Sbor. geol. věd	Geologie 45	Pages 65—90	4 figs.	3 tabs.	1 pl.	Praha 1990 ISSN 0581-9172

Geology of Palaeozoic sediments of the deep borehole Jablůnka 1 (Beskydy Mts., NE Moravia) – comparison with the deep borehole Münsterland 1

Geologie paleozoických sedimentů vrtu Jablůnka 1 (Beskydy) – srovnání s vrtem Münsterland 1

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Received June 12, 1987

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Carpathians
Middle Devonian
Upper Devonian
Lower Carboniferous
Upper Carboniferous
Stratigraphy
Anchimetamorphism
Geothermal palaeogradient

Dvořák, J. (1990): Geology of Palaeozoic sediments of the deep borehole Jablůnka 1 (Beskydy Mts., NE Moravia) — comparison with the deep borehole Münsterland 1. — Sbor. geol. Věd, Geol., 45, *65—90*. Praha.

Abstract: Palaeozoic rocks of the borehole Jablůnka 1 were drilled between 2890—6318 m. They are represented by the lower part of the Ostrava Formation (base of the Namurian A — coal-bearing molasse), the Hradec-Kyjovice Formation (boundary between the Namurian and Viséan — flyschoid sediments), the Moravice Formation (Upper Viséan — calcareous shales), the Líšeň Formation (Upper Viséan—Upper Frasnian — organoclastic and nodular micritic limestones), the Macocha Formation (Frasnian—Givetian — reef-limestones) and a terrestrial Basal Clastic Formation (?Eifelian—Emsian?). The beds lie mainly subhorizontally. The metamorphic gradient is very steep — from diagenesis to strong anchimetamorphism. The thermal palaeogradient during Carboniferous times reached 70—80 °C . km^{-1}. A comparable borehole Münsterland 1 was situated symmetrically near the NW margin of the Variscan foreland basin of the Rhenohercynicum.

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Introduction

A partly cored deep borehole Jablůnka 1 served as a reference borehole for prospecting for potential oil- and gas-bearing structures below the Carpathian flysch nappes in NE Moravia. Palaeozoic sediments overlie the Proterozoic crystalline rocks which formed the foreland of the Variscan tectogene. The tectogene was situated to the W of the borehole. The Palaeozoic sediments in the borehole were investigated by a team of geologists from the Geological Survey in Prague and Brno, the Institute of Geology of the Czechoslovak Academy of Sciences, the Moravian Petroleum Survey in Hodonín, the Geological Survey in Ostrava, and the Silesian Museum in Opava. The overlying sequence — the Carpathian flysch — had been evaluated previously (P e s l et al. 1982).

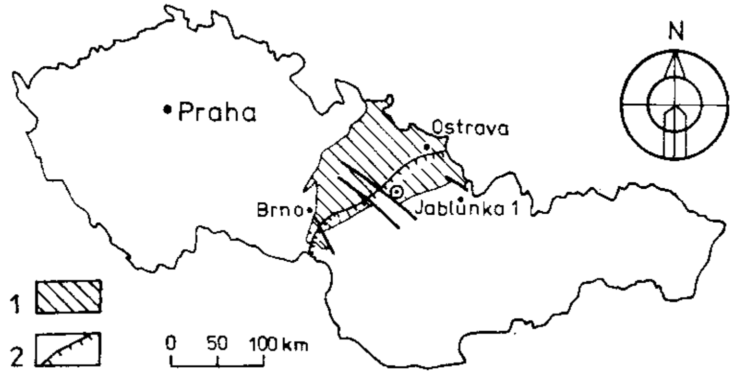
Biostratigraphy was taken as a basis for the evaluation of facies development, thickness, and tectonic development. A complete list of fauna, relevant for the stratigraphical setting, was given in the paper by F r i á - k o v á and Z u k a l o v á (1986) which is referred to herein. The stromatoporoid fauna was investigated by V. Zukalová, rugose corals by A. Galle, tabulate corals by J. Hladil, conodonts by O. Friáková, foraminifers by J. Kalvoda, ostracods by M. Bless (the Netherlands), and flora by E. Purkyňová. J. Polický studied sediments of the coal-bearing Carboniferous, Z. Kukal the underlying deposits. M. Adamová evaluated sedimentary geochemistry. The intensity of metamorphism was studied by means of light reflectance of disseminated organic matter (P. Müller), illite crystallinity (K. Weber — FRG) and mineral and structural and textural changes traced by standard optical microscopy (Z. Kukal). All the reports (except for the contribution by K. Weber) are deposited in Geofond, Prague (Geological Documentation Centre) (P e s l 1983). Lithostratigraphic subdivision is based on the interpretation of well logging data. The author thanks Dr. A. Whittaker (Nottingham) for revision of the English text.

Stratigraphic and facies development

Basal Clastic Formation (6278—6318 m)

The sediments of Devonian age were deposited on the intensively weathered basement consisting of biotitic gneisses of Prepalaeozoic age. This process started in Lower, and continued into Middle Devonian times. The lowest part of the section consists of a 40 m thick sequence of grey and green conglomerates, sandstones, siltstones and shales. These sediments are mostly of continental origin and were deposited in rivers. The marine transgression proceeded gradually from the west eastwards. The conglomerates and sandstones are composed of mature detritus which indicates intensive weathering of the underlying crystalline rocks. The source area, lying in the east, was predominantly of gneisses with some contribution from granitoids and partly also from erosional relics of quartzites and phyllites, possibly of Upper Proterozoic age.

Granitoids of the basement are characterized by a large positive regional magnetic anomaly E of the borehole Krásná 1 and NE of the borehole Jablůnka 1. It is probable that the stable granitoid massif limited the Devonian marine transgression to the east. This massif formed a part of the Variscan foreland in this part of the basin.

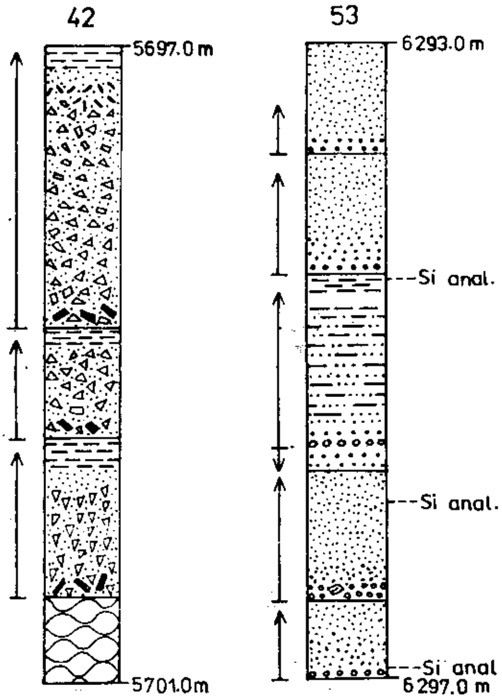


1. Location of the borehole Jablůnka 1
1 — Devonian and Carboniferous in Moravia; *2* — outer border of the Carpathian nappes

Some quartz clasts of volcanic origin have been found which indicate contemporaneous (and/or immediately preceding) acidic volcanism in the environs. This is the first occurrence of volcanic quartz in Moravia at this stratigraphical level.

Clastic material was mature to supermature (83—85.5 % of SiO_2 in the sandstones — see tab. 1). The higher content of K_2O (2.26—2.8 %) corresponds to the presence of potassium feldspars. Even the clayey sediments exhibit considerable maturity (the Al_2O_3/Na_2O ratio attains to 104.8). Great amounts of K_2O (up to 7.24 %) together with volcanic quartz might indicate an admixture of acidic volcanogenic material. Quartz clasts are generally angular which speaks in favour of rapid transport and deposition of washed weathered residue from the peneplain surface. The sediments are arranged in fining-upward sequences 0.6—1.3 metres thick. The grain size of the sandstones can be characterized by a pronounced bimodality. All these facts suggest deposition from unstable periodic river flows (see figs. 1 and 2).

