Bulletin of Geosciences, Vol. 80, No. 1, 105–112, 2005
 ISSN 1214-1119

Lower Miocene coal measures buried by the Krupinská planina Plateau volcanics (southern Slovakia)

Dionýz Vass [1, 2] – Ján Milička [4] – Miroslav Pereszlényi [5] – Michal Elečko [3]

[1] Catholic University, Faculty of Education, A. Hlinka Square 56/1, 034 01 Ružomberok, Slovak Republic.
[2] Geological Institute of Slovak Academy of Sciences, branch Banská Bystrica, Severná 5, 974 01 Banská Bystrica, Slovak Republic.
E-mail: dionyz.vass@orangemail.sk
[3] Štátny geologický ústav D. Štúra – Geological Survey of SR, Mlynská dolina 1, 817 04 Bratislava, Slovak Republic
E-mail: takacova@gssr.sk
[4] Faculty of Science Comenius University Mlynská dolina G, 841 15 Bratislava, Slovak Republic. E-mail: milicka@fns.uniba.sk
[5] Eurogeologic a. s., Tomášikova 26, 821 01 Bratislava, Slovak Republic. E-mail: mperesz@egco.sk

Abstract. During the Early Miocene the Salgótarján Formation, of Ottnangian age, originated in the Novohrad/Nógrád Basin of southern Slovakia and northern Hungary. The formation contains coal measures. The brown coal was mined at Salgótarján, Borsod (Hungary), the Modrý Kameň-Veľký Krtíš area, and more recently at the Baňa Dolina mine (Slovakia). Because the Baňa Dolina coal reserves are almost exhausted further prospecting has been focused on the Krupinská planina Plateau, where several boreholes discovered the coal-bearing Pôtor Member of the Salgótarján Formation. The boreholes for coal prospecting drilled during the 1980s and 1990s verified the continuation of the Pôtor Member beneath the Middle Miocene volcanics of Krupinská planina Plateau.

The distribution of the coal measures is tectonically controlled. The coal field of the Baňa Dolina mine is limited to the north by the Šahy Antiform, a folded and faulted structure having a SW-NE axis. To the north of the Šahy Antiform (in the area of the Krupinska planina Plateau) the Salgótarján Formation coal measures are significantly controlled by the Dačov Lom Graben, where the coal seam is concentrated in the partial depressions and grabens. The Červeňany Depression and Veľký Lom Depression are both situated on the eastern wing of the Dačov Lom Graben. There are three coal seams in the Baňa Dolina coal field. To the north, beneath the Krupinská planina Plateau, only the third (lower) coal seam is well developed. The upper and middle coal seams are represented mostly by coal shale. The grade of coalification is brown coal orthophase, according to vitrinite reflectance: sub-bituminous B coal (Muttbraunköhle).

Key words: coal measures, Lower Miocene, Novohrad/Nógrád Basin, S Slovakia, N Hungary, tectonic control

Introduction

The coal-bearing Salgótarján Formation originated during the Early Miocene in the Novohrad/Nógrád Basin of southern Slovakia and northern Hungary (Fig. 1). The brown coal has been mined in Salgótarján, and later in the Borsod-Ózd area (Fig. 1). A brown coal deposit was discovered (Modrý Kameň or southern Slovakian Brown Coal Deposit, Čechovič 1948, 1952) during the middle of the 20th century in the Ipeľská kotlina Depression (southern Slovakia). There are three coal seams in the Pôtor Member of the Salgótárján Formation. Only the first and second seams (i.e. the upper and middle) were extensively mined. Later mining was concentrated in the Baňa Dolina mine at the town of Veľký Krtíš (coalfield of the Baňa Dolina mine, Fig. 2). Today these coal reserves are almost exhausted and the Baňa Dolina mine will be closed in the near future.

During the 1960s the continuation of the coal measures was discovered in the vicinity of the Vátovce settlement (Fig. 2). The coal measures are deeply sunk in the Strháre-Trenč Graben (Vass et al. 1979), where the seams

Figure 1. Recent contours of the Novohrad/Nógrád Basin's erosional remnants (southern Slovakia – northern Hungary). The basin originated in the Ottnangian and disappeared after the Karpatian (Early Miocene). Compiled from Vass et al. (1979), Fülöp et al. (1984), Vass (1992), Vass and Elečko (1992).

