Sedimentology of the Subsilesian Unit

Summary of the Czech text

Introduction

The Subsilesian Unit (after HANZLÍKOVÁ et al. 1953) represents the lowermost group of the superficial nappes of the Outer West Flysch Carpathians on the territory of the Czech Republic between the rivers Morava (in the west) and Olše (in the east), Fig. 1. Together with the Ždánice Unit between the rivers Morava and Danube, it composes the Ždánice-Subsilesian Unit, which is the easternmost prolongation of the Helveticum from Eastern Alps. According to the prevalence of the Frýdek Formation and the paucity of equivalents of the Ždánice-Hustopeče Formation some authors (ROTH - HANZLÍKOVÁ in BUDAY et al. 1967 etc.) classify the Subsilesian Unit as a segment of the Ždánice-Subsilesian Unit s.l. or as a separate unit (ČTYROKÝ - STRÁNÍK 1995).

The sequence of the Subsilesian Unit consists predominantly of pelitic rocks of the Upper Cretaceous (Turonian) up to the Late Oligocene. The entire sequence is limited on its bottom and on its top by thrusts. Subsilesian Unit is divided into two nappes. The lower nappe was thrust on the deposits of the older foredeep after the sedimentation of the Karpatian (the older Young Styrian nappes). The upper nappe was thrust (together with the nappes of the Silesian Unit) over the older Subsilesian nappe and over the younger foredeep of the Lower Badenian during and at the end of the sedimentation of this stage (the younger Young Styrian nappe). The uppermost part of the profile through the older nappe was weathered before thrusting of the younger nappe (JURKOVÁ 1964, 1967, 1975 and others).

The nappes of the Outer West Flysch Carpathians were thrust over the SE passive margin of the Variscan West European Platform. The West European Platform below the Subsilesian Unit consists at depth of the Precambrian crystalline of the Brunovistulicum with the Paleozoic cover (from the Early Devonian up to the Late Carboniferous). The epi-Variscan platform is covered by sediments of the Carpathian foredeeps (partly Eggenburgian, Ottnangian, mainly Karpatian and Lower Badenian) – Fig. 2.

The nappes of the Subsilesian Unit were thrust over the basement over the distance of 20 km (after the results of the boreholes Jablunkov 1, Písek 1 in the NE, Ostravice 1, Čeladná SV-6, Rožnov 1 in the S and Hrachovec NP 518 and Valašské Meziříčí 1 in the SW. The area of the distribution of the lower nappe is known only there, where it is covered by deposits of the Lower Badenian (JURKOVÁ l.c.). A breccia of Karpatian rocks is present at the base of the lower nappe (the so-called parautochthonous Karpatian - SVATUŠKA et al. 1991 and others).

Subsilesian Unit crops out in the Podbeskydská pahorkatina area and Hostýnské vrchy Upland. Some exposures were found in the tectonic windows of Ženklava, Frýdlant and Jablunkov (under the Silesian Unit) and as some tectonic slices in the Silesian Unit.

Sedimentological study of the Subsilesian Unit is very complicated. Its sequence is markedly disturbed by slices, ductile deformations and by crushing. The thickness of the slices fluctuates between several metres and hundreds of metres (ROTH 1971). The outcrops of the Subsilesian Unit are very scarce. They concentrate in river beds or ravines. Additional information was obtained from several hundreds of boreholes drilled for hardcoal seams in the Variscan basement and for gas traps in the Lower Miocene (summary in ĎURICA - SUK et al. 1991).

