New stratigraphic subdivision of the Tertiary in the Sokolov Basin in Northwestern Bohemia

Nové stratigrafické členění terciéru sokolovské pánve v sz. Čechách

(2 figs, 1 table)

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An updated stratigraphic division of the Tertiary fill in the Sokolov Basin is proposed. Lithostratigraphic units are defined, in principle, by lithological criteria. The lithostratigraphic scale is fixed to time points established by means of biostratigraphic and magnetostratigraphic data. A great number of marker beds, composite marker beds and marker horizons enhanced correlation among heteropic units. The Tertiary volcani-sedimentary succession of the Sokolov Basin, up to nearly 400 m thick, is divided into four formations: The Staré Sedlo Formation (Eocene / Oligocene boundary, ca. 35 Ma) represents the initial, fluvial stage of the basin development. The Nové Sedlo Formation (Oligocene to Early Miocene, ca. 24–23 Ma) reflects the first dynamic stage of the area extension, accompanied by intensive volcanism and tectonic subsidence. The Nové Sedlo Formation is subdivided into three heteropically interfering members: the Davidov Member, the Josef Member and the Chodov Member. The Sokolov Formation (Early Miocene, ca. 23–21 Ma), separated from the previous formation by a disconformity, represents the second stage of extension, subsidence and volcanism. It is subdivided into four heteropically interfering members: the Habartov Member, the Těšovice Member, the Anežka Member and the Antonín Member. The Cypris Formation (Early Miocene, ca. 21–17 Ma) with member of the Čankov Sand is characterized by a stepwise cessation of endogenic processes. The Staré Sedlo, Nové Sedlo and Sokolov formations are separated by disconformities. The Sokolov Formation underlies the Cypris Formation with a conformity indicating an abrupt regional change of the environment.

Key words: Sokolov Basin; lithostratigraphy; Tertiary; western Bohemia; Czech Republic

Introduction

The Sokolov Basin belongs to traditional areas of brown coal, kaolin and clay mining in the Czech Republic. The basin is situated in the western part of the Krušné hory Mts. piedmont graben in NW Bohemia. Through years of mining since 1789, the basin fill has been well exposed and its lithostratigraphic division has undergone various changes. This paper aims to update our knowledge in this respect and focuses also on establishing a firm framework of formal lithostratigraphic units defined in accordance with the International Stratigraphic Guide edited by Salvador (1994).

History of research

The most frequently used stratigraphic divisions of the Tertiary in the Sokolov Basin, proposed by Hokr (1961) and Václ (1964), have been challenged by mining practice. Both variants of the lithostratigraphic scheme contained elements of permanent value, yet they both are out of date at present. The large amount of research and mining works during the last 40 years have brought a lot of new data which lead to amendments and new explanations of the geological structures exposed in this area. Thus, the question of the stratigraphy has come up again. The latest concepts submitted by Shrbený et al. (1986, 1994) contained progressive elements but did not avoid problems. They suffered from neglecting formal requirements of the stratigraphic classification and new data. The units were defined after combined litho-, bio- and chronostratigraphic criteria.

The period 1856–1898 (partly persisting to 1931)

Hochstetter (1856) divided the fill of the Sokolov Basin into two units called “Abtheilungen” (“levels”, “divisions”). They were separated by volcanic eruptions in the level between the Miocene coal seams. The separating zone of tuffs was believed to be connected with an unconformity and with a sudden subsidence of the basin. Jokély (1857) separated the tuffs as the third independent unit – “the basaltic level”. This concept was used for further 75 years.

The period 1903–1914

Rotky (1903) divided the Tertiary of the Sokolov Basin into three units called “Stufen” (“levels” or “stages”) in a different way. His concept may serve as a sort of inspiration for the present attempts:

1. The Staré Sedlo Member (“Alt-Satteler Schichten”)
2. The Middle or Basaltic Stage (“mittlere oder basaltische Stufe”). This unit, essentially different from the basaltic unit of previous authors, included all volcanic rocks as well as all coal seams
3. The Cypris Shale (“Cyprisschiefer”).

The period 1918–1949

The dynamic development of coal mining has reinforced a descriptive division of the strata instead of the analytical one. In the frame of Hochstetter’s and Jokély’s “levels”, some more lithological units easily recognizable by miners were established (Michler, 1927, Petrascheck,

1926–1929, Apfelbeck, 1931). But these horizons did not continuously cover the complete set of strata.

The period 1950–1985 (partly persisting to the present time)

The intensive survey for coal, kaolin, clays and uranium, as well as the solution of the hydrogeological, geotechnical and mining conditions, led to the establishment of an official stratigraphy of the Sokolov Basin used in 1960–1980s. It has been commonly used in the region till present as the single accepted stratigraphy. By gradual connection of the old lithological horizons in both vertical and lateral direction, the complete set of strata has been finally recovered. At first, the Tertiary fill was divided into a heterogenous system of stratigraphic units of a different quality (Tásler, 1952, Šantrůček – Tásler, 1957, Náprstek, 1958, Kukla, 1959, Kukla et al., 1961, Hokr, 1961). Václ was the first (Václ, 1964), who divided the Tertiary fill into five formations: the Staré Sedlo Formation, Josef Coal Seam Formation, Volcanogenic Formation, Main Coal Seam Formation and Cypris Formation. The concept was integrated in regional syntheses (Zoubek, 1963, Václ, 1964, Havlena, 1964, Havlena, 1983).

The five formations were sometimes formally grouped into two or three "sedimentary stages" or "sedimentary cycles" (Náprstek, 1958, Kukla, 1961, Zoubek, 1963, Václ, 1964, Havlena, 1964, Forman – Obr, 1977).

The period after 1986

Shrbený et al. (1986, 1994) divided the basin fill into three formations:

1. The Staré Sedlo Formation
2. The Nové Sedlo Formation (including the Josef Seam, volcanic rocks, thinner seams and carbonaceous clays)
3. The Sokolov Formation (including the Antonín and Anežka seams and the Cypris Shale).

This classification, considerably relying on biostratigraphic data, attempted to correlate the lithostratigraphic units with the chronostratigraphic scale. It is well arranged, using properly geographic names for the units. Its major drawback is in a combination of the litho-, bio- and chronostratigraphic principles. The three formations are assemblages of traditional litostratigraphic units with heterochronal boundaries. However, they were believed to be characterized by uniform biostratigraphic content. The three formations reflect the triad Eocene – Oligocene – Miocene. The formations were not characterized in detail and were defined without selection of stratotype sections. This was in a contradiction to recommendations of the International Stratigraphic Commission (Salvador, 1994) and of the Czech stratigraphic classification (Chlupáč – Štorch, 1997).

The principal features of the previous lithostratigraphic concepts of the Sokolov Basin can be characterized as follows:

1. The lithostratigraphic principles prevailed. The palaeontologic record is patchy, therefore the biostratigraphic dating plays a local, even though important role. The magnetostratigraphy has not been carried throughout the complete set of strata. The isotope dating has not been applied at all.
2. Clear and generally accepted criteria for definition of lithostratigraphic boundaries have been missing. The first-rank bounding planes were correlated with different levels and the number of formations varied.
3. Hence, only formal, rigid stratigraphic schemes have been achieved. Any subsequently exposed sets of strata that differ from the currently known geological setting of the central part of the basin have been mechanically added to any adjacent unit, no matter whether they are related or not. Various conventions serving for practical use, were adopted without proper understanding the basin evolution and associated endogenic and exogenic processes.