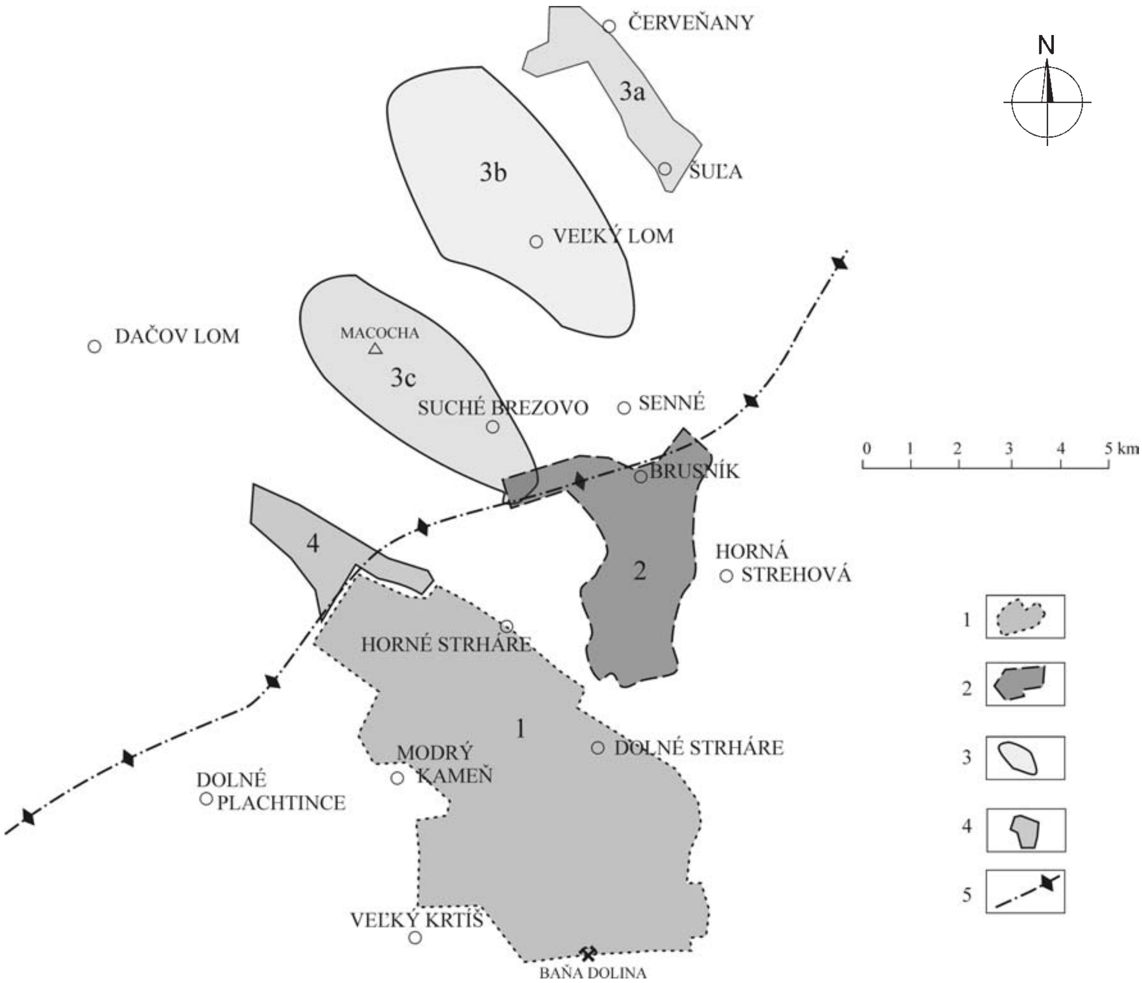

Figure 2. Coal measures of the Pôtor Member (Šalgótarján Formation) in the Ipeľská kotlina Depression (south of Šahy Antiform), and buried by the Krupinská planina Plateau (north of Šahy Antiform).
1 – coal field of Baňa Dolina mine, 2 – coal field Vátovce. In both coal fields (1 and 2) three coal seams are present. 3, 4 – coal fields on northern slope of Šahy Antiform: 3a – Červeňany Depression, 3b – Veľký Lom Depression, 3c – Macocha Depression, 4 – Imrovka Depression. In coal fields 3a and 3b only the third coal seam appears. In coal field 4 the third and first coal seams appear, though it's the thickness and quality of the latter are reduced. 5 – axis of Šahy Antiform.

exist at a depth of about 500 m. These coal reserves are not of economic interest.

In the 1970s an antiform buried by Middle Miocene andesite volcanics of the Krupinská planina Plateau was discovered based on about 350 coal prospecting boreholes (Šahy Elevation, Vass et al. 1979; Šahy Antiform, Vass 2003) – Fig. 6. This antiform had a decisive role for the tectonic evolution and paleogeography of the southern Slovakian region during the Late Oligocene and Early Miocene (Fig. 3). The coal seams of the Salgótarján Formation wedge out in the antiform's apical part. In spite of this, the presence of the Pôtor Member with one coal seam on the northern slope of Šahy Antiform was discovered by deep boreholes (to the north of the antiform apical ridge, deeply buried beneath the volcanics of the Krupinská planina Plateau). Because the coal reserves of the Baňa Dolina mine in the Ipeľská kotlina Depression were rapidly depleted by the end of the 20th century, further coal prospecting was focused on the northern slope of the Šahy Antiform. The prospecting boreholes, supported by geophysical methods, uncovered new coal reserve; but the Pôtor Member coal-measures are buried several hundred metres beneath the Krupinská planina Plateau. Coal prospecting during the 1980s was concentrated in the area around Červeňany village (Laffers et al. 1990) and during the 1990s in the area of the villages of Veľký Lom, Suché Brezovo, and Lešť (see Fig. 2).

In the present paper we attempt to evaluate the results of both coal prospecting campaigns, not only with respect to the coal-measures but also with regard to the new data concerning the tectonics controlling the evolution of the coal measures.

