New Knowledge of the Development of the Petřkovice Member in the South of the Czech Part of the Upper Silesian Coal Basin (Czech Republic)

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ABSTRACT: Modelling of the development of thickness of the Petřkovice Member and its partial sequences in the south of the Czech part of the Upper Silesian Coal Basin brought interesting information about the character of spatial development of this unit. It was found that the east-west polarity (characteristic of the development of all strata units of the Ostrava Formation) began to manifest itself as late as of sedimentation of the upper part of the Petřkovice Member. The development of thicknesses of the lower part of this member has the insular character that indicates spatial variability in sedimentation. The sedimentation of the lower part of the Petřkovice Member has thus retained the spatial development of thicknesses typical for this area, e.g. in the period of sedimentation of basal clastics of Devonian age and of clastic-carbonate formation of Early Carboniferous age. This information has helped us to complete our knowledge of the beginning of coal-bearing sedimentation in this part of the basin, and has thus contributed to the supplementation of our picture concerning the development of the oldest parts of paralic complex of the Czech part of the Upper Silesian Coal Basin.

KEY WORDS: Czech part of the Upper Silesian Coal Basin, Petřkovice Member, Main Ostrava Whetstone, Seam Leonard Whetstone.

Introduction

At the Section of Mineral Raw Materials of the Institute of Geological Engineering of VŠB-Technical University of Ostrava, several initial studies concerning selected problems of coal-bearing Carboniferous in the Czech part of the Upper Silesian Coal Basin (CUSB) are being dealt with. They are focused on extent and the comprehensiveness of databases and to choose generally methodological procedures in the study of geological and mining characteristics of selected units of the CUSB. The study that concerned with the Petřkovice Member, brought interesting knowledge of the development of this unit in the south of the CUSB and completed our knowledge about the character of the beginning of coal-bearing sedimentation in this part of the basin.

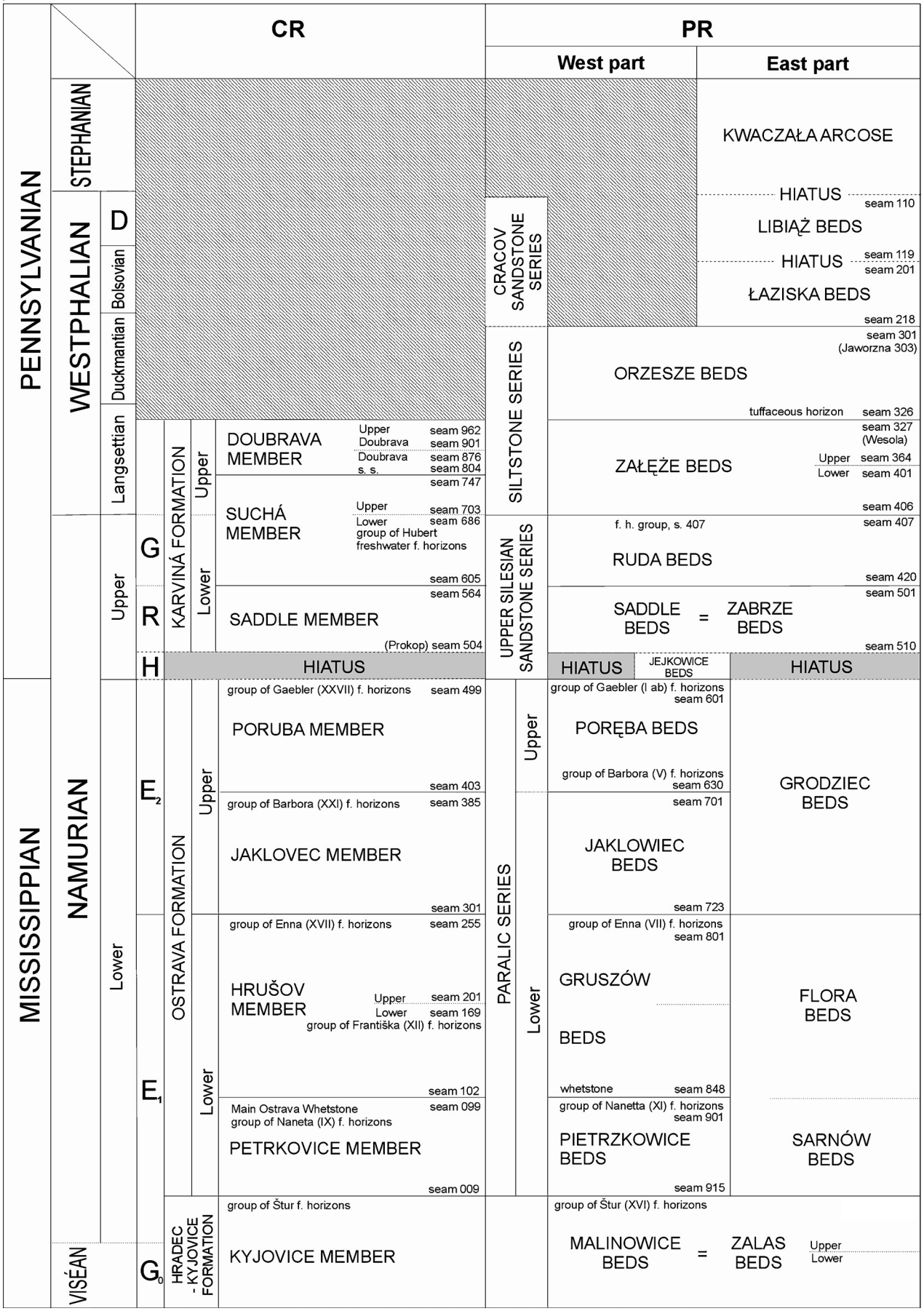
Petřkovice Member in the Czech Part of the Upper Silesian Coal Basin

