Problems of the „Pannonian Median Massif" and the plate tectonic concept. Contributions based on the distribution of Late Paleozoic — Early Mesozoic isopic zones

By SÁNDOR KOVÁCS, Budapest *)

With 4 figures

Zusammenfassung

Nach einem kurzgefaßten historischen Überblick zur Deutung des „Pannonischen Massivs" oder „Tisia" wird die Verteilung der Fazies von Mittel- und Oberkarbon sowie Untertrias bis Lias auf den beiden Seiten der Zagreb-Zemplin-Linie — welche den Untergrund des Karpatenbeckens in zwei Abschnitte zerteilt — kurz untersucht. Sie zeigt einerseits, daß die Igal-Bükk-Zone (die Igal-Bükk Eugeosynklinal von WEIN, 1969) — welche eine Verbindung zwischen den NW Dinariden und dem dinarisch-typischen Bükkium darstellen soll — nur eine tektonische Zone ist, hingegen nie eine paleogeographische Einheit gewesen sein kann.

Der nördliche, äußerste Teil des „Tisia" (Mecsek-Bihor kristalliner Gürtel und seine sedimentäre Decke; DANK u. BODZAY, 1971) weist eine Ausbildung und Fazies auf, welche für den nördlichen (nordöstlichen) marginalen Komplex der Tethys typisch ist. Auch Faziesübergänge vom Vorland in der Richtung der offenen See sind immer N → S gerichtet. Alle Erklärungen, die eine autochthone Lage der Zonen entlang der Zagreb-Zemplin-Linie mit einbeziehen, müssen mit der Tatsache fertig werden, daß der nördliche Teil der „Tisia" einen zentralen Teil eines teilweise emporgehobenen Kristallinrückens darstellt (kein Faziesübergang nach Norden). Sie war eher Teil der nördlichen (nordöstlichen) marginalen Serie der Tethys. Daher erscheinen allochthone Modelle, welche horizontale Bewegungen in größerem Maßstabe andeuten, eher glaubwürdig zu sein. Der Stil der spätherzynischen Entwicklung und die Verteilung der Fazieszonen von Untertrias bis Lias deuten an, daß der „Tisia" Teil der nördlichen (nordöstliche) Shelf der Tethys bis Ende Lias war (übereinstimmend mit der Meinung von BLEAHU 1976); dann spaltete er sich ab und keilte sich mit horizontalen Bewegungen zwischen den NW Dinariden und dem Bükkium dinarischen Types ein; dies könnte Ende Jura—Anfang Kreide stattgefunden haben.

Abstract

After a short historical review of conceptions about the "Pannonian Median Massif" or "Tisia", the distribution of Middle—Upper Carboniferous and Lower Triassic—Liassic facies is briefly examined on the two sides of the Zagreb-Zemplin line dividing into two main segments the basement of the Carpathian basin. It shows on the one hand, that the Igal-Bükk zone ("Igal-Bükk eugeosyncline" of WEIN, 1969), thought to establish a connection between the NW-Dinarides and the Dinaric-type Bükkium, is only a tectonic zone and could never have been a paleogeographical unit. On the other hand, the northern, marginal part of "Tisia" ("Mecsek-Bihor crystalline belt" and its sedimentary cover; DANK & BODZAY, 1971) exhibits a development and facies characteristic of the northern (northeastern) marginal complex of the Tethys. Also, facies-transitions from the foreland toward the open sea are always of N → S direction. All autochthonous explanations must face the striking differences along the Zagreb-Zemplin line, which seem to exclude the possibility that the northern part of "Tisia" was a central, partly emerged crystal-

*) Address of the author: Dr. S. KOVÁCS, Hungarian Geological Institute, H-1143 Budapest, Népstadion u. 14.

line ridge (no facies-transitions toward N!); it was rather part of the northern (northeastern) marginal complex of Tethys. Therefore allochthonous models suggesting larger-scale horizontal movements give a much more plausible explanation. The style of Late Hercynian development and the distribution of Lower Triassic-Liassic facies zones suggest, that "Tisia" was part of the northern (northeastern) shelf of the Tethys until the end of the Liassic (in accordance with the opinion of Bleahu), then split off and was wedged in by horizontal movements between the NW-Dinarides and the Dinaric-type Bükkium by the end of the Jurassic — beginning of the Cretaceous.

Résumé

Après une brève revue historique des conceptions sur la »Masse médiane pannonienne« ou la »Tisia«, on examine brièvement la distribution des facies du Carbonifère moyen-supérieur et du Trias-Lias aux deux cotés de la ligne de Zagreb-Zemplin divisant le soubassement du Bassin Carpathique en deux ségments principaux.

Ce qui est démontré, c'est d'une part que la zone Igal-Bükk (le »géosynclinal Igal-Bükk«, Wein, 1969), considérée comme l'établissement d'une communication entre les Dinarides du NW et le Bükkium de type dinarique, ne représente qu'une zone tectonique, mais qu'elle ne peut jamais être une unité paléogéographique. D'autre part la partie septentrionale, marginale de la »Tisia« (la ceinture crystalline de »Mecsek-Bihor« et sa couverture sédimentaire; Dank-Bodzay, 1971) présente un développement et un faciès caractéristique du complexe marginal septentrional (nordoriental) de la Téthys. Les transitions de faciès de l'avant-pays vers la mer ouverte sont également de direction N—S. Toutes les explications autochtonistes doivent faire face aux différences accentuées le long de la ligne Zagreb-Zemplin, ce qui semble exclure la possibilité que le Nord de la »Tisia« ait été une dorsale cristalline centrale, émergée (aucune transition de faciès vers le N!); elle a fait plutôt partie du complexe marginal du N (NE) de la Téthys. C'est pourquoi les modèles allochtonistes suggérant des mouvements horizontaux plus vastes donnent une explication plus plausible. Le style du développement éohercynien et la distribution des zones faciales du Trias inférieur-Lias suggèrent que la »Tisia« a fait partie du shelf septentrional (nordoriental) de la Téthys jusqu'à la fin du Lias (en accord complet avec l'opinion de Bleahu, 1976) et qu'ensuite elle s'était décollée et coinné par des mouvements horizontaux entre les Dinarides du NW et le Bükkium de type dinarique vers la fin du Jurassique et le début du Crétacé.

Краткое содержание

После краткого исторического обзора понятия „Паннонский Массив", или „Тисия", приводят анализ распространения фация в среднем и верхнем карбоне, а также от нижнего триаса до лайоса по обе стороны линии Загреб-Земплин, разделяющей фундамент бассейна Карпат на две части. При этом установили, что зона Игаль-Бюкк (евгеосинклиналь Игаль-Бюкк по ВАЙН'у, 1969), которая вероятно представляет собой связь между Северозападом Динарид и Бюккимом динарского типа, является только тектонической зоной, и ни в коем случае не могла быть палеогеографической единицей.