Proposal of the new stratigraphic division

Principles highlighted:

- the recommendations of the international stratigraphic classification (Salvador, 1994) and of the Czech stratigraphic classification (Chlupáč – Štorch, 1997) are fully respected,
- benefits of the complete up-to-date knowledge of the area,
- only units well recognizable during field mapping works have been considered,
- a hierarchy of units allowing further specification is developed (formations, members, complemented by informal marker beds, composite marker beds and marker horizons),
- all the lithostratigraphic units are defined or re-defined,
- the criteria applied in recognition of unit boundaries are given,
- the same principles are used for the whole set of strata,
- heterochronity of units and the heteropic substitution of local facies is respected,
- type sections (localities) are selected,
- field for subjective interpretations is minimized,
- the classification strives to be synoptic and easy as much as possible.

The update of formal stratigraphy of the Sokolov Basin proposed herein is based on lithostratigraphic principles. The time-scale is fixed on important levels dated biostratigraphically and magnetostratigraphically (Tab. 1, Fig. 1). The newly proposed correlations of the units are strongly supported by 63 marker beds and horizons, which mostly cover the whole basin and are (almost) isochronal. They help to point out to the heterochronity of boundaries and the heteropic substitution of the members. Magnetostratigraphic sections scattered in different parts of the basin need to be complemented in the future. A detailed description of the designated stratotypes is beyond the scope of this paper.

Table 1. Proposed stratigraphic scheme of the Sokolov Basin.

Chrono-stratigraphy	Formation	Member	Characteristic rocks	Typical environment
Holocene			antropogenic deposits, fluvial loams, peats, porcelanites	antropogenic, fluvial
Pleistocene		nine local terrace benches	gravels, loams, loess loams, block fields, peats, porcelanites, mineralized faults	fluvial, eolian, solifluction
unconformity				
Burdigalian *Ottnangian-Karpatian*	**Cypris Formation**		laminated claystones illite-montmorillonite-kaolinitic, admixtures of Ca-Mg-Fe-carbonates, Fe-sulfides, analcite and bitumen; often diastems	lake-playas complex
		Čankov Sand	sands, silty claystones	delta
			laminated claystones illite-montmorillonite-kaolinitic, admixtures of Ca-Mg-Fe-carbonates, Fe-sulfides, analcite and bitumen; diastems	lake-playas complex
			laminated kaolinitic clays, admixtures of siderite, sulfides or sulfates	permanent lake
Burdigalian *Eggenburgian*	**Sokolov Formation**	**Antonín Member**	humic coal; local diastems	mires
		Těšovice Member	bazaltic rocks, tuffs, tuffites, sediments of gravity flows (altered)	volcanic, gravity flows
		Anežka Member	sapro- and liptodetritic coal	mires
		Habartov Member	sands, sandy and silty clays (bioturbated)	fluvial, swamps
disconformity				
Chattian – Aquitanian *Egerian*	**Nové Sedlo Formation**	**Chodov Member**	bazaltic rocks, tuffs, tuffites (altered)	volcanic, swamps, lakes
Rupelian		**Josef Member**	sapropelitic and humic coal; local diastems	mires
Oligocene		**Davidov Member**	clayey sands / sandy clays with gravel admixture – unsorted, unbedded; local diastems	creep, fluvial
disconformity (tectonic movements and hydrothermal activity)				
Upper Eocene – Lower Oligocene	**Staré Sedlo Formation**		sands and sandstones, gravels and conglomerates, locally clays - sorted, bedded; diastems	fluvial
local disconformity				
Paleogene			kaolins and silica rezidues of metamorphites and granites	weathering
unconformity (tectonic fracturing and hydrothermal activity, Triassic - Cretaceous)				
Upper Proterozoic - Upper Carboniferous	Saxothuringian Unit: polymetamorphosed crystalline complexes – the Ohře, Krušné hory, Slavkovský les and Thüringen-Vogtland units and the Karlovy Vary pluton			

Definitions of the lithostratigraphic units

The Staré Sedlo Formation

Characteristics. The Staré Sedlo Formation (Václ, 1964, sensu "Altsatteler Braunkohlensandstein" by Rossmässler, 1840) deposited during the initial period of the development of the Krušné hory piedmont trough. It does not closely follow the structures of the Sokolov Basin (Rojík, 2004).

Until recently, almost all the clastic sediments at the base of the Tertiary fill were assigned to the Staré Sedlo Formation. However, the palaeomagnetic research (Kropáček – Malkovský, 1993, Pruner – Venhodová, 2004), palaeontological data (Knobloch et al., 1996) and the study of petrology, bedforms and joint systems (Rojík, 2004) revealed that a large part of these sediments is much younger and is now re-assigned to the Nové Sedlo Formation (Davidov Member).

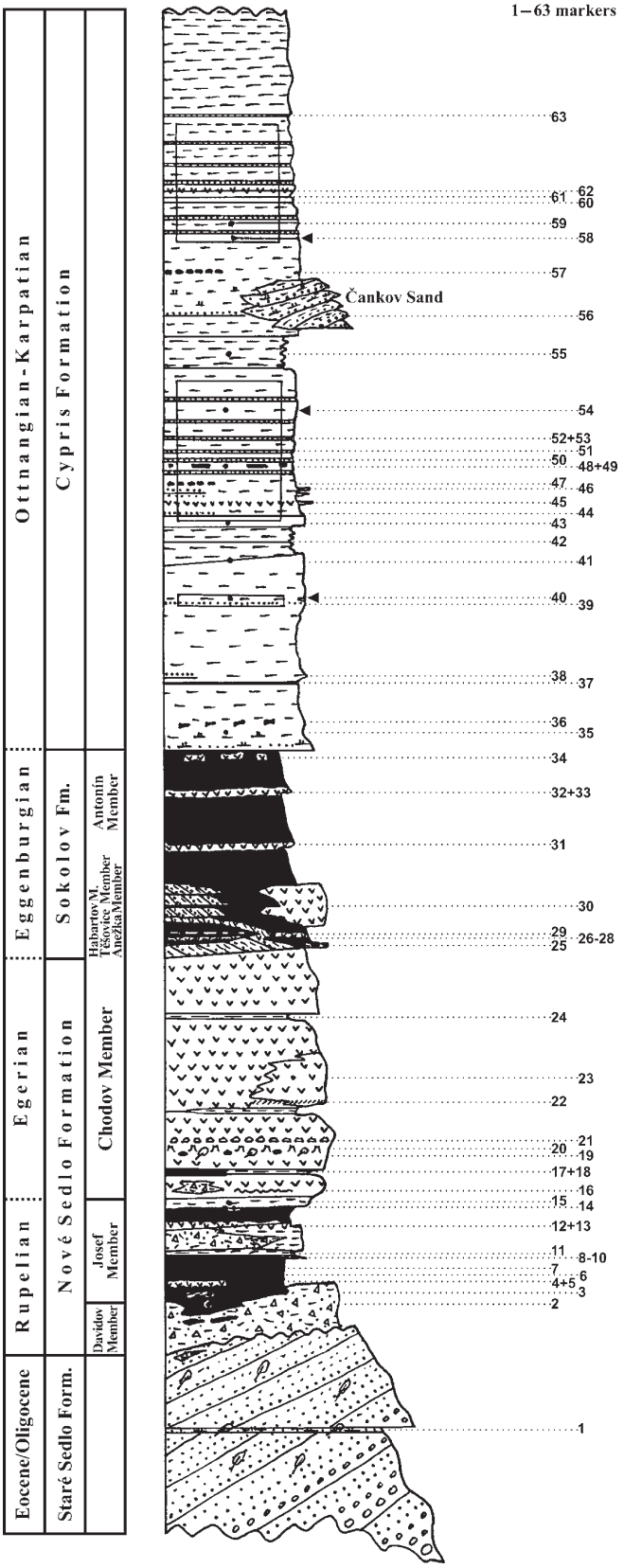
The Staré Sedlo Formation, up to 42 m thick, lies on the weathered crystalline basement. The boundary with the overlying Nové Sedlo Formation (Davidov Member) is disconformable, accompanied by local denudation and weathering, including a silcrust. Rojík (2004) proposed a structural interpretation of the area and identified a change in orientation of the stress vector during the hiatus.

