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Jurassic of the innermost Western Carpathian zones - its importance and influence on the geodynamic evolution of the area

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Abstract: In comparison with other tectonic units, the Jurassic of the innermost Western Carpathian zones has been preserved only rudimentarily. The character of Jurassic sediments, however, indicates that they must have been much more extensive and their present absence has been caused by later erosion. The importance of Jurassic sediments for the reconstruction of the geodynamic evolution of the area is extraordinary, as they record the tectono-sedimentary events of the Jurassic period.

The most important phenomenon of this zone was the Meliatic oceanic domain, the closure of which led to Upper Jurassic structuring of the innermost Western Carpathian zones. A new sedimentary cycle started only after a great hiatus - in the Senonian and it ended definitely the Mesozoic evolution stage.

Key words: Western Carpathians, Jurassic, tectono-sedimentary evolution

General framework

The Western Carpathians are, similarly as the Alps, a multi-stage mountain system, consisting of several regional tectonic units, generated during repeated Upper Jurassic, Cretaceous and Tertiary convergence. Mutual interrelations of such created units are not always clear, leading in some cases to controversial opinions on their palinspastic arrangement.

The long-term (over 130 Ma) convergent trend of the Western Carpathian section of the Alpids led to the formation of a belt mountain range, where usually only parts of the original sedimentary basins and their basement have been preserved. These remnants were further many times reduced, laterally dislocated and even rotated due to repeated oblique collisions. The shortening of the space achieved such a degree that superficial nappes are wholly detached from their basement (flysch nappes of the Outer Carpathians, nappes of Hronicum and Silicicum).

Considering the above facts we necessarily arrive to the conclusion that the elaboration of paleogeographic reconstructions, or of a geodynamic model, is in this case not a simple and, above all, not an unambiguous task. The risk to start in a wrong direction is great, which is confirmed by the present "overproduction" of geodynamic models. Experience shows that problems start to appear already in the moment where general, globally used models are attempted to be applied to a mountain range, where geology has been studied for over a hundred years. The authors of the model are in such a case exposed to a special problem: how to harmonise the existing, many times extraordinary quantity of regional-geological information. To be honest, we must admit that to date the authors only rarely succeeded in this, especially as far as the Carpathian system is concerned. In spite of certain scepticism I must say that the elaboration of paleogeography or geodynamic modelling is in a certain way a very exciting journey, full of discoveries, but also a "marche arriére". With certain exaggeration we could say that it is in a way an "intellectual challenge" presented by Nature to us, geologists, which is worth of being accepted.

In view of my personal experience with such "modelling journeys" the presented contribution is not aimed at solving the whole extent of problems related to the geodynamic evolution of the Inner Western Carpathians. Its aim is rather to provide information on the possible geodynamic evolution of the innermost Western Carpathian zones, on the example of the Jurassic of Meliaticum and Silicicum, where, most probably, we are confronted with first manifestations of Mesozoic convergent tectonics in the Western Carpathians.

In comparison with other tectonic units, the Jurassic of the innermost Western Carpathian zones has been preserved only rudimentarily. The character of Jurassic sediments however shows that they must have been much more extensive and their present absence is most probably the result of later erosion.

Although Jurassic sediments are in comparison with Triassic ones represented only to a limited extent, their importance for the reconstruction of the geodynamic evolution of the back part of the Western Carpathians is extraordinary. This special importance lies in the fact that they are the last known, or preserved,

sediments of the Triassic-Jurassic cycle, which contain records of tectono-sedimentary events.

Another sedimentary cycle followed only after the Paleo-Alpine structuring associated with uplift, caused by the closure of the Meliatic domain. The new sedimentary cycle started after a considerable hiatus - in the Senonian and it ended definitively the Mesozoic stage in this area.