Северная, внешняя часть „Тисии" (кристаллический пояс Mecsek-Bihor и его осадочный покров; Dank u. Bodzay, 1971) проявляется и как фаций, и как образование единицы, типичной для северного краевого комплекса Тетиса. Переходы фация с предгорья в направлении открытого моря всегда простираются в северо-южном направлении. При всех теориях, говорящих об автохтонном положении зон вдоль линии Загреб-Земплин, нельзя замалчивать факт, что северная часть „Тисии" представляет собой центральную часть частично поднятого кристаллинового хребта (без фациальных переходов на север). Ее скорее всего можно считать северной (северовосточной) краевой серией Тетиса. Поэтому аллохтонная модель, которая указывает на горизон-

тальное движение большого масштаба, кажется более вероятной. Стиль позднегерцинского развития и подразделения зон фация от нижнего триаса до лайоса указывает на то, что „Тисия" до конца Лайоса (соответственно гипотезе Bleahu, 1976) была частью северного (северо-восточного) шельфа Тетиса; затем она откололась и вклинилась горизонтально между северо-западом динарид и Бюккимом динарийского типа; это, вероятно, произошло в конце юры – в начале мела.

1. Introduction

The idea of the "Pannonian" or "Hungarian Median Massif" was born partly in the reaction of Hungarian geologists, especially Lóczy, sen. (1918) against the exaggerations of Uhlig's (1907) nappe theory, and partly in the early geotectonic conceptions of the Alpine-Carpathian and Alpine-Dinaric chains (Kober, 1921). It was represented as being a rigid, cratonic median massif (Internide, Zwischengebirge) between these mountain belts (Zentraliden) and in part also included Mojsisovics's (1880) "Orientalisches Festland". Prinz (1926) extended it to include the greater part of the Inner Carpathian area and introduced the name "Tisia", after the Tisza river, for it. However, soon more mobilistic views arose against this orthodox, rigid interpretation, because the mountain areas in Hungary, outcropping from beneath the thick Neogene cover, exhibited Alpine facies and there was no sharp structural boundary between these "Centralides" and the "Internide". Telegdi Roth (1929) gave the first mobilistic interpretation of "Tisia", emphasizing that its history was not very different from that of the surrounding mountain chains until the Middle Cretaceous, and there was only one "Tisia" event at the end of the Cretaceous, when it acted as the median massif of the Outer Carpathians. Subsequent mobilistic views were presented by Pávai Vajna (1931), Rozlozsnik (1936) and Horusitzky (1961). However, for several decades it was really considered as a cratonic median massif more or less independent from its surroundings. Vadász (1961) called attention to the fact that there is no sharp difference between it and the neighbouring mountain chains. However, this opinion relied more on structural grounds than on paleogeographical ones. It was almost uniformly accepted that several Mesozoic geosynclinal "branches" separated by crystalline ridges extended from the Tethys into this median massif. (Four "cratogeosynclines", strangely without any trace of their coasts, and five crystalline "geanticlines" were postulated within Hungary!)

The discovery of the flysch-belt in the Great Hungarian Plain, in the "heart" of the Pannonian median massif (Körössy, 1959), and the Dinaric affinity of the Bükk Mountains (Balogh, 1964) were already great blows to the concept of this uniform median massif. Later its site was more and more restricted, essentially to the basement of the Great Hungarian plain.

Balogh (1972) gave an excellent and thorough review of the concepts concerning the "Pannonian massif". For more details about the pre-plate tectonic state of this problem the reader is referred to his work.

Wein (1969, 1973) grouped and summarized the structural belts of the Hungarian basin. Dank & Bodzay (1971) were the first to point out, that the crystalline ridges separating the above mentioned "geosyncline branches" are in reality formations of older structural stages outcropping on the margins of belts built of Mesozoic rocks.

The advent of plate tectonics has brought a revolution in the geotectonic concepts referred to the Pannonian basin, enabling a more mobilistic, and realistic, interpretation of the "ancient rigid, cratogenic Pannonian massif". It was Szádeczky-Kardoss (1971), who introduced the theory of the new global tectonics in Hungary. However, exaggerations of its application also soon appeared (e. g. five "subduction zones" in the Carpathian basin; Szádeczky-Kardoss, 1975).

Patrulius et al. (1971) and Géczy (1973 a, b) were the first to point out the striking differences between the Mesozoic of the two segments of the Carpathian basin separated by the Zagreb—Zemplin line, the northwestern one having a southern aspect, and the southeastern one having a northern aspect. They explained this facies-inversion, after Laubscher (1971), by horizontal movements along a wrench fault.

Szepesházy (1975, 1979), on the basis of his rich experience from deep bore holes into the basement of the Great Hungarian Plain, looked for the connections between that and the Northwestern Carpathians and Eastern Carpathians, and the Apuseni Mountains. Without using plate tectonic arguments, he also suggested that this facies-inversion must have happened due to later movements.

Channel & Horváth (1976), Bodzay (1977), Wein (1978 a, b) and Varga (1978) also explained this facies contrast by horizontal movements and suggested a northern origin for the present southern (southeastern) segment. Channel & Horváth applied the name "Tisia microplate" for the former "Pannonian median massif" or "Tisia" and established its boundaries: the Zagreb—Zemplin line on the northwest, the Mureş ophiolite belt on the east and southeast, the bifurcating Vardar-zone on the south and the Subpelagonian (or Serbian or Ophiolite) zone on the southwest. Its extent was approximately the same as that of Tollmann's "Tisia Zwischengebirge" depicted on his map (1969). Wein (1978 a, b) renewed Uhlig's (1907) classical hypothesis on the basis of Laubscher's (1971) plate tectonic reconstruction. His life work shows at the same time how the idea of "Tisia" has developed from a cratonic median massif with "coastless cratogeosynlines" to an integral part of the Alpine-Carpathian orogenic belt during its Paleozoic-Mesozoic history in the thinking of Hungarian geologists. His last papers (Wein, 1978 a, b) had historical meaning for Hungarian geotectonics. Unfortunately, his death prevented him from completing this work.

However, it was a problem of almost all these reconstructions, that on the basis of the Western Alps, following Laubscher (1971), they presumed that all thick carbonate series originated on the southern, African shelf of the Tethys, and they also placed the Western Carpathians there. The present author does not agree with this concept (Kovács, 1980).

The Roumanian geologist Bleahu (1976 and in Ianovici et al., 1976) suggested a model for the development of "Tisia", with which the present author is in considerable agreement. Only minor additions can be made to his basic concept.