The main diagnostic features of the Staré Sedlo Formation for the field recognition are the following:
- lithology: predominantly well sorted clastic sediments (sandstones),
- bedforms: typical for fluvial systems (channels, aggradation levels),
- coexistence of sediments and products of kaolinic weathering (quartz and/or ferric cement, lenses of redeposited kaolins),
- flora: occurrence of characteristic assemblages described by Knobloch et al. (1996),
- absence of volcanic admixture.

Features distinguishing the Staré Sedlo Formation from the overlying Davidov Member of the Nové Sedlo Formation are as follows (Rojík, 2004):
- distinct stratification,
- mostly diagonal bedding,
- often a sudden wedging out of the strata,
- great variability in size and roundness of clasts (but the largest quartz pebbles are well rounded),
- relatively high degree of sorting (poorly sorted sediments are rare and mostly intercalated between well sorted sediments),
- relatively high structural maturity (an analogy to the degree of sorting),
- often intensive lithification of rocks with silica cement into quartzite,
- unimodal distribution of clasts (except for rare cases at the base),
- mineralogical and chemical composition of sediments very different from inferred source rocks (upwards the tendency to dominance of quartz),
- high mineralogical and chemical maturity (mostly monomict sediments).

Dating. The biostratigraphic dating of the Staré Sedlo Formation is based on plant fossils. The flora has been assigned to Late Eocene in age (Knobloch et al., 1996) with a probable overlap to the Oligocene (Konzalová, 1969, 1973, Konzalová – Kvaček, 1980, Bůžek et al., 1988). The dating to the Eocene is supported by the index fossil *Steinhauera subglobosa* and other palaeotropical taxons *Eotrigonobalanus furcinervis*, *Daphnogene cinnamomea*, *Laurophyllum syncarpifolium*, *Rhodomyrtophyllum retic-*

THE SOKOLOV BASIN:
STRATIGRAPHIC SCHEME OF THE TERTIARY



Explanation:
MB = marker bed
CMB = composite marker bed
MH = marker horizon

63	CMB	Pellet limestones
62	CMB	Analcime claystones
61	MB	Convolution horizon
60	MB	Black shale horizon
59	CMB	Upper pelocarbonates
58	CMB	Upper magnetic horizon
57	MB	Upper magnetic chert
56	MB	Phlogopite horizon
55	MB	Banded claystones
54	CMB	Middle magnetic horizon
53	CMB	Sulfur layers
52	MB	“Double-layer” (green clay + pelocarbonate)
51	MH	Grid horizon (pelocarbonate)
50	MB	Pyrite ridges (pelocarbonate)
49	CMB	Lower pelocarbonates
48	MB	Upper fish horizon
47	MB	Lower magnetic cherts
46	CMB	Upper shale horizon
45	MB	Tuffite coloured horizon
44	CMB	“Twins” of the greigite horizon
43	MB	Accompanying blue-grey clays
42	MB	Papery shale
41	MH	Colour boundary
40	CMB	Lower magnetic horizon
39	MB	Greigite horizon
38	MB	Lower shale horizon
37	MB	Companion (bituminous claystone)
36	MB	Fish zone I. B
35	MB	Blue-grey clays
34	MB	Intercalation “18 inches” (Antonín seam)
33	MB	Green clay intercalation (Antonín seam)
32	MB	Intercalation 8 (Antonín seam)
31	MB	Intercalation 20 (Antonín seam)
30	MB	Intercalated Seam (Habartov Member)
29	MB	Middle intercalation (Anežka seam)
28	MB	Intercalation 30 (Antonín seam)
27	MB	Tuffite horizon (Anežka seam)
26	MB	Intercalation 35 (Antonín seam)
25	CMB	Pelosiderite horizon (Antonín Member)
24	MB	Upper coal horizon
23	MH	Main red beds
22	MB	Laminated red beds
21	MB	Pumice stone horizon
20	MH	Stock horizon
19	CMB	Fossil plant horizon
18	MB	Lower coal horizon
17	CMB	Intercalated Seam (Chodov Member)
16	MH	Basal red beds
15	MB	Sulfide bed
14	MB	Silica roof (Josef seam)
13	MB	Tuffitic claystone (Josef seam)
12	CMB	Tonstein beam (Josef seam)
11	MB	Bituminous claystone
10	MB	Sandstone bank
9	MB	Pyrite roof (Josef seam)
8	MB	Stone roof (Josef seam)
7	MB	Middle bright coal (Josef seam)
6	MB	Cube (Josef seam)
5	MB	Allochthonous coal (Josef seam)
4	MB	Tuffite intercalation (Josef seam)
3	MB	“Big intercalation” (Josef seam)
2	MB	Basal sapropelitic coal (Josef seam)
1	MB	Black sandstone

Fig. 1. Stratigraphic column of the Tertiary in the Sokolov Basin.
Note: Three frames in the Cypris Formation illustrate ranges of the three strongly magnetic horizons (Nr. 40, 54 and 58).

ulosum, *Sterculia labrusca* and an archaic element *Protopteris laubei* (Knobloch et al., 1996, Chlupáč et al., 2002). This flora is in its aspects similar to that of the localities Kučlín, Kostomlaty and Lbín in the České středohoří Mts., where the Late Eocene age was proved by radiometric dating (Kvaček, 2002). A stratigraphic overlap to the Oligocene is inferred from the occurrence of *Trigonobalanopsis rhamnoides* (syn. *Castanopsis toscana), Laurophyllum acutimontanum* and scarcity of *Doliostrobus* (Konzalová – Kvaček, 1980) in association with palms and without elements typical for colder climate, similar to the biozone Pg 18 in the Weisselster Basin (roof of the Eocene), further from the occurrence of *Populus(?) leuce* (Z. Kvaček, pers. com.) and of some advanced entire forms of *Eotrigonolobalanus* (Kvaček, 2002).

On the basis of magnetostratigraphy, Malkovský (1995) believes the Staré Sedlo Formation to be of Oligocene age. His opinion is based on the drill Či-165 located 1 km W of Svatava. There, the clastic sediments underlying the Josef seam are ca. 24 Ma old (Kropáček – Malkovský, 1993, Malkovský, 1995), but they should be ranged into the Davidov Member (see below).

During the deposition of the Staré Sedlo Formation the kaolinic weathering was still persisting (as indicated by the coexistence of silica and/or ferric cement and of redeposited kaolinitic clays), before the cooling around the Eocene/Oligocene boundary. This corresponds with the fact that the sediments in the Erika sand pit near Lomnice do not contain heavy minerals of volcanic origin. According to the magnetic properties, the sandstones from the outcrops between Staré Sedlo and Královské Poříčí are not older than 35 Ma (Pruner – Venhodová, 2004). All these facts confirm that the Staré Sedlo Formation of the Sokolov Basin originated in a time span close to the Eocene/Oligocene boundary.