Lithostratigraphy and facies of the Subsilesian Unit

Lithostratigraphy of the Subsilesian Unit was defined predominantly by MENČÍK - PESL (1953), ROTH (1962), ROTH et al. (1962a, b), HANZLÍKOVÁ - PÍCHA - CICHA (1963), ELIÁŠ (1964, 1991, 1993) and MENČÍK et al. (1983). Defining of the lithostratigraphic units and facies is very complicated due to the intricate tectonic structure and facies relationships. This complexity is documented by the example of the so-called Variegated Subsilesian Member (ROTH l.c., MENČÍK et al. 1983, etc.) of the Upper Cretaceous up to Late Eocene age, especially by the stratigraphic position of the red shales. This "Member" was used as a key horizon for structural purposes. But a detailed analysis of the stratigraphic position of the red beds (for example in the borehole Kozlovice SV-1 etc.) documented that the "Variegated Subsilesian Member" represents randomly distributed lenses of red shales in the Frýdlant Formation. Therefore it is not possible to use the lenses of red shales as a key horizon for stratigraphic correlations.

The following lithostratigraphic units are used in this paper for the description of the Subsilesian Unit:
Frýdek Formation (Late Cretaceous, Turonian–Danian)

Frýdlant Formation (Late Cretaceous–Late Eocene)
Menilitic Formation (Early to Middle Oligocene)
Ženklava Formation (Late Oligocene).

Frýdek Formation (Turonian–Danian) was named after the town of Frýdek, now a district of the town Frýdek-Místek. This formation was defined by HOCHSTETTER (1852) as Baculite Marls from Frýdek. The principal description of this formation was given by ANDRUSOV (1959), ROTH (1962), ROTH et al. (1962a, b), HANZLÍKOVÁ - ROTH (1963) and MENČÍK et al. (1983). The shape of the sedimentary body of the Frýdek Formation is irregular. The lower boundary is tectonic. The upper boundary of the Frýdek Formation is characterized by a gradual transition to the Frýdlant Formation. This boundary is not synchronous in the whole area of the distribution and it ranges from the Campanian up to the Danian. The thickness of the Frýdek Formation is about 500 m.

The Frýdek Formation consists predominantly of grey to brown-grey calcareous claystone, marl and argillaceous limestone. The sequence of these rocks encloses sparse intervals of fine- to medium-grained turbidites – calcareous sandstones and clastic limestones (Tab. 1, Figs. 4, 5, 6, 7). Concretions of argillaceous ironstone (argillaceous siderite and ankerite) are present. Tilloid conglomerates compose very important parts of some sections, especially in the rear part of the Subsilesian Unit. These slump bodies are very frequent in the Třinec furrow, in the Jablunkov tectonic window (BOUČEK 1952, PŘIBYL - BOUČEK 1956 and others). These deposits contain blocks and pebbles of crystalline rocks, Devonian and Lower Carboniferous limestones, sandstones, shales and hardcoal of the Upper Carboniferous age and intraclasts from the Subsilesian Unit. The slump bodies with the prevalence of intraclasts mainly of shallow water origin are characteristic for the inner parts of the Subsilesian Unit. The thickness of the slump bodies reaches up to tens of metres.

Klokočov Member (Maastrichtian–Danian) was named after Klokočov, the eastern part of the town of Příbor. This member was defined by REMEŠ (1906), SLAVÍČEK (1907), BECK (1910, 1911) and TRAUTH (1911). It was included in the map of BECK - GÖTZINGER (1932) as the "Nullipora Sandsteine" or "Klogsdorfer Sandsteine mit Korallen", together with the "Frydeker Mergl" to the lithostratigraphic unit Klokočov Member. ROTH (1957, 1962) and ROTH et al. (1962a, b) did not suggest, that the Klokočov Member contains the claystone of the type of the Frýdek Formation and placed it together with the sandstones of the Frýdlant Formation as the Stráž Facies into the Subsilesian Submenilitic Formation. ELIÁŠ (1991) redefined the Klokočov Member (sensu BECK l. c.) as a member of the Frýdek Formation. In the Klokočov Member, according to this definition, it is possible to distinguish two facies: the sandstone and the claystone facies.

The sandstone facies encompasses turbidites and fluxoturbidites. The sequence of these deposits consists of conglomerates and sandstones prevailing over claystones (Fig. 9). The thickness of these sequences reaches several decimetres to metres. The clasts in the conglomerates consist of quartz, crystalline rocks (phyllites) and rocks of the Upper Carboniferous age (sandstones, hardcoal). Very important is the presence of the clasts of the hermatypic hexacorals (ELIÁŠOVÁ 1989).