2. Problems of the Late Paleozoic development

Before the advent of conodont studies it was generally believed that the Hercynian orogeny had an important role in North Hungary. Without fossils, except in the Szendrő IIIrd series, it seemed to be quite obvious, that the anchi — to

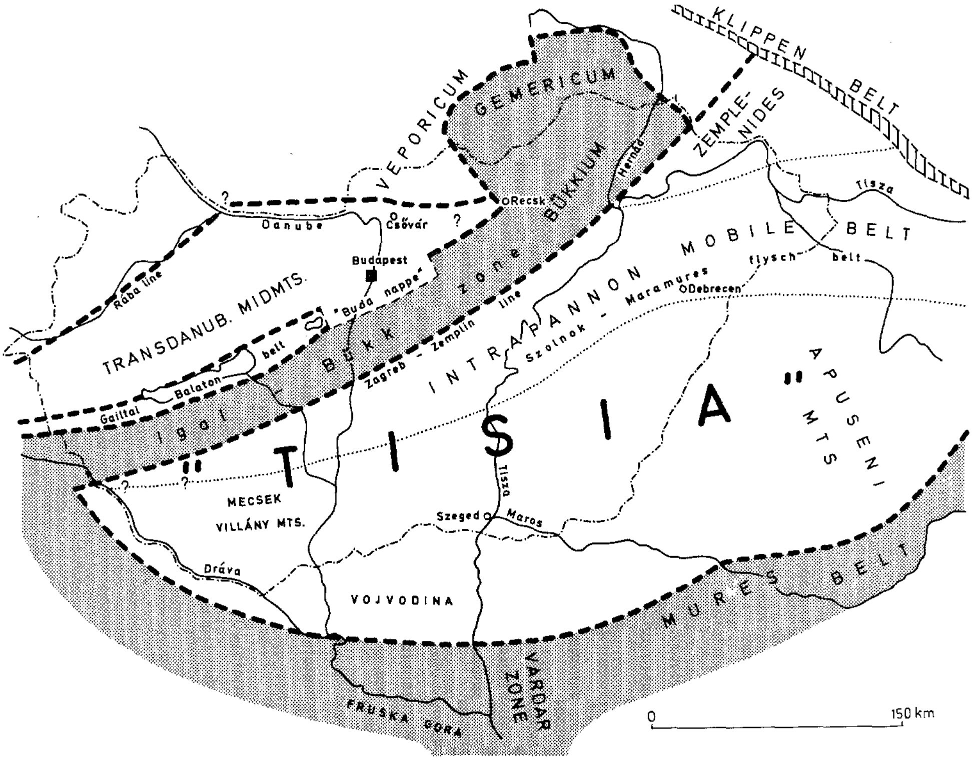


Fig. 1. Tectonic sketch of Hungary and its surrounding, showing the position of Tisia. *Remarks:* 1: The Silica nappe, belonging to the highest Subtatricum and thrust over the Gemericum, is not indicated; 2: The Darnó line in the continuation of the Gailtal-Balaton belt, formerly thought to have been of major tectonic importance, is now realized to be only a young, Neogene fault system (ZELENKA et al., in press).

slightly epimetamorphic Paleozoic series of the Szendrö and Uppony Mountains underwent a Hercynian (Sudetic phase) orogeny and constitute the direct basement of the nonmetamorphosed or only slightly metamorphosed Middle Carboniferous to Permian of the Bükk Mountains (BALOGH, 1964; BALOGH & KÖRÖSSY, 1968 and 1974). BALOGH (1964) showed with a very thorough analysis the Dinaric relationship of the latter.

However, conodont studies have proved the Serpukhovian-Bashkirian age of the Szendrő IInd and part of the Uppony IInd series, thus excluding the probability of any break in sedimentation between the Szendrő-Uppony and Bükk Paleozoic (KOZUR & MOCK, 1977; KOVÁCS, KOZUR & MOCK, in press). Also, parts of the Bükk Mesozoic show the same degree of metamorphism as the Uppony Paleozoic (ÁRKAI, 1973 and ÁRKAI et al., in press; KOZUR & MOCK, 1979; KOVÁCS, in press). From this it follows, that the tectogenesis and metamorphism of the B ü k k i u m (Middle Carboniferous-Mesozoic of the Bükk Mountain, Devonain-Carboniferous of the Szendrő and Uppony Mountains.) is of Alpine origin, and the Hercynian orgeny did not play an important role here, or at least the effect of the Alpine orogeny was very much stronger (c. f. Kozur & Mock, 1979 and Kovács, Kozur & Mock, in press). The facies is of Dinaric and Carnic Alpine type, the lower Middle Carboniferous is represented by Hochwipfel flysch-type sediments in all three mountains, while the higher Middle Carboniferous to Upper Carboniferous is represented by Auernig-type series in the Bükk Mountains (Balogh & Barabás, 1972; Kozur & Mock, 1977; Kovács, Kozur & Mock, in press). The area of the Bükkium was mobile and a site of marine sedimentation throughout the whole Hercynian — Alpine cycle (the eugeosynclinal Jurassic is proven by the newest Radiolarian finds of H. Kozur), thus representing a " Dinaric fragment or island" this far to the North.

The Dinaric relations of the Bükk Late Paleozoic were formerly explained by a prong, extending from the northwestern part of the Dinaric sea to the Bükk Mountains, because in several deep bore holes marine Upper Paleozoic has been found in one belt (Balogh & Körössy, 1968 and 1974; "Igal-Bükk eugeosyncline" of Wein, 1969).

On the contrary, this marine Upper Paleozoic belt weakly affected, or not at all, by the Hercynian orogeny is bordered both on the northwest by crust of the Central Western Carpathians and to the southeast by that of the Mecsek-Bihor belt, constituting the basement of the northern part of the Great Hungarian Plain, (Dank & Bodzay, 1971) stabilized during the Hercynian orogeny, with strong Carboniferous granitization [1]) followed by terrestrial Upper Carboniferous to Permian molasse sedimentation. They constituted the sialic basement of miogeoclines and miogeosynclines (shelves) during the Alpine geosynclinal stage.

The Upper Paleozoic marine strip connecting the Bükkium with the Dinarides is not wider than 20—30 kms in its present day extension. (For a map see Flügel, H. W., 1975, fig. 7.). This "Igal-Bükk eugeosyncline" does not continue up to the east of the Bükk Mountains being cut by the Zagreb-Zemplin line beneath the thick Miocene volcanics of the Tokaj Mountains. The Zemplenides follow on the eastern side of this main tectonic lineament with Hercynian metamorphism and a terrestrial Upper Carboniferous — Permian molasse sequence (Balogh & Körössy, 1974; Szepesházy, 1979, 1980; Pantó, 1968; Grecula & Együd, 1978).