Stratotypes. Typical and accessible sections of the Staré Sedlo Formation occur in the Erika sand-pit northwest of Lomnice, on the hill Kamenitý 1 km northwest of Svatava, along the railway 1–2 km east of Královské Poříčí and in the Ohře valley near Staré Sedlo. Important are the drills near the Svatava (Sv-39, Sv-55), Královské Poříčí and former Jehličná villages (Knobloch et al., 1996).

The Nové Sedlo Formation

Characteristics. The name for the Nové Sedlo Formation, suggested by Shrbený et al. (1986, 1994), is optimal and is preserved. However, the unit needs to be re-defined in order to meet formal requirements of the present stratigraphic procedure.

The Nové Sedlo Formation reflects the first period of the basin extension between the Early Oligocene (Rupelian) and the early part of the Early Miocene (Burdigalian). In contrast to the Staré Sedlo Formation, deposits distinctly followed the structure of the Sokolov Basin. The common feature of the Nové Sedlo Formation is the dominance of volcanic rocks with coal-bearing sediments. The volcanism and tectonic subsidence were synchronized in several subsequent pulses (Rojík, 2004). Therefore, the Nové Sedlo Formation is composed of up to 270 m thick set of rocks, which repeated many times and interfered as heteropic facies (volcanic, lacustrine, coal-forming mire facies and gravity flows). Lithologically, the unit is characterized by a multiphase alternation of effusive and pyroclastic rocks, re-deposited kaolinized rocks, coal and a wide array of transitional rocks (Tab. 1).

According to facies and rocks alternation three particular litostratigraphic members can be distinguished. A great number of marker beds (Fig. 1) indicate, that the members, in spite of partly similar plant assemblages, are heterochronal.

The Nové Sedlo Formation is disconformably deposited on either coarse-grained clastic rocks of the Staré Sedlo Formation or on more or less deeply weathered crystalline complex. In both cases the boundary is unconformable, marked more or less by erosion, by weathering including kaolins and silcrusts, by a structural re-setting of the area, by a change of the stress vector and by sudden lithological change.

The overlying rocks, in turn, are separated by another disconformity from the Nové Sedlo Formation (Fig. 2). Sands and silty, tuffitic or bituminous titanium-rich kaolinitic clays belong to the basal member of the Sokolov Formation, deposited in widely spread alluvial cones transiting into mires. In the proposed concept, the Nové Sedlo Formation can be easily distinguished in the field from the underlying and overlying formations.

Dating. The lower part of the Nové Sedlo Formation including the Josef Seam is dated to Early Oligocene by index palynomorphs *Boehlensipollis hohli*, *Milfordia incerta* and *Cupaneidites eucalyptoides* (Konzalová, 1981). Higher parts contain Oligocene mammals, but also new plant elements (macrofossils of *Quercus rhenana*) that indicate an overlap with Early Miocene (Z. Kvaček, pers. com.).

Stratotypes. The typical complete sections of the Nové Sedlo Formation occur in the opencast mines Družba west of the Nové Sedlo town, Jiří between Vintířov and Lomnice. Important parts of the formation are accessible in the Medard-Libík pits between Svatava and Habartov, Silvestr north of Březová and Osmosa west of Božičany (Rojík, 2004).

The Davidov Member

Characteristics. The Davidov Member represents the lowest part of the Nové Sedlo Formation. It is a new litostratigraphic unit in the Sokolov Basin. Its name is derived from Davidov, a historical miners' village, now a part of the municipality Svatava, 3 km northwest of

Sokolov. This unit meets calls of several generations of geologists who pointed out the necessity of solving the problem of stratigraphy at the base of the Sokolov Basin (Juranka, 1954, Kukla, 1959, Hokr, 1961, Křelina, 1975, Pazdera, 1985, etc.). Namely, similar climatic and weathering conditions repeated many times during the Paleogene and produced several cycles of rocks, which are similar in composition but different in age (Rojík, 1991, 1997).

The Davidov Member is composed of several cycles of proluvial sediments. The main, almost continuous accumulation in thickness of 2–40 m occurs at the very base of the Nové Sedlo Formation and underlies the Josef Seam. Smaller wedge-like bodies of identical rocks intercalate the Josef Member in thickness of up to 16 m and the Chodov Member, especially along the synsedimentary faults. In all these cases the boundaries of the Davidov Member are without distinct hiatus, conformable, lithologically contrasting, easily recognizable in the field.

The Davidov Member is separated from the Staré Sedlo Formation by a hiatus, although both units were usually considered to coincide. The existence of a disconformity follows from the partial denudation and weathering of the underlying rocks, from the structural changeover of the area (Rojík, 2004), from the change of magnetic properties of rocks (Kropáček – Malkovský, 1993, Malkovský, 1995) and from the palaeontology (M. Konzalová, pers. com. for the drills at Davidov).

The Davidov Member represents the base of the Nové Sedlo Formation. It is developed almost continuously in the whole Sokolov Basin. Moreover, in places it alternates in a finger-like manner with the Josef and Chodov members.

The diagnostic features of the Davidov Member contrasting with all the surrounding units can be defined as follows:

- unsorted transition sediments containing clay, silt, sand and gravel fractions,
- bimodal distribution of particles (granulometric peaks in both clay and sand fractions),
- origin mostly by gravitational processes; the laminar character of flow,
- bedding indistinct or none,
- low structural maturity in spite of a high mineralogical and chemical maturity;
- very poor rounding of clasts,
- gradation (normal or negative) often present,
- mineral composition similar to the underlying residues (i.e. insignificant length of transport).

Dating. In the palynological assemblage of the Sv-41 drill near Svatava – Davidov a facies of ferns, conifers, Myricaceae and Fagaceae occurs, not allowing a direct dating. The thermophile flora characteristic of the Staré Sedlo Formation is here missing but the arctotertiary elements are not yet present (M. Konzalová, pers. com.). Magnetostratigraphic age of the clastic sediments in the Či-165 drill near Svatava – Davidov closely below the Josef seam is ca. 24.0 Ma (Kropáček – Malkovský, 1993).

Stratotype. The Medard-Libík opencast mine near Svatava – Davidov, including the drills Sv-41 and Sv-54, represent the typical locality (Rojík, 2004).

The Josef Member

Characteristics. This is a traditional lithostratigraphic unit of the Sokolov Basin, up to 20 m thick. In this proposal it has a hierarchic status of a member as a part of the Nové Sedlo Formation. The name Josef (former Josefi) should be retained for both coal seam and formal lithostratigraphic member. It is proposed as a *nomen conservandum*. In some respects, however, it can be considered also as a geographic name derived from the mining claims and a coalmine near Svatava (J. Jiskra, pers. com.).

The Josef Member is defined by the organic sedimentation of coal and sapropelites and by the sedimentary environment of overgrowing lakes transforming to mires. Lithologically, the member is dominantly composed of coal of sapropelititic and humite types, of bituminous well-bedded claystones and plastic kaolinitic clays. Coarse-grained unsorted proluvial sediments, wedging here between the coal benches, belong, on the contrary, to the Davidov Member. The environment is typical for the heteropic facies alternation. In this member, 13 marker beds were found, especially tuffs and sapropelites (Fig. 1, for more information see Rojík, 2004).

The boundary of the Josef Member to the underlying rocks (the main accumulation of the Davidov Member, the Staré Sedlo Formation or strongly weathered crystalline complex) is defined by a sudden change in granulometry. Upwards, to the base of the Josef Member the sediments are: (1) distinctly finer, free of sand admixture (Pátková, 1973); (2) much better sorted; (3) thin-bedded. Possible occurrences of coal pigment and/or sulfides are not decisive for the stratigraphic assignment.