The claystone facies of the Klokočov Member comprises two types. The first type is the claystone facies s.s., only with very scarce beds of sandstones. The second one is characterized by sets of sandstone beds with thicknesses of several metres.

The sandstone/mudstone ratio in the claystone facies of the Klokočov Member is 0.7 (this ratio is higher than in the typical sequences of the Frýdek Formation, where this ratio has values of 0.1–0.2). The thickness of the sandstone beds in the claystone facies s.s. reaches usually 1–5 cm and sporadically up to 50 cm (Figs. 11, 19). The sandstone beds are normal graded and laminated in their upper parts. Some sandstone beds have a shape of lenses decimetres to metres in length.

The sequences of the facies of the claystone contains some 3–6 m thick complexes of sandstone beds (Fig. 13).The sand/shale ratio in these complexes is 1.3–1.4. These sandstone beds have very distinct lower bedding planes with erosion marks and trace fossils. These beds are characterized by indistinct normal vertical grading in the coarse-tail, combined with internal lamination (with traces of the convolute lamination) and traces of ripple-marks and cross-bedding in the upper parts of the beds. Some of the sandstone beds are homogeneous or chaotic bedded, with random orientation of flat clasts. The occurrence of couplets of beds with the alternation of homogenous and laminated structures and/or with cross-bedding is typical (Fig. 12). According to the published examples (READING et al. 1986 etc.) we interpret these sequences as tempestites.

The sandstones are accompanied by white-grey clayey micrite or marl with dark grey spots (bioturbation).

The thickness of the Klokočov Member is about 50 m. This member is typically developed in the area between Nový Jičín and Příbor and in the valley of the Olše River.

Frýdlant Formation (after the town of Frýdlant nad Ostravicí, ELIÁŠ 1993) develops gradually from the Frýdek Formation. Its lower boundary is asynchronous. The transition between the Frýdek and Frýdlant formations was dated to the Campanian–Danian. The upper boundary of this about 800 m thick formation is gradational, too. The progressive gradual contact with the Menilite Formation is dated to the lowermost Oligocene.

The Frýdlant Formation was formerly labelled as the "Subsilesian Submenilite Formation", partly as the "Subsilesian Variegated Member" (MENČÍK - PESL 1955, ROTH 1957, 1962, MENČÍK et al. 1983), Třinec Member and Gúty Member (MENČÍK et al. 1983). Frýdlant Formation in its definition comprises also the Stráž Sandstone, which represented one of the members of the "Subsilesian Submenilite Formation" also (HANZLÍKOVÁ et al. 1955, MATĚJKA 1957, ROTH 1962, ROTH et al. 1962a, b, MENČÍK et al. 1983).

Frýdlant Formation is characterized by very strong differentiation of facies. In some parts of its sequence, a very fine alternation of multicoloured claystone with green, grey and black claystones is visible. These beds are several centimetres up to several metres thick. The limiting factor for the determination of some facies are also the big tectonic disturbances (MENČÍK 1960, HANZLÍKOVÁ - PÍCHA - CICHA 1963, MENČÍK et al. 1983, JURKOVÁ 1983). Therefore, it is very difficult and subjective also, to define some members in the Frýdlant Formation. That is why we define only some lithofacies in the Frýdlant Formation.

In the Frýdlant Formation it is possible to distinguish the following principal lithofacies:

a) the facies of spotted claystones,
b) the facies of black-grey claystones,
c) the facies of sandstones and conglomerates,
d) the facies of variegated claystones.

The lithofacies of slump bodies (the conglomerates with disorganized structure) has a separate position. This facies is developed partly in the frontal part of the Subsilesian Unit (between Hranice na Moravě and Nový Jičín) and in the Třinec Furrow in the rear part of this unit. Some slump bodies are developed partly in the inner parts of the Subsilesian Unit, too. The deposits of these slump bodies are described together with the rocks of the lithofacies of spotted claystones.

