazine, this volume.

Moshier S. O. & Waples D. W., 1985: Quantitative evaluation of the Lower Cretaceous Mannville Group as a source for Alberta's oil sands. AAPG Bull., 69, 161-172.

Tissot B. P. & Welte D. H., 1984: Petroleum formation and occurrence, 2nd edn. Springer-Verlag, New York.

Waples D. W., 1985: Geochemistry in petroleum exploration. D. Reidel Publishing CO., IHROC, Boston, 231.