The Petřkovice Member is the oldest unit of the Ostrava Formation. The member was named after the municipality of Petřkovice, a present-day district of the town of Ostrava. Its delimitation carried out by Šusta (1928) still holds in principle true. The Petřkovice Member is separated from the older Kyjovice Member by the top of the group of Štúr faunistic horizons (f. h. g.). Its upper boundary in the CUSB is formed by the top of the so called Main Ostrava Whetstone. The Petřkovice Member belongs to the Lower Namurian (Fig. 1).

The geology of the Petřkovice Member has been described in many published works. However, more data can be found in unpublished studies and reports, reserves estimations, concepts of production outlooks, and others (for instance Weiss et al. 1969, Ševčík 1985). Lately, this information was summarised in the monograph edited by Dopita (1997). Properties of the CUSB coal, including the seams of the Petřkovice Member, were also described in the studies by Martinec et al. (2005) and Sivek et al. (2003). The mentioned publications also contain other references. Above all else it is necessary to state Jansa (1967), Adamusová et al. (1992), Dopita and Kumpera (1993) and Kumpera (1997).

At present the Petřkovice Member crops out merely in the west of the Ostrava part of the basin (Landek area, localities of Bobrovníky and Hošťálkovice). Almost in the whole area of the CUSB the Petřkovice Member is overlain by younger Carboniferous sediments, autochthonous Neogene sediments, sediments of Quaternary age, and in places by the Outer Carpathians Nappes. The Petřkovice Member crops out on the Carboniferous relief in a narrow zone along the west rim of the basin. Eastwards, it plunges below younger coal-bearing units. In the Frenštát and Karviná parts, it is submerged deeply in depression structures below younger coal-bearing units. The post-erosional extent of occurrence of the Petřkovice Member in the CUSB can be seen in Fig. 2.