The lithofacies of spotted claystones is present in the whole sequence of the Frýdlant Formation. The prevalent rock of this facies is the spotted claystone, grey, green-grey, with light and dark grey spots. The amount of sand and silt admixture varies greatly (Tabs. 3, 4, Figs. 14, 16). The content of the limy admixture is the lowest in the lower part of the sequence (Paleocene) and rises up to the upper part of the sequence (latest Eocene). It reaches its maximum below the Menilite Formation, in the equivalents of the Globigerina Marl (Šešor Horizon) – Tab. 6.

The claystones of this facies are partly homogeneous, lacking internal structures, partly laminated. Horizontal lamination prevails over cross-bedding. In the outcrop (Guty creek) it was found cross-bedded sets in the laminated claystone (Fig. 15). Intercalations of fine-grained sandstones (Tab. 3, Fig. 16) and limestones (Fig. 4) of small thickness are randomly present. In some sections the sandstone beds are concentrated into sets several metres thick. According to their structures, these sandstones and limestones can be classified as turbidites or fluxoturbidites (Fig. 17a). Sandstone turbidites are more frequent in the time interval from Danian to Middle Eocene and the allodaphic limestone in the Danian–Paleocene and in the Middle Eocene.

The slump bodies in the Frýdlant Formation belong to two principal types. In the first type intraclasts predominate (prevalence of claystones from the Frýdek and Frýdlant formations) – boreholes Bartošovice 1, Žabeň NP 111 etc. These slumps were situated on the foot of slopes of the intrabasinal highs. The slump bodies of the second type contain extraclasts (crystalline rocks, Paleozoic limestones etc.). They crop out along the inner and outer margins of the Subsilesian Unit (localities Rouské, Bernartice – Fig. 19, Polom – Fig. 20, the valley of the Olše River near the town of Bystřice nad Olší – Fig. 18, etc.).

The uppermost part of the sequence of the facies of spotted claystone was studied in the borehole section H-507 (village of Černotín, east of the town of Hranice, in the valley of the Bečva River). This borehole encountered green-grey, brown-grey spotted claystones and calcareous claystones, which represent partly the stratigraphic equivalent of the Globigerina Marl (Šešor Horizon).

The petrographical characteristics of the facies of spotted claystones are given in Tables 3–8 and in Figs. 14 and 16.

The lithofacies of black-grey claystones (anoxic facies, ROTH 1962 and others) is characterized by the prevalence of dark-grey up to black-grey claystones, with a variable admixture of silty and sandy fractions and with insignificant contents of calcareous fraction. The intercalations of turbidites (sandstones and allodaphic limestones) are infrequent (Tables 3, 4, Fig. 7). This facies was typically developed in the Paleocene. In the area of the Třinec Furrow it can be partly mapped (Guty Member; MENČÍK - PESL - PLIČKA 1956, MENČÍK et al. 1983).

The lithofacies of conglomerates and sandstones (Stráž Sandstone, together with the Klokočov Sandstone – ROTH 1957, 1962, ROTH et al. 1962a, b, MENČÍK et al. 1983 and others) is characterized by the presence of turbidites and fluxoturbidites – 10–250 cm thick sandstone beds (amalgamated sandstone bands over 10 m thick). These sandstone beds are either randomly distributed or built up sequences of sandstone beds up to 10 m thick. In some sections in this facies it is possible to observe beds of fine-grained petromict conglomerates with clasts of crystalline rocks, granitoids, Devonian and Carboniferous rocks and hardcoal. The sandstones from this facies contain bioclastic admixture (algae, forams, corals, molluscs etc.). The sandstones contain micrites and biomicrites (Tabs. 3, 4, 8, fig. 7).