The boundary of the Josef Member to the overlying Chodov Member was originally established according to the presence of volcanic admixture in sediments (Hokr, 1961, Václ, 1964). As the volcanogenic material occurs commonly also in the Josef Member (Rojík, 1997), the difference is not in presence but in dominance of volcanic material. This boundary is usually conformable, with a diastem in places and slightly heterochronal.

Dating. The pollen spectra of the upper coal bench of the Josef Seam contain *Boehlensipollis hohlii* W. Kr. and other index microfossils of the Rupelian (Konzalová, 1981, Bůžek et al., 1988). The clays between the lower and upper coal benches contain typical Oligocene representatives of Lauraceae and *Eotrigonobalanus furcinervis* (Kvaček et al., 1989). Palynologic spectra of the upper bench of the Josef Seam and of the Chodov Member are similar and both contain a high number of the arctotertiary elements (Konzalová, 1981 and pers. com.). The interpretation of magnetostratigraphic measurements on the drill cores Či-165 near Svatava revealed the age of the Josef Member of 23.95–23.65 Ma (Kropáček – Malkovský,

1993, Malkovský, 1995), which corresponds rather to the Late Oligocene.

Stratotypes. The typical section of the Josef Member is accessible in the Medard-Libík open pit mine near Svatava, and is represented in the drills Sv-41, Sv-53 and Sv-55 (Rojík, 1997).

The Chodov Member

Characteristics. The time interval of the volcanic activity in the Sokolov Basin has been considerably extended in comparison with previous works (Hokr, 1961, Václ, 1964). It ranges from the very base of the Nové Sedlo Formation (Oligocene, ca. 24 Ma) till the upper part of the Cypris Formation (Miocene, ca. 17 Ma). The distribution of the primary volcanic products culminated in the Chodov Member (around the Oligocene/Miocene boundary, ca. 23.5–23.0 Ma) and again in the Těšovice Member (Lower Miocene, ca. 22.5–22.2 Ma).

The volcanic bodies in the Sokolov Basin indicate that the ancient W–E running structures opened at the very beginning of extension of the graben (Oligocene, ca. 24 Ma). The major source of pyroclastics in both volcanic members was the volcanic system of the Doupovské hory Mts. In the basin itself, the most important were both marginal faults: Ohře Fault in the South (Rybáře – Hory – Těšovice – Dasnice) and the northern line of the Krušné hory Fault in the North (Hradecká – Rotava – Kraslice – Počátky). Particular vents are associated with en-echelon faults and are connected with synsedimentary active horsts along the marginal faults. Both marginal faults are accompanied by a large number of effusions of geochemically well-differentiated alkaline olivine-rich lavas of nephelinite to melilitite composition (Rojík, 2004).

In relation to older classifications, the Chodov Member corresponds to the Volcanodetritic Formation *sensu* Hokr (1961) as well as to the lower part of the Volcanogenic Formation *sensu* Václ (1964). In accordance with the principles of stratigraphic classification (Chlupáč – Štorch, 1997) the rank of the unit was lowered to a member within the Nové Sedlo Formation. The name is derived from Chodov, an important miners' town in the centre of the Sokolov Basin. In the surroundings of Chodov there exist the most important sections of this unit (mines for coal, kaolin, bentonite and basalt quarries).

The dominance of effusive, pyroclastic (tuffs) and epiclastic (tuffites) rocks is the main typical feature of the Chodov Member. To the characteristic features of all volcaniclastic deposit belong devitrification, argillitization, growth of authigenic carbonates, anatase, etc. The unit contains enhanced concentrations of elements related to the alkaline volcanism (Ti, V, P, Th, REE, Ba, Sr, Ag). The Chodov Member reflects the first culmination phase of the volcanic and tectonic activity in the Sokolov Basin. It distinctly differs from the underlying and overlying members where coal-bearing systems with a much lower dynamics of endogenous and sedimentary processes dominate. The thickness of the Chodov Member decreases from the usual value of 80 m at the foot of the Doupovské hory stratovolcano (in places, the thickness even exceed 200 m) to 3 m at the southwestern corner of the Sokolov Basin.

The boundary of the Chodov Member with the underlying strata (Josef or Davidov members) is conform, in a form of slightly heterochronal lithological transitions, defined by the megascopically distinct material, in which altered pyroclastic particles prevail.

The boundary to the overlying Sokolov Formation (Habartov, Anežka or Antonín members) is sharp, often erosional, distinctly heterochronal (Fig. 2). It is marked by a sudden change in lithology (cessation of mostly coarse-grained pyroclastic rocks) and facies (development of fine bituminous and flood-plain sediments). Around this boundary, a strong retreat of the arctotertiary flora was observed (Konzalová, 1992). Simultaneously, some mineralogical indicators of a climate warming were found (dominance of kaolinite, occurrence of Al-hydrates, suddenly increasing anatase content). It would be an interesting question, how closely this climatic change correlates with the interruption of the volcanic activity.

Dating. The fossil mammals *Anthracotherium magnum*, *Entelodon* sp., recovered in the tuffite at the Erika pit northwest of Lomnice, have been ranged to Chattian ≈ Lower Egerian, i.e. Late Oligocene (Fejfar – Čtyroký, 1977). The flora suggests Late Oligocene to early Early Miocene age (Konzalová, 1969, Kvaček et al., 1989). Arctotertiary elements, such as *Alnus*, *Liquidambar, Carya, Fagus*, and palaeotropical *Quercus rhenana* and *Mastixiaceae* are characteristic. Towards the roof of the member the plant assemblages are enriched with thermophile subtropical taxons including *Mastixia amygdalaeformis* (Holý, 1975) and *Mastixia venosa* (Kvaček et al., 1989). Konzalová (1992) recognized former Volcanodetritic Formation from the overlying Main Coal Formation according to the pollen spectra. Unfortunately, the latter criterion cannot be applied in the field and its role in the formal justification of the Chodov Member is subordinate. The magnetostratigraphic measurements in the Či-165 drill near Svatava (Kropáček – Malkovský, 1993, Malkovský, 1995) suggest latest Oligocene / earliest Miocene age (ca. 23.6–22.9 Ma). The radiometric age of the tephrite at Vojkovice at the western foothill of the Doupovské hory Mts. is 23.3 Ma (Kopecký, 1987–1988).

Stratotypes. The typical sections of the Chodov Member are now accessible in the Medard-Libík coal pit near Habartov, in Jiří and Družba coal pits between Chodov and Sokolov, in the Osmosa kaolin pits near Chodov, Podlesí near Sadov and in the Dasnice quarry (Rojík, 2004).

The Sokolov Formation

Characteristics. The name for the Sokolov Formation was suggested by Shrbený et al. (1986, 1994), but in a wider

sense, i.e. including the Cypris Shale. This formation is here re-defined as a lithostratigraphic unit of the Sokolov Basin that reflects the second period of an intensive basin extension, volcanism and tectonic subsidence. The depositional architecture attained the ultimate distinct structure of the Sokolov Basin. Lithologically, the Sokolov Formation, up to 300 m thick, is characterized mainly by coal seams accompanied by the alluvial, volcanic and gravity deposits that partly interfinger. The heteropic relation of members in the Sokolov Formation is illustrated in Fig. 2. The main feature of the Sokolov Formation is the dominance of coal-bearing sediments. The coal-forming environment prevailed in the basin during the Early Miocene (late Burdigalian Miocene climatic optimum). According to different lithologies, four lithostratigraphic members have been distinguished within the Sokolov Formation (Tab. 1, Fig. 1).