Main paleogeographic domains of the Inner Western Carpathians

In the Inner Western Carpathian area there are generally distinguished three paleotectonic units: Gemericum, Silicicum and Meliaticum. This order shows also their palinspastic arrangement, which has been accepted by several geologists (KOZUR & MOCK, 1973, ANDRUSOV, 1975, GRECULA 1983, MELLO et al. 1992, KOVÁCS et al. 1989, KOVÁCS 1992, KOZUR 1992, KOZUR-MOSTLER 1992, HAAS et al. 1995). An unavoidable result of this arrangement was the south-vergent thrust of the Silica Nappe onto Meliaticum, which was opposite to the vergency of other units of the Western Carpathians. A recently carried out structural investigation has shown that tectonic structure of the Inner Western Carpathians on Slovak territory formed due to north-vergent thrusting (HÓK et al., 1995), which confirmed the in the 80-ties expressed, but never published idea (RICOU 1986). This information as well as the present mutual position of the above mentioned units allow to suggest the following palinspastic arrangement (in present orientation, from north to south) Gemericum- Meliaticum - Silicicum. Practically the same arrangement has been presented recently by DALLMEYER et al (1996).

However, as indicated by several paleomagnetic studies from the Western Carpathian area (MÁRTON et al.,1988 and 1991, KRUCHYK et a., 1991 and KRS et al. 1993), Western Carpathian tectonic units are rotated in anti-clockwise direction, in the range from 110° (for the Permian) to 30° (Upper Cretaceous). Although this information is at present largely not reflected in paleogeographic reconstructions, it is evident that eventually it will influence the view on the original orientation of the paleogeographic zones. This paleomagnetic information, however, will not influence the sense - vergency - of tectonic polarity, which, even after rotation, remains from inside to outside.

Gemericum: within the Inner Western Carpathians, it represents the outermost (lowermost) tectonic unit, where the Paleozoic is dominant. We must however note that Mesozoic history of this paleogeographic domain is still a great unknown entity. With any certainty, only Lower Triassic sediments may be confirmed here (IVANOV 1953). In the Nižná Slaná depression, we could include here a part of the Štítnik Formation (VOZÁROVÁ & REICHWALDER 1983, MELLO 1992). The presence of the Middle Triassic is probable, based on lithology (MELLO 1992). Stratigraphically higher Mesozoic, or maybe Jurassic members have never been proved! The chronic absence of the Mesozoic, especially the Jurassic, led to considerations that this space could be the home area of the Silica Nappe, which slipped due to gravitation to the south.

Meliaticum: Although Meliaticum, as a regional tectonic unit, was introduced into Carpathian literature more than twenty years ago (KOZUR & MOCK 1973), we must note that it is still the subject of lively discussions. In the Western Carpathians there is scarcely such a unit, which would have to undergo so many changes in its stratigraphy and sedimentology.

The originally Middle-Upper Triassic succession was gradually complemented by the Jurassic (KOZUR & MOCK 1985), while, at the same time, a continuous bed succession was being considered. From paleogeographic viewpoint, it was considered an oceanic domain opened already in the Middle Triassic (Pelsonian- Illyrian) and surviving into the Jurassic, and its width was estimated at 800-1000 km (KOZUR 1979 and 1991).

The evidence of Upper Triassic age of a part of limestones included into Meliaticum (KOZUR & MOCK 1973) caused a "small earthquake" and, at the same time, it started, so to say, a "Meliatic age".

At the end of the 80-ties and beginning of 90-ties, "meliatomania" was the fashion of the day and from several localities in northern Hungary (e.g. Tornakápolna, Szarvaskö) there were described successions identified as Meliatic (KOVÁCS 1984 and 1992, RÉTI 1985). Occurrences of Meliaticum were described even in the Austrian Alps (MANDL - ONDREJIČKOVÁ 1991, KOZUR 1991 and KOZUR & MOSTLER 1992). This new situation caused a wave of speculations and authors introduced the idea of the "Meliatic-Hallstatt Ocean" (KOZUR 1991).

Similarly, in the Western Carpathians, where the term "Meliaticum" originated, there were described several new occurrences of Meliaticum: Jaklovce (MOCK et al. 1993), Folkmár (KOZUR & MOCK 1995), Čoltovo (MELLO & GAAL 1984), the borehole Brusník (VOZÁROVÁ & VOZÁR 1992), borehole Držkovce (MELLO et al.1995) and, recently, Ondrejisko in Stratenská hornatina Mts. (HAVRILA & OŽVOLDOVÁ 1996 in press). It must be noted that the last mentioned occurrence is especially important for the analysis of the mutual relationship of Meliaticum and Silicicum. In view of the fact that it is situated below the Stratenský Nappe, as well as the north-vergency of the Silicicum itself (HÓK et al.1995), we can hardly doubt the ultra-Meliatic origin of the Silica Nappe! This fact, as well as our new investigations at the localities Jaklovce and Folkmár allow to disrespect the recently presented hypothesis on the "Folkmár suture zone", sensu KOZUR & MOCK (1995). The existing regional geologic information excludes the existence of two sutures in Meliaticum.