It is sometime very difficult to determine the presence of this facies as very similar sandstones are present in other facies of the Frýdlant Formation, too. The lithofacies of conglomerates and sandstones typically developed in the Paleocene, very often together with the lithofacies of black-grey claystones. The lithofacies of the conglomerates and sandstones is developed typically in the area between the towns of Valašské Meziříčí – Nový Jičín – Příbor, between the villages of Mošnov and Paskov and in the area of the Třinec Furrow.

The lithofacies of variegated claystones (ROTH 1957, 1962, ROTH et al. 1962a, b, MENČÍK et al. 1983 – the "Subsilesian Variegated Member") is characterized by the prevalence of claystones and calcareous claystones over sandstones. Very typical is the presence of red and brown-red claystones. Intercalations of sandstones are subordinate and their thickness generally does not exceed 10 cm.

The variegated claystones are developed as the intercalations in most of the sequence of the Frýdlant Formation. Therefore, it is not possible to define them as the lithostratigraphic unit "Variegated Member" and they cannot be used for correlation (cf. ELIÁŠ 1983, 1993). The same situation was described for the Ždánice Unit by ADAMOVÁ - STRÁNÍK (1984).

The composition of the rocks of the lithofacies of variegated claystones is characterized in Tables 3 and 8 and in Fig. 7.

The Menilitic Formation (Lower to Middle Oligocene) is about 50–100 m thick. The base of the Menilitic Formation is conformable and gradational, with a gradual change from brown claystones of the Frýdlant Formation to deep brown claystones of the Menilitic Formation (HANZLÍKOVÁ 1981, MENČÍK et al. 1983). The typical rocks of the Menilitic Formation are deep brown bedded cherts. They are composed of quartz and opal, with some impurities. The cherts are associated with white-grey marly limestones and with prevailingly brown claystones (Tab. 8). The colour of this rock is whitish after weathering. A very instructive section of the Menilitic Formation was described by BUBÍK (1989) from the Třinec Furrow. In this section, the described claystones are followed by intercalations of coarse-grained subgreywackes associated with orthoquartzites. The sandstones from this section contain bioclastic admixture (big forams, algae etc.). Bioclastic breccias were encountered in some sections in the Menilitic Formation (tectonic window of Ženklava etc.).

Specific facies development of the Menilite Formation is the facies with slump bodies. This facies is developed in the Olše River valley. In this section, the beds of paraconglomerates, several metres thick form intercalations in the section of claystone over 100 m thick. These paraconglomerates contain clasts of crystalline rocks, limestones and sandstones of Devonian and Carboniferous ages and intraclasts of Cretaceous and Paleogene rocks from the southern slope of the Subsilesian Basin.

Ženklava Formation (Late Oligocene; the name after the village of Ženklava, 5 km SW of the town of Kopřivnice; typical outcrops in a valley of a small creek ca. 150 m SW of the church in the village of Ženklava) developed gradually from the Menilite Formation. The upper boundary of this, a dozen metres thick formation, is tectonic. The Ženklava Formation is characterized by the presence of the Bouma sequences with deep grey, fine-grained calcareous subgreywackes in its lower parts and black-grey claystones in its upper parts (Fig. 21).

The evolution of the Subsilesian Unit

The Subsilesian Unit, as the NE part of the Ždánice-Subsilesian Unit, is characterized by the non-flysch development from the Turonian up to the Late Oligocene. The cumulative thickness of the Subsilesian Unit is about 1 200–1 500 m. This thickness, in comparison with the thicknesses of the Silesian Unit (over 8 000 m) and Magura Group (over 4 500 m) is relatively low. The ratio of the coarse/fine-grained deposits is also very low in the Subsilesian Unit (about 0.15). The possibilities of basin analysis are very limited, because the Subsilesian Unit has a very complicated tectonic structure. The sandstone/claystone ratio is the lowest in the Late Eocene and Early Oligocene deposits (the upper part of the Frýdek Formation and Menilitic Formation (Tables 5, 7, Fig. 22). The Upper Creta-

ceous up to Middle Eocene sandstone beds are present, but the prevalence of claystones over sandstones and clastic limestones is also significant. The Ženklava Formation contains frequent beds of turbidites.

