ANN. INST. GEOL. PUBL. HUNG. | vol. LXX. | Budapestini, 1987

Proceedings of the VIIIth RCMNS Congress

COMMENTS ON THE EARLY HISTORY OF PARATETHYS

by

I. CICHA and I. KRYSTEK

In the last few years, the opinion has prevailed (above all BÁLDI, 1979; 1984) that, from the viewpoint of the evolution of the independent sedimentation realm of the Paratethys, the interval exhibiting the first signs of endemicity and isolation in the older section of the regional Kiscellian stage rather than at its base is of prime importance. This time span is characterized by the appearance of horizons with *Spiratellae* and by the deposition of beds with *Cardium lipoldi* and *Ergenica cimlanica.* The appearance of Spiratellae etc is a prominent anoxic event in the evolution of the older Oligocene sedimentation area of the sedimentation realm. For instance, BÁLDI (1979) supposes that the full separation of the Tethys and Paratethys took place at that time.

However, detailed studies on the history of sedimentation areas in the Pre-Caucasian region, the southern part of the USSR, the West Carpathians, and the Alpine foredeep have shown that the appearance of anoxic regime probably did not take place during a limited time interval. For instance, in the Pouzdřany sedimentation area this regime appears neither in zones NP21 and 22 respectively nor does it show up in the regions of the pre-Alpine molasses or the southern territories of the USSR. The first evolutional stage of Paratethys should also examined from the viewpoints of sedimentology and tectonics.

The broad and longitudinally rather dissected area of flysch sedimentation at the external side of the Alpie—Carpathian orogenic belt attained its maximum in Early Cretaceous time. From the area bearing the character of marginal seas (with oceanic depths and a crust more or less of oceanic type), it extended as far as the platform margin, gradually passing there to non-flysch epiplatform facial types.

As a result of subduction movements, the process of intensive reduction started at least since the Laramian movements, that means by the and of the Createaceous but probably as early as the movements during the Late Cretaceous. The area was gradually folded while nappe subunits were being formed and thrusted over one another toward the foreland during the reduction of space. Sedimentation went on more or less continuously in the area left in front of the unit immediately formed, resulting in sequences that, mostly, were stratigraphically more complete, provided that the lower members were not separated tectonically.

This "inheritance" of a part of the sedimentation area of the older (and broader) area of sedimentation is one of the universal evolutional features of the whole region that can be traced to the incipient molasse sedimentation. The culminating spatial reduction due to the folding of the internal units and gradual shallowing results in the onset of molasse sedimantation that—upon completed subduction of the remnants of the basement of the former flysch basins and incorporation of the oldest molasse sediments into the last nappes—advances to the platform margin into the new-forming molasse basins.

New molasse basins were formed where the mobility of the basement provided adequate conditions, not only in the platform foreland but also within the new-forming mountains and at their inner sides (intramontane and backdeep basins) as a result of tensile stresses beyond the zone of fading-out compression. In the depressions at the back part in some places sedimentation lithologically identical with the molasse one went on since the Upper Cretaceous, as at the back part existed conditions for forming of the basins with "molasse like" sedimentation. Dilatation took place here since the outset of shortening of the external parts of the Tethys area in which the flysch was deposited.

VASS (1980) calls the sediments originating in this period "early molasse", because they were formed subsequently to the main folding. From a more or less formal point of view, the sedimentation areas on the backpart of the forming mountains, in which molasse-type sedimentation occurred synchronously with flysch sedimentation in the Tethyan realm proper, should better be called premolasse areas, because they were situated on an other plate o plate fragment the displacement of which caused the compression of the northern (oceanic) branch of the Tethys. These basins were not formed by the disintegration of the Tethys, but were incorporated into the Paratethyan molasse region later, after the disintegration.

In the external Alpine—Carpathian zone, the stage of Tethys disintegration and Paratethys formation is that of the transition from flysch to molasse sedimentation. This process, occurring in close interrelation with the tectonic movements, can be traced, step by step, from the very similar types of lithological development. Interregional comparison makes possible to distinguish transverse facies zonality as well and to establish common features therein.

Flysch-to-molasse transition in the Alpine—Carpathian region

Generally, it can be said that between the typical flysch sequences that developed over a long period of time, locally as early as the Lower Cretaceous up to the Paleogene, and the typical molasse, series comprising a bituminous clay formation have been deposited. It contains menilitic cherts and is called the Menilitic Formation that, in its typical development, exhibits neither flysch nor molasse character. It should be noted, however, that the upper section of the Menilitic Formation is frequently substituted by the Krosno lithofacies that, on the contrary, does show flysch character in its typical development.