It is highly probable that the upper parts of the Clastic Formation have been reworked during the marine transgression.



2. Detailed sections of two cores of the borehole Jablůnka 1
Core bit No 42: limestone breccias with graded bedding. At the base nodular limestones (Famennian). Core bit. No 53: rhythmic arrangement of conglomerates and sandstones of the river deposits (Basal Clastic Formation — Lower to Middle Devonian in age). Si anal. — samples for the silicate analyses. For lithological symbols see pl. 1. The *arrows* indicate graded bedding of the rhythms (which is also negative in one of the cases)

Macocha Formation

Lažánky Limestone (5 836—6 278 m)

Impure carbonates were deposited soon after marine transgression over a flat surface. At the base there are dark micritic clayey limestones, often laminated, which alternate with dark, fine-grained dolomites. These are devoid of macroorganisms; only some indeterminate shell fragments and some possible biogenic sphaeroids have been found. Large amounts of pyrite are present in the clayey laminae. Dolomitization is of early diagenetic character and witnesses a possible origin in a hypersaline supratidal environment.

The sea encroached step by step over shallow depressions in the highly peneplanized relief, where stagnant water accumulated, and the life conditions of the reef-building organisms were highly unfavourable. These conditions improved later, when the transgression advanced and the sea flooded a large surrounding area.

Rich coral and stromatoporoid faunas occur around the core depth of 6 150 m and indicate an Upper Givetian age. The thickness of the Middle Devonian sediments in the borehole Jablůnka 1 does not exceed 200 m (including the Basal Clastic Formation).

Intensive dolomitic sedimentation continued up to the lowest Frasnian, as evidenced also by geophysical logging. This type of sedimentation fades out slowly, but even at the depth of 6 000 m some intercalations of dark dolomitic limestones occur and at the depth of 5 905 m some scattered dolomite rhombs are present. The dark colour is typical also for the upper part of the Lažánky Limestone, a predominantly limestone sequence. The limestones are mostly biomicritic. Some lenses of coarser biosparites consist of crinoid debris, brachiopod and pelecypod shells, some fragments of bryozoans, corals and stromatoporoids. On the other hand, in the micrites, ostracodes, sponge spicules, sphaeres and primitive foraminifers predominate. Some micritic intraclasts with obscure algal texture have been also observed. Bioclasts are sometimes rounded and reworked and micrite washed away. The ubiquitous organic matter is, together with pyrite, concentrated into streaks and films. The terrigenous admixture is mostly represented by clay, except that in the uppermost parts of the sequence some slight admixture of clastic quartz of silt size occurs.

The sedimentary environment can be characterized as a shallow carbonate platform. Locally a stagnant anoxic environment influenced the pyrite nd organic matter accumulation. Clay suspension in water prevented the development of reef fauna. Two alternating stages can be recognized: the first, one accompanied by faster subsidence rates of the sea floor, characterized by rich fauna and pure carbonates (corals, stromatoporoids) and the second, one characterized by slow subsidence and condensed sedimentation of clayey micrites with microfauna typical of sheltered lagoons. The presence of conodonts indicates temporary communication with the open sea. The terrigenous admixture, small thickness of the unit (for the Frasnian about 300 m) and the anoxic environment suggest the proximity of the coast.

The uppermost part of the Lažánky Limestone of Upper Frasnian age differs from the underlying sequence. It is characterized by the presence of biodetrital and microbrecciate limestones together with biomicrites comprising laminae of dark shales with sandy admixture. In the coarse-grained layers many fragments of crinoids, brachiopods and corals occur; also clasts of micritic, biomicritic, intraclastic and biodetrital limestone (average size 1 cm) are present. In the micrites some silicified valves of ostracods (Genera *Acratia* and *Zeuchnerina*) have been found; there are typical Middle and Upper Devonian forms.

The dark shale is highly mature chemically (Al_2O_3/Na_2O ratio 60.07) and rich organic matter ($C_{org} = 1.89$ %). Scattered quartz grains (up to 0.25 m) and the rich silty admixture indicate the proximity of a shoreline. Temporary strong currents transported limestone clasts eroded in neighbouring shallows together with fragments of shallow water organisms, corals and also the terrigenous detritus. This can be considered as a first signal of the commencing regression.

Table 1

Thickness of Palaeozoic lithostratigraphic units, borehole Jablůnka 1

		Depth interval [m]	Thickness [m]
	Ostrava Formation	2 900—3 950	1 050
	Hradec-Kyjovice Formation	3 950—5 283	1 333
	Moravice Formation	5 283—5 405	122
Líšeň Formation 431 m	Hády-Říčka Limestone	5 405—5 495	90
	Křtiny Limestone	5 495—5 500	5
	Hády-Říčka Limestone	5 500—5 600	100
	Křtiny Limestone	5 600—5 625	25
	Hády-Říčka Limestone	5 625—5 730	105
	Křtiny Limestone	5 730—5 836	106
	Lažánky Limestone	5 836—6 278	442
	(dolomites	6 080—6 265	185)
	Basal Clastic Formation	6 278—6 318	40

Total thickness of Palaeozoic rocks is 3418 m.

Líšeň Formation (5405—5836 m)

The unit consists of two lithofacies — the Křtiny Limestone and the Hády - Říčka Limestone which exhibit a mutual interdigitation. The Křtiny Limestone is characterized by a prevalence of micritites and clayey sediments, which were deposited in a quiet marine environment. By contrast, the Hády-Říčka Limestone is rich in biodetritus. Stronger currents played an important role during their deposition. In the Jablůnka 1 borehole, the total sequence of this formation, except for some thin layers, is of dark grey colour.

The limestones at the depth of 5 730—5 836 m are mostly dark grey to black, of micritic character, generally with nodular structure or in layers 1—5 m thick with some laminae and thin beds (1—4 cm) of black calcareous shales (with 24.48 % CaO). Large amounts of disseminated pyrite characterize the shales (2.20 % C_{org}). These pyrite aggregates group in places into large concretions of up to several centimetres in diameter.

The limestones are mostly micrites and biomicrites with some ostracod valves, sponge spicules, pelecypod shells and crinoid debris. No erosion of bioclasts can be observed. Some micrites have increased amounts of organic matter.

Quartz admixture is generally present; silty quartz attains to 3 %. Individual corroded quartz clasts of up to 0.2 mm in diameter can be observed and some phosphatized bioclasts have been also found.

Chemical maturity of these sediments is lower as evidenced by the Al_2O_3/Na_2O ratio (18.72) and the K_2O/Na_2O ratio (4.8). Less weathered material was washed into the basin.

Table 2

Approximate thicknesses of Palaeozoic biostratigraphic units, borehole Jablůnka 1

		Thickness [m]	Borehole depth [m]
Namurian	over	1 050	3 950
Namurian A/Upper Viséan		1 333	5 283
Viséan	ca	227	5 510
Tournaisian	ca	100	5 610
Famennian	ca	210	5 820
Frasnian	ca	300	6 120
Givetian	ca	158	6 278
Emsian—Eifelian?		40	6 318

The sedimentary environment was quiet, mostly anoxic, below wave base and possibly could be interpreted in terms of a shallow bay. The Křtiny Limestone was depositing during a period of regression from the eastern part of the basin, where land uplift took place accompanied by a more intensive erosion of coarser and finer terrigenous material.

A huge input of fine terrigenous material in suspension caused reefal associations to perish. However, rich conodont fauna indicates communication with an open sea and enables more precise stratigraphic correlation.

Deposition of the Křtiny Limestone, commenced probably during the Upper Frasnian. However, in Middle Famennian times (? the Palmatolepis marginifera Zone ?) deposition of the Hády-Říčka Limestone started. The thickness of the Křtiny Limestone (106 m) hereabout is comparable with surrounding regions and indicates a local instability of the basement.