The paleogeographic reconstruction of the Ždánice-Subsilesian Unit is based on its tectonic position in the system of the Outer Flysch West Carpathians, on its internal structure and facies distribution and on the transport directions (ROTH - HANZLÍKOVÁ in BUDAY et al. 1967, ELIÁŠ 1974, SLACZKA et al. 1976, 1984, MENČÍK et al. 1983, ELIÁŠ - ELIÁŠOVÁ 1984, 1995 and others).

On the Czech territory it is possible to follow the sedimentary records in the Ždánice-Subsilesian Unit from the Oxfordian (Klentnice Formation in the Pavlovské vrchy Hills - ELIÁŠ 1991) to the Early Miocene (Ždánice Unit - STRÁNÍK et al. 1993). It is very probable that the Ždánice-Subsilesian Basin originated in the time of the Early Jurassic extension on the North Tethyan passive margin, i.e. on the southern border of the West European Platform (ELIÁŠ 1974, SAUER et al. 1992, ELIÁŠ - ELIÁŠOVÁ 1995). The Upper Jurassic and the Lower Cretaceous sedimentary records are known fragmentarily in the Waschberg Zone only. An uninterrupted sequence of sediments in the Subsilesian part of the Ždánice-Subsilesian Unit is known from the Turonian (Frýdek Formation) to the Late Oligocene (Menilitic Formation). In the Ždánice part of the Ždánice-Subsilesian Unit there are also younger formations and the sequence can be followed from the Turonian to the Lower Miocene. The Pavlov Formation (STRÁNÍK et al. 1996), earlier the Klement Formation or the beds with Belemnitella mucronata ("Mucronate Member") in the Waschberg Zone represent a part (or a facies) of the Frýdek Formation only.

The sedimentation of the Frýdek Formation took place in the anoxic environment, very probably in the relatively shallow basin with normal salinity. This Upper Cretaceous basin was vertically differentiated in detail. According to the spatial distribution of the slump bodies and proximal turbidites and fluxoturbidites it is possible to distinguish: a) the inner (or the southern) slope-foot facies at the foot of the Baška Cordillera (slump bodies in the Olše River valley south of the town of Třinec) and b) the outer (or the northern) slope-foot facies (between the towns of Hranice na Moravě and Nový Jičín) at the contact with the West European Platform.

It is possible to correlate the inner slope-foot facies with the Čejč-Zaječí Zone of the Ždánice Unit.

According to the distribution of facies and forms of sedimentary bodies it can be supposed that the main source areas of the clastics were situated in the south (Baška Cordillera) and in the north (southern margin of the West European Platform, party the Pavlov carbonate platform). It is very probable that the source of the pelitic material was lying in the extensive northern foreland of the Ždánice-Subsilesian Unit. The Baška Cordillera was more important as a source of coarse clastics at the margin of the West European Platform. According to the redeposited micrite and clasts of the Tertiary limestone (slump body at the locality of Rouské) it is possible to suppose that the carbonate sedimentation took place on the southern margin of the West European Platform in some time intervals (Upper Cretaceous, Eocene – Fig. 23).

The deposits of the Upper Cretaceous up to the Middle Eocene are characterized by the presence of lenses of coarse clastics and slump bodies with the prevalence of intraclasts (clasts of claystone and marl, coral limestone etc.). These lenses are distributed in the central part of the Subsilesian Basin. These bodies of sediments do not have any relations to the marginal sources of clastics (Klokočov Member, the sandy facies of the Frýdek Formation and the sandstone facies of the Frýdlant Formation, formerly the "Sandstone of the Stráž type"). These deposits contain redeposited clasts of shallow-water carbonates, together with shallow-water benthos (SLAVÍČEK 1906, TRAUTH 1911, HANZLÍKOVÁ et al. 1955, VAŠÍČEK 1988, ELIÁŠOVÁ 1989, ELIÁŠ 1991, 1993). These carbonates and redeposited organisms indicate the presence of the relatively small intrabasinal elevations, which represented complementary source areas of clastics of the Subsilesian Unit.