The lower boundary of the Petřkovice Member, as delimited above, is difficult to identify in some cases. Generally it can be said that the lower part of the Petřkovice Member is characterized by the higher sand content in contrast to the underlying barren Kyjovice Member. Thus complexes of sandstones of the lower part of the Petřkovice Member in which erosion phenomena can be observed are overlain sharply by the claystones and siltstones of the uppermost part of the Štúr f. h. g. The fact that this boundary is sometimes unclear is caused by missing of thick sandstone layers or locally developed marine horizons exceeding the base of coal-bearing Carboniferous. The occurrences of seams are not any reliable feature for the accurate determination of the boundary, because they can also be found in the Štúr f. h. g. As a tool for the determination of the lower boundary of the Petřkovice Member, the occurrence of the so-called "spirifer" sandstone is used. Nevertheless, it was not found in all logs of boreholes and mine workings. Such areas were this horizon has not developed probably exist.



■ **Fig. 1.** Lithostratigraphic table of the Czech and Polish parts of the Upper Silesian Coal Basin (Sivek et al. 2003).

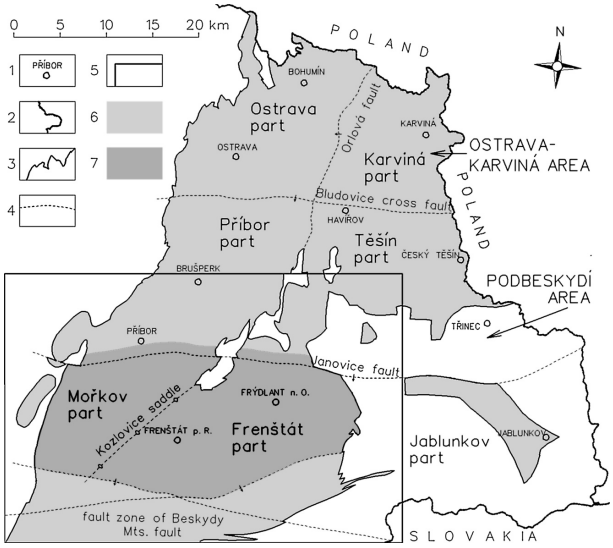
The upper boundary of the Petřkovice Member in the CUSB is placed in the top of the Main Ostrava Whetstone. In the CUSB as whetstones are designated the rocks consisting of a mixture of terrigene and pyroclastic materials which were deposited outside coal seams. The Main Ostrava Whetstone is a light grey pelitic rock. It is characterised by considerable lateral stability, thickness and especially relative uniqueness of occurrence. For these reasons, it is taken as a significant correlation horizon in the basin. The whetstone that occurs about 30 m under the seam Karel (No. 106) was described by Petrascheck (1913) for the first time. At present we know that the Main Ostrava Whetstone occurs in the whole area of the CUSB west of the Orlová fault. In the south of the Podbeskydí area, there are know boreholes where the Main Ostrava Whetstone has never been found. In the Karviná part, its occurrence has not been proved, but knowledge of its occurrence in the Polish part of the basin (in the close vicinity of Czech-Polish border) shows that the occurrence of the Main Ostrava Whetstone is probable in the Karviná part of the basin (in the deep borehole SV-2 in the south-east of the Karviná part it was not found).

The Petřkovice Member contains many horizons (especially faunistic but also of whetstones and tonsteins), which are important for the identification and the correlation of coal seams and thus for the understanding of geological structure and development of the basin. They differ in stability and thus also in importance to the study of geology of the basin. In the southern part of the Podbeskydí area, the **whetstone of the seam Leonard (No. 032)** seems to be a stable and well identifiable horizon. This horizon is sometimes used as a boundary dividing the Petřkovice Member into the lower and the upper parts. In the south of the CUSB this boundary is placed in the top of whetstone of the seam Leonard (Dopita et al. 1997). In the studied area, it is a stable horizon and the determination of this boundary is in principle reliable.