Lithology of the Pôtor Member coal measures

First a description of the basic features of the Pôtor Member in the Ipeľská kotlina Depression, i.e. on the southern flank of the Šahy Antiform, is given. The Pôtor Member reaches 30–50 m in thickness. It is composed of cross-bedded or massive sand/sandstone with clay and sandy-clay intercalations, and with three brown coal seams. The

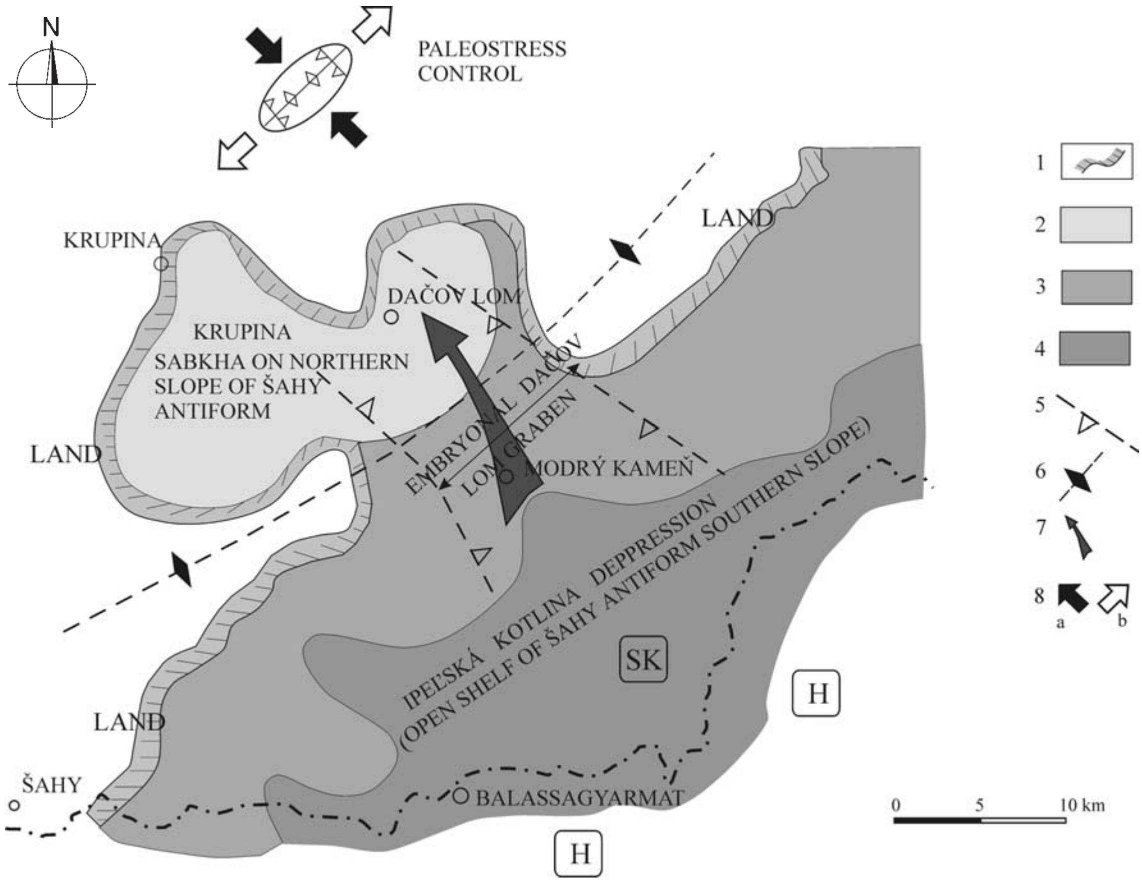

Figure 3. Barrier effect of the Šahy Antiform as a crucial factor in the origin of Krupina Sebhka (Late Oligocene–Early Miocene) on the northern slope of the antiform.
1 – shore line, 2 – sabkha evaporites, 3 – clastic littoral deposits (shallow shelf), 4 – pelitic deposits (deep shelf), 5 – normal fault, 6 – antiform axis, 7 – direction of marine incursions into sabkha, 8a – compression, 8b – extension.

lower (third) coal seam overlies the base of the Pôtor Member. Its maximum thickness is 5 m. The seam's lower part (approximately 1/3 of its thickness) is composed of coal shale with thin layers of the coal. Most of the coal seam of brown coal are of variable quality. From 5 m to 30 m above the lower seam is the middle (second) coal seam, which is also of variable thickness (maximum 5 m). This seam consists of three layers of coal shale with average thicknesses varying between 55 cm and 78 cm. The upper (first) coal seam is from 15 m to 30 m above the middle seam; its thickness (about 3 m) and quality are relatively uniform. The coal shale intercalations are very thin or are absent (Vass et al. 1979).

On the northern flank of the Šahy Antiform the thickness of the Pôtor Member reaches a maximum of about 50 m. This member is comprised of sandy-clay, sand/sandstone. There is only one coal seam along its base, which is an equivalent of the lower (third) coal seam. At the top and in the middle of the member are layers of coal shale with thicknesses less than 1 m. These represent the equivalents of upper and middle coal seams. The thickness of the lower coal seam is variable. The maximum thickness in the Červeňany Depression is 6.7 m, and in the Veľký Lom Depression it is about 4 m. The coal is not homogeneous. It is intercalated by coal shale, and its petrographic characteristics vary from a xylitic dedritic brown coal to a clayey semidetritic coal. The coal seam lithology in both partial depressions is shown schematically in Figs 4 and 5.