Intensive investigation of Meliaticum within the project "Geodynamic evolution of the Western Carpathians" in recent years brought new, surprising information forcing us to change radically the opinion on the stratigraphy and sedimentology of Meliaticum. It has been proved (MOCK et al. 1992, 1993 and our own studies) that the continual Triassic-Jurassic bed succession at the classical locality is a Jurassic olistostrome! It has been discovered that the "bed successions" of Middle and Upper Triassic occurring there are more or less disintegrated blocks in a formation of dark, non-calcareous shales with intercalations of radiolarites of Bathonian-Callovian age. Similar conclusion has been reached at other localities as well (boreholes Brusník and Držkovce, Čoltovo).

Based on the present knowledge on the Jurassic of Meliaticum s.s. (RAKÚS et al. in press), we include here only a formation of dark to black non-calcareous shales with occasional passages of gradational sandstones of flyschoid character, spotted claystones and black or green, sometimes also red radiolarites of Bathonian-Callovian age (ONDREJIČKOVÁ 1990, OŽVOLDOVÁ in MOCK et al. 1993) and irregular olistostromatic accumulations. The size and composition of the olistostrome material varies from several cm^3 to several m^3. The material are above all various Triassic limestone types: crystalline limestones - marbles, quartzose and sandy limestones, cherty limestones, radiolarites, basic volcanites and serpentinites (MOCK et al. 1992, VOZÁROVÁ & VOZÁR 1992).

From the paleogeographic viewpoint, we understand Meliata as an "oceanic" domain, connected by a system of transformational faults with the Vardar, and not Kimmerian ocean, sensu KOZUR (1991). In view of the fact that in the Slovak part of the Inner Western Carpathians there are not known more important occurrences of basic volcanics, comparable e.g. with those in the Apusenians, we assume that Meliata had on the Slovak territory a more or less limited extent (rhomboschasma sensu DERCOURT et al. 1990).

Recently, STÄMPFLI (1996) published a paper, in which he considered Meliata to be a "back arc basin" . The result of a petrologic study of basic rocks of Meliaticum (IVAN & KRONOME 1996) appears to be consistent with this idea. Stämpfli (.l.c.) put the origin of Meliata already into the late Permian! In view of geological information available in the Western Carpathians we can hardly consider oceanic character of Meliata from the Permian!

As far as the beginning of sedimentation in so defined Meliata is concerned, we note that the oldest biostratigraphically proved sediments of Meliaticum are ? Rhaetian - Lower Jurassic in age (HLÔŠKOVÁ in MELLO et al. 1994). As it has been already mentioned, Doggerian-Bathonian-Callovian age has been repeatedly proved from radiolarites, intercalated in shales (KOZUR & MOCK 1985, ONDREJIČKOVÁ 1990, OŽVOLDOVÁ in MOCK et al. 1993). In this time, Meliata achieved the maximum of its extension, which resulted in oceanic character of the sedimentation and the formation of a new oceanic crust (HOVORKA & SPIŠIAK 1993).

The origin of the olistostromatic material is still a problem. In view of the fact that the material was transported into the Meliatic basin already lithified, as well as the fact that its age, including basic rocks, is Triassic-? Jurassic, we could assume that its origin was in the obducted parts of Kimmerides sensu STÄMPFLI (1995).

In the Upper Jurassic, Meliata was gradually but rapidly closed. Parts of the sedimentary prisms of Meliaticum could be subducted below the thrust Silicicum domain, while they were exposed to HTP conditions, as it is documented in the Bôrka Nappe (MAZZOLI et al 1992, MALOUSKI et al. 1993 and DALLMEYER et al. 1996). We assume that the duration of Meliata did not exceed approximately 50 Ma.

Silicicum: we consider it as the innermost situated paleotectonic unit of the Inner Western Carpathians, composed of several superficial nappes. Its basement is unknown. Characteristic features of Silicicum are the absence of a Paleozoic-Hercynian fundament and, for the Carpathians, a thick development of Triassic sediments, showing an affinity to the Austro-Alpine facial area (Apulian microplate).

