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Contribution to the geology of the northern part of the Plzeň Basin and the southern part of the Carboniferous Žihle Basin

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Abstract. The Žihle Basin is a structure trending approximately in a N-S direction. While Carboniferous deposits overlap the Upper Proterozoic basement on the eastern side of the basin, the western boundary is comprised of the prominent Maloměřice-Chrášťovice Fault. This dislocation has probably existed since before the Carboniferous sediments were deposited, and continues further to the south and north. Tectonic movements have been repeated here throughout geological history. Structurally, the basin is an asymmetric one-sided graben. Among other faults in the system, those trending WNW–ESE and NW–SE are the most frequent.

The Carboniferous deposition started in Westphalian D (Nýřany Member of the Kladno Formation). Older sediments (Radnice Member) were also deposited only locally (mostly in the south). The deposition continued during the Stephanian (Týnec Formation). As the lithology of the Nýřany Member and Týnec Formation are similar (mostly arkoses, feldspathic sandstones, and conglomerates of fluvial origin, with lesser interbeds of mudstone and fine sandstone), and comparative markers are rare and unreliable, the units mentioned above cannot be differentiated. The situation is different south of the Střela River (especially in the surroundings of Kaznějov), where the Týnec and Kladno formations can be distinguished (also based on data from several boreholes). The Střela River is the conventional approximate boundary between the Žihle and Plzeň basins. Thin coal seams and their claystone or mudstone equivalents found at the western margin of the basin at Chrášťovice, and at the eastern one NE of Mladotice, belong to the Chotíkov Group of Seams of the Nýřany Member, while seams from Žebnice and the Richardka hunting lodge ENE of Nebřeziny belong to the Radnice Group of Seams.

Key words: Kladno and Týnec formations, lithology, stratigraphy, tectonics

Introduction

The new geological mapping of sheet 12–31 Plasy 1 : 50,000 was concluded in 1994–1995 (Mašek and Prouza 1996). This map is comprised mostly of the rocks of the Barrandian Proterozoic, though approximately one third of its area concerns the Late Paleozoic rocks of the Plzeň, Žihle, and Radnice continental basins. The mapping contributed to the further understanding of the Žihle Basin, all but the northernmost part of which is presented on the map (Fig. 1).

The Žihle Basin is a small separated basin of an elongated N-S shape, situated N of Plzeň (Holub and Pešek 1992). It is connected with the Kladno-Rakovník Basin in the north and with the Plzeň Basin in the south. The Manětín Basin, lying west of it, is separated by a strip of Late Proterozoic rocks. The basin is surrounded by the rocks of the Late Proterozoic, which also form its basement. The boundary is mainly tectonic, and locally transgressive. The southern boundary with the neighbouring Plzeň Basin is conventionally considered to be the Střela River. Havlena (1964) assumed there to be a transverse Proterozoic ridge in this approximate area (between Kralovice and Žlutice). More recent geological mapping (Mašek and Prouza 1996) and data from boreholes drilled in the Kaznějov and Plasy areas (Opekar and Spudil 1986) do not substantiate this assumption. The rocks of the Proterozoic basement crop out in the Střela River valley due to the deep erosion of the river and its tributaries.

Most of the Žihle Basin was explored in the 1920s by Andrusov (1925). The results of his mapping were used for map sheet 4051 Kralovice, published in 1936 (Andrusov et al. 1936, 1940). The Carboniferous rocks cropping out on this sheet south of the Střela River were drawn by L. Čepek (Andrusov et al. 1936), who was at that time engaged in the geology of the Plzeň Basin. Some other authors, especially paleontologists, have also worked there (Němejc 1941, 1957, 1958, 1962, Němejc and Šetlík 1953, Šetlík 1954), but the whole area has not been systematically mapped. Data from five shallow boreholes drilled in 1958 in the Kaznějov-Rybnice area (max. depth 33.40 m) were evaluated by Malecha (1959). A detailed investigation for coal and kaolinic clay deposits was carried out in the 1980s and 1990s in the Kaznějov surroundings. The results of this research leaned on the data from the recently drilled boreholes, and contributed significantly to the knowledge of the northern promontory of the Plzeň Basin. Most of these results, as well as the re-evaluation of past stratigraphy, exist in unpublished reports, especially in a study by Opekar et al. (1994). Several studies of the investigations of the Plzeň Basin were published by J. Pešek. The most important results, ideas, and conclusions are summarized in several monographs (Pešek 1968, 1994, Pešek et al. 2001).