From these geological facts it follows, that this " Igal-Bükk eugeosyncline" is only a tectonic zone and could never have been a paleogeographical unit. Such a narrow prong ("gulf"), bordered on both sides by continental land masses with terrestrial molasse sedimentation, would only explain a connection between the Dinaric and Bükk seas, but not the identity of the sedimentary facies (which were controlled by synsedimentary tectonic movements) and certainly not the same geotectonic development! Even, if we suppose that this "seaway" was much more wider than today, it is quite impossible that this zone would have escaped stabilization during the Hercynian tectogenesis between two blocks strongly stabilized during Carboniferous orogenic phases and with extensive Carboniferous granitization. Othervise we must imagine a wide oceanic area between them, which was later subducted, but this conflicts with the distribution of the Lower Triassic to Liassic facies zones, as we will see later. Also, the present position of the Mecsek-Bihor belt, in the southern neighbourhood of the Bükkium, conflicts with the well known southward progression of the Hercynian orogeny in the Eastern Alps (Schönlaub, 1979).

During the preparation of this manuscript, a paper has been published by MAJOROS (1980), on the Permian paleogeographical problems of the Transdanubian Midmountains (West Hungary). He also refutes the existence of the "Igal-Bükk trough" and suggests the original proximity of the Dolomites in the Southern Alps and the Transdanubian Midmountains on the basis of their almost identical Permian facies. According to him, they have moved away from each other along transcurrent faults.

3. Outline of the distribution of Lower Triassic — Liassic facies zones in the Carpathian basin and surrounding areas

The Triassic, and to some extent also the Liassic, formations of the Eastern Alps, West Carpathians, Apuseni Mountains and East Carpathians have many features in common. According to TOLLMANN (1968, p. 213) from the beginning of the Triassic the transition from the proximal ("vorlandnahe"; external, near-shore) to the distal ("vorlandferne"; internal, offshore) facies can be followed very clearly throughout the whole Alpine-Carpathian region, especially in the Scythian and Norian stages. The facies zones have been established by TOLLMANN (1965, 1974, 1977) and BYSTRICKÝ (1973). The tectonic units of the North Apuseni Mountains (Bihor autochton, Codru nappe system) are correlated with those of the Western Carpathians by PATRULIUS et al. (1971), SĂNDULESCU (1972), BLEAHU (1976), IANOVICI et al. (1976) and PATRULIUS (1976), and the units of the Inner Dacides with the North Apuseni Mountains by IANOVICI et al. (1976). According to TOLLMANN (1974) all these regions belong to the North Alpine and Central Alpine facies regions. The latter originally had a more northerly position.

The formations in the Apuseni Mountains continue towards the west-southwest in the basement of the Great Plain (SZEPESHÁZY, 1979; KURUCZ, unpubl. thesis, 1977). The carbonate platform-type Middle and Upper Triassic in the basement of Vojvodina (KEMENCI & ČANOVIČ, 1975) represents the continuation of the upper Codru nappes. The Late Paleozoic and Mesozoic of the Mecsek and Villány Mountains is correlated with different parts of the Bihor autochton, though the former is always interpreted as a more northern type (PATRULIUS et al., 1971; PATRULIUS, 1976; IANOVICI et al., 1976; FÜLÖP, lecture, 1979). A correlation has also been drawn between the Late Paleozoic and Triassic of Mecsek-Villány and the Zemplín Inselberg (GRECULA & EGYÜD, 1977).

3.1. Lower Triassic

The Lower Triassic transgression shows the same uniform trend in the mountains of the North and Central Alpine facies regions. Sequences are fully marine in the southern, internal units (Werfen Formation) becoming more and more continental (Quarzites; "Buntsandstein") towards the northern, external units (TOLLMANN, 1965, 1974, 1977; BYSTRICKÝ, 1973; MARSHALKO, 1978; IANOVICI et al., 1976). This direction is east-west in the present-day Eastern Carpathians (cf. SĂNDULESCU, 1975).

[1]) The Gailtal-Balaton belt, which also contains a great quantity of Carboniferous granites, is not dealt with in the present paper.

Bystrický, (1973, p. 16) distinguishes two facies areas in the Lower Triassic of the West Carpathians:

(a) a continental facies area with quartzites, quartzose sandsones and conglomerates ("Buntsandstein"; Tatric, Križna nappe and Seisian of the Choč nappe), and

(b) a marine facies area with variegated sandstones, clayey and marly shales and limestones (Werfen Formation; Silica and Stratena nappes, Campilian of the Choč nappe).

From this facies pattern it is obvious, that in the North and Central Alpine facies regions a gradual transgression took place from the interior part of the geosyncline toward the outer foreland situated to the north or northeast. Such a gradual transgression towards the foreland can be clearly traced in an east-west direction in the Southern Alps (Bosellini, lecture, 1979 and Bosellini & Gaetani, 1980).

In the Dinarides and in the Bükk Mountains the Lower Triassic is fully marine with sedimentary continuity above a marine Permian (Balogh, 1964; Ramovš, 1974). On the contrary, most of the Lower Triassic is continental in the area southeast of the Zagreb—Zemplin líne: Jakabhegy sandstone (analogue of the Buntsandstein) in the Mecsek Mts. (Nagy, 1968; Balogh, 1980) and, according to Grecula & Együd (1977), in the Zemplín Inselberg. Furthermore, according to Patrulius et al. (1979, p. 2), the Lower Triassic of the Bihor autochton seems to be almost exclusively continental but referred to as "Werfen Quartzite".

3.2. Middle Triassic

In the Middle Triassic the first rifting period of the Tethys, resulting in the "Porpyrite-radiolarite" formation of the Dinarides and Hellenides, took place, which aborted toward the northwest in the Southern Alps (Bechstädt et al., 1978). At this time the Triassic sea reached its greatest extent; most of the Hercynian domain in Europe was covered, though appearing in different stratigraphic levels, by the "Muschelkalk" sea. Thus, this situation is not so characteristic for paleogeographic investigations in the Alpine-Carpathian region, having a somewhat different arrangement from that of the Lower and Upper Triassic (cf. Tollmann, 1974, 1977 and Mello & Polák, 1978). But it is noteworthy to mention, that in the Ramsau dolomites of the northern units (Križna nappe, Tatricum) pseudomorphs after gypsum crystals can be found, indicating a hypersaline environment (Mišík, 1972).

To the southeast of the Zagreb—Zemplín line, the lithofacies of the Middle Triassic of the Mecsek Mountains shows similarities to the German Muschelkalk (Nagy, 1968; Kozur, pers, comm.) and to the West Balcanic Middle Triassic of Bulgaria. On the contrary, the Middle Triassic of the Balaton Highland (Transdanubian Midmountains) exhibits a typical South Alpine development, with Buchenstein Formation and thick "pietra verde" accumulations. In the Bükk Mountains, the Anisian dolomite building ends with a subaerial erosional phase with "Richthofen"-conglomerate type and then significant volcanic activity follows in the Lower Ladinian, with intermediate lavas (Balogh, 1980). The Middle Triassic of the Meliata series of the Innermost West Carpathians is characterized by the early appearence (Pelsonian) of deep water sediments (red limestones with conodonts of Dinaric province and radiolarites; KOZUR & MOCK, 1973 a, b) and can be compared with the Inner Dinarides (KOVÁCS,1980), but shows a surprising similarity to the Budva zone (MARCOUX, pers. comm., 1980).