Tectonic influence on the evolution of the Pôtor Member coal

The crucial tectonic factor in the origin and evolution of the Pôtor Member coal measures was the Šahy Antiform (Fig. 6/I). The direction of the antiform's axis is NE-SW. The antiform originated during the Kiscellian (Oligocene) in a paleostress field in which the main compression was oriented in a NW-SE direction (Fig. 6/IIA). During the Egerian the compression was replaced by extension in the same direction, and the antiform was broken by longitudinal faults. Those faults are epigenetically confined to both flanks of the antiform (Fig. 6/IIB). In the Early Eggenburgian the main compression rotated to the vertical position, and extension in a NE-SW direction caused the breaking of the antiform by perpendicular faults (NW-SE), thus causing the development of the Dačov Lom Graben (Vass et al. 1993; Fig. 6/IIC).

When the Pôtor Member was deposited in the apical part of the antiform, conditions were unfavourable for coal sedimentation. In the top of the antiform the coal seams are either missing or the lower coal seam is present in a reduced

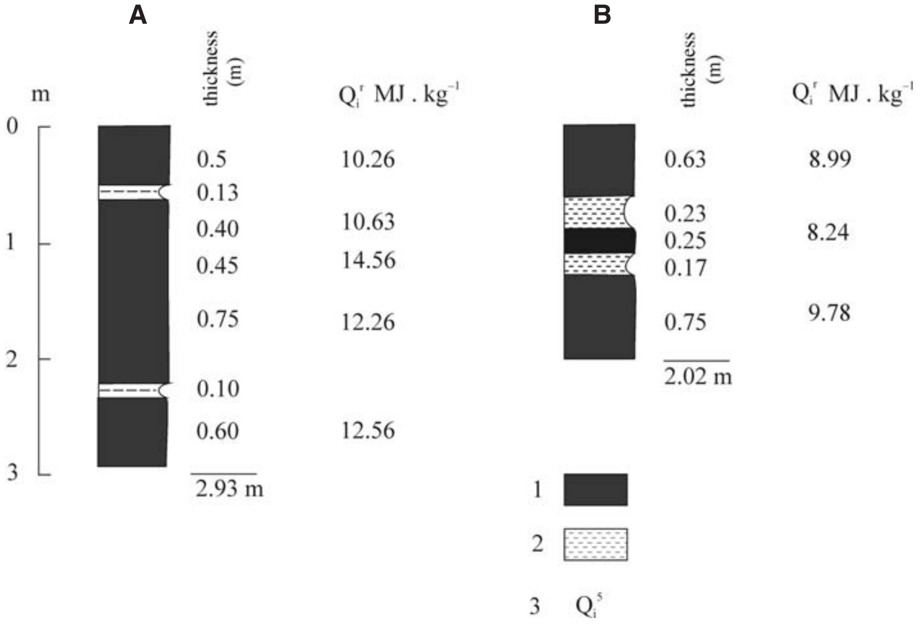

Figure 4. Scheme of the lithology of the third coal seam of the Pôtor Member in the Veľký Lom Depression, and caloric value Q_i^r as function of coal quality: A – coal of economic interest, B – coal of potential economic interest (after Bartek et al. 1998).
1 – coal, 2 – clay/claystone, 3 – caloricity.

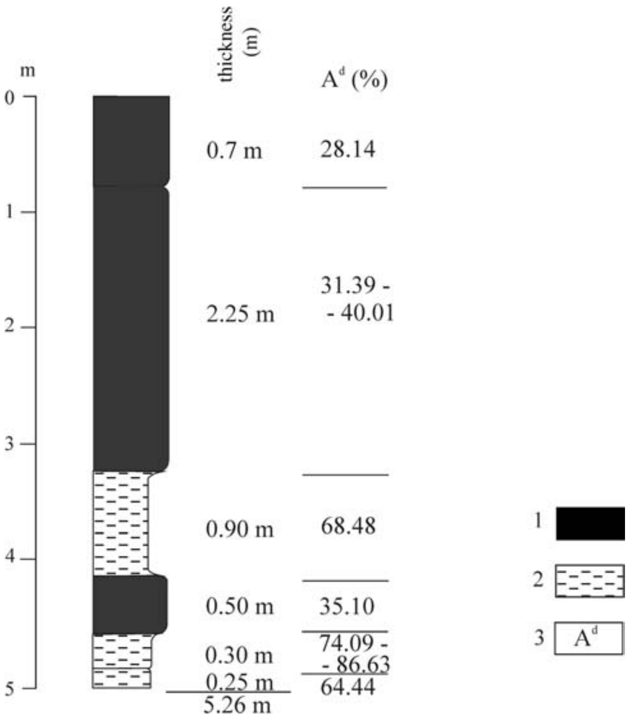

Figure 5. Lithology of the third coal seam of the Pôtor Member from borehole ČV-8 in Červeňany Depression, and the ash contents as a function of coal quality.
1 – coal, 2 – coal shale, 3 – ash contents in dry state.

thickness (less than 1 m, Maďar in Bartek et al. 1998). The Pôtor Member is developed on the northern flank of the antiform, but is comprised of only one coal seam, an equivalent of the lower (third) seam (Fig. 4). The middle (second) and the upper (first) coal seams are missing. They are replaced by layers of coal shale. An exception is the occurrence of the upper coal seam in the partial Imrovka Depression, but the thickness, quality, and areal distribution of the coal seam are considerably reduced.