The model of the relationships between the intrabasinal elevations (the local sources of the clastics) and the sediments of the Subsilesian Basin is documented by the position of the principal facies of the Klokočov Member in the area of the town of Příbor (ELIÁŠ 1991). North of this town a tectonic slice with turbidites, fluxoturbidites and slump deposits is developed. In these deposits, clasts of silicified colonies of Hexacorallia are very important (ELIÁŠOVÁ 1989). South of the town of Příbor we can find tectonic slices with shallow-water deposits – claystones with beds of tempestites. In a tectonic slice lying farther to the south, near the village of Lubina, claystones and marls of the Frýdek Formation are developed with intercalations of slump bodies with intrabasinal clasts (i.e. without exotic blocks).

According to the paleogeographic interpretations we suppose that the tempestites and the limited carbonate sedimentation with hexacorals took place on an intrabasinal elevation. The facies distribution in the Subsilesian Basin indicates that the slopes of this elevation were very steep. On the foot of the slopes of this elevation, turbidites, fluxoturbidites and slumps were deposited. The same sedimentary conditions can be postulated for other intrabasinal bodies of sandstones and conglomerates in the Frýdlant Formation, too.

These elevations developed under extensional regime in the Upper Cretaceous and Paleogene as a system of tilted

blocks which divided the Subsilesian Basin in a set of depressions and elevations (only partly submerged). It is very probable that during the process of tilting a system of subbasins developed in the Subsilesian Basin, which were characterized by different depths and geochemical – redox-conditions (anoxic facies with black grey claystone, aerated facies of variegated claystone and "neutral" facies with grey-green claystone). Turbidites and fluxoturbidites accumulated in the deepest parts of the subbasins, very often in the facies of black-grey claystones.

In the Late Eocene and Early Oligocene, extensional deepening of the Subsilesian Basin took place. The input of clastics from source areas was reduced. In the time of the deposition of the brown claystone of the Frýdlant Formation and the Menilite Formation the facies differentiation diminished.

The sediments of the Menilitic Formation and the equivalents of the Ždánice-Hustopeče Formation in the Subsilesian Unit are very scarce. Therefore, they are not studied from the paleogeographic point of view. According to the presence of the Lower Miocene deposits in front of the Ždánice-Subsilesian Unit in the area of the town of Ostrava (Eggenburgian, Karpatian, ČTYROKÝ 1958, 1995, JURKOVÁ et al. 1983, JURKOVÁ in MENČÍK et al. 1983) it can be supposed (from the relationships of these sediments to the Ždánice-Subsilesian Basin in southern Moravia) that the sedimentation in the Subsilesian part of this unit took place in the Uppermost Oligocene and the Early Miocene, too. The sedimentation ended probably in the time of the older phases of the Young Styrian movements by thrusting of the lower (older) Subsilesian nappe.

Equivalents of the Ždánice-Subsilesian Unit in the Carpathians and Alps

The unity of the Ždánice-Subsilesian basin is documented by the presence of the same facies – lithological units in the Ždánice and Subsilesian units. The equivalents of the Frýdek Formation in the Ždánice part of the Ždánice-Subsilesian Unit are the grey marls of the Frýdek Formation type near the village of Střílky (POKORNÝ 1954) and Pavlov Formation in the Pavlovské vrchy Hills (STRÁNÍK et al. 1996). The Frýdek, Frýdlant and Menilite formations have identical lithological and stratigraphic developments in the whole Ždánice-Subsilesian Unit. From this point of view it is possible to correlate the southern slope-foot facies of the Subsilesian Unit with the slope-foot facies of the Čejč-Zaječí Zone of the Ždánice Unit.