The rocks underlying the Sokolov Formation belong to the volcanogenic facies of the Chodov Member of the Nové Sedlo Formation. The boundary is disconformable, marked by an erosion plane, weathering zone and by a sudden lithological change (Fig. 2).

The rocks overlying the Sokolov Formation are laminated mudstones of the Cypris Formation. This boundary is marked by an abrupt change of the facies and lithology. It is conformable, without hiatus, minor diastems rarely occur. Thus, the Sokolov Formation in this proposal can be well distinguished in the field from its underlying and overlying formations.

Dating. The occurrence of a thermophile mastixioid flora recovered within the Sokolov Formation at Bukovany has been assigned to the pronounced warm period of the Early Miocene (Holý, 1975, Mai, 1995). It does not differ much from that at the base of the Cypris Formation and corroborates an age of late Burdigalian. Palaeomagnetostratigraphic data suggest a time-span between ca. 23 and 21 Ma (Kropáček – Malkovský, 1993, Malkovský, 1995).

Stratotype: The typical complete sections of the Sokolov Formation occur in the Družba opencast mine west of the Nové Sedlo town and in the Jiří mine between Vintířov and Lomnice (Rojík, 2004).

The Habartov Member

Characteristics. The Habartov Member is a new unit recognized within the Sokolov Formation. The proposed unit has recently been discussed by Rojík (1991). It is named after Habartov, a miners' town in the western part of the Sokolov Basin. The most important sections of the Habartov Member are exposed in the adjacent Medard-Libík coalmine. The maximum thickness of 35 m has been attained there.

The Habartov Member (Burdigalian ≈ Eggenburgian) represents a sedimentary log of the period in the development of the Sokolov Basin, which is characterized by a distinct suppression of coal-forming deposition in favour of the inorganic sedimentation. The cause is probably consistent with the increasing humidity of the climate and with the revival of the tectonic activity, in places accompanied by the volcanism of the Těšovice Member. The Habartov Member is characterized by silty and sandy clays (kaolinitic, titanium-rich, often with Al-hydrates and carbonate nodules) with re-deposited volcanoclastic admixture and sands, which originated in widely spread alluvial cones. Typical are intercalations of bituminous clays.

The relation of the Habartov Member to the underlying Chodov Member: The boundary is marked by the termination of the pyroclastics fall, erosion, weathering and spread of terrigenous sedimentation. This boundary can be easily set in the field, because it is sharp, often erosional, with springs along the separating plane after fresh opening by a mine. In contrast to the Chodov Member, the sediments of the Habartov Member become suddenly darker, mostly softer and very fine, clayey.

The relation to the Anežka Member: The Habartov Member neighbours the Anežka coal seam (Fig. 2). The boundary is heterochronal, either sharp or, more often, developed an oscillationg transition.

The relation to the Antonín Member: The upper part of the Habartov Member interferes with the Antonín lignite seam. The boundary has a character of a sudden oscillating transition from the lighter, indistinctly bedded silty clays and sands of the Habartov Member to the dark, thin-bedded bituminous sediments.

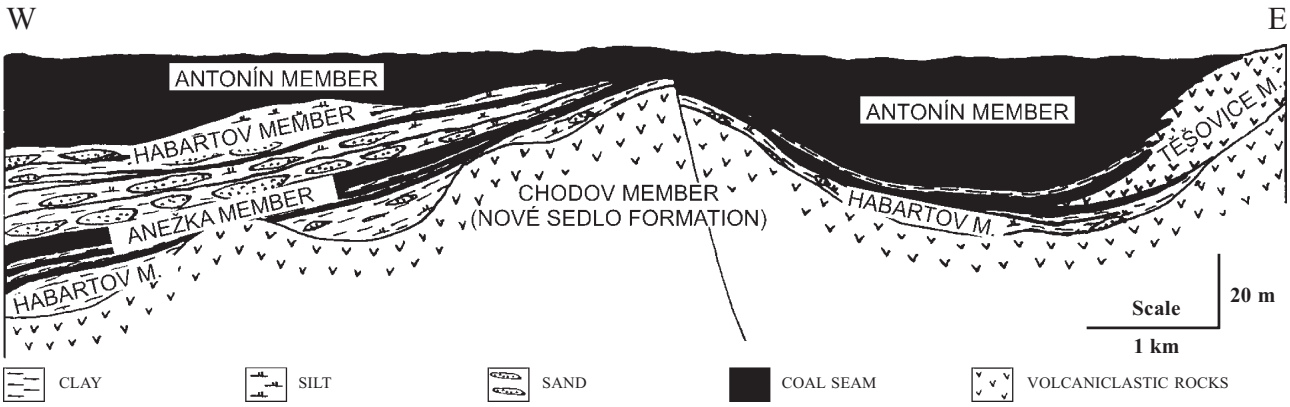


Fig. 2. Geological section across the Sokolov Formation showing heteropic relations of the members.

The relation to the Těšovice Member: The upper part of the Habartov Member interfingers with the tuffs and lava flows of the heteropic Těšovice Member. The lithology, textures and facies of the clastic sediments of the Habartov unit differ very sharply from cinder cones generated by several volcanic centres.

Dating. The sands of the Habartov Member contain endocarps of Mastixiaceae *Tectocarya elliptica* and *Mastixia thompsonii* (Holý, 1975), which suggest a warm climatic optimum within the Early Miocene. Magnetostratigraphically, major part of the member originated in the reversely polarised interval of 22.5–22.2 Ma (Kropáček – Malkovský, 1993, Malkovský, 1995).

Stratotype. The most important outcrops of the Habartov Member are present in the Medard-Libík pit between Habartov and Svatava and in the proposed "Sokolov Badlands" natural monument in the former Silvestr coal pit 1 km north of Březová (Rojík, 2004).

The Těšovice Member

Characteristics. The Těšovice Member is a newly proposed member of the Sokolov Formation in the Sokolov Basin. Its name is derived from Těšovice, a municipality 1 km east of Sokolov, where an important outcrop of this member exists.

The Těšovice Member is wedged between the Miocene coal-bearing strata. It is developed in the form of pyroclastic and effusive rocks that originally might have tephrite – nephelinite composition. The unit occurs in the Doupovské hory volcanic system and around the volcanic centres close to the master faults in the Sokolov Basin. The thickness at the foot of the Doupovské hory Mts. reaches 270 m (Václ, 1964) and in the basin itself, in places, exceeds 100 m (Družba mine near Nové Sedlo, Selský vrch near Otovice).

The Těšovice Member corresponds with the second peak of the volcanic and tectonic activity of the Sokolov Basin and is clearly separated from the Chodov Member (the first volcanic maximum). Its definition feature is almost exclusively the occurrence of altered fragmented pyroclastic and effusive rocks. An intensive endogenic activity has rebuilt the relief of the basin and the distribution of facies around the eruptive centres. Petrology, mineralogy, geochemistry and facies of the Těšovice Member distinctly differ from those of underlying and overlying units, which originated in mire and fluvial environments. Due to the specific freatomagmatic textures (Rojík, 2004) the Těšovice Member is well recognizable in the field from the Chodov Member. If both volcanic members are in touch, which is rarely the case, they are separated by a hiatus expressed by an erosion plane and by weathering.