The stratigraphical interval 5 625—5 730 m is documented by only two cores which are not representative of the whole section. From the cores, and also from the logging, it can be concluded that dark grey biodetrital and microbreccial limestones prevail with some interlayers of biomicrites and calcareous shales. In the lower parts of this interval three graded units were found — 1.8, 0.7 and 1.0 m thick. They have breccia at their base overlain by biodetrital and micritic limestone (fig. 2). The breccia contains angular and subangular fragments of limestones (1—3 cm in diameter). Near the base of the rhythm shards of calcareous shales are present. Some subrounded limy clasts can be considered as reworked, already diagenetically lithified nodules. Limestone fragments are mostly composed of biomicrites with foraminifers, sponge spicules, ostracods, crinoid debris and trilobites. They are slightly silicified in places. A fragment of bituminous dolomite was also found which migh indicate a presence of shallow coastal sedimentation in wider surroundings.

Biodetrital limestones contain, locally, a slight admixture of silty quartz. Bioclasts are of the same character as in the microbreccias. They show, however, better sorting. Clasts with algal texture have also been found. The admixture of organic matter with disseminated pyrite is generally present.

The conodont fauna indicates an Upper Famennian age of this limestone horizon (the zones Palmatolepis gracilis expansa and Palmatolepis rugosa trachytera were identified). In the limestone breccia the same conodont association as in the immediately underlying bituminous micrite was found. This means that these bituminous limestones were eroded, reworked and deposited within the limestone breccia soon after their sedimentation.

Chemical parameters (ratio $Al_2O_3/Na_2O = 97.92$) show that the clayey material was strongly weathered and highly mature. Deposition took place in anoxic environment within a shallow water basin, which was temporarily supplied with coarser detritus by episodic currents. The basin can be taken for a near shore environment.

As to the logging, the topmost interval, 18 m thick, is similar to the interval 5 540—5 600 m where crinoidal biodetrital limestones are present.

The core and the logging curves show a 25 m thick (5 600—5 625 m) horizon of dark grey to black biomicrites with clayey admixture. The increased amount of organic carbon (1.28 C_{org}) is accompanied by pyrite occurring in massive laminae on a millimetre scale. In the biodetritus, ostracod valves, gastropods, sphaeres, foraminifers and sponge spicules prevail. Crinoid debris is commonly silicified. In places, pronounced lamination of biomicrites with biodetrital limestones is present.

The exact age of this unit could be identified neither on the basis of conodonts, nor by means of foraminifers. According to the silicified ostracods, the upper layer of this horizon conjoins the lowermost Tournaisian. The depositional environment was shallow with quiet conditions episodically replaced by a current dominated marine basin. Clay material washed from the landmass was moderately mature (Al_2O_3/Na_2O = 13.52). Deposition took place mostly in an anoxic environment below wave base. High values of SiO_2/Al_2O_3 ratio (4.72) are caused by secondary silicification.

Core data (core No 39) and geophysical log (5 500—5 600 m) show similarity of the lower parts of this interval with the preceding interval.

The overlying sequence, however, is somewhat different, with prevailing thinly bedded biodetrital limestones, similar to core Nos 36 and 37 (see pl. 1).

The lower part, evidenced from core No 39, is developed as light grey biodetrital limestones (the light colour is exceptional) passing in places into biomicrites. In the whole core, large scale fragments of crinoid debris prevail (two cross-sections of the whole calix were observed). Clasts up to 4 cm in size, of dark coloured micrites or light coloured biodetrital limestones are present. The micrite clasts have no sharp outlines. Some fragments of corals and bryozoans are also present. The presence of micrite pockets within bioclasts is typical.

The conodont fauna proved the age of core No 39; it belongs to the lower part of the Upper Tournaisian.

The sediments were deposited in an agitated oxygenated shallow water environment. This is exceptional within the predominantly dark limestones deposited mostly in the anoxic environment.

The topmost 5 m thick bed of the Křtiny Limestone (5 495—5 500 m) is markedly characterized by geophysical logs and by core No 38. A 1.5 m thick bed of dark grey shale occurs in the core. It has a heterogeneous character: in the 0.2 m thick topmost interval pure clayey shale, possibly with volcanogenic material, is present (as evidenced by a silicate analysis, Al_2O_3 amounts to 29.88 %, TiO_2 1.17 % an increased amount of Na_2O is 2.31 %). The low SiO_2/Al_2O_3 ratio (1.74) indicates the absence of free quartz.

20 centimetres lower, a thin section identified sandy shale with 10 % of fine- and medium-grained sand (maximum grain size 0.5 mm). Monocrystalline quartz prevails being accompanied by porphyry and aphanite grains.

At 0.7—0.8 metres below the top of core No 38, siliceous shale with

Table 3

Chemical analyses of the rocks from the borehole Jablůnka 1

Core bit. No	Borehole depth [m]	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
11	3 063.00	63.07	0.70	9.21	2.06	1.79	0.050	1.31	6.52	0.68	1.68	0.15
13	3 207.00	58.59	0.95	19.76	0.90	3.47	0.040	1.86	0.20	1.50	3.93	0.32
14	3 317.00	56.06	1.02	21.98	1.30	3.87	0.095	2.24	1.33	1.52	4.05	0.48
18	3 695.00	61.34	0.83	22.59	0.95	3.30	0.045	1.87	0.29	1.84	3.70	0.65
20	3 894.00	56.26	0.91	20.47	1.67	5.54	0.116	2.84	0.46	1.89	3.22	0.35
21	4 000.80	57.72	0.96	18.63	0.66	5.67	0.094	2.74	1.51	2.02	2.95	0.19
26	4 500.00	57.40	1.25	19.49	1.97	4.44	0.052	2.50	0.36	2.46	2.74	0.30
27	4 602.30	55.25	0.94	20.79	0.79	6.82	0.069	2.83	0.79	1.89	3.22	0.21
28	4 696.00	54.86	1.11	21.33	0.84	4.98	0.045	2.34	0.30	1.85	3.06	0.33
30	4 903.00	56.85	1.04	20.87	1.72	5.29	0.065	2.62	0.27	1.94	3.05	0.18
31	5 002.80	55.01	0.82	19.82	0.60	6.39	0.093	3.33	1.64	2.02	3.32	0.17
32	5 098.60	65.54	0.87	14.44	0.79	4.63	0.083	2.29	1.62	2.74	1.94	0.20
34	5 303.50	55.84	0.85	20.05	2.61	4.45	0.100	2.71	0.89	1.98	3.55	0.15
38	5 497.20	52.09	1.17	29.77	0.39	1.79	—	1.23	0.69	2.31	3.34	0.066
40	5 602.70	52.41	0.55	11.09	1.11	1.11	0.004	2.64	13.59	0.82	2.83	0.051
42	5 698.00	22.93	0.17	5.19	0.34	0.96	0.011	2.36	35.81	0.053	1.38	0.065
44	5 804.40	35.64	0.34	8.24	0.50	0.93	0.013	3.05	24.48	0.44	2.11	0.090
45	5 852.70	47.68	0.79	15.62	2.54	1.58	0.018	3.43	10.65	0.26	5.37	0.085
53	6 294.45	59.16	1.06	23.06	1.37	1.62	0.034	1.00	0.29	0.22	7.24	0.056
53	6 295.90	85.48	0.25	6.80	0.77	0.82	0.054	0.38	0.55	0.10	2.26	0.092
53	6 296.95	83.02	0.26	7.50	0.83	2.04	0.087	0.56	0.32	0.23	2.80	0.081

The analyses were performed by the staff of the chemical laboratory of the Geological

an admixture of silty quartz was identified. It is rich in sericite, microcrystalline quartz, phosphatized organic remains, and even silica ooids (0.15 mm across). Chain-like and spherolitic aggregates are typical of this chalcedonic silica. The porous and streaky structure strongly suggests decalcified sediments. Macroscopically, some clay fragments have been near the base.