However, the sedimentology of the Menilitic Formation has not yet been fully characterized. Its faunal or floral characteristic is full of contradictions. The majority of authors consider it a formation deposited on the lower part or at the base of the continental slope (HANZLÍKOVÁ, 1981; KRHOVSKÝ, 1981; STRÁNÍK, 1981). Even though the formation is characterized, by the occurrence of bituminous shales in the broadest sense of the word, it exhibits by far no uniform development throughout the external Carpathians. Locally, transverse facies transitions with varying amounts of clastics can be found, forming thicker or thinner horizons in the menilitic facies.

Mostly, transverse zonality is apparent in the facies development. For instance, in the East Carpathians of Roumania (according to DUMITRESCU and SANDULESCU, 1974; MICU in SANDULESCU et al., 1980), the innermost part of the Tarcău unit still exhibits prevailing Fusaru flysch development during Oligocene time comprising a Slonc facies with olistoliths in its uppermost part, whereas the outer part of this unit already displays the typical development of the Menilitic Formation.

There, the latter comprises two horizons of Kliwa sandstones separated by the flysch sequence of the Podu Morii beds or by the Vinetisu sequence of strata that (DUMITRESCU and SANDULESCU, 1974) represent the latest occurrences of flysch facies. In the Tarcău unit, the sedimentation of bituminous mudstones with menilites seems to be the most high-reaching one throughout the Carpathians—as high as zone NN 2—3—apparently substituting there also the lowermost sections of the Lower Miocene Salt Formation. The equivalents of the Salt Formation—the lower Gypsum Horizon or the Lopătari Formation—overlie the Supramenilitic Horizon with a distinct disconformity (MICU in SANDULESCU et al., 1980).

The Supramenilitic Horizon is still developed as the highest (nonmolassic) member in the southern part of the more external unit of the Marginal folds. In the northern part and also further in the most external Subcarpathian unit we can see the beginning of the first appeareance of molassic developments at the end of Oligocene as the Gura Soimului beds, resp. as the Goru Misina beds (MICU, 1982) They represent a transition between the Menilitic Formation and the Lower Miocene Salt Formation and they are not lithologically uniform. They are generally characterized by longitudinal and transversal interfingering of the bituminous facies with the molassic sandyconglomeratic facies (MICU in SANDULESCU, 1980), but there differences exist from west to east. The calcareous nannoplancton of the Gura Soimului beds contains a Lower Miocene assemblage with species continuing their evolution from the Oligocene.

In the Ukraina, in Poland, and partially also in Czechoslovakia, the upper section of the Menilitic Formation is commonly substituted by the Krosno lithofacies that invariably shows flysch character. In a number of units such as the Premagura, Dukla, Čorna-Gora, Silesian, Subsilesian, and SkoleUnits, sedimentation terminates with this lithofacies, while it continues with molasse facies in other—the most external-units such as the Boryslaw, Pokuty, Stebnik, Sambor—Rozniatow or Ždánice and Pouzdřany units in Moravia.

The Krosno lithofacies seems to extend to a stratigraphically rather high position, at least to the Egerian or even Eggenburgian, as can be concluded from studies by WIESER (1979) and OLSZEWSKA (1982).

The Krosno lithofacies is extremely thick (up 4000 m) in the Silesian unit, particularly in its southeastern part in Poland, evidencing, in this area, an extraordinary subsidence during the late flysch sedimentation in the Carpathians.In accordance with its microfaunistic character, OLSZEWSKA (1980) correlates the upper section of the Krosno lithofacies to the Polanica beds that play an important role at the flysch/molasse transition in the so-called internal zone of the foredeep in the Boryslaw—Pokuty unit (Stebnik unit) and extend stratigraphically to the upper sections of the Egerian or the lower part of the Eggenburgian (OLSZEWSKA, 1980; JINORIDZE, 1979; DANYŠ et al., 1974; NAY et al., 1974). The Polanica beds are practically flyschoid in character or substituted by the conglomeratic Sloboda facies, or by the Vorotyšča Salt Formation in their upper section.

Thus, the facies zonality established in the East Carpathians of Roumania also appears in the Ukrainian and Polish regions, similarly as do the transitions from flysch to flyschoid or molasse peri-Carpathian saliferous development in comparable tectonic units in the outermost zone.