The Těšovice Member interferes as a heteropic facies with the lower part of the Antonín Member (localities Hájek, Lesov, Otovice, Družba pit near Nové Sedlo and Marie pit near Královské Poříčí) (Fig. 2). In places, where the Anežka Seam is developed (localities Těšovice, Sokolov, Vítkov), the Těšovice Member is sandwiched between the Anežka and Antonín seams. The unit is always resting immediately and conformably upon the underlying beds (Habartov, Anežka or Antonín members respectively), whereas the overlying Antonín Member is separated from volcanic cones and lahars by an unconformity.

Dating. The biostratigraphic assignment of the Těšovice Member is based on palynologic data only. The organic detritus preserved in tuffs contains the same pollen and spores assemblages as the Antonín and Anežka seams, which are taxonomically more varied and more thermophile than those in the Chodov Member (Konzalová, 1973, Konzalová – Kvaček, 1980).

Stratotype. The Těšovice Member is occasionally accessible at the Družba opencast mine west of Nové Sedlo (Rojík, 2004). Little outcrops exist in the village Těšovice and in the Marie pit near Královské Poříčí.

The Anežka Member

Characteristics. The traditional lithostratigraphic unit of the Sokolov Basin is formally designated as a member subordinated to the Sokolov Formation. The name Anežka (Agnes in former German papers) for both coal seam and litostratigraphic unit is a *nomen conservandum* but can be also considered as a geographic name (mining claims and coalmine west of the Svatava village – J. Jiskra, pers. com.).

The dominant and diagnostic rock-type of up to 16 m thick Anežka Member is the autochthonous coal of saprodetritic and liptodetritic type. The organic sedimentation developed owing to the coincidence of a warm humid climate and of a temporary break in the tectonic and volcanic activity.

The bottom- and top boundaries of the Anežka Member are conformable but heterochronal and have a character of a sudden oscillation transition. Typical is the tendency to a finger-like splitting of the coal benches close to the neighbouring units.

The Anežka Member immediately underlies the tuffs and lava flows of the Těšovice Member, the sands of the Habartov Member or the bituminous clay and lignite of the Antonín Member. In the localities, where sandy alluvial cones of the Habartov Member occur, the Anežka seam approaches their base. Some sandy beds, however, lie even under the seam. Despite of this complicated heteropic facies alternation, boundaries of the Anežka Member can be always reliably set in the field due to the pronounced petrographic contrasts, rapid oscillating transitions and the specific coal lithotypes.

It should be emphasized that in the western part of the Sokolov Basin, where both coal seams are developed, the Anežka Seam is always the older one. It is separated from the Antonín Seam by a part of the Habartov Member or, at least, by a clay intercalation. In the central part of the

basin the Anežka seam has not been developed at all. There, the sedimentation of the lower part of the Antonín seam was synchroneous with that of the Anežka seam in the western part. This opinion is supported by three independent observations:

– Tuffite intercalation of the Anežka Seam in the western part of the basin is similar to the intercalation No. 30 of the Antonín Seam in the central part of the basin (R. Galek, pers. com.). In the western part of the basin, the bottom part of the Antonín Seam, including the intercalation No. 30, has not been developed;
– Kaolinitic titanium-rich sandy clays with Al-hydrates underlie the Anežka Seam in the western part. The same clays underlie the Antonín Seam in the central part of the basin;
– The pyroclastic rocks interbedded in the lowermost part of the Antonín Member in the central part of the basin and tuffs overlying the Anežka Seam in the western part of the basin are identical;

Dating. Konzalová (1969, 1973, 1985) pointed out that palynologic spectra of the Anežka and Antonín seams do not exhibit any differences and both suggest Burdigalian age. Bůžek et al. (1988) found thermophile pollen spectra, dominantly composed of palaeotropic *Fagaceae*. According to the palaeomagnetostratigraphic data extrapolated from the Či-165 drill near Svatava (Malkovský – Kropáček, 1993, Malkovský, 1995), the Anežka Member is about 22.6–22.5 Ma old.

Stratotype. The typical section of the Anežka Member occurs in the Medard-Libík pit, 2 km west of Svatava (Rojík, 2004).

The Antonín Member

Characteristics. The traditional name Antonín (in former German mining maps Anton or Antoni) is retained as a *nomen conservandum* and assigned to both lignite seam and a lithostratigraphic unit. It had also a geographic meaning and designated claims and lignite mine in Svatava (J. Jiskra, pers. com.).

The Antonín Member forms the uppermost part of the Sokolov Formation in the Sokolov Basin. Its dominant and diagnostic rocks are autochthonous lignites of the humite type. The thickness of this member reaches 70 m (JD-4545 drill near Sadov). The organic sedimentation during the Burdigalian warm and humid climate developed whenever the tectonic and volcanic activity in the basin declined.

The boundary of the Antonín Member with the underlying Habartov Member is oscillating, heterochronal, conform, marked by the onset of bituminous clays and lignite deposition.

Within the Antonín Member, tuffs of the Těšovice Member are also developed in places. They are in a sharp contrast with the Antonín Member, both in lithology, textures and genesis. Therefore, it is easy to distinguish the two units.

The boundary with the overlying Cypris Formation is sharp, almost isochronal, conform, caused by a sudden change in the lithology and facies.

Dating. Konzalová (1969, 1973, 1985) pointed out that pollen spectra of the Burdigalian seams are similar each to other and, as a whole, differ from the associations of the Chodov Member. According to the palaeomagnetostratigraphic data from the drill Či-165 (Kropáček – Malkovský, 1993, Malkovský, 1995) in the western part of the Sokolov Basin, the age can be ranged to a time span of 22.2–21.3 Ma. In the central part of the basin, due to the connection of seams, the base of the Antonín Member may reach to ca. 22.6 Ma.

Stratotypes. The most important sections of the Antonín Member occur in the Jiří and Družba opencast mines in the central part of the basin. A typical section of the western part of the basin was described by Rojík (2004) in the Medard-Libík pit near Habartov.

The Cypris Formation

Characteristics. The Cypris Formation is a typical *nomen conservandum* (Reuss, 1851, 1852, Václ, 1964). The formation has a specific lithology, textures and facies. It has been accepted by geologists of many generations. Cypris Formation represents an important stage of the basin development and fulfils criteria of lithostratigraphic formations. An attempt to change this traditional approach and extend the unit for an unclearly defined part of the coal-bearing Miocene strata (Shrbený et al., 1986, 1994) did not find much support.

The Cypris Formation reflects the Miocene period of the common development of Sokolov and Cheb basins, which is characterized by a stepwise decline in the dynamics of tectonic and volcanic processes. A slow sedimentation of prevalently fine-grained terrigenous material commenced in permanent fresh-water lakes and continued into brackish meromictic intermittent lakes. The sedimentation was influenced by a warm climate with a tendency to aridization. The diagnostic sediments of the Cypris Formation are laminated claystones with an essential presence of kaolinite, illite and minerals of the smectite group, further with a constant admixture of dispersed primary carbonates and of algae- and pollen-derived organic matter.

The thickness of the Cypris Formation reaches 182 m in the NS-82 drill. Alltogether 28 (composite) marker beds more or less extending all over the basin have been described (Tab. 2, more information in Rojík, 2004).

The boundary between the Sokolov Formation (Antonín Member) and the Cypris Formation is very sharp, locally oscillating in detail, conform, almost isochronal. It reflects a regional change of environment from the coal-forming mire to a lake. Traces of erosion and weath-

ering of the lignite roof are rare, e.g. in the Medard coal pit (Bůžek et al., 1996). The irrigation of the mire resulted from a long-term subsidence, which began earlier on the levelled relief. Presumably, the subsidence was caused by a combination of tectonic, compaction and coalification processes (Rojík, 2004).