These days, the Petřkovice Member outcrops in the CUSB in the extent clearly exceeding the post-erosion areas of occurrence of younger units. In spite of rather extensive occurrence of the Petřkovice Member, in the prevailing part of this area the Petřkovice Member has been verified only by surface exploration boreholes. The same situation was met in the south of the Podbeskydí area that was the subject of our study. In mine workings the Petřkovice Member has been verified only in some parts of the basin, namely in the west of the Ostrava part of the CUSB, in the area of the so-called Ostrava brachysyncline and further in the north of the Podbeskydí area, in the Příbor part (Fig. 2), in the Paskov and Staříč mines. Whereas the mines in the west of the Ostrava part belonged to the oldest mines in the CUSB, the mines in the Podbeskydí area ranked among the youngest ones. Nevertheless, it should be mentioned that coal seams of the Petřkovice Member were undoubtedly mined in the CUSB first (outcrops of coal seams in the slope of the Landek Hill).

Initial data and methodological procedures

The study was elaborated for the southern part of the Podbeskydí area of the CUSB (Fig. 2). This part of the basin shows many

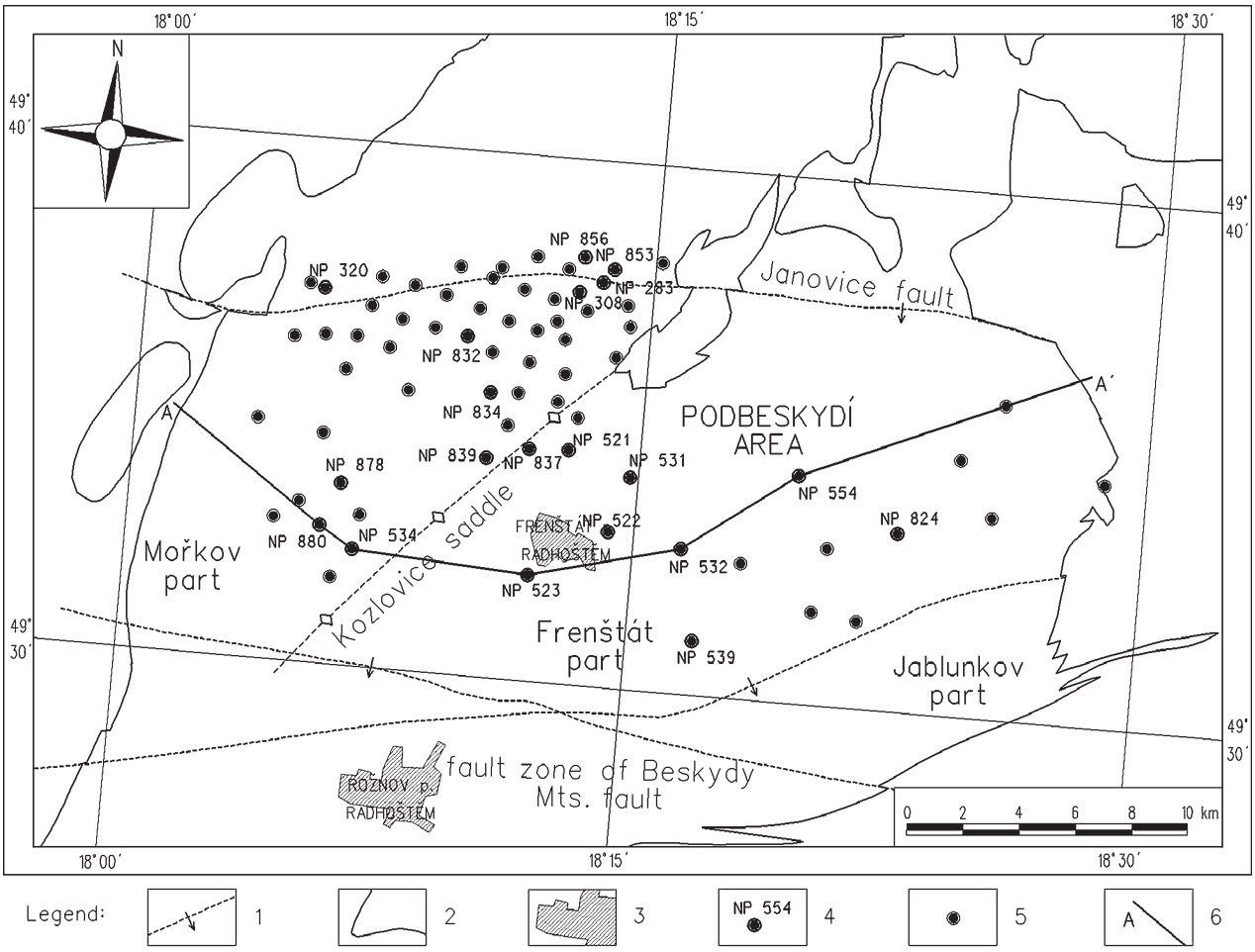


■ **Fig. 2.** Regional division and the occurrence of the Petřkovice Member in the Czech part of the Upper Silesian Coal Basin 1 – settlements, 2 – frontiers, 3 – post-erosional boundary of the basin, 4 – significant structure, 5 – locations of figures nos. 3, 4, 5, 6 – occurence of the Petřkovice Member, 7 – studied area.

different features in the development of the most paralic units. Reduction of thickness of layers, change in the character of faunistic horizons etc. (e.g. Dopita et al. 1997) were stated most frequently.

The Petřkovice Member was divided, for the purposes of the study, into two partial units (lower and upper); the boundary between them was placed in the top of whetstone of the seam Leonard. We have prepared three models of thickness of the Petřkovice Member: lower part, upper part and a model of thickness of the whole member.