The remaining part of the core consists of dark biomicrites, with a faintly developed nodular structure in places and with an interlayer of calcareous shales with some small clasts of limestones. Also some intercalations of microbreccias with small intraclasts (0.12 mm across) appear, which consist of algal micrite. Calcitic sphaeroids, foraminifers, radiolarians (?), sponge spicules have also been identified. In the surrounding layers foraminifers prevail together with brachiopod valves and fragments. Pyrite is concentrated on bituminous films. Chemical analyses indicate strong silicification and only low clay content. This corresponds also to macroscopically identified chert concretions in the interval of 5 499.30—5 499.40 m.

According to the conodonts this interval could be roughly identified as corresponding to the Tournaisian—Viséan boundary, but the foramini-

Table 3

CO_2	$C_{org.}$	H_2O^+	H_2O^-	Al_2O_3/Na_2O	K_2O/Na_2O	Fe_2O_3/FeO	SiO_2/Al_2O_3	Rock composition
8.27	0.68	4.02	0.54	13,54	2.47	1.15	6.84	siltstone
3.56	0.39	4.62	0.20	13,17	2.62	0.26	2.96	shale
1.01	1.10	4.43	0.32	14.46	2.66	0.36	2.55	shale
0.32	0.25	1.74	0.19	12,27	2.01	0.29	2.71	shale
1.53	0.70	3.99	0.34	10.83	1.70	0.30	2.75	shale
1.61	0.71	4.08	0.32	9.22	1.46	0.11	3.09	shale
1.88	0.41	4.44	0.22	7.92	1.11	0.44	2.94	shale
0.46	0.72	4.91	0.32	11.00	1.70	0.11	2.65	shale
3.59	0.30	5.57	0.22	11.53	1.65	0.17	2.57	shale
0.53	0.29	4.99	0.22	10.75	1.57	0.32	2.72	shale
1.38	0.68	4.39	0.27	9.81	1.64	0.09	2.77	shale
1.46	0.25	2.92	0.13	5.27	0.70	0.17	4.53	shale
0.55	0.99	5.00	0.27	10.12	1.79	0.58	2.78	shale
0.48	0.57	5.13	0.89	12.88	1.44	0.21	1.74	shale
10.58	1.28	3.85	0.21	13.52	3.45	1.00	4.72	calcareous shale
28.62	1.47	0.55	0.17	97.92	26.03	0.35	4.41	clayey limestone
20.47	2.20	0.28	0.12	18.72	4.79	0.53	4.32	clayey limestone
8.07	1.89	3.98	0.38	60.07	20.65	1.60	3.05	calcareous shale
0.19	0.04	3.85	0.57	104.80	32.90	0.84	2.56	shale
0.55	0.04	1.38	0.23	68.00	22.60	0.93	12.57	sandstone
0.33	0.04	1.51	0.15	32.60	12.17	0.40	11.06	sandstone

Survey, Prague.

feral fauna, which is rich and better preserved, enabled the identification of a Lower Viséan age.

Coarse terrigenous detritus suggests rapid episodic inflow to the quiet anoxic environment.

The source of authigenic silica can be found in the volcanogenic material and possibly also in the organic skeletons built by silica.

The highest limestone unit (5 405—5 495 m) consists of dark grey to black, fine-grained, biodetrital limestones, passing into biomicrites. There is a fining-upward of detritus. Large brachiopods are pressure-deformed; rugose corals, crinoid fragments, gastropods, foraminifers, bryozoa, sponge spicules and trilobites are present. Moreover there are algal intraclasts, calcareous sphaeroids and cortoids. Micritization of bioclasts is very common, but silicification is rare. Some peloids were found. A terrigenous admixture of silty quartz is ubiquitous. In the topmost core there is a 3 cm thick layer of black clayey shale with a lamina of siliceous shale. Films and streaks of organic matter with pyrite are abundant in places.

Conodonts have not been found in this interval and this is why the foraminifers were used for age identification. These allow an identification of the base of the Upper Viséan from cores No 35 up to 37.

The rich coral fauna, the association of large and small brachiopods, foraminifers and crinoids indicate a shallow water environment of an open sea with slight currents which were mostly incapable of removing the micrite. During diagenesis anoxic conditions prevailed.

Moravice Formation (5283—5405 m)

This interval displays special log characteristics and consists of black and dark grey clayey shales with pyrite concretions (up to 3 cm across) and rare brachiopod shells and crinoid stems. Some bioclasts are pyritized. The admixture of organic matter is considerable (2.76 to 5.77 %). Coarser terrigenous material is absent, even though the SiO_2/Al_2O_3 ratios show the presence of free silica (2.78 and 2.63). The shales are partly slightly calcareous.

The exact age could not be palaeontologically determined. This interval possibly belongs to the higher parts of the Upper Viséan judging from the palaeontologically proved Upper Viséan in the top of the underlying Hády-Říčka Limestones and the Namurian A in the overlying beds.

The sediments contain immature clastic material as evidenced by low values of the Al_2O_3/Na_2O ratio (13.25 and 10.12). Fine clayey detritus was deposited in quiet anoxic environment. Strong clayey input prevented the sea floor from colonisation by sessile and vagile benthos.

Hradec-Kyjovice Formation (3950—5283 m)

The bottom and top of this interval was determined by geophysical logging. The base coincides with the disappearance of the last sandy and silty bed in the shales. The top is marked by the base of a pronounced sandstone bed in the overlying formation.

This sequence is 1 333 m thick and consists mostly of dark grey and black silty shales with laminae of grey calcareous siltstones which are grouped in laminites. The sandstones layers are very rare. All the siltstones and sandstones are slightly calcareous, while some calcareous sphaeroids were found in the matrix. Sandstones and siltstones exhibit streaky lamination, ripple bedding and lenticular bedding. Some laminae and beds have sharp bottoms with load casts and flute casts. Graded bedding was also observed and micro-slump structures are common.

The clastic material consists predominantly of quartz plus some aphanites and plagioclases. Muscovite flakes are common; in siltstones some phosphate grains were found.

Black colouring corresponds to an admixture of organic matter (C_{org} generally below 1.0 %, maximum 1.23 %). Plant fragments were found in places, but fauna occurs only in the form of indeterminated "ghosts".

Siltstones from the 5 100 m depth yielded the following heavy mineral association (J. Otava): zircon — 54.8 % (rounded grains prevail), apatite — 31.9 %, tourmaline — 12.3 % (mostly brownish and greenish varieties), rutile — 5.5 %, sagenite in biotite — 4.1 % and brookite — 1.4 %.

In Jablůnka 1, the sandstone and siltstone layers are quite rare if compared with those from the borehole Branky 1 and Branky 2, where greywackes and polymictic silstones are abundant. This hints at the sorting mechanism of material coming from the west, or at local input from the southern or eastern environs.

The probable model combines the input of clayey and silty material from the west with the input of sand and some silt from the local source in the south and the east.

The clayey material is immature (Al_2O_3/Na_2O — mean value 9.31 calculated from 8 analyses). This is in contrast with the quartzose nature of the sandstones and siltstones. It is thought that shales and siltstones were transported from the W (with biotites) and were deposited in a shallow bay in a quiet anoxic environment. Lighter coloured calcareous silstones and sandstones were washed into the basin episodically from the east during storms and similar events. During this time, the stagnant conditions were changed into current-dominated environment.

The Hradec-Kyjovice Formation corresponds in age to the boundary interval between the Lower and Upper Carboniferous.

Ostrava Formation (2900—3950 m)

This interval was delimited on the basis of logging. It was subdivided into the lowest part, corresponding to the Štúr Marine Band (95 m), Petřkovice Beds (thickness 548 m) and lower part of the Hrušov Beds (thickness 307 m). The Petřkovice and Hrušov beds are separated by a volcanogenic siltstone bed (core No 13).