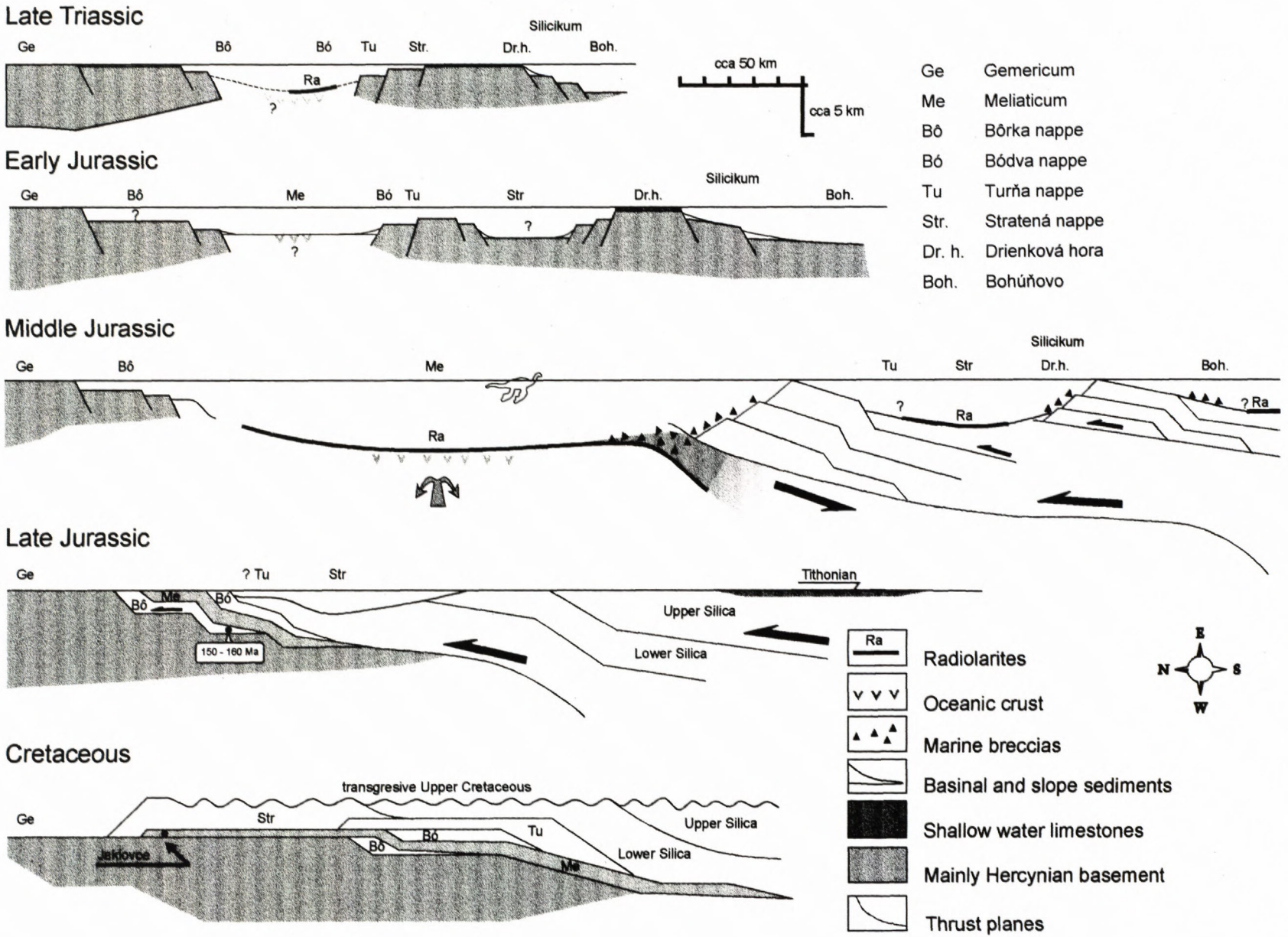
In the Jurassic, the area of Silicicum was near to Meliata (? rim basin), which is indicated by the similar sedimentary-tectonic regime in the Doggerian. The closure of Meliata led to an intensive structuring of Silicicum leading to a nappe structure and its subsequent uplift (? Kimmeridgian). The last occurring Jurassic sediments are shallow-water algal limestones, which we however know only from secondary occurrences (MIŠÍK & SÝKORA 1980).