There are not many good outcrops in the relatively flat area of the Žihle Basin. Relatively numerous and large outcrops of the sections formed by the firm psammites and/or psephites occur to the E and SE of the Odlezly village. No boreholes have been drilled down to the Proterozoic basement of Carboniferous in the area N of the Střela River up to the northern margin of sheet 12–31 at Plasy. The documentation of excavations made in 1995 for installing a

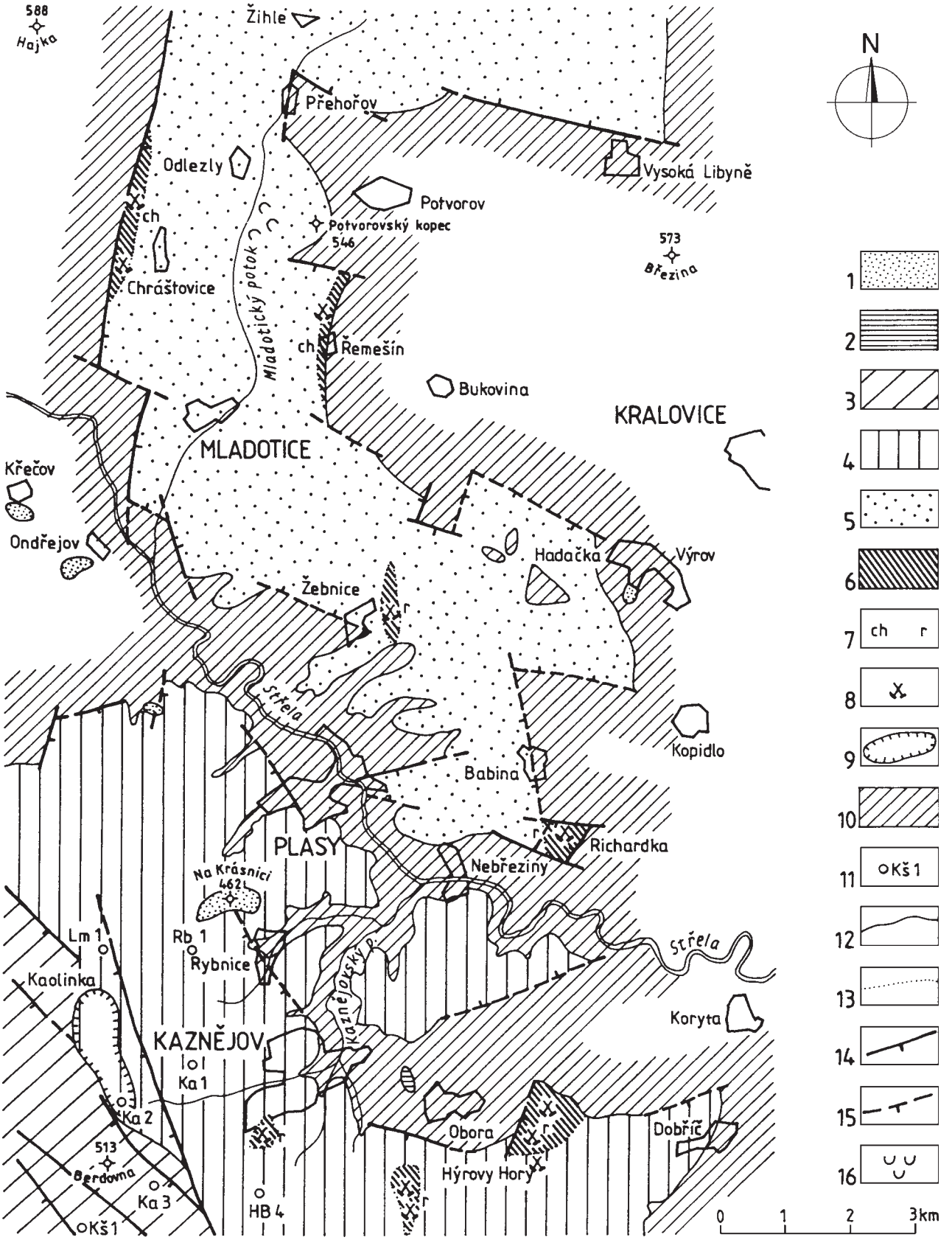

Figure 1. Geological sketch-map of the Žihle Basin.
Tertiary: 1. gravels and sands, 2. quartzite; Carboniferous – Stephanian, Barruelian: 3. Týnec Formation; Westphalian D – Cantabrian: 4. Kladno Formation, Nýřany Member; Westphalian D–- Barruelian: 5. undifferentiated Týnec Formation and Nýřany Member (Kladno Formation), 6. coaly development of Carboniferous units, 7. Chotíkov and Radnice Group of Seams, 8. old abandoned mines, 9. kaolin opencast; Late Proterozoic: 10. Kralupy-Zbraslav Group, undifferentiated, 11. borehole, 12. boundary of units, proved, 13. transitional boundary, 14. fault proved, 15. fault inferred, 16. landslide area.

pipeline from the Mladotice train stop to the SW surroundings of Potvorov, and from the northwest surroundings of Vysoká Libyně to the N margin of the map, is therefore very valuable (Moravcová et al. 1995).

The deposition of Carboniferous sediments in the Žihle Basin started in the Late Bolsovian or even in the Westphalian D, on an elevation of approximately N-S direction on the Late Proterozoic basement. The oldest deposits belong to the Kladno Formation. While in the southern part of the basin the sediments of the Radnice Member are locally present (e. g., at Žebnice and Richardka), the deposition in the area to the north started later. The latter deposits belong mostly to the Nýřany Member. The rocks of the Kladno Formation are overlain by the Týnec Formation. Neither of these units can be distinguished from the other in most of the Žihle Basin.

In the early phase of the Bolsovian deposition (Radnice Member), the depocentres of the Plzeň and Žihle basins were probably separated by a low elevation, though they later became connected. The largest subsidence, the maximum thickness of the Carboniferous fill, and the most complete sequence of strata is found in the Žihle Basin at Žihle village, and in the Plzeň Basin at Líně and Zbůch.

Geology of the surroundings of Kaznějov

The stratigraphy of this area belongs to the northern part of the Plzeň Basin. It is well known from the drilling of boreholes, many of which reached the Late Proterozoic basement. The deepest of them, borehole Kš 1 east of Krašovice, is 509.20 m deep. The basement was reached at 504 m. The total thickness of basinal fill decreases continuously to about 140 m towards the NE at Kaznějov.

Radnice Member (Bolsovian)

Deposits of the lowermost part of the sequence of strata in the Kaznějov area belong to the Radnice Member of the Kladno Formation. Its thickness varies between 0–160 m.

A layer of breccia with clasts of Proterozoic sediments occurs locally at the base of the unit, followed by a sequence of sandstone and feldspathic sandstone with conglomerate layers and grey mudstone interbeds. The Radnice and Plzeň Coal horizons, as well as several thin layers of tuffs and tuffites (maximum several centimetres thick) have been sampled by the boreholes.