In the Štúr Marine Band sandstones prevail over siltstones and shales (as judged from the logging). In core No 20 a marine fauna was found (crinoid stems, pelecypods and *Euphemites sudeticus* — kindly identified by F. Řehoř), which, unfortunately, is not stratigraphically diagnostic. Sandstones are represented by greywackes; in core No 20 phosphatic greywacke with 8 % phosphate grains was found. This greywacke has a mean grain size of 0.12 mm, maximum grain size 0.32 mm. At this time a sudden input of coarse-grained material into the basin took place. This deposition had not been accompanied by subsidence which means that after some time the shallow sea was silted and converted into a fresh-water environment. Proximity of coastal marshes is documented by abundant flora remains. The sedimentation rate was faster than the rate of subsidence and thus marine sedimentation passed into molasse deposition, which filled the foredeep (easternmost zone of maximum subsidence).

Petřkovice and Hrušov Beds (2 900—3 855 m)

The beds are similar from the viewpoint of petrography and facies. Because of this, and also because of discontinuous coring, these two units are described together in one section.

According to the logging records, sandstones are a predominant component of the two units. They are represented by greywackes, but calcareous sandstones occur, too. The greywackes are commonly coarser grained with all the transition into finer varieties. Coarse grained greywackes occur near the basis of sandstone layers; their bottoms are often sharp. They are ill-sorted with more than 10 % of feldspars. Finer-grained varieties are dark grey, although sometimes a pale colour is caused by silicification. Even a brown colour was recognized, the cause being a siderite admixture. The greywackes generally have a poorly developed matrix, although there are abundant clasts of sedimentary quartzites, graphitic quartzites, silicites, clayey shales, phyllites and also gneisses. Some pegmatite and porphyry clasts are also recorded. Plagioclasses are represented by an acid oligoclase. Mica is common, mostly in finer sandstones and siltstones. Biotite is commoner than muscovite (in the underlying Hradec-Kyjovice Formation muscovite predominates). This change is possibly caused by an intensification of detritic transport from the west, because for this source area biotite with sagenite inclusions is typical.

A heavy mineral suite is represented by zircon, apatite, tourmaline, sphene and garnet. The greywacke matrix is of illite and sericite, only rarely with kaolinite. Silicification is common, while carbonatization is represented by siderite growth, Carbonatic sandstones in core No 13 exhibit much evidence of the replacement of feldspars and matrix by siderite.

Siltstones and shales are generally dark coloured containing coaly pigment and plant detritus. Lamination, parallel and ripple laminations are typical structures. The siltstones with chaotic bedding and *Stigmaria* traces betoken the presence of underclays deposited in marshes. They are accompanied by coal seams.

Apart from plant detritus, the siltstones contain biotite. Larger flakes of muscovite are scarce.

Claystones are mostly of freshwater origin. They contain a silty admixture and bitumens and replace coal seams in places.

All the above sediments were deposited quickly in the environment including marine basin margins. The following local environments are suggested: marine alluvial (with silstones and fine sandstones parallel--bedded with plant detritus), delta lobes (fine-grained to coarse-grained greywackes, with siltstone fragments and oblique bedding), lagoons and bays (fine-grained sandstones, siltstones and clayey siltstones with irregular lens-like and wavy bedding), swamps and peats (underclays, coal seams), ephemeral lakes and swamps (dark sandstones, claystones and shales rich in bitumen).

The broader environment can be characterized as a lowland rich in lakes and lagoons, gently sloping seawards. The western margin of the basin was uplifted episodically and this influenced the cyclic sedimentation of the Ostrava Formation. The material washed into the basin was not mature ($Al_2O_3/Na_2O = 12.28$ — mean value from eight analyses). Some slight increase in maturity can be observed compared with the underlying formation. This trend continues upwards and in the Westphalian sediments the values of the above ratio reach 49.

The Petřkovice Beds are coal-bearing. By means of geophysical logging 55 coal seams with a total thickness of 27 m were registered (38 seams with thickness less than 0.5 m, 15 seams between 0.5 and 1.0 m and 3 seams thicker than 1 m).

The Hrušov Beds have 27 coal seams with a total thickness of 11.9 m (19 seams with thickness less than 0.5 m, 4 seams between 0.5 and 1 m and 4 seams thicker than 1 m). This characteristics corresponds to the general appearance of the Ostrava Formation in the western part of the basin.

The Petřkovice and Hrušov Beds are stratigraphically divided by a layer of volcanogenic siltstones (in Czech known by a local term "brousek" — whetstone) which was found in core No 13 in the incomplete thickness of 2.6 m (its maximum thickness in the Ostrava Coal Basin is 13 m). This bed contains I-M mixed layer clay minerals. The lamination is pronounced; some minor cross bedding and incomplete slump structures were observed. Plant detritus accompanies the dark laminae. Volcanogenic material is partly carbonatized, partly silicified. Quartz grains are in the form of shards but bipyramidal corroded grains are also present.

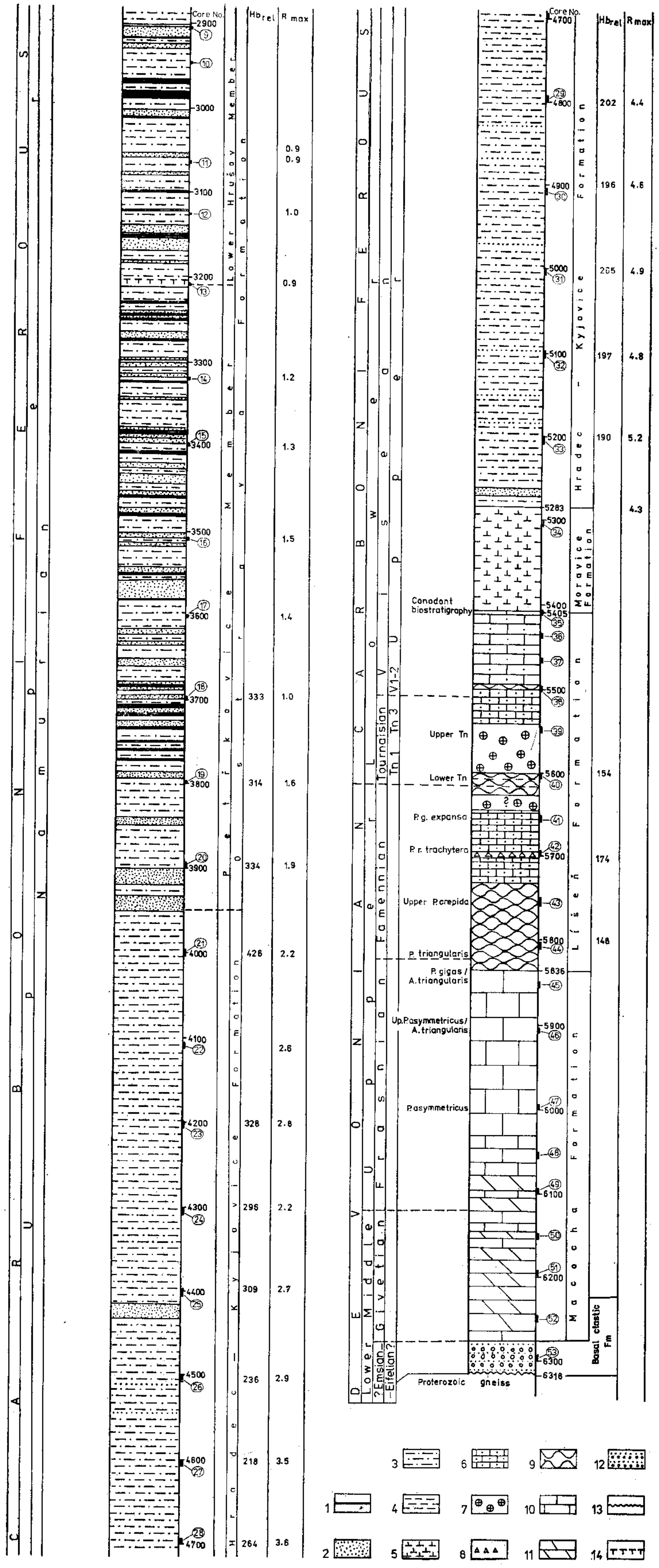
Feldspars are generally kaolinized; sanidine strongly prevails among them. Plagioclases (albite to oligoclase) are scarce. Siderite growth is commonly at the expense of micas, bleached biotite contains needles of sagenite, while zircons are euhedral and subhedral. The sorting of detritus is considerable; the sediment bears the character of aeolian silt (K u k a l 1964). The chemical composition of these sediments approaches that of some acidic magmatic rocks. The ratio of TiO_2/Al_2O_3 is low (0.04—0.06). It is quite probable that the deposition of the above mentioned layer accompanied a strong volcanic eruption. Aeolian transport of volcanic dust took place and this material was partly mixed with terrigenous detritus. The layer was quickly covered with overlying sediment which prevented it from subsequent erosion. It can be supposed that this activity is connected with the culminating subsequent volcanism in the Zwischengebirge (Median mass) of the Variscan tectogene.