Tectono-sedimentary development of the area (Fig. 1)

When reconstructing the tectono-sedimentary development of the Inner Western Carpathians in the Jurassic, we base our considerations above all on information provided by the rock record of Meliaticum and Silicicum. For well-known reasons, Gemericum can be used for this purposes only to a very limited extent. We attempted to harmonise the numerous regional data with the general geodynamic development in this section of the Alpids. The selection of time levels was made bearing in mind the possible stratigraphic control and an important tectono-sedimentary event.

Late Triassic (215-205 Ma)

In the time of the Late Triassic, the area of the Inner Western Carpathians, above all Silicicum, was in extensional regime, which resulted in the division of the origi-


Late Triassic
Ge
Bô
Bó
Tu
Str.
Dr.h.
Boh.
Silicikum
Ra
?
cca 50 km
cca 5 km
Early Jurassic
Ge
Bô
Me
Bó
Tu
Str
Dr.h.
Boh.
Silicikum
Middle Jurassic
Ge
Bô
Me
Tu
Str
Dr.h.
Boh.
Silicikum
Ra
? Ra
Late Jurassic
Ge
? Tu
Str
Tithonian
Bô
Me
Bó
150 - 160 Ma
Upper Silica
Lower Silica
Cretaceous
transgresive Upper Cretaceous
Ge
Str
Bó
Tu
Bô
Me
Jaklovce
Upper Silica
Lower Silica
Ge Gemericum
Me Meliaticum
Bô Bôrka nappe
Bó Bódva nappe
Tu Turňa nappe
Str. Stratená nappe
Dr. h. Drienková hora
Boh. Bohúňovo
Ra Radiolarites
Oceanic crust
Marine breccias
Basinal and slope sediments
Shallow water limestones
Mainly Hercynian basement
Thrust planes
E
N
S
W

nal, in the Middle Triassic formed carbonate platform, into a system of intra-platform basins with deep-water sedimentation (radiolarites in the Bódva Nape, Hallstatt limestones and Zlambach Beds in the Silica Nappe). At the same time, shallow-water carbonate platforms with reef-lagoon facies occur here as well (of Dachstein reef limestone type), separated from basin areas by normal synsedimentary faults (?Drienkova hora Fault). The same fault system appears to have controlled also the extent of Rhaetian sediments, which has been proved with certainty only in intra-platform basins. Its presence in horst elevations is problematic.

In Meliata itself, the presence of the Late Triassic is questionable. The reason may be found in the different view on the definition of Meliata and, especially, on the beginning of its formation as a domain. With certain limitations, we could include into the Uppermost Triassic the formation of black shales with small lithoclasts of carbonates, known from the borehole Držkovce (MELLO et al. 1994). Based on sporomorphs and microplankton, they are classified as Rhaetian? to lower Liassic (HLÔŠKOVÁ 1994).

In the Bôrka Nappe, we include into the Upper Triassic to ?Liassic also the formation of black shales and sandstones (MELLO 1992).

Early Jurassic (205 - 180 Ma)

The extensional regime started in the Late Triassic, continued in the Liassic and controlled the distribution of facies. In elevated parts (Muráňska plošina Plateau, Geravy, Drienková hora), the Lower Liassic (probably Sinemurian, RAKÚS et al. in press) is transgressive in relation to Norian limestones. The continuing extensional regime caused the formation of open fissures, the depth of which could reach several tens of meters (Geravy). These neptunic dikes are filled with red biomicritic limestones of Toarcian age (canyon of the Muráň River below the Meliata village). In basal Liassic limestone, there are often present breccias (Bleskový prameň) indicating synsedimentary activity of the faults (fault escarpment).

In intra-platform basins, spotted marls of Allgäu Beds type sedimented, with layers of sandy-crinoid limestones (calciturbidites) and calcareous sandstones (Bohúňovo). In these beds, the occurrence of blue amphiboles has been recorded in the heavy fraction (personal communication of Dr. Aubrecht), which would indicated erosion of obducted ophiolitic complexes.