The boundary with the overlying Nýřany Member is indistinct. It has therefore been fixed to the top of the so-called brown tuffite underlying the Touškov Group of Seams, or, where lithologically distinct, to the base of the equivalent of the multicoloured and/or red sediments of the Komberk Horizon (Pešek 1994, Opekar et al. 1994). The coal seams of the Radnice Member are known from old mines in the area SW and SE of Obora village (the Hýrovy Hory and Julius mines - Němejc 1941, Havlena 1964). The Hýrův důl mine is 104 m deep and sediments of the Nýřany Member probably crop out at its surface. The Radnice Group of Seams were also mined in the 19th century south and southwest of Kaznějov (the Martini mine 155 m, the David mine 114 m deep – Němejc 1941, Havlena 1964).

Nýřany Member (Westphalian D – Cantabrian)

In comparison with the underlying Radnice Member, the proportion of feldspathic sandstones and arkoses in the Nýřany Member is much higher. It may reach 75–85%. Sandstones usually contain a variable pebbly admixture and conglomerate layers. They intercalate with fine sandstone and variegated, sometimes grey mudstones.

Coal seams, mostly without economic importance, occur in four levels. There are two beds of coal and coaly claystones about 0.5 m thick at the base of the unit, interpreted as the Touškov Group of Seams). Several equivalents of the Nýřany Group of Seams (thin layers of coal and dark grey mudstone) occur in the lower part of the unit. The Chotíkov Group of Seams occurs in the middle of the Nýřany Member and the overlying Nevřeň Coal Horizon at the top of it. The borehole Kš 1 (Krašovice) penetrated seams at the following depths: Touškov Seams at 353.03 (0.97 m thick) and at 362.62 m (1.08 m), Nýřany Seams at 274.20 m (two beds 20–30 cm thick), and the Chotíkov Seams at 133.67 m (0.43 m), 137.84 m (1.26 m), and 138.44 m (approximately 20 cm – Opekar et al. 1994). The equivalent of the Nevřeň Seams was reached by borehole Mr 1 (Mrtník) NW of the kaolin opencast mine at Kaznějov (outside the field of Fig. 1). Several thin interbeds of tuffs and tuffites, usually accompanying the coal seams, have been sampled by the boreholes. The total thickness of the Nýřany Member at Kaznějov is 280–340 m.

Týnec Formation (Barruelian)

Sediments of this unit crop out in the area W and SW of Kaznějov in the tectonically downthrown block (the faults west of Rybnice and Kaznějov). The most common deposits of this formation are feldspathic sandstones and arkoses, similar to the Nýřany Member. The presence of red-brown mudstones, which are characteristic of this unit, were revealed by boreholes and the Kaznějov opencast mine works. Pelites of variegated colours (violettish, greenish, pinkish) are locally present. Sediments of this type are, however, also known from the marginal facies of the Nýřany Member. They pass laterally into red, and rarely grey deposits.

The boundary of the Týnec and Kladno formations is often difficult to determine. It is given as the first psammitic layer overlying the Nevřeň Coal Horizon.

The average thickness of the unit in the Kaznějov area is 100–120 m (61.50 m in borehole Kš 1). Arkoses and feldspathic sandstones of the Týnec Formation and the Nýřany Member are often deeply weathered to kaolin, which is mined in large opencasts (e. g., at Kaznějov and Horní Bříza – outside the area of Fig. 1).

The area N of the Střela River (the southern part of the Žihle Basin)

The geology of the area demarcated by the Střela River to the south and Žihle village to the north is based on geological mapping and its correlation with the substantially investigated Kaznějov surroundings.

The deposits of this part of the basin belong to the stratigraphic span from the Late Bolsovian (or mostly Westphalian D) to the Barruelian, i. e. to the Kladno and Týnec formations. Due to their lithological similarity, the absence of borehole data, and a lack of reliable marker horizons, these units cannot be differentiated. As proven in the Kaznějov area, the Radnice Member wedges out northwards. The deposition in the prevailing part of the Žihle Basin thus probably began in the Westphalian D with the sediments of the Nýřany Member. The Radnice Group of Seams has been determined paleontologically only at Žebnice and Richardka.