The other tectonic structure that played an important role in the geologic evolution of the south Slovakian Lower Miocene was the Dačov Lom Graben. This graben originated in the Early Miocene stress-field with vertically oriented maximum compression, and extension acting in a NW-SE direction. The faults that confine and/or longitudinally divide the graben originated earlier (i.e. Oligocene faults of embryonic Dačov Lom Graben, see Fig. 6/IIA).

The boreholes drilled for coal prospecting campaigns in the 1990s were focused on evaluating the quality and quantity of the coal measures beneath the volcanics of the Krupinská planina Plateau (Laffers ed. 1990, Bartek et al. 1998). This activity, accompanied by geophysical methods (Maďar in Bartek et al. 1998), indicated the pronounced effects that the Dačov Lom Graben had on the Pôtor Member coal measures on the Šahy Antiform's northern flank.

The faults of the Dačov Lom Graben not only confined the graben, but also subdivided it into partial depressions and high blocks (Fig. 6/IIC). The thickness, lateral extension, and quality of the Pôtor Member lower coal seam are thus strongly controlled by fault tectonics. On the high blocks the coal seam is either absent or is strongly reduced, while it is present in the partial depressions. Its largest thickness occurs in two depressions of the eastern Dačov Lom Graben wing: in the Veľký Lom Depression and the Červeňany Depression (4 m, and 6.7 m, respectively – Fig. 7).

Similar and even smaller thickness of the lower coal seam also occur in the Baňa Dolina coal district on the southern slope of the Šahy Antiform. The entire thicknesses of the Pôtor Member and the Salgótarján Formation are similar (ca 50 m and 200 m, respectively). The influence of the Dačov Lom Graben on the Pôtor Member, and the quality and distribution of its coal, in the Ipeľská kotlina Depression was noted by Vass et al. (1979). The mobile zone of the Dačov Lom Graben during the Ottnangian was favourable to the origin and continuation of the swamp and bog environments that produced the coal.

Properties of the coal on the Šahy Antiform northern flank

The lower coal seam of the Pôtor Member on the Šahy Antiform northern flank is sunk to a depth ranging from 200 to