Metamorphism and tectonics

The light reflectance of disseminated organic matter (studied by P. Müller) indicates a rapid transition from a zone of diagenetic changes (depth 2 900—4 600 m) to the zone of anchimetamorphism (deeper than 4 600 m). The lower zone corresponds to the meta-anthracite stage. Maximum light reflectance was found at the depth of 2 906.5 — 0.7 %, to 5 201.6 m — 5.2 %. The gradient is steeper for coal fragments (0.3 % R_{max} for 100 m) than for finely disseminated organic matter in claystones and siltstones (average 0.2 % R_{max}). This difference is caused by a more rapid migration of organic matter from the coal than from claystones. The migration possibilities are the lowest in early lithified micritic limestones. The possibility of migration of organic compounds during early diagenesis is evidenced by the quantity of organic carbon in shales (av. 0.65 %) and limestones (av. 1.7 %). Except for this, the gradient of reflectance changes in the finely disseminated organic matter becomes steeper with increasing depth: up to 3 900 m — 0.1 $R_{max} . 100\ m^{-1}$, from 3 900 to 4 300 m — 0.2 $R_{max} . 100\ m^{-1}$ and to 5 200 m — 0.3 $R_{max} . 100\ m^{-1}$. In the underlying carbonates the metamorphism cannot be evaluated by means of reflectance because it is influenced by limestone diagenesis.

The illite crystallinity also rises with increasing depth (the results are courtesy of K. Weber from FRG). The gradient is 15 $Hb_{rel} . 100\ m^{-1}$ (see pl. 1). However, there is a drop in the illite crystallinity by about 100 Hb_{rel} close to the depth of 4 000 m. This is caused by the presence of marine deposits which exhibit lower values of illite crystallinity than the fresh water ones (W e b e r *in* T e i c h m ü l l e r et al. 1979).

SECTION THROUGH THE PALAEOZOIC ROCKS, BOREHOLE JABLŮNKA 1
(BASED ON THE RESEARCH OF THE CORES AND LOGGING CONSTRUCTED BY J. DVOŘÁK AND A. TĚŽKÝ)



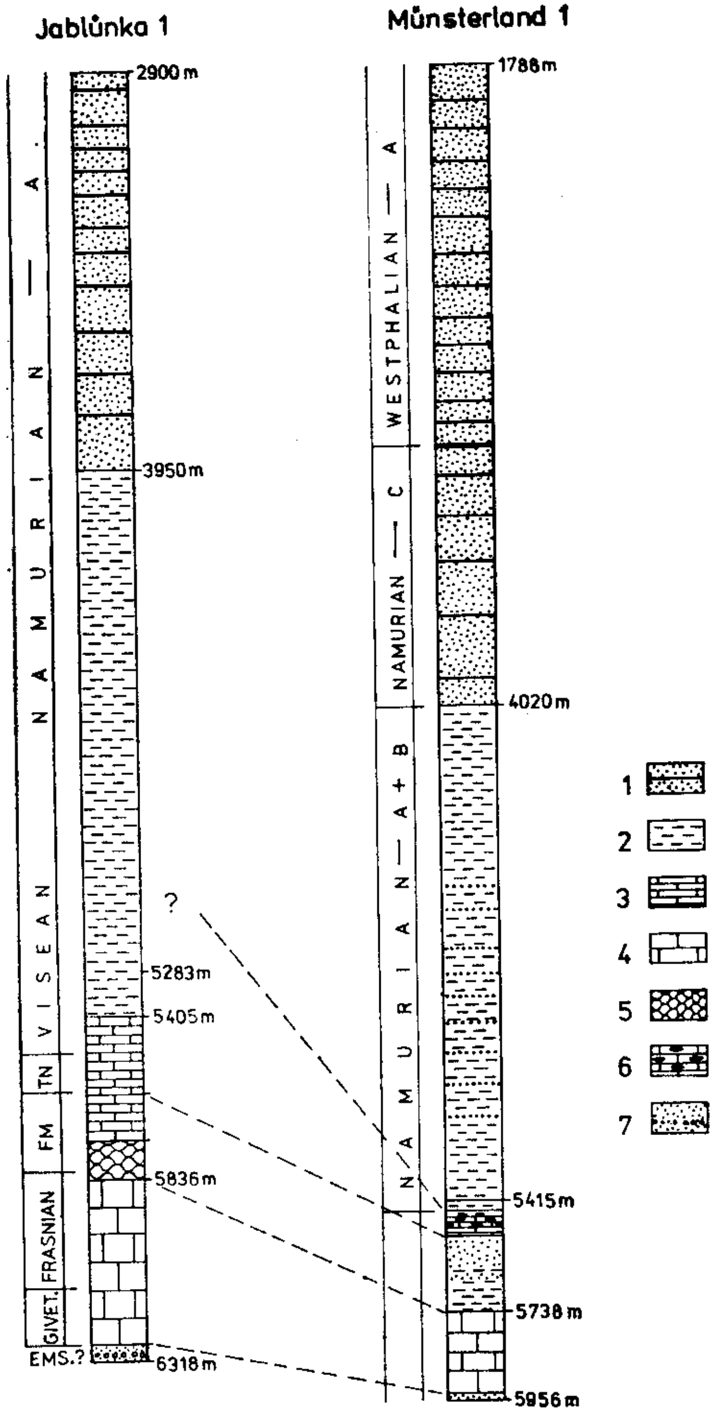
1 — thicker coal seams; 2 — greywackes and sandstones; 3 — siltstones and shales; 4 — shales; 5 — calcareous shales; 6 — biodetrital limestones; 7 — crinoidal limestones; 8 — limestone breccias; 9 — nodular limestones; 10 — reefal limestones with reef-building fauna; 11 — dolomites and dolomitic limestones; 12 — quartz sandstones and conglomerates; 13 — break in sedimentation; 14 — tuffites; R_{max} — the values of maximum reflectance of finely disseminated organic matter; Hb_{rel} — illite crystallinity values

Based on the method of Bunterbath (Bunterbath et al. 1982), the thermal palaeogradient for the Carboniferous was calculated by P. Müller. The resulting value amounts to 70—80 °C . km^{-1}, about double the value of the present day one. This suggests a high heat flow regime for the whole Variscan tectogene. P. Müller calculated the thickness of eroded overlying beds. His estimate is 390 m which is in accord with the geological situation in the wider surroundings. The upper parts of the Palaeozoic in the borehole Jablůnka 1 are weathered to a depth of 100 m. Adjacent areas have been represented by a broader peneplain since the Mesozoic.

Microscopic evaluation of metamorphic changes also shows increasing recrystallization with increasing depth. Z. Kukal described the strong flattening of organic remains at the depth of 5 467 m. At the depth of 5 497 m cleavage is present in the shales and at deeper levels, around 5 752 m, quartz beards start to form in pressure shadow around the clasts. The strongest deformations were observed near the base of the Palaeozoic sequence near the depth of 6 250.5 m where the clay matrix is strongly recrystallized, into a chlorite-illite mixture. Cleavage is pronounced and calcite totally recrystallized. Near a 6 290 m depth the sandstones have already attained quartzitic texture; quartz grains are subject to tectonic crushing and chloritic cumuloblasts are developed.