The undifferentiated Kladno and Týnec formations

Most of the outcrops in the area north of the Střela River are formed by arkoses and feldspathic sandstones. There are also minor layers of red-brown, variegated, or grey pelitic rocks, mostly mudstones. Psammites are usually coarse- to medium-grained. They commonly contain pebbly admixture or conglomerate layers. The pebbles are mostly well-rounded to rounded, less frequently subangular. They often reach 10 cm, are rarely 20 cm, and locally (the surroundings of Nebřeziny, SW of Plasy) reach even 30 cm in diameter. Quartz is the most common component (70–90%), followed by grey quartzite (locally up to 30%), lydite (5–10%), and crystalline rocks (up to 5%). Feldspars are mostly kaolinized. Diagonal bedding, evidence of erosion, and channel structures are frequent. These sediments are of fluvial origin.

Some arkoses and feldspathic sandstones (especially those with clayey matrix) are weathered and consequently soft. They have been dug out in sandpits, gravel pits, and small quarries (e.g., NW of Mladotice, E of Žebnice, at Odlezly, NE of Chrášťovice etc). Locally, especially in the area between Potvorov and Odlezly, the psammites have siliceous or carbonate cement, are firm, and were quarried as building stone (such as for the Romanesque church of St. Nicolaus at Potvorov and for the monastery at Plasy) and for millstones. Abandoned quarries exist in the forest W and SW of Potvorov, where some rock exposures are up to 10 m high. This locality is known because of a vast rock landslide that occurred here in 1872 (400 m wide and 500 m long – Janský 1976, 1977). As a result of this event, the Mladotice creek was dammed, and a natural lake formed (with a maximum depth of 7.7 m, and an approximate length of 800 m). The slumping area of Mladotice (also Odlezly) Lake was proclaimed as a natural monument in 1975.

Small iron nodules, lenses, and thin layers or hematitic cementation occur locally in the feldspathic sediments. At least some of them are ferricrusts.

Red-brown, rarely variegated or light grey mudstones were sampled by shallow boreholes S of Žihle village. They also occur as small fragments in eluvium, e.g., W of Řemešín.

Thin layers of whitish to creamy tuffs and/or tuffites have been found in the forest 2 km S of Mladotice. They are secondarily silicified. Similar rocks accompany coal seams, e.g., at Chrášťovice, Řemešín, and Kaznějov.

Localities containing coal seams in outcrops or at shallow depth were known to the early miners of this area. The oldest shallow shafts (e.g., at Chrášťovice, Řemešín, Richardka S of Babina) were deepened during the 19th century (Andrusov 1925, Němejc 1941, Havlena 1964). The coal seams of the Nýřany Member were mined (according to the above mentioned authors) at Chrášťovice and Řemešín. This was confirmed recently by Z. Šimůnek and J. Drábková (personal communication). According to Pešek (1994) the coals probably belong to the Chotíkov Group of Seams. Another coal seam was discovered in a trench excavated for a pipeline in 1994 NE of Řemešín. Dark grey claystones, tuffitic sediments (tonsteins), hematitized sediments, iron concretions, variegated mudstones, and breccias with fragments of Proterozoic shales occur in the coal seam horizon W of the village. The breccias evidence the overlap of the Nýřany Member onto the Proterozoic basement.

A seam mined E of Žebnice was interpreted as the Radnice Group of Seams. According to a position within the basin, a relation to the Nýřany Group of Seams is possible, which was also admitted by Němejc (1941).

About 20 old, small piles can still be found at the Richardka hunting lodge S of Babina. The coals probably belong to the Radnice Group of Seams (Andrusov 1925, Havlena 1964). This has recently been confirmed by spore assemblage analysis (J. Drábková, personal communication).

Fragments of dark grey claystones and hematitized sediments of tonstein type have been found in eluvial deposits SE of Žihle at the upper margin of the map (Fig. 1).

A 30 cm thick layer of dark grey mudstones, with remnants of plants and roots, crops out in a rock wall of arkose above the railway SSE of Odlezly (Žďárek forest). This layer, lying in the upper part of sequence of strata, probably corresponds to the Týnec Formation, and may be an equivalent of the Plachtín Horizon of the Manětín Basin (Tásler and Skoček 1964).