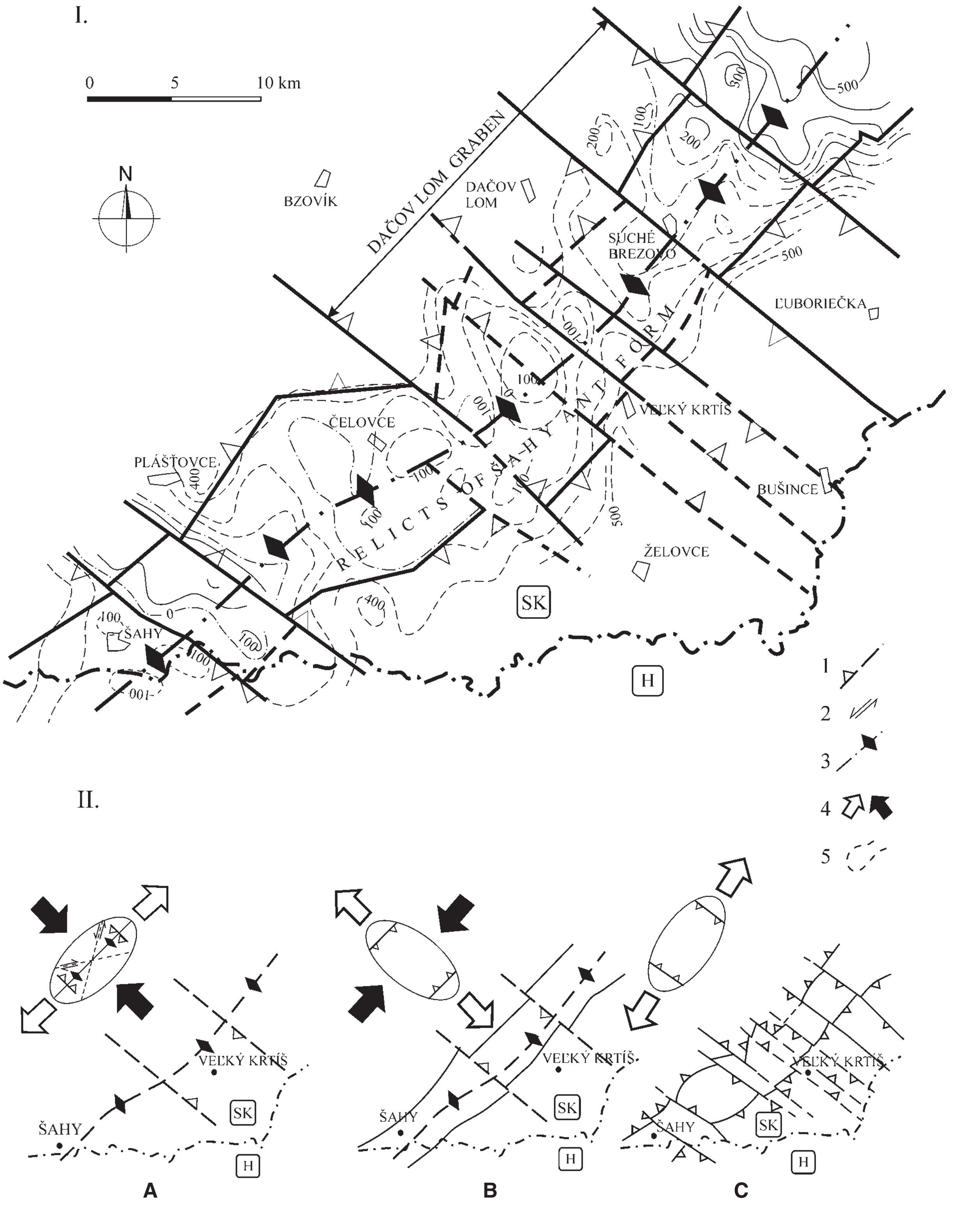

Figure 6. I: Remnants of the Šahy Antiform confined by NE trending faults and transversely broken by the faults of the Dačov Lom Graben.
1 – normal fault, 2 – strike-slip fault, 3 – axis of Šahy Antiform, 4 – paleostress directions (black arrow: compression, empty arrow: extension), 5 – isohypses of pre-Cenozoic basement
II: Variations in the paleostress field in time (after Vass et al. 1993).
A – Middle Kiscellian: Maximum compression oriented in NW-SE direction. The Šahy Antiform originated and the early Dačov Lom Graben began to open.
B – Late Oligocene: Paleostress event when maximum compression rotated from NW-SE direction to NE-SW direction. The NW-SE extension caused the development of faults confining both flanks of the Šahy Antiform.
C – Early Miocene: Maximum compression rotated to the vertical position, while extension was working in a NE-SW direction. The fault activity of the Dačov Lom Graben culminated