Surface exploration boreholes were the source of input data for the study. Data processing was preceded by the reinterpretation of all drilling logs included into the study; emphasis was put especially on the identification of horizons used in the study (upper and lower boundaries of units, top of whetstone of the seam Leonard). The exploration boreholes were divided into groups according to the extent of verification of the Petřkovice Member as follows: 1. boreholes penetrated all deposits of the Petřkovice Member (20 boreholes, i.e. 27.8 %), 2. boreholes with the incomplete record of the Petřkovice Member (52 boreholes, i.e. 72.2 %) (Fig. 3). The boreholes that did not verify the whole sequence of the Petřkovice Member can be subdivided into the following three groups: 1. boreholes with the eroded upper part of the Petřkovice Member, 2. boreholes not drilled to the base of the Petřkovice Member, 3. boreholes with the eroded upper part of the Petřkovice Member and not drilled to the base of the Petřkovice Member. The models of changes of the thickness of deposits of the whole unit were done above all on the basis of complete boreholes as models of the former thicknesses. The boreholes of the other groups were used, according to the character of verification of the Petřkovice Member, in the creation of the model of thickness of the lower or upper part of the unit.



■ **Fig. 3.** Map of the southern part of the Podbeskydí area with the location of the surface boreholes 1 – significant structure, 2 – post-erosional boundary of the basin, 3 – settlements, 4 – surface boreholes used for the modelling of the thickness of the Petřkovice Member, 5 – other surface boreholes, 6 – location of the cross-section A – A′.

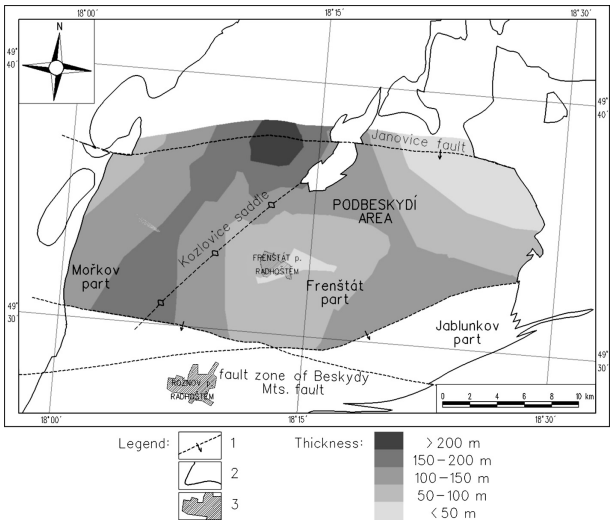


Fig. 4. Thickness of the lower part of the Petřkovice Member 1 – significant structure, 2 – post-erosional boundary of the basin, 3 – settlements.