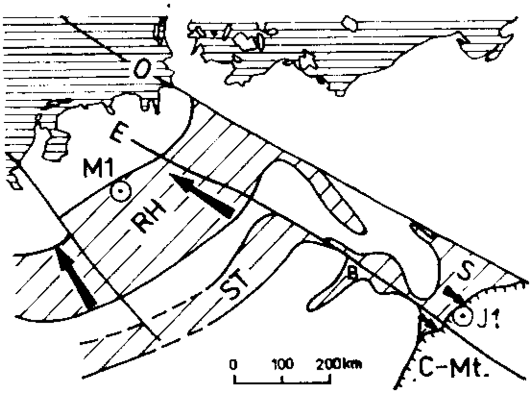
The dip of beds was measured from cores and proves that it is very gentle for the whole area. Local steepening of the dip (20—30°) was found for instance between 3 790 and 4 120 m. They are related to some local normal faults which can be observed in core No 19 (3 794—3 799 m). This core shows detailed folding interrupted by fault planes dipping 60—70°. Near the base of the Palaeozoic (6 248—6 300 m) the dip steepens up to 20—36°. This can be explained by the influence of local heterogeneities in the Proterozoic basement.

At most levels shales exhibit abundant fault polishing, parallel to the bedding planes. Local slickensides are parallel to dip direction. Limestones exhibit pencil structure in places. Similar structures are unknown from Palaeozoic zones, influenced by Variscan tectonics, but they were identified in the boreholes Němčičky 1 and 2, SE from Brno, deep below the Carpathian nappes. Palaeontological proof of the existence of an overthrust there has been put forward. It is highly probable that the deformation style is not of Variscan but of Alpine type and age. A great complex of the horizontally layered Palaeozoic in the vicinity of Jablůnka was evidently divided by numerous thrust planes parallel to bedding planes into overthrusting slices during the movement of the overlying Carpathian nappes. The intensity of movement along the individual thrust planes, however, amounted only to several millimetres or centimetres.



3. The correlation of schematized sections of boreholes Jablůnka 1 and Münsterland 1. True thicknesses in the borehole Münsterland are given
1 — coal bearing formations; *2* — shales and siltstones; *3* — biodetrital limestones, dark grey; *4* — reefal carbonates; *5* — nodular limestones; *6* — silicified limestones and shales with silicites; *7* — sandstones

Münsterland. Nevertheless, all these lithotypes were deposited during a continuous marine regression. In the Münsterland borehole the regression started earlier — from Middle to Upper Frasnian times dark dolomitic shales were deposited.



4. The tectonic map of the Middle European Variscides with position of boreholes Jablůnka 1 and Münsterland 1
RH — Rhenohercynicum; ST — Saxothuringicum; B — Barrandian; S — Sudeticum (Moravian Palaeozoic); C-Mt. — Carpathian Mts.; O — Odra (Oder) — lineament; E — Labe (Elbe) — lineament. The *arrows* indicate tectogene polarity

Reefal limestones with coral and stromatoporoid faunas of Givetian and Frasnian ages correspond to a marine transgression. Their thickness at Jablůnka is double that in the Münsterland borehole (442 m and 220 m respectively). Basal clastic sediments are of marine origin in their uppermost parts at Jablůnka as well as at Münsterland which, unfortunately, did not reach the lower portions of this sequence.

The total apparent thickness of the Palaeozoic in the Münsterland borehole exceeds 4 168 m, while in the Jablůnka borehole it is 3 418 m (in the latter case it is the true thickness). The true thickness in the Münsterland borehole is 3 550 m.

The stratigraphical sequence and general trends in development are closely comparable in the two sequences. However, there are some vertical shifts in several important lithostratigraphic boundaries. In the Rhenohercynicum, marine sedimentary conditions persist till the end of Namurian B times, due to greater mobility of the basin basement. The paralic conditions lasted till the end of Westphalian C times for similar reasons. In the borehole Jablůnka 1 rapid sedimentation started sooner, influenced by the rejuvenated subsidence — as early as near the Viséan —Namurian boundary. In the Münsterland 1 borehole the corresponding event can be dated to the Namurian A. In Moravia, the tectonegetic process during its last stage was far faster and more pronounced, evidently due to limited mobility of the Variscan foreland, which is deeply buried beneath the Carpathians.

Metamorphism is less intense in the borehole Münsterland 1 (see T e i c h m ü l l e r et al. 1979). Gradient R_{max} . 100 m^{-1} is 0.17 %, and

Hb_{rel} . 100 m^{-1} is 11.5. The thermal palaeogradient in the Münsterland 1 borehole was calculated to be 50 °C . km^{-1} (Buntebarth - Teichmüller 1979). This is in accordance with the generally higher metamorphism of the Moravian Palaeozoic as compared to the Rhenohercynicum. It can also be concluded that there is no direct relation between basement mobility and thermal metamorphism.

K tisku doporučili I. Chlupáč a V. Skoček
Přeložil Z. Kukal

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Geologie paleozoických sedimentů vrtu Jablůnka 1 (Beskydy) – srovnání s vrtem Münsterland 1

(Résumé anglického textu)

Jaroslav Dvořák

Předloženo 12. června 1987

Vrt Jablůnka 1 byl situován poblíž mobilní zóny ssv.—jjz. směru, vyznačené v s. části Ostravska orlovskou vrásou a ji doprovázejícími diskontinuitami (Dvořák 1982). Vliv této mobilní zóny můžeme spatřovat v téměř neustálé komunikaci s otevřeným mořem (přítomnost konodontové fauny) a relativně proti okolí ve větších mocnostech famenu, tournai a hlavně hradecko-kyjovického souvrství (rozhraní spodní/svrchní karbon).

Vápence lažánecké se ukládaly během pozvolné transgrese moře ve směru od Z k V. Proti tomu souvrství líšeňské bylo deponováno v době ústupu moře z v. platformní části pánve, což se projevilo silnějším přínosem klastického materiálu z pevniny. Obnovená zrychlená subsidence celého okolí ve svrchním visé vedla k rozsáhlejší transgresi moře do oblastí již dříve zaplavených devonským mořem. Při rozhraní spodního a svrchního karbonu byl do pánve snášen též klastický materiál z blízkého v. a j. okolí. Změna nastala až s nástupem hrubozrnné klastické sedimentace ostravského souvrství, kdy byla většina materiálu přinášena od Z.

Přechod z mořské do paralické (molasové) sedimentace je dán vztahem mezi subsidencí a přínosem klastického materiálu do pánve (Dvořák 1975). I když subsidence z absolutního hlediska byla v té době nejintenzívnější (bylo deponováno ca 120 cm sedimentů za 1 000 let), přínos klastického materiálu z vyvrásněného a vyzdviženého variského pohoří na Z byl ještě rychlejší. Popisované vztahy mezi rychlou subsidencí a přínosem klastického materiálu byly primární příčinou nakupení a zachování rostlinného materiálu ve formě uhelných slojí. Převážně tmavé zbarvení všech paleozoických sedimentů dokládá usazování ve špatně větrané mělkovodní zátoce s redukčním prostředím.

Strmému teplotnímu gradientu v karbonu odpovídá do hloubky rychle stoupající přeměna hornin ze silnější diageneze v nejvyšších metrážích až do silnější anchimetamorfózy na bázi paleozoika. Alpínská tektogeneze se projevila vznikem hojných, s vrstevními plochami paralelních tektonických zrcadel s rýhováním, svědčícím o hojných, ale nepříliš rozsáhlých posunech se z. vergencí („hromádka karet").

Paleozoikum na vrtu Jablůnka 1 nebylo porušeno žádnou významnou dislokací.