3.3. Upper Triassic (Norian Stage)

In the North and Central Alpine facies regions, which, in the broad sense, can be traced from the Rhätikon to the Perşani Mountains, an original length of 1500 kms according to TOLLMANN (1974), the zonal arrangement of facies and the transition from the proximal to the distal facies is very well expressed in the Norian stage. So, the situation at this time is especially useful for paleogeographic investigations. These facies zones are as follows from the continental foreland towards the pelagic margin of the shelf (cf. TOLLMANN, 1965, 1974, 1977; ZANKL, 1967, 1971; BYSTRICKÝ, 1973 and KOVÁCS, 1980).

a. Carpathian Keuper facies zone: with different continental or continental-lagoonal detrital rocks (mainly of Keuper development) or hiatuses
b. Main dolomite facies zone
c. Dachstein limestone facies zone
d. Hallstatt limestone facies zone.

They bear witness to carbonate sedimentation on a wide shelf over the Epihercynian platform. The width of this shelf was a hundred or even several hundreds of kms. In the West Carpathians the eugeosynclinal series of the Meliata group and (West) Bükk Mountains(?) follow southward in the palinspastic reconstruction (MOCK, 1978; KOVÁCS, 1980).

There is an important break of the facies zones of this shelf in the Northeastern or Ukrainian Carpathians, both between the eastern end of the Subtatric nappes (a little to the east of the Hernád river) and the Maramureş "massif" of the Eastern Carpathians, and the Bihor autochton. This break is now occupied by the Zemplenides and the Intrapannon mobile belt or Szolnok-Maramureş flysch belt (SZEPESHÁZY, 1979, 1980). But in a paleogeographical reconstruction, as we will see later (fig. 3) it can be filled with "Tisia".

In the Apuseni Mountains the Vaşcău nappe belongs to the Hallstatt facies zone. Its Midle Triassic "Hallstatt-Schreyeralm" limestone (IANOVICI et al., 1976; PATRULIUS et al., 1979) shows many features in common although not exactly the same with the Nádaska limestone of the Silica nappe in the West Carpathians (KOVÁCS, 1979). The absence of Upper Triassic Hallstatt limestones can be explained by the present small extent of the nappe. They may have been eroded and only a thick Dachstein carbonate platform comparable with the "Wandkalk" of the Northern Limestone Alps (PATRULIUS et al., 1979 and PLÖCHINGER, pers. comm.) could have survived erosion.

In the East Carpathians the situation is much more complicated. The Upper Triassic of the Bucovinian and Subbucovinian nappes is not known (MUTIHAC & IONESI, 1974; SĂNDULESCU, 1975) and the Triassic sequence of the Transylvanian nappes can only be reconstructed from olistoliths in the Lower Cretaceous wildflysch. According to Dr. PATRULIUS (pers. comm., 1979) these olistoliths may have been derived from the Mureş ophiolite belt, where the Triassic, so far, has not yet been proven.

In the northwestern part of the Dinarides the facies trends are the opposite of those in the North and Central Alpine regions. Here the Hallstatt facies is present on the northeastern margin of the Outer Dinaric shelf, namely in the Bosnian zone, as well as in certain subzones of the Serbian (or Ophiolite or Subpelagonian) zone, while the Outer Dinarides (High Karst and Dalmatian zones) are characterized by extensive (Dachstein) limestone and dolomite buildups (Abouin et al., 1970; Dimitrijević, 1974).

In western Hungary, south of the Zagreb—Zemplín line in the Mecsek Mountains the Norian is represented by continental detrital formations and in the Villány Mountains by a hiatus, while north of the line, in the Transdanubian Midmountains, representing the South Alpine faciesregion (Kovács, 1980), it is represented by Main dolomites and Dachstein limestones.

The correlation of Triassic tectonofacies in the North and Central Alpine facies regions, based mainly on the Norian facies zones, is shown in fig. 2 and the very schematic original arrangement of Norian isopic zones in the Alpine—Carpathian —Dinaric region in fig. 3.

3.4. Liassic

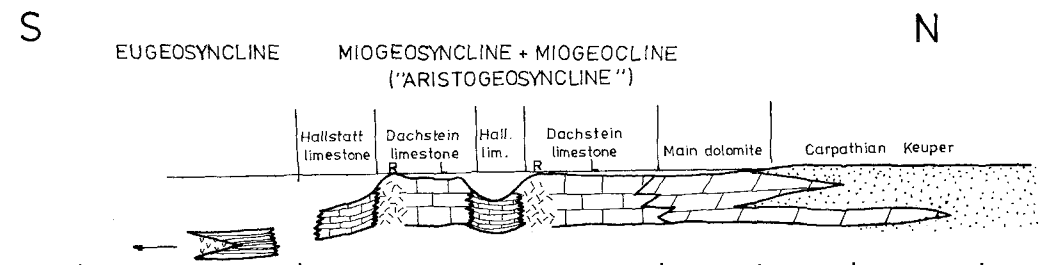
The regions belonging to the North and Central Alpine facies regions are characterized by the same trend of proximal and distal facies, as in the Lower Triassic and in the Norian stage. The northern units contain detrital facies (coal-bearing Gresten formation, as well as sandy crinoidal limestones, sandy marls and shales), suggesting the proximity of a continental terrain. In most of the units, even in the southernmost and highest ones, e. g. in the overlier of the Hallstatt Triassic (Medwenitsch, 1957) and in the Silica nappe (Bystrický, 1973), the spotty marl (Fleckenmergel) facies is very common, and toward the south it is accompanied by red Adneth limestones, which are also present in the Vaşcău nappe of the Apuseni Mountains (see Panin et al., 1974 and Patrulius, 1976).

Since the work of Patrulius et al. (1971) many authors have correlated the Mesozoic of the Mecsek—Villány Mountains in southern Transdanubia (Hungary) with that of the North Apuseni Mountains (among others Bleahu, 1976; Patrulius, 1976; Ianovici et al., 1976; Fülöp, 1979, lecture).

The Liassic of the Mecsek Mountains is made up of very thick coal-bearing Gresten facies overlain by spotty marl (Fleckenmergel) facies. The sediment transport direction (as also in the Upper Triassic) was from north to south (Nagy, 1971). The Liassic palinspastic section of the Apuseni Mountains also manifests a sediment transportation from north to south (Patrulius, in Ianovici et al., 1976, p. 169, fig. 306).

On the contrary, the Jurassic of the Transdanubian Midmountains, to the northwest of the Zagreb—Zemplín line, does not show any trace of detrital faces (Fülöp 1971; Géczy, 1973 a, b). These differences between the Jurassic of this area and that of the Mecsek Mountains are thoroughfully discussed by Géczy (1973 a, b), to which the reader is reffered for further details.