The methodological procedures in the creation of spatial models of development of chosen parameters of the Petřkovice Member were based on the application of software environments MicroStation and InRoadSide from the company Bentley Systems, Inc.

As already mentioned, the degree of our knowledge of the Petřkovice Member considerably varies within the CUSB. In the south of the Podbeskydí area, the development of this unit is known merely from the surface exploration boreholes and it can be expected that any substantial change in the degree of exploration of the Petřkovice Member in this area will not occur in the near future.

Development of the thickness of the Petřkovice Member in the south of the Podbeskydí Area

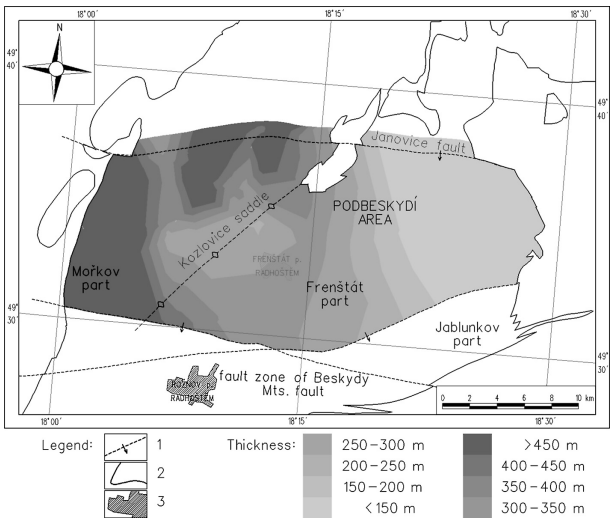
Development of the thickness of the lower part of the Petřkovice Member

The thickness of the lower part of the Petřkovice Member in the studied area ranges from 32.2 m to 223.0 m (Fig. 4). The

greatest thicknesses of this member occur west of the centre of the area. It forms a relatively distinct zone running in the NNE-SSW direction. In this zone, maximum thickness is concentrated in its northern part, along the boundary of studied area, in the vicinity of the Janovice fault. The zone narrows approximately in its middle part; southwards and primarily northwards it broadens markedly. Another, less distinct zone of increased thicknesses of the lower part of the Petřkovice Member runs in the NNW-SSE direction. Along its north edge, it joins the already described zone of NNE-SSW direction. Within the zone, any increased values of thickness as with the first zone were not observed. The lowest thicknesses of the lower part of the Petřkovice Member are not, in contrast to the highest thicknesses, concentrated into one continuous area. They form two areas, where the first one is located in SSE in the vicinity of the so-called fault zone of Beskydy Mts. Fault, and the more distinct second one is located in the north-eastern corner of the Podbeskydí area. Minimum thicknesses diminish there even below the limit of 50 metres, whereas in the former area described above, thicknesses amount to 50–100 metres and only in a very small area decrease to less than 50 metres (approximately in the centre of the area). The thickness of the lower part of the Petřkovice Member declines west of the zone of highest thicknesses. In the west part of the Podbeskydí area the third area of minimum thicknesses of the lower part of the area thus probably occurs. As for its development relatively little information is, however available.