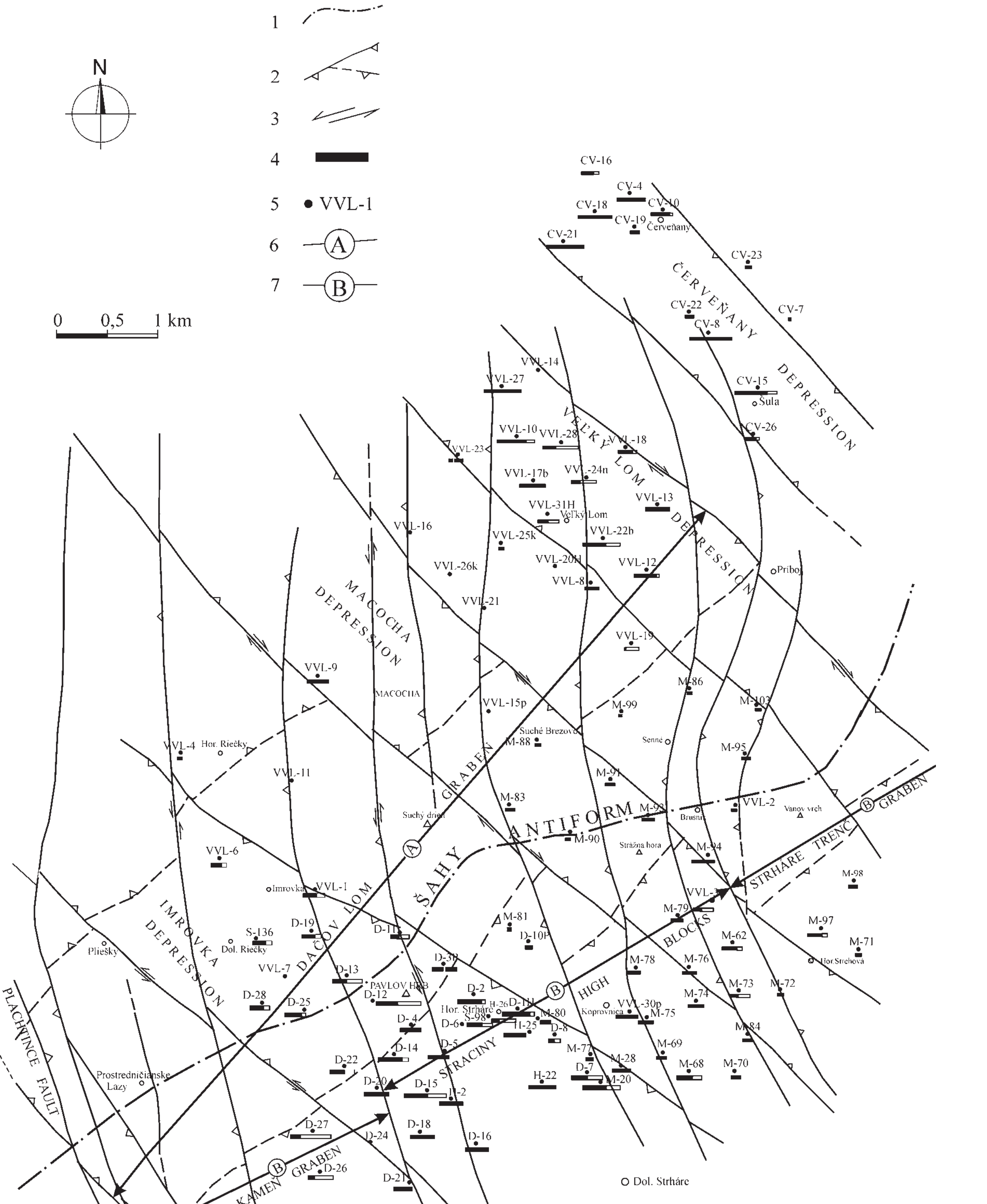

Figure 7. Early Miocene and lower Middle Miocene (Badenian) faults and blocks in the area between the villages of Červeňany, Brusník, Modrý Kameň, and Horné Plachtince and their relationship to the Šahy Antiform. The figure shows newly defined partial depressions within the Dačov Lom Graben. See the asymmetric distribution of the third (lower) coal seam of the Pôtor Member (Šalgótarján Formation) within the Dačov Lom Graben.
The oldest faults are of SW-NE direction, they confine the Šahy Antiform being generated in the paleostress field with maximum compression in NE-SW direction during and after the Egerian (Late Oligocene). Those faults are epigenetically broken by the faults of the Dačov Lom Graben, Early Miocene in age, and originating in the Early Miocene stress field with vertically oriented maximum compression and with extension in a NE-SW direction. The youngest faults epigenetically break the fault systems of SW-NE and NW-SE direction, and had been generated in the Badenian in a paleostress field with maximum compression in a NNW-SSE direction. All paleostress field and fault directions are in present coordinates.
l – axis of Šahy Antiform, 2 – normal faults, 3 – strike-slip, 4 – relative thickness of coal seam, 5 – borehole, 6 – Late Oligocene – Early Miocene graben (Dačov Lom Graben), 7 – lower Middle Miocene (Badenian) grabens and high blocks

650 m, though the most common depth is between 400–600 m. The coal thickness varies from 0.6 m to 6.7 m. The coal quality is inhomogeneous. Within the coal-seam are intercalations of coal-shale, and even in the coal itself the ash contents and caloric value are variable (Table 1).

The contents of water W_t^r vary from 11.56–33.19%.

The ash contents A^d are 26.83–58.94%.

The sulphur contents S^d are 1.6–4.74%.

The arsenic contents A_s^d are 11–76 g . t^{-1}.

The caloric value Q_i^r is 5.45–14.56 MJ . kg^{-1}.

The degree of coalification is brown coal orthophase.

The organic geochemistry of the coal, according to Rock-Eval pyrolysis, is as follows:

T.O.C. is from 6.26% to 49.9%, s_2 (bounded hydrocarbons): 7.68–48.14 mg . g^{-1}, HI (hydrogen index): 75–266 mg . g^{-1}, T_{max} (maximum temperature of pyrolysis): 388°–428 °C and R_0 (vitrinite reflectance): 0.36–0.49%.

According to Rock-Eval pyrolysis the organic matter of the coal is of terrestrial origin (dry land plants, Fig. 8). According to microscopic photometry the coal matter is composed of vitrinite macerates, particularly by humotelinite. The grade of coalification corresponds to sub-bituminous B coal (Muttbraunköhle).

The total coal reserves are of 76 765 kt. The economic reserves are 22 934 kt, while the potentially economic reserves are 12 098 kt, and prognostic sources are of 41 733 kt.

The coal of the northern flank of the Šahy Antiform is currently not of economical interest. The main reason is the depth of the coal seam, which is buried by a thick complex of Krupinská planina Plateau volcanics (400–600m).

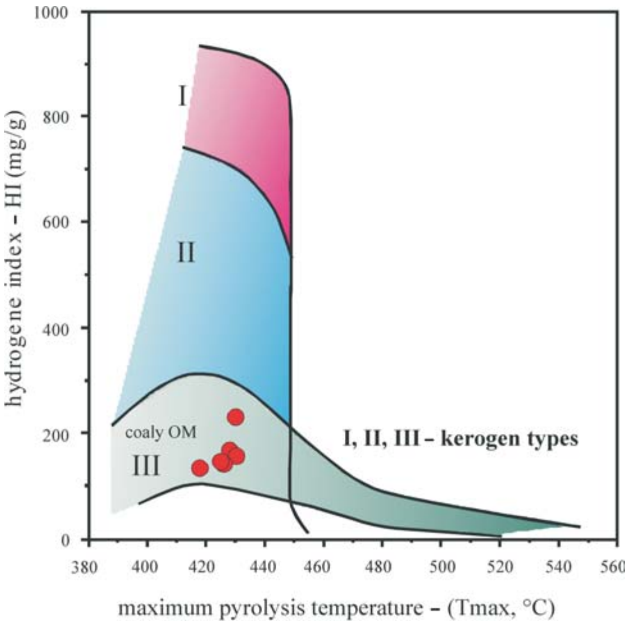

Figure 8. Projections of the coal seam (third coal seam) from the Šahy Antiform northern slope in a modified van Krevelen's diagram. The organic matter of the coal seam is of kerogen type III and derives from dry land plants.