The striking similarites between the Jurassic of the Mecsek Mountains, and



NORTHERN LIMESTONE ALPS	—	Kalkhochalpin (Juvavicum)	Kalkvoralpin (Tirolicum)	(Bajuvaricum)	Mittel-ostalpin	Unter-ostalpin	
WEST CARPATHIANS	← Bükk; Meliata (+Foederata?) series	Silica nappe	Stratena nappe	Hronicum (Choč + Sturec nappe) + Strážov n.	Veporicum: Struženík series	Veporicum: Velký Bok. ser.; Fatricum (Križna nappe)	Tatricum
APUSENI MOUNTAINS	Mureş belt (?)	Vaşcău nappe	Dieva + Moma nappe	Arieşeni nappe	Finiş nappe	Vălani nappe	Bihor autochtonous
EAST CARPATHIANS	Transylvanian nappes: Perşani series	Transylvanian nappes: Haghimăş series	?	?	?	Bucovinian nappe	Sub-bucovinian n.; Maramureş nappe

Fig. 2. Correlation of the Triassic tectonofacies in the North and Central Alpine facies regions, based mainly on the situation in the Norian stage (mostly after TOLLMANN, 1975 and BLEAHU, in IANOVICI et al., 1976). (Abbreviations: R = reef facies, L = lagoonal facies.)

that of the South Carpathians and Balkanides in Bulgaria, have been well known since the time of Mojsisovics's "Orientalisches Festland" (1880). However, a direct connection is broken by the different development of the Liassic in the basement of Vojvodina (black shales; Kemenci & Čanovič, 1975) and more so by the eugeosynclinal Vardar—Mureş belt.

The eugeosynclinal Jurassic of the Bükk Mountains and Meliata series in North Hungary and South Slovakia, which has recently been shown by Dr. Kozur's radiolarian finds, is only comparable with that of the Inner Dinarides.

4. Autochtony or allochtony of "Tisia"?

Based on the distribution of Lower Triassic to Lower Jurassic facies zones discussed above, let us try now to interpret the position of "Tisia" (sensu Channel & Horváth, 1976) in two different ways.

4.1. Autochtonous position

If we suppose, that "Tisia" was always in about the same position, as shown on fig. 5, it raises the following contradictions, even keeping in mind that the eugeosynclinal belts surrounding it (Vardar—Mures belt, Subpelagonian belt, Intrapannon mobile belt) were much wider than in the present structural situation.

4.1.1. If the Mecsek Mountains and the Bakony Mountains were always in the same position as at present, traces of detrital sediments should also be present in the Jurassic of the latter; however this is not so (Géczy, 1973 a, b). The pelagic Jurassic of Bakony is very similar to that of the Lombardian Jurassic basin in the Southern Alps (Fülöp, 1971; Gaetani, 1975), and its Triassic belongs to the South Alpine facies region (Kovács, 1980). The "Balaton-Velence crystalline ridge" south of it was not an elevated continental mass during the Mesozoic, but formed of deeper structural elements as a continuation of the Periadriatic lineament, elevated by later tectonic processes (Dank & Bodzay, 1971). The absence of detrital Jurassic formations in the Bakony makes it quite impossible, that these two areas were in their present position in the Lower and Middle Jurassic, even if we suppose a wide oceanic area between them, because sediment transport in the Mecsek was from north to south (Nagy, 1971) [2]). It also excludes the possibility, that the source area of the Jurassic shales of the Bükk Mountains (formerly placed in the Ladinian, but their Jurassic age has recently been demonstrated by Dr. Kozur using Radiolarians) was the same as that of the Gresten Formation and spotty marls (Fleckenmergel) of the Mecsek-Bihor belt. Sandstones with coalified plant remains in the southwestern Bükk Mountains cannot be used as evidence of a link toward the Mecsek-type Liassic, because, on the one hand, they are from olistostromes and olistoliths and, on the other hand, they contain *Anotopteris* sp., the age of which is Carboniferous to Triassic (Balogh, 1964). The Mecsek-Bihor granite belt was not a central, emergent crystalline ridge during the Lower Triassic to Liassic, but a northern margin, like the Helveticum, which could never have supplied detritus towards the north.

4.1.2. If "Tisia" was always in its present position as an "island", it must have had a central, emergent dry land during the Lower Triassic to Lower Jurassic, which would have had to have been surrounded by a carbonate platform belt from both the northern and southern sides. That is, a ring-like, symmetrical arrangement of isopic zones would be expected around it. However, the distribution of facies zones and the direction of sediment transport show unambiguously, that the arrangement of proximal to distal facies was from the north to the south (NAGY, 1971; PATRULIUS in IANOVICI et al., 1976; KOVÁCS, 1980), the same as in the Eastern Alps and Western Carpathians. Carbonate platform facies are only present in the southern parts or units, in the Codru nappe system and in the basement of the southern Great Plain (IANOVICI et al., 1976; PATRULIUS et al., 1979 and KEMENCI & ČANOVIČ, 1975). On the contrary, Mecsek-type Permo-Triassic and Jurassic has been explored by numerous deep bore holes to the southeast of the Zagreb-Zemplín line [3]) as far as the northeastern boundary of Hungary (DANK & BODZAY, 1971, SZEPESHÁZY, 1977, 1979). One may suppose, that this missing northern flank of Tisia, which would represent a transitional zone between the two main segments of the Carpathian basin, is thrust under the northwestern unit. However, according to geophysical measurements, a mass of high specific gravity can be found beneath the sediments of the Transdanubian Midmountains (ÁDÁM, 1979, and in WEIN, 1978), which could hardly indicate an underthrust light sialic crust.

Also, if "Tisia" was in the present position, the Lower Triassic transgression would have had to reach its northern part from the north, from the so-called "Igal-Bükk trough". However, there is no sign of such a Lower Triassic transgression. In the case of the Apuseni Mountains it was from the south to the north (IANOVICI et al., 1976; PATRULIUS et al., 1979).

4.1.3. Transition of proximal to distal facies is in a north to south direction in the Eastern Alps and Western Carpathians; in the case of autochtony the opposite direction should be present to the south of the "Igal-Bükk trough".

4.1.4. According to several authors, the early appearance (Bythinian-Pelsonian) of basinal facies with "Asiatic" conodonts in the Rudabánya Mountains (Northeastern Hungary) and the Meliata series (Southern Slovakia) suggests a connection towards the East Carpathians (Transylvanian nappes) at this time (KOZUR, 1979). The author is in agreement with this conclusion, but in the sense of fig. 3. In case of autochtony of "Tisia" a connection between the Innermost West Carpathians and the Transylvanian nappes is quite impossible, because the eastern continuation of the Bükkium and Gemericum, as well as that of the Silica nappes is cut by the Zagreb-Zemplín line, the eastern side of which is followed by the Zemplenides, with quite different Carboniferous to Triassic, resembling that of the Mecsek Mountains (GRECULA & EGYÜD, 1977; SZEPESHÁZY, 1979, 1980).