Development of the thickness of the upper part of the Petřkovice Member

In the studied area, the thickness of the upper part of the Petřkovice Member varies from 116.8 m to 491.6 m (Fig. 5). The highest thickness of this member occurs in the west, where it forms an extensive continuous area that probably extends northwards and southwards behind the boundary of the studied area. To the east the thickness decreases near the north rim

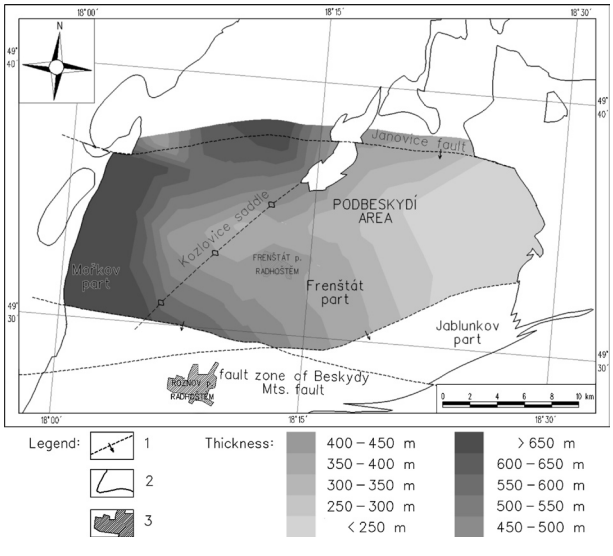


■ **Fig. 5.** Thickness of the upper part of the Petřkovice Member. For explanations see fig. 4.

of the area to a narrow zone of lower values and then grows again to its maximum more than 450 m. On the contrary, in the southern part the thickness diminishes to 300–350 m. Approximatelly in the middle, a small island that is elongated in the east-west direction occurs; nevertheless, in the north it runs out to the already described extensive area. In a very small area the thickness is reduced to less than 200 m. More eastwards, the thickness of the upper part of the Petřkovice Member diminishes slowly. This development probably continues also to the north and south of the Podbeskydí area of the CUSB. This is a region of minimal thickness of the upper part of the Petřkovice Member in the studied area. It is evident that the upper part of the Petřkovice Member, in contrast to the lower part of the unit, shows a conspicuous east-west polarity.

Development of the total thickness of the Petřkovice Member

The lowest value of the total thickness of the Petřkovice Member in the studied area is 243.4 m; the highest thickness reaches 685.3 m (Fig. 6). In the western half of the region, there are areas with the greatest thicknesses of this member. The thickness of the unit there exceeds 650 m. The first area is situated in the vicinity of the western boundary of the occurrence of the Petřkovice Member and is elongated in the NNE-SSW direction; in the south (in the vicinity of the so-called fault zone of Beskydy Mts. Fault). The other area with the thickness of more than 650 m forms a small island situated in the surroundings of the Janovice fault. It is evident that this area will continue northwards. The area of low thicknesses can be seen in the eastern half of the studied region. The lowest thicknesses (less than 250 m) are related to the area along the eastern boundary of the basin. The mentioned area most probably continues eastwards as well, whereas to the north the thickness grows moderately up to 450 m. The thickness of the Petřkovice Member gradually increases from the zone of lowest thick-



■ **Fig. 6.** Total thickness of the Petřkovice Member. For explanations see fig. 4.

nesses westwards, too. This zone penetrates between the already described areas of higher thicknesses and separates them from each other.

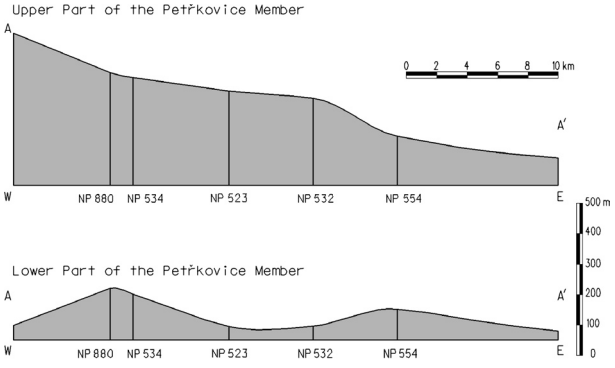
In the spatial development of the Petřkovice Member in the southern part of the Podbeskydí area, a marked east-west polarity can be observed. This is primarily a result of described reduction of the upper part of the Petřkovice Member in the east-west direction.