Conclusion

The coal field discovered on northern flank of the Šahy Antiform lies deeply buried by the Krupinská planina Plateau neovolcanics. These coal measures belong to the Salgótarján Formation. They are of the Ottnangian age, and originated within the Early Miocene Novohrad/Nógrád Basin.

The coal measures of the Pôtor Member on the northern flank of the Šahy Antiform contain only one coal seam equivalent of the lower (third) coal seam of the Baňa Dolina main coal field in the Ipeľská kotlina Depression (the southern flank of the Šahy Antiform). The thickness of the coal seam varies from 0.6 to 6.7 m. The coal quality is inhomogeneous. Within the coal seam there are intercalations of coal shale, and even in the coal itself the ash contents and caloric value significantly vary.

The development of the coal seam was tectonically controlled. First, the Šahy Antiform (a folded and faulted structure) divided the coal field in the Ipeľská kotlina Depression (coal district of Baňa Dolina and Vátovce coal field) from that on the antiform's northern flank. The coal seam's evolution was strongly influenced by the Dačov Lom Graben and its partial depressions and high blocks. The largest coal seam thickness and relatively better coal quality occur at the Červeňany and Veľký Lom partial depressions situated on eastern wing of the Dačov Lom Graben.

The coal is deeply buried by Middle Miocene volcanics of the Krupinská planina Plateau. It is for this reason that the coal fields on the Šahy Antiform northern slope are not of economic interest.

Table 1. Quality parameters of the Pôtor Member coal on northern slope of Šahy Antiform (after Bartek et al. 1998, Laffers ed. 1990)

parameters of coal quality	3rd coal seam in Veľký Lom Depression		3rd coal seam in Červeňany Depression
	economic reserves[1]	potencially reserves[2]	
caloric value Q [MJ . kg^{-1}]	7.48–12.97	8.29–9.78	0.64–16.9 5.45–13.16[1]
water contents W_t^r [%]	18.25–27.03		11.56–33.19 (Φ 24.96)
ash contents A^d [%]	34.43–58.94		9.93–88.87 (Φ 48.48) 26.83–65.6[1] (Φ 42.23)
sulphur contents S^d [%]	2,74–4,74		1.6–3.44 (Φ 2,26)
arsenic contents As^d [g . t^{-1}]	16–24		5–169 (Φ 36) 11–76[1]

[1] coal of economic reserves, [2] coal of potentially economic reserves

Acknowledgements. The paper was supported by the projects of VEGA No. 1/9263/02, 1/9264/02, 2/3178/23, 2/3179/23.

References

Bartek V., Šarkan J., Hash J., Skaviniak M. (1998): Záverečná správa z úlohy Veľký Lom – Lešť, vyhľadávací prieskum, hnedé uhlie. (Veľký Lom – Lešť brown-coal exploration. Final report.) Report, Slovak Geol. Survey – Geofond, Bratislava (in Slovak).

Čechovič V. (1948): Správa o výskumných prácach v okolí Modrého Kameňa od 21. 7. 1946 do 1. 3. 1948. (Report about exploration activities in town of Modrý Kameň vicinity 21. 7. 1946–1. 3. 1948). Report, Slovak Geol. Survey – Geofond, Bratislava (in Slovak).

Čechovič V. (1952): Geológia juhoslovenskej panvy (Geology of Southern Slovakian Basin). Geol. Práce, Zošit 33, Bratislava, 1–53.

Fülöp J., Hámor G., Jámbor A. (1984): Geological map of Hungary 1 : 500,000. Hungarian Geol. Inst., Budapest.

Laffers F., ed. (1990): Záverečná správa z úlohy Ľuboriečka – Červeňany, hnedé uhlie, vyhľadávací prieskum. (Ľuboriečka – Červeňany brown coal exploration. Final report.) Slovak Geol. Survey – Geofond, Bratislava (in Slovak).

Vass D. (2003): The Šahy Antiform and its role in the tectonics and paleogeography of the Hungarian Paleogene Basin and the Novohrad/Nógrad Basin (S. Slovakia and N. Hungary). Acta Geol. Hungarica 46, 3, 269–289.

Vass D., ed. (1992): Geologická mapa Lučenskej kotliny a Cerovej vrchoviny, 1 : 50,000. (Geological Map of Lučenská kotlina Depression and Cerová vrchovina Upland.) Geol. ústav D. Štúra, Bratislava.

Vass D., Elečko M., eds (1992): Vysvetlivky ku Geologickej mape Lučenskej kotliny a Cerovej vrchoviny. (Explanatory notes to the Geological Map of Lučenská kotlina Depression and Cerová vrchovina Upland.) Geol. úst. D. Štúra, Bratislava, 196 pp. (in Slovak).

Vass D., Hók J., Kováč P., Elečko M. (1993): Sled paleogénnych a neogénnych tektonických udalostí v juhoslovenských kotlinách vo svelte napäťových analýz. (The Paleogene and Neogene tectonic events of Southern Slovakia depressions in the light of the stress-field analyses.) Mineralia Slovaca 25, 79–92 (in Slovak with English summary).

Vass D., Konečný V., Šefara J., eds (1979): Geologická stavba Ipeľskej kotliny a Krupinskej planiny. (Geology of Ipeľská kotlina Depression and Krupinská planina Mts.). Geol. Úst. D. Štúra, Bratislava, 277 pp. (in Slovak with English summary).