The Cypris Formation is the youngest Tertiary formation of the Sokolov Basin. Thus, the erosional boundary between the Cypris Formation and the overlying Vildštejn Formation can be studied only in the Cheb Basin. Here, in the clay pit Nová Ves 2, the laminated sapropelitic claystone of the Cypris Formation is modified to a residuum (green clay with a collapsed texture – technological type "GE") and a fossil soil horizon (green-brown bio-turbated clay with white permineralized roots). The Vildštejn Formation (Pliocene), separated by a hiatus, begins with a soil horizon densely penetrated with carbonised rootlets of water plants (kaolinite clay – technological type "K").

Dating. In the Sokolov Basin only local biostratigraphic correlation on the basis of fish assemblages can be used for fixing relationship of the Cypris Formation with the adjacent Cheb Basin. Because there are only two fish biozones developed – zone I. B *Palaeotinca egeriana* and *Leuciscus sokoloviensis* at the base of the formation and zone II *Leuciscus sokoloviensis,* which represent major part of the succession (Obrhelová – Obrhel, 1983), the Cypris Formation is incompletely developed in the Sokolov Basin compared with the Cheb Basin. The zones correlate with the Mammalian biozone MN 4 (Ottnangian) well documented by a rich fauna from Dolnice in the neighbouring Cheb Basin (Fejfar, 1974). The palaeobotanic data from both basins suggest the Ottnangian – Karpatian age (Bůžek et al., 1996).

The palaeomagnetic age of the Cypris Formation in the Sokolov Basin is ca. 21.3–16.5 Ma (Kropáček – Malkovský, 1993, Pruner – Venhodová, 2004), according to the sections in the drill KP-122 and in the Družba mine, both near the village Královské Poříčí.

Stratotypes. The holostratotype must be selected within the Cheb Basin (e.g. Mokřina) because the unit was first defined there. In the Sokolov Basin the typical and complete sections of the Cypris Formation occur in the Jiří, Družba, Marie and Lomnice open pit mines.

The Čankov Sand

Characteristics. The Čankov Sand was first mentioned by Schardinger (1890) and described by Juranka (1954), Kukla (1959) and Šantrůček et al. (1962). It is developed in separated Otovice depression in the eastern part of the Sokolov Basin, near the Čankov village 4 km north of Karlovy Vary. These deposits, up to 30 m thick, originated as delta bodies along the Čankov fault and were progradating to the depocenter. The stratigraphic position within the Cypris Formation was confirmed by Kopecký (1961) who found ostracods *Cypris angusta* above the sands in the 40 m thick set of laminated claystones.

The Čankov Sand, regarded as a particular member within otherwise monotonous claystone succession of the Cypris Formation, is separated from the underlying claystones by an erosion plane and represents an upwards fining set of strata of cross-bedded sands, sandstones and conglomerates intercalated by sandy clays. The transition to the overlying claystones is sharp and well contrasting for any fieldwork.

Dating. No direct data for this unit are available.

Stratotypes. The typical section occurs in the sand pit at the Čankov village near Karlovy Vary. Typical drilling works are JD-4546 (Obr, 1971) and KH-10 (Šantrůček et al., 1962).

Note to the correlation of the Krušné hory (Erzgebirge) Tertiary piedmont basins

The Staré Sedlo Formation of the Sokolov Basin corresponds in age especially to the localities Nový Kostel in the Cheb Basin, Český Chloumek in the Teplá Upland, Valeč in the Doupovské hory Mts. (Knobloch et al., 1996) and Kučlín in the České středohoří Mts. (Kvaček, 2002). All these localities contain similar plant remnants.

The clastic rocks of the Davidov Member deposited during structural modification of the collapsed Sokolov Basin may correspond to the Krásný Dvůr Formation in the Most Basin (Váně, 1999), as indicated by similar lithology and textures.

The onset and cessation of the basin extension have a similar age respectively, in all the piedmont basins. In the Sokolov Basin, and very probably in the Cheb Basin, the extension period is represented by the Nové Sedlo, Sokolov and Cypris formations. These formations are likely equivalent to the Most Formation (i.e. the Basinal Complex of the Most Basin in its informal stratigraphy).

Major differences among the basins are in the age of their volcanism, which is most intense in the Most Basin and adjacent České středohoří Mts. between 36–17 Ma (Hurník, 2001) or 42–17 Ma (Kopecký, 1987–1988), while in the Sokolov Basin it took place mainly in the time range of 24–17 Ma (Rojík, 2004) and in the Cheb Basin probably culminated between 23–16 Ma. The volcanic activity was generally spreading from NE to SW. This fact explains why the Staré Sedlo Formation in the České středohoří Mts. contains volcanic admixture (Kvaček, 2002) and in the Sokolov Basin likely not (Rojík, 2004). In the Most Basin volcanic maxima and periods of sedimentation were separated in time. The volcanic Střezov Formation, i.e. the "Subbasinal Volcanic Complex" of informal stratigraphy, was overlain by the

"Basinal Complex", i.e. The Most Formation, after a pronounced hiatus. However, in the Sokolov Basin and probably in the Cheb Basin the effusive and pyroclastic rocks interfered much more tightly with the sediments of the Nové Sedlo, Sokolov and, in part, the Cypris formations.

It is obvious, that the more details we know about the stratigraphy of the particular basins, the more differences appear among them. It is necessary to avoid extrapolation of any unit from one to another neighbouring basin (for instance the Střezov Formation to the Sokolov Basin), unless the continuity is clearly corroborated (as is the case with the Cypris Formation of the Cheb and Sokolov basins). The present stratigraphic study of the Sokolov Basin aims to inspire future studies by specialists and research teams working on Tertiary of the Bohemian Massif.

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Nové stratigrafické členění terciéru sokolovské pánve v sz. Čechách

Je předložen aktualizovaný návrh stratigrafie terciéru sokolovské pánve. Litostratigrafické jednotky jsou definovány podle litologických kritérií. Litostratigrafická škála se opírá o chronostratigrafická data odvozená na základě biostratigrafických a magnetostratigrafických výzkumů. Množství litohorizontů a jednoduchých či složených litologických obzorů dovoluje přesnou korelaci mezi heteropickými jednotkami. Terciérní vulkanicko-sedimentární výplň pánve je rozdělena do čtyř souvrství: Starosedelské souvrství (hranice eocén/oligocén, ca. 35 Ma) reprezentuje iniciální, převážně fluviální stádium vývoje pánve. Novosedelské souvrství (oligocén až nejspodnější miocén, ca. 24–23 Ma) odráží první fázi regionální extenze pánve, doprovázenou intenzívním vulkanismem a tektonickou subsidencí. Toto souvrství se skládá ze tří členů, které se zčásti heteropicky zastupují či prolínají: davidovských vrstev, josefských vrstev a chodovských vrstev. Sokolovské souvrství (spodní miocén, ca. 23–21 Ma), oddělené od předcházejícího souvrství diskordancí, odráží druhou fázi extenze pánve, tektonické subsidence a vulkanismu. Je rozděleno do čtyř členů, heteropicky se prostupujících a označených jako habartovské vrstvy, těšovické vrstvy, anežské vrstvy a antonínské vrstvy. Cyprisové souvrství (spodní miocén, ca. 21–17 Ma) s lokálně vyvinutým členem čankovských písků je charakterizováno postupným vyhasínáním dynamiky endogenních procesů. Starosedelské, novosedelské a sokolovské souvrství jsou oddělena diskordancemi. Hranice mezi sokolovským a cyprisovým souvrstvím je konkordantní, odráží však náhlou regionální změnu prostředí.