The continuation of the Ždánice-Subsilesian Unit to the south is the Waschberg Zone. This zone joins the Ždánice-Subsilesian Unit with the Helveticum of the Eastern Alps. The Ždánice-Hustopeče Formation in known from the tectonic window near the village of Rogatsboden. The Upper Cretaceous hexacorals from locality Au (VETTERS 1925) are partly similar with the hexacorals of the Klokočov Member (ELIÁŠOVÁ 1989). The claystones of the Helveticum in borehole Urmansau 1 (ELIÁŠ 1981) and the rocks of the Helveticum north of Salzburg are very similar to the claystones of the Frýdlant Formation.

It is necessary to notice the similarity between the lithology and chronostratigraphy of the Helveticum and Ultrahelveticum and the Ždánice-Subsilesian Unit in Vorarlberg. It is possible to correlate the Quintner Limestone and the "Schrattenkalk" Limestone with the Ernstbrunn Limestone, the horizons of condensed sedimentation with the Klement Formation and the Amden Marl with the Frýdek Formation. A partial similarity exists between the facies of the Ultrahelveticum in the Feuerstätter Nappe and the facies with slump bodies in the Třinec Furrow valley and in the Čejč-Zaječí Zone.

On the Polish territory it is possible to follow the typical development of the Ždánice-Subsilesian Unit to the Bielsko-Biała area. Continuation of this unit to the east is not clear. We correlate the Subsilesian Unit and the Klippen Unit (near the town of Andychow) in Poland with the Kelč development of the Silesian Unit in the Czech Republic.

Conclusions

The Ždánice-Subsilesian Unit in the Outer West Carpathians represents the western continuation of the Helveticum of the Eastern Alps. The stratigraphic sequence of the Ždánice-Subsilesian Unit comprises the period from the Oxfordian up to the Lower Miocene. The Triassic deposits are known as clasts only (SOTÁK 1990). The character of the Triassic depositional area is not known so far; it took place before the development of the system of rift basins of the Outer Flysch Carpathians.

The Ždánice-Subsilesian Basin developed in the Early Jurassic in an extensional regime as the outermost (northern) rift basin of the system of the Outer Flysch West Carpathians. The system of the basins developed on the South European (or North Tethyan) passive margin (ELIÁŠ 1979, ELIÁŠ - ELIÁŠOVÁ 1984, 1995). This concept of paleogeographic development of the Outer West Carpathians is something different from the paleogeographic and paleotectonic reconstructions of the Eastern Alps. In the Eastern Alps the Helveticum and Ultrahelveticum together with the North Penninicum were reconstructed as a northern margin of a large, partly oceanic sedimentary basin.

The basinal facies of the Ždánice-Subsilesian Basin from the Late Cretaceous up to Late Eocene in mainly pelitic. The sedimentation took place under an extensional regime, in the sedimentary basin with a very complex topography. The topography of the Ždánice-Subsilesian basin was characterized by a system of tilted blocks, which gave rise to elevations (or submarine highs) separating partial depressions of different depths and geochemical conditions. The differences in the redox potential were the most important. These paleogeographic conditions were reflected in the character of the claystones of the Frýdlant Formation (black-grey claystone – anoxic facies, variegated claystone – aerated facies, grey-green claystone – neutral facies). The intrabasinal highs (partly with carbonate sedimentation) represented local sources of clastics (partly also bioclasts and micrite). The main sources of clastics for the Ždánice-Subsilesian Basin were situated along the margins of the basin.

In the Latest Upper Eocene the facies differentiation of the Subsilesian Basin diminished, probably as a consequence of the vast extensional regime and subsidence. Sedimentation of brown claystone prevailed in the whole basin as a precursor of the sedimentation of the Menilite Formation. Equivalents of the younger beds, Ženklava Formation, are preserved very rudimentarily.

The Ždánice-Subsilesian Unit was thrust over the deposits of the Karpatian foredeep (the older Young Styrian movements) and subsequently in the Lower Badenian over the sediments of the Lower Badenian Foredeep (the younger Young Styrian movements).

The Ždánice-Subsilesian Unit represents the lowermost part of the Outer Carpathians accretionary wedge, which is thrust over the foreland of the West European Platform.