4.1.5. There is a close similarity between the Liassic of the Mecsek and that of the South Carpathians (Resiţa), as well as that of the West Balkanides in Bulgaria, on which MOJSISOVICS's (1880) "Orientalisches Festland" was based. However, a direct connection between these areas is broken by the different type of Liassic

[2]) It should also be mentioned, that according to BÓNA (1979) the Upper Triassic sporomorph-association of the Mecsek Mountains is very different from that of Transdanubian Midmountains. The sporomorph-association of the Liassic coal measures is also different from that of Gresten, but very similar to those in Roumania.

[3]) Apart from basic rocks, the Mecsek-Bihor belt constitutes the basement of the Intrapannon mobile belt (SZEPESHÁZY, 1977, 1979).

of Vojvodina (black shales; Kemenci & Čanovič, 1975) and by the Vardar-Mureş ophiolite belt. But according to the palinspastic reconstruction suggested by Bleahu (1976, p. 14—18, fig. 2 and in Ianovici et al., 1976, p. 590—591, fig. 175) and the present author (fig. 3.), their connection is easy to explain: both the Mecsek-Bihor belt and the South Carpathians belonged to the proximal margin of the same stable shelf.

4.2. Allochtonous position

If we suppose an original northeastern position of "Tisia" as suggested by Patrulius et al., (1971), Géczy (1973 a, b), Bleahu (1976), Patrulius (1976), Szepesházy (1975, 1979, 1980), Wein (1978 a, b), Kovács (1980) and others, the following objections can be raised against it:

4.2.1. The scale of horizontal movements. To get the present-day position of "Tisia", we have to suppose a dextral slip along the Zagreb-Zemplín line in the order of 300—500 kms, which might have been combined with some rotation, concomittantly with the formation of the Intrapannon mobile belt (Upper Jurassic-Lower Cretaceous). Some 10—15 years ago it would still have been a utopy, but now even actualistic examples of such larger-scale horizontal movements are known (e.g. the San Andreas fault). The Paleogene slip along the Periadriatic lineament was between 100—150 and 300 kms according to Tollmann (1978), established on the basis of a critical review of all available data. In the Upper Jurassic-Lower Cretaceous, during the main oceanisation stage in the Western Tethys, there must have been enough space for even larger horizontal movements.

4.2.2. Could the North Apuseni Mountains be the continuation of the Eastern Alps — West Carpathians? There are many features in common in the Triassic and Liassic formations of the two areas, which have been known for a long time. The eastern continuation of the Subtatric nappes is cut by the Zagreb-Zemplín line (Grecula & Varga, 1979) and there is an "empty" space between the West Carpathians on one hand, and the Maramureş unit and Bihor Autochton on the other, which is occupied by the Zemplenides and the Intrapannon mobile belt viz. its eastern part, the Szolnok-Maramureş flysch belt (Szepesházy, 1975, 1979, 1980). In case of autochtony a transition from proximal facies to distal facies must also be present to the north of the Bihor autochton (see also points 4.1.2. and 4.1.3.) However, it is missing. The former continuity of the West Carpathians and the Apuseni Mountains has already been suggested by Patrulius et al. (1971), Săndulescu (1972), Bleahu (1976), Patrulius (1976), Kovács (1980) and others. However, when correlating two areas supposed formerly to have belonged together we have always to look at the differences, as well; these difficulties were pointed out by Kozur (1979), who reached an opposite conclusion. Here we must emphasize, that in case of long-distance correlation we may not except the total identity of all part-sections, but only that of the main features in the geologic history of the separate areas. One of the most important ones (if not the most important one) is the distribution of facies zones, which reflects the effectivness of the facies-law. Even within the main facies zones there are differences, which make it possible to distinguish subfacies (Tollmann, 1974, 1976). There are at least as many differences between the Eastern Alps and West Carpathians, as between the latter and the Apuseni Mountains; however, nobody would think that the Eastern Alps do not continue into the West Carpathians. And we must also not forget that the original distance between the Western Carpathians and the Apuseni Mountains must have been about 300 kms! (PATRULIUS, 1976). The presence of Upper Anisian reptiles of poor swimming ability in the Bihor Autochton, which are also present in the Germanic basin, points to the close connection of these two areas (PATRULIUS et al., 1979, p. 6) and excludes the possibility that the Bihor Autochton was to the south of the Meliata series at this time.

4.2.3. The presence of some tuff(?)-traces and green clay intercalations in the Mecsek Mountains (NAGY & RAVASZ-BARANYAI, 1968; WÉBER, 1978), which were sometimes thought to be evidence of its South Alpine affinity. However, the amount is so small, that it can be ignored, when compared with the Middle Triassic tuffs of the Balaton Highland. Moreover, green clay intercalations are present even in the Middle Triassic of the Tatricum (BYSTRICKÝ, 1973).

4.2.4. The pelagic open-sea trough north of the Tatrides, suggested by MIŠÍK et al. (1977) on the basis of the presence of Hallstatt limestone pebbles in the Cretaceous (Albian?) conglomerates of the Pieniny Klippen Belt, seems to be in contradiction with the marginal position of the continental-lagoonal Carpathian Keuper facies zone. However, we think that it is not the only possible explanation for the origin of these conglomerates (see also MICHALÍK, 1978; VARGA, 1978; HORVÁTH et al., 1977). Olistostromes with smaller or larger Hallstatt limestones blocks are well known from several klippen regions in the Tethys realm (Transylvanian nappes in the East Carpathians, Kotel zone in northeastern Bulgaria, Himalayas) but their origin is as yet unsolved (TOLLMANN, 1968, p. 236—241).

As for those in the Pieniny Klippen Belt, an alternative model may be suggested, as regards to the distance between the Margecany line, where the Silica nappe can be originated (MOCK, 1980), and the Klippen Belt; it is only 30—40 km. The possibility cannot be excluded, that from this line, with a fan-like structure, a Silica-type Triassic may have been thrust toward north, as well, which was later completely eroded. Because the paleocurrent-system in the Klippen Belt flysch-geosyncline was from the southeast to the northwest (CONTESCU, 1974), debris flows and slumpings may have transported its remnants together with some Albian sediments in the westernmore parts of this trough in the Upper Cretaceous (to form olistostromes).