The Pouzdřany sedimentation area represents a certain evolutional transition between the pre-Alpine basins and the sedimentation areas adjoining the Carpathian belt. There, the Moutnice limestones and, particularly, the Pouzdřany marls the sedimentation of which terminates in zone NP22 were deposited at the Eocene/

Oligocene boundary. At present the Eocene/Oligocene boundary is unanimously placed in zone NP21 between the foraminiferal zones of *Turborotalia cerroazulensis* (Upper Eocene) and *Globigerina angiporoides*, *Pseudohastigerina naguwichiensis*. As a whole the Pouzdřany marls are bathypelagic sediments of the open sea. The deposition of the Pouzdřany marls was followed by the sedimentation of non-calcareous diatomites, dolomites and calcareous diatomites assigned to zone NP23 (or to the lower section of the Uherčice Formation). The period adverse to the evolution of marine fauna continued up to the brown or grey clays of the zones NP23 and mainly NP24 overlying the diatomite series. Clay sedimentation persists up to zone NP25, i.e. to the oldest Egerian time during which glauconitic sands were deposited, while pelagic sediments of the upper bathyal zone were deposited in the course of younger Egerian time. The latter sediments are called Boudky marls and terminate the Egerian sedimentation together with the freshened Křepice Formation in the original sedimentation area of Pouzdřany. The diatom series of strata (KRHOVSKÝ, 1981) is considered to be equivalent to the older section of the Menilitic Formation.

In general, the biostratigraphic evaluation of the principal younger Tertiary sedimentation areas in the Alpine—Carpathian region points to certain differences in the western, i.e. pre-Alpine section and in the region adjacent to the Carpathians. In the pre-Alpine regions of Bavaria, Vorarlberg and Austria, the boundary facies of the Eocene and Oligocene placed in zone NP21 are characterized mainly by Lithothamnium limestone facies in the basement of which Discocyclina marls are present. Upwards, to the overlying strata up to the older section of zone NP23, appear signs of a certain transition to brackish character, impoverishment in faunas, probably in connection with a certain isolation of the sedimentation space. But simultaneously at the Eocene/Oligocene boundary the flysch Deutenhausen beds "Altdorfer Flysch" etc were still depositing in the inner side of that time sedimentary area.

As follows from the general review, the typical Menilitic Formation did not develop in this region. Nevertheless, partly the so-called "Fischschiefer"correspond to it facially and stratigraphically.

The following Formations "Heller Mergelkalk, Bändermergel" (zone NP23), "Tonmergelschiefer" (NP24) are, according to FUCHS, of flyschoid character and to a certain extent they are analogous with the Krosno-Ždánice lithofacies in the Carpathians. In the Alpine external zone the conditions are similar to those in the Carpathians including the cross-facies zonality.

Conclusions

1 A large-area unification of flysch troughs that were not closed with the Old Pyrenean—Illirian phase (between the Lutetian and Priabonian) or later, during the Pyrenean phase (between Priabonian and the Oligocene) took place in the Carpathians and partly in the Alps by the end of the Eocene and in the beginning of the Oligocene. Lithofacies of the Globigerina marls and especially of the Menilitic Formation and its equivalent "Fischschiefer" extended in the outer external zone of the Carpathians (contingently of the Alps) prove this unification.

2 In the course of the sedimentation of menilite—bituminous claystones (with or without menilite cherts) which has various facial differentiations and a maximum time extent beginning of Kiscellian—beginning of the Miocene, flysch and non-flysch facies of bituminous claystones (eventually with transitions into molasse developments) substitute each other. Transversal facial zonality is often obvious.

3 In connection with the beginning of Paratethys formation (i.e. the outset of Tethys desintegration), it is important to mention that during Late Oligocene still the sedimentation of flysch and flyschoid sequences took place both in the Carpathians and in the pre-Alpian region. Some of these (e.g. the Krosno Formation in the Silesian unit of the Carpathians) are thousands of meters mighty. In this period one still cannot be speak about any signs of desintegration in the area of Tethys itself situated on the external side of the forming fold mountains.

4 Shallow seas situated at the back part of the mountains have in the individual basins their own development essentially different from the flysch sedimentation areas of the Tethys s.s. northern branch. Numerous paleogeographical changes including the main anoxic period mentioned e.g. by BÁLDI et al. (1984) are more or less only of local importance. "Molasse like" sedimentation at the back-part of the fold mountains synchronous with the external flysch sedimentation should be differentiated from the molasse proper itself and designated as the premolasse.