Occurrences of Tertiary sands and gravels overlying the Proterozoic basement are found at Křečov, Ondřejov, Výrov, and Rybnice (Na Krásnici). A small occurrence of Tertiary quartzite occurs NW of Obora.

Tectonics

The most prominent tectonic line of the area is an expressive fault of N-S direction, which forms the western boundary of the downthrown block of Carboniferous deposits of the Žihle Basin. It goes from the western surroundings of

Žihle (it continues northwards from the northern boundary of the map in Fig. 1) to the railway stop at Mladotice. The movements on this postsedimentary active line continued until the Tertiary (Pešek et al. 2001). Part of this fault was named the Maloměřice-Chrášťovice Fault by Smetana (1927). According to Chrt et al. (1966) it is a part of the prominent Plzeň-Žatec Zone, going across the Doupovské hory Mts. to the Fláje Massif and further into Germany (Elznic et al. 1974).

The main axis of the basin also has an approximate N-S direction. It is the continuation of an axis of the Plzeň Basin (the Plzeň-Žihle Depression of Havlena 1964). The axis of the basin is shifted to the west, causing the basin to be asymmetric. The section of Mladotice creek between Přehořov and the eastern surroundings of Chrášťovice may be also tectonically predisposed.

The strata in the middle of the basin are subhorizontal, with a general very gentle dip towards the south. The dips at its margins are higher, approximately 7° (locally even more) towards the N-S axis of the basin. Due to this structure, the oldest strata with coal seam horizons (e.g., the Chotíkov Group of Seams at Chrášťovice and Řemešín, and Radnice Group of Seams at Richardka) are present at the W and E margins of the basin, while a younger part of the stratigraphic sequence, with the most intensive subsidence (corresponding to the Týnec FM), is preserved in its center.

Even though the western margin of the basin is tectonic, the Carboniferous sediments of different stratigraphic levels transgressively overlay the Proterozoic basement in the east. Some second-rate faults occur in parts of the eastern margin of the basin.

Small faults of the N-S to NNW-SSE directions occur south of Žihle and at Babina. A flexure of similar direction with anomalous dips (7–10° towards the west) occurs at Řemešín. They follow a hypothetical fault in the pre–Carboniferous basement. Faults of WNW-ESE directions are relatively common. They form a shallow partial tectonic graben limited by the Mladotice-Výrov and Žebnice-Kopidlo lines. A small graben-like structure of the same direction occurs at Richardka. Faults of NW-SE to NNW-SSE direction occur in the western surroundings of Kaznějov. Faults of WSW-ENE directions are rare.

Conclusions

1. The Carboniferous fill of the Žihle Basin south of Žihle village belongs to the Kladno (mostly to the Nýřany Member) and Týnec formations, and corresponds to the stratigraphic span from the Bolsovian to the Barruelian. Due to their lithological similarity, the absence of borehole data, and a lack of reliable key horizons, these units cannot be differentiated.
2. Arkoses and feldspathic sandstones with pebbly admixtures and conglomerate layers are the most common lithotypes.
3. Coal seams mined at Obora (Hýrovy Hory), Richardka (S of Babina), and Žebnice have been interpreted as the Radnice Group of Seams. Coal seams from Chrášťovice and Řemešín belong probably to the Chotíkov Group of Seams of the Nýřany Member. Dark grey fossiliferous mudstone from the Žďárek forest, SSE of Odlezly, is a probable equivalent of the Plachtín Horizon of the Týnec FM.
4. The basin is structurally asymmetric: a side graben with a prominent N-S fault on the western margin of the structure. Part of it is known as the Maloměřice-Chrášťovice fault. The fault continues northwards as the Plzeň-Žatec Line, and southwards in the Plzeň Basin.
5. Besides Tertiary sand and gravel deposits known from several localities, an occurrence of quartzite is present NW of Obora (ESE of Kaznějov).

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