Discussion on the thickness variability of the Petřkovice Member

From the spatial development of the thickness of the lower and the upper parts of the Petřkovice Member and also from the development of the total thickness of this unit (Figs. 4, 5, 6) can be deduced:

1. The total thickness such as the upper part of the Petřkovice Member in the south part of the Podbeskydí area declines from west to east. Whereas the thickness of the unit in the west of the area is about 650 m, this value falls eastward to less than 250 m. The presented **finding proves the east-west polarity in the development of total thickness of the Petřkovice Member in the southern part of the Podbeskydí area**. This is influenced by the thickness of the upper part of the Petřkovice Member that in the south of the Podbeskydí area goes down from the west to the east and shows distinct east-west polarity.
2. The development of thicknesses of the lower part of the Petřkovice Member has the insular character with indications of elongation of some areas of increased thicknesses in the NNE-SSW direction. This development shows spatial variability in sedimentation; **the east-west polarity of the thicknesses does not exist in the lower part of the Petřkovice Member.** It began to manifest as late as in the upper part of the Petřkovice Member (Fig. 7).

The east-west polarity is characteristic for the thicknesses of units of the paralic complex in this part of the basin. This polarity was also confirmed in the other units of the Ostrava Formation, namely the Poruba Member (Sedláčková at al. 2007) as well as the Jaklovec Member (Kandarachevová at al. 2008). It is also known from the Hrušov Member (e.g. Dopita et al. 1997).



■ **Fig. 7.** Cross-section A – A′: changes in the thickness of the lower and upper parts of the Petřkovice Member in the south of the Podbeskydí area.

The finding that the east-west polarity in the south of the Podbeskydí area began to manifest intensively as late as in the period of formation of the upper part of the Petřkovice Member and thus it did not coincide with the lower boundary of the Ostrava Formation is undoubtedly interesting. It seems that the sedimentation of the lower part of the Petřkovice Member has the spatial development of thicknesses typical of this area, e.g. in the period of sedimentation of basal clastics of Devonian age and of clastic-carbonate formation of the Early Carboniferous age (Kumpera 1972, 1983).

Explanation of the origin of east-west polarity in the development of thickness of the Ostrava Formation in the south of the CUSB requires further analyses. From the point of view of our present-day knowledge, we assume that it is a case of reaction to the continuing shifting of sedimentation centres eastwards as known from the development of the lower Carboniferous deposits (e. g. Kumpera 1983), which was according to our opinion in this phase of basin development accompanied also by the narrowing of its sedimentation area in the east-west direction. The above mentioned phenomena can be related to the gradual mobilization of still rigid blocks of Brunovistulicum occurring in the basement of this part of the basin. Thus a reduction in thicknesses of the upper part of the Petřkovice Member and younger units of the Ostrava Formation of the CUSB in the east-west direction could be regarded as a reaction to the upwarping of east rims of the sedimentation area which is typical for foreland basins.

It is well known that the former extent of the Upper Silesian Coal Basin was substantially larger. The centre of sedimentation of the paralic Ostrava Formation of the CUSB was at least identical with the present-day west boundary of the basin if it did not occur west of this boundary. At present, the solution of this question is not possible, because we do not know both the western and eastern borders of the basin. Nevertheless, it is more than probable that the present extent of the basin corresponds to its eastern border, whereas the western border has been eroded in the whole extent.

In addition, it cannot be excluded that the reduction of the thickness of the Petřkovice Member in the east of the Frenštát part, repeated also in younger units of the paralic complex, can also signal the vicinity of the former boundary of the Petřkovice Member in this part of the CUSB. Such explanation is supported, to a certain extent, by the above-mentioned changes in the character of some faunal horizons of the Ostrava Formation in the CUSB, especially by the freshening of them in the SSE direction.

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