5 The molasse sedimentation begins no sooner than after termination of the collision, i.e. after the connection of the newly formed shallow molasse basins of foredeep type with intramontanes depresions and back-arc basins. At the same time during the Savian movements this area became isolated from the deep ocean spaces of Tethys rests. Since that time we can speak about Paratethys. This conception corresponds to the redefinition of the term Paratethys presented by SENEŠ (1959, 1961).

In case of the Carpathians it is undoubtedly after the Savian movements, i.e. since Eggenburgian. In the Alps the Purchkirchner Series has a character lithologically close to the molasse, however, according to FUCHS (in OBERHAUSER, 1980) it lacks flysch material that appears in Eggenburgian "Nagelfluh" with glauconitic sandstones with conglomerates. This most probably indicates the end of flysch nappes moving toward the front of the Alps and since this very moment the Alpian molasse zone gets a character of a genuine foredeep. Consequently, the Purchkirchner Formation can be also considered as a premolasse and the molasse sedimentation in the proper sense also begins no sooner than in Eggenburgian.

REFERENCES

BÁLDI T. 1979: Oligocene and Lower Miocene formations in Hungary. — D. Sc. thesis, manuscript, Dept. Geol. L. Eötvös Univ. Budapest (in Hungarian).

BÁLDI T. 1984: The terminal Eocene and Early Oligocene events in Hungary and the separation of anoxyc cold Paratethys. — Eclogae geol. Helv. 77. (1):1—27.

DANYŠ V. V., KULČICKIJ J. O. and LOZYNJAK P. J. 1975: Tektoničeskoje rajonyrovanije Ukrajinskich Karpat i ich obščeje strukturnoje položenije v Karpatskom duge. — Proc. Xth congr. CBGA, sect. 3. Tectonics: 12—119, Bratislava.

DUMITRESCU I. and SANDULESCU M. 1974: Flysch zone. — Tectonics of the Carpat. Balcan Reg. Expl. to the tect. map. GÚDŠ, 253—264. Bratislava.

FUCHS W. 1976: Gedanken zur Tektogenese der nördlichen Molasse zwischen Rhone und March.— Jb. Geol. Bundesanst. 119. (2):207—249.

HANZLÍKOVÁ E. 1981: Biostratigrafie a ekologie menilitových vrstev na Moravě. — Zemní Plyn Nafta 26. (1): 29—44. Hodonín.

JINORIDZE N. M. 1979: Pecularities of time-spatial differentiation for halogen deposits. — Ann. géol. pays hellén. (Hors sér.). 2.:569—583.

KRHOVSKÝ J. 1981a: Stratigrafie a paleoekologie menilitového souvrství ždánické jednotky a diatomitu pouzdřanské jednotky. — Zemní Plyn Nafta 26. (1):45—62. Hodonín.

NEY et al. 1974: Zarys paleogeografii i rozwoju litologiczno facialnego utwórov miocenu zapadliaka przedkarpatskiego. — Prace geologiczne. 82.:1—65. Warszawa.
OBERHAUSER et al. 1980: Der geologische Aufbau Österreichs. — Wien—New York.
OLSZEWSKA B. 1982: Uwagi o biostratigrafii serii menilitowokrósnieńskej w polskich Karpatach zewnetrznych. — Kwart. geol. 26. (1):137—145.
SANDULESCU M. et al. 1980: Cretaceous and Tertiary Molasses in the Eastern Carpathians and Getic Depression. — Guidebook for the Field Works of the Group 3. 3. Com. on the Probl. IX. Bucharest.
STRÁNÍK Z. 1981: Litofaciální vývoj a korelace menilitových vrstev ve flyšovém pásmu Karpat na Moravě. — Zemní Plyn Nafta 16. (1):9—18. Hodonín.
VASS D. 1980: Principles of subdivision and principal typs of the West Carpathian molasse basins and depressions. — Veröff. Zentralinst. Physik Erde. 58.:155—171.
WIESER T. 1979: Korelacja horyzóntov tufowych warstw krosnieńskich na podstawie cech mineralogicznych i wieku bezwglednego. — Kwart. geol. 23. (4):930.

I. CICHA
Ustredni Ustav Geologicky
Hradebni 9
PRAHA 1

I. KRYSTEK
Katedra Geologie e Paleontologie Ujep
Kotlárská 2
60000 BRNO