Srovnání vrtu Jablůnka 1 s vrtem Münsterland 1

Vrt Münsterland 1 byl situován zrcadlově symetricky při sz. okraji variské předhlubně rhenohercynika [k pozici srov. Dvořák - Paproth 1969, k vrtu Münsterland 1 — sine (1963)]. Oba vrty mají podobný stratigrafický sled a faciální vývoj. Pouze část vrstev svrchního karbonu vrtu Münsterland 1 je porušena vrásovým ohybem, doprovázeným přesmykem. Nadloží paleozoika vrtu Jablůnka 1 je tvořeno téměř 2 900 m mocným karpatským flyšem, u vrtu Münsterland jen 1 788 m mocnou platformní křídou, terciérem a kvartérem. Uhlonosný svrchní karbon je reprezentován na vrtu Jablůnka 1 přes 1 050 m mocnou spodní částí namuru A, na vrtu Münsterland 1 010 m mocným vestfálem A a 700 m mocným namurem C (pravé mocnosti). Bezuhelný svrchní karbon (event. přechod do karbonu spodního) má na vrtu Jablůnka mocnost 1 333 m a na vrtu Münsterland 1 320 m (namur A a B), přičemž báze je tvořena černými břidlicemi (Alaunschiefer — 23 m). Proti vrtu Jablůnka je spodní karbon na vrtu Münsterland silně kondenzován (celková mocnost 69 m), i když na vrtu Jablůnka nedosahují převážně vápencová souvrství velkých mocností (327 m). Litologicky se spodní karbon vrtu Münsterland poněkud liší — v tournai převládají níže tmavé vápence, výše černé břidlice se silicity, kdežto ve visé se níže střídají silicifikované vápence se silicity a výše černé břidlice, lokálně s vložkami biodetritových vápenců. Tyto připomínají moravické souvrství na vrtu Jablůnka a přechod do podložních vápenců.

Mocnosti sedimentů famenského stáří jsou prakticky shodné (Jablůnka — 210 m, Münsterland — 203,5 m). I když jsou litologicky tyto sedimenty velmi odlišné — na jedné straně hlíznaté a biodetritové vápence a na druhé straně (vrt Münsterland) břidlice a výše pískovce, ukládaly se všechny tyto litotypy během postupné mořské regrese. V okolí vrtu Münsterland započala regrese někdy uprostřed frasnu — ve svrchním frasnu se ukládaly tmavé dolomitické břidlice.

Mořské transgresi odpovídají níže uložené útesové vápence s korálovou a stromatoporoidovou faunou givetského a frasnského stáří, které však na vrtu Münsterland mají poloviční mocnost (220 m) než na vrtu

Jablůnka (442 m). Bazální klastické sedimenty jsou jistě v okolí vrtu Jablůnka v nejvyšší části mořské (transgresívní) jako na vrtu Münsterland, kde však nebylo hlouběji vrtáno (pod 5 956 m).

Celková nepravá mocnost paleozoika na vrtu Münsterland přesahuje 4 168 m, na vrtu Jablůnka 3 418 m (v tomto případě je to též mocnost pravá). Pravá mocnost na vrtu Münsterland je 3 550 m. Jsou zde tedy značné analogie vrstevního sledu a tendencí celkového vývoje. Některá významná litostratigrafická rozhraní jsou jen poněkud časově posunuta. V důsledku vyšší mobility podkladu pánve setrvává v rhenohercyniku déle sedimentační prostředí mořského charakteru (do konce namuru B) a paralické do konce vestfálu C. Zrychlená sedimentace jako důsledek obnovené subsidence podkladu nastala v okolí vrtu Jablůnka dříve — již kolem rozhraní visé/namur, kdežto v okolí vrtu Münsterland až během namuru A. Na Moravě probíhal celý tektogenetický proces v závěrečné etapě rychleji a výrazněji, patrně v důsledku omezené mobility variského předhoří, dnes hluboce ukrytého pod Karpaty.

Metamorfóza je na vrtu Münsterland méně intenzívní než na vrtu Jablůnka (srov. T e i c h m ü l l e r et al. 1979). Gradient R_{max}/100 m — 0,17 %, Hb_{rel}/100 m — 11,5 a teplotní paleogradient byl na vrtu Münsterland vypočten na 50 °C/km (B u n t e b a r t h - T e i c h m ü l l e r 1979). Tato skutečnost je v souladu s celkově vyšší metamorfózou moravského paleozoika proti rhenohercyniku. Současně dokládá, že mobilita podkladu pánve s teplotní přeměnou nemají společnou závislost.

Vysvětlivky k tabulkám

T a b u l k a 1. Mocnosti litostratigrafických jednotek paleozoika na vrtu Jablůnka 1.

T a b u l k a 2. Přibližné mocnosti biostratigrafických jednotek paleozoika na vrtu Jablůnka 1.

T a b u l k a 3. Silikátové analýzy vrtu Jablůnka 1.

Vysvětlivky k obrázkům a příl. 1

1. Situace vrtu Jablůnka 1.
   1 — devon a karbon na Moravě; *2* — vnější okraj karpatských příkrovů.
2. Detailní profily dvou jader vrtu Jablůnka 1.
   J. č. 42: Gradačně zvrstvené vápencové brekcie (famen). Na bázi hlíznaté vápence. J. č. 53: Rytmická stavba slepenců a pískovců říčních sedimentů bazálního klastického souvrství devonu (spodní—střední devon ?). Si anal. — silikátové analýzy. Litologické symboly jako u příl. 1. *Šipky* ukazují gradační zvrstvení rytmů (v jednom případě též z části negativní).
3. Korelace schematizovaných profilů vrtů Jablůnka 1 a Münsterland 1. Mocnosti u vrtu Münsterland 1 přepočítány na pravé.
   1 — uhlonosná souvrství; *2* — břidlice a prachovce; *3* — tmavě šedé biodetritové

vápence; *4* — útesové karbonáty; *5* — hlíznaté vápence; *6* — silicifikované vápence a břidlice se silicity; *7* — pískovce.

4. Strukturní mapa středoevropských variscid s vyznačením pozice vrtů Jablůnka 1 a Münsterland 1.

RH — rhenohercynikum; ST — saxothuringikum; B — Barrandien; S — sudetikum (moravské paleozoikum); C-Mt. — Karpaty; O — oderský lineament; E — labský lineament. *Šipky* značí polaritu tektogenu.

Příl. 1

Profil paleozoika vrtu Jablůnka 1. Sestavil na základě výzkumu jader a karotáže J. Dvořák a A. Těžký.

1 — mocnější uhelná sloj; *2* — droby a pískovce; *3* — prachovce a břidlice; *4* — břidlice; *5* — vápnité břidlice; *6* — biodetritové vápence; *7* — vápence krinoidové; *8* — vápencové brekcie; *9* — vápence hlíznaté; *10* — převážně čisté vápence s útesotvornou faunou; *11* — dolomity a dolomitické vápence; *12* — křemenné pískovce a slepence; *13* — přerušení sedimentace; *14* — tufity, R_{max} — hodnoty maximální odraznosti jemně rozptýlené organické hmoty, Hb_{rel} — hodnoty krystalinity illitu.

Геология палеозойских отложений в глубокой буровой скважине Яблунка-1 (Бескиды, с.-в. Моравия) — сравнение со скважиной Мюнстерланд-1

Палеозойские породы во скважине Яблунка-1 были пробырены на грубине 2890-6318 м. Они представлены нижней частью остравской свиты (нижний намюр А — угленосная моласса), градецко-киёвицкой свитой (предел между намюром и визе — флишоидные отложения), моравицкой свитой (верхний визейский ярус — известковистые снапцы), лишеньской свитой (верхний визейский ярус до верхнего франа — биодетритовые и микритовые сгустковые известняки), мацошской свитой (фран до живета — рифовые известняки) и терригенной базальной свитой обломочных пород (? эйфель до эмса ?). Слои залегают преимущественно субгоризонтально. Градиент метаморфизма очень крутой — с диагенеза по сильный анхиметаморфизм. Температурный палеоградиент во время карбона достигал 70—80 °C/км. Сравниваемая буровая скважина Мюнстерланд-1 была расположена симметрично вблизи с.-з. окраины варисского предгорья Реногерцинской зоны.

Přeložil A. Kříž