In the Stratenský Nappe, a formation of black shales and biomicritic limestones with spongoliths sedimented in this time. Small penetrations of basic volcanites occur here rarely.

In Meliata, the Liassic is represented by the sedimentation of dark to black shales, with thin layers of gradationally bedded sandstones and spotted claystones, while in some places (the cutting of the Muráň River) the formation is of flyschoid character.

Middle Jurassic (180 - 155 Ma)

The time of the Middle Jurassic could be described as "revolutionary" in the geotectonic development of the Inner Western Carpathians. The extension reached its maximum, due to subsidence and the activity of extensional listric faults, resulting in the oceanisation of existing basins. This regime resulted above all in the formation of a new oceanic crust (basaltic pillow lavas in Szarvaskö (CZÁSZAR et al. 1990). In the Bathonian-Callovian (approx. 169 -159 Ma), first subductional movements occurred in Meliata, resulting in the formation of low-angle disjunctive-nappe surfaces and the movement of nappes in Silicicum. This is indicated by the olistostromatic beds in radiolarites of Bleskový prameň (MELLO 19973, SÝKORA & OŽVOLDOVÁ 1995, RAKÚS et al. in press), or in Aggteleg karst (LESS & SZENPÉTRY 1988). Similarly, in Meliata itself, the majority of olistolithic accumulations falls into this time.

Late Jurassic (150 - 145 Ma)

In this time, the continuing subduction led to complete closure of Meliata as an oceanic domain. The structuring of Silicicum continued especially in its back parts, where a system of nappes formed. The subsequent uplift resulted in the interruption of sedimentation. Sedimentation continued only in frontal parts of the Silica Nappe system, as a "carried basin" (Stratenský Nappe), with pelagic limestone facies. In this time (probably after the Oxfordian), Meliata, including the Bôrka Nappe, was already buried below Silicicum and exposed to HTP conditions (MALOUSKI et al. 1993, DALLMEYER 1994, DALLMEYER et al. 1996).

The uplifted back parts of Silicicum became again a sedimentation area, which was however, contrary to the deep-water sedimentation in the Doggerian, markedly shallow-water (algal limestones with Clypeina). Although Tithonian limestones are found at a secondary occurrence (MIŠÍK & SÝKORA 1980), there are no serious doubts as to their belonging to the Silica Nappe System. The great facial contrast between the Doggerian and Tithonian appears to support well the idea of an uplift due to Upper Jurassic tectonogenesis.

In view of the above mentioned tectono-sedimentary development and the fact that in the whole Inner Western Carpathian area there is a chronic absence of Lower Cretaceous sediments, we assume that in this time the area was without sedimentation. A new sedimentation cycle started only in the Sennonian, with a lagoon-marine cycle.

Conclusion

The above outlined "scenario" of the geodynamic development in the Inner Western Carpathians appears to correspond well with the present level of information on the geology of this region. As follows from the above mentioned facts, Jurassic sediments proved to by a suitable key for the deciphering of the tectonic-sedimentary development. Testing should follow, which would show to which extent the proposed model is rational. Regardless of the result of the test I would like to direct the attention to three moments resulting from the paper:

- as the first one I would like to mention that the Western Carpathians, similarly as the Alps, are a multistage mountain range, where a time sequence of great tectonic events may be observed. The tectonosedimentary development of the Jurassic in the Inner Western Carpathians would appear to support this idea.
- indisputable progress in the knowledge of stratigraphy and sedimentology of Meliaticum, and, subsequently, of the tectonic structure, was achieved only due to extensive and consistent use of biostratigraphic methods. Again, the importance of biostratigraphic methods for synthetic studies has been proved.
- two decades ago, the problems of Meliaticum did not exist, and even not so long ago, it appeared to be a purely Western Carpathian problem. Within a few years, and it must be said that thanks to a great investigative effort, it became the problem of Alpine geology, the effects of which may be estimated only with great difficulty. In view of certain historical and cultural facts, the Alps will most probably remain a model terrain, on which the attention of the geological community will be focused, as it has been recently written, very charmingly, by Professor TRÜMPY (1996). With certain satisfaction we may state, on the example of Meliata, that even an incomparably smaller territory, with a less rich history of investigations, such as the Western Carpathians, may become a source of inspiration for a thoroughly studied mountain range.

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