4.2.5. Finally we have to deal with faunal evidences, the interpretation of which is still rather contradictory. GÉCZY (1973 a, b) and VÖRÖS (1977, and in HORVÁTH, VÖRÖS & ONUOHA, 1979, p. 210—211, fig. 1) argued for the northern origin of "Tisia", based on Liassic ammonite and brachiopod faunas, which can also be concluded from facies analysis, this being the northern facies type. They explained the differenciation of the Mediterranean and European faunal provinces by the presence of an oceanic belt, separating them. However, the Penninic ocean began to open only in the Dogger (DIETRICH, 1976). On the contrary, KOZUR (1979) argued for a southern origin of the Apuseni Mountains related to the Southern Alps, based on Triassic conodonts (presence of *Pseudofurnishius murcianus* v. d. BOOGAARD in the North Apuseni Mountains), holothurian-sclerites and ostracods.

Pseudofurnishius murcianus (Upper Ladinian—Lower Carnian) is a conodont typical of restriced basin environments behind or within carbonate platforms. It has been found in only one sample in each of the following areas: the Italian part of the Julian Alps (NICORA, pers. comm.), the northern Dinarides northwest of Ljubljana (RAMOVŠ, 1977) and in the Vălani nappe of the Apuseni Mountains (KOZUR, 1979). Mostly it is the only platform conodont in a usually poor conodont association. Until now it has not been found in the Eastern Alps and West Carpathians, but can be expected from such restricted basin facies.

Another problem is the occurrence of Lower Anisian conodonts in the Germanic basin, since in the Alpine shelf ("aristogeosyncline" sensu TOLLMANN, 1977) no conodont-bearing facies is present at this time. We are in full agreement with Dr. KOZUR (1980) that they must have come from the North Tethys through North Dobrogea (Tulcea zone), but this connection [4]) must now be hidden, if not entirely destroyed, beneath the Outer Carpathian nappes, east of the Bucovinian and Subbucovinian nappes.

Finally, we must add at this point, that any paleobiogeographical consideration, being either mobilistic or non-mobilistic, should not merely rely upon paleontological data. It must be carried out together with the analysis of sedimentary facies, the natural environment in which the fossils are embedded, otherwise pure paleontological speculations may lead to misinterpretations and false conclusions (such as the first plate tectonic reconstructions in the Tethys, relying only upon the contour and fitting of microplates). Also, there is a danger that paleobiogeographical analysis of different fossil groups may yield quite different reconstructions. Whatever reconstruction is decided upon, it must be in accordance, or at least must not contradict, with field geological data of the whole area concerned!

5. Conclusions

Our present knowledge is far from enabling us to solve all tectonic and paleogeographic problems of the Carpathian basin and mountain chains surrounding it, but as we can see, an allochtonous model for "Tisia" gives a much more plausible explanation for the distribution of Late Paleozoic to Early Mesozoic isopic zones and the geological history of this area at that time. This model can be summarized as follows:

As we could see during the review of Middle Carboniferous to Liassic isopic zones, the northwestern part of the Dinarides in one hand, viz. the Bükkium and most probably the Gemericum (but in all cases the depositional site of the Meliata series) at this time must have constituted the adjacent parts of the same eugeosynline. These areas are to-day 400—500 kms away from each other and the "Igal-Bükk zone", supposed to connect them, is a tectonic belt but not a paleogeographic unit (see point 2.). Also, in the present day position the eastward connections of the Bükkium and Meliata series are broken by the Zagreb-Zemplín line (see points 2, 3.1. and 3.3.). The Dinarides and the Bükkium become separated from each other later when a stable sialic block of northern [5]) (northeastern) marginal origin was wedged in between them. This block was part of the

[4]) That is, the southeastward continuation of the Polish-East Carpathian gate (SENKOWICZOWA & SZYPERKO-SLIWCZYNSKA, 1975, p. 139 and fig. 57).

northern, stable (passive) continental margin of Tethys until the end of the Liassic (BLEAHU, 1976; KOVÁCS, 1980; see fig. 3). In the Lower Triassic the transgression took place from the central, Dinaric sea (including Bükkium) towards Apulia and stable Hercynian Europe. The rifting in this central, Dinaric sea, which was something resembling a gulflike termination of the Tethys towards the northwest at that time, began in the Middle Triassic (but with eastward shifting according to the polarity of the geosynclines) and aborted toward the northwest (BECHSTÄDT et al., 1978). This rifting basin, which was not yet very wide [6]) in the Middle and Upper Triassic, was surrounded by wide shelves covered by vast, thick carbonate platforms, with intraplatform basins (which sometimes created restricted environments). In the Norian stage the (pelagic) margin of these shelves was marked by the Hallstatt limestone facieszone (fig. 2), including isolated Dachstein carbonate platforms (such as "Hochjuvavikum", Durmitor nappe). Behind the narrow reefal front (Dachstein reef limestone) the extended lagoons of the lagoonal facies of the Dachstein limestone and the ultra-back-reefal Main dolomite followed. The northern or northeastern shelf was formed on the stable (passive) continental margin of the Ephihercynian region. Its continental side was indicated by the interfingering of the carbonate platforms with the Carpathian Keuper facies zone (with typical Carpathian Keuper or different detrital formations or hyatuses), that is, by sabkhalike facies. Also in the Liassic, the proximal regions had a plentiful supply of detritus (Gresten formation, sandy limestones and to the south more and more marls and "Fleckenmergel").

The main oceanisation phase of the Tethys took place during the Upper Jurassic — Lower Cretaceous and the opening of the Penninicum began in the Dogger (DIETRICH, 1976). The Klippen Belt, the Magura zone and the Outer Dacides constitute a continuation of the Penninicum (MAHEL', 1980). But most probably only the North Penninicum continues towards the east: the Ligurian-Piemontian belt seems to wedge out in the West Carpathians, at least it is not known east of the Rechnitz-Kőszeg window. This (North) Penninicum bifurcates N of the Batiza klippes (SZEPESHÁZY, 1979, 1980; MAHEL', 1980): one branch continues in the Outer Dacides (Black flysch and Ceahlau nappes), then in the Severin nappe in the South Carpathians, while the other is in the basement of the Pannonian basin, in the Intrapannon mobile belt (JUHÁSZ & VASS, 1974; SZEPESHÁZY, 1979). It seems very probable, that the disrupture of the above mentioned uniform northern or northeastern carbonate platform belt was concomittant with the opening of this Penninicum, as suggested by BLEAHU (1976), that is, with its separation from stable Europe (which process was compared with the formation of back-arc basins by him). Due to a dextral slip along the Zagreb-Zemplín line, combined with an anticlockwise rotation, the segment representing the "Tisia microcontinent" split off the stable European margin constituting the northern (northeastern) shelf of the Tethys and has become wedged in its present position. By the end of the Jurassic — beginning of the Cretaceous the palinspastic situation depicted on fig. 4 must have been realised. The missing segment

[5]) The "northern" origin is used here sensu lato.

[6]) According to Prof. Dr. KARAMATA's (Beograd) personal communication during the EGS symposium in Budapest, 1980, the eugeosynclinal basins of the Subpelagonian and Vardar zones were not broader than 80—100 km in the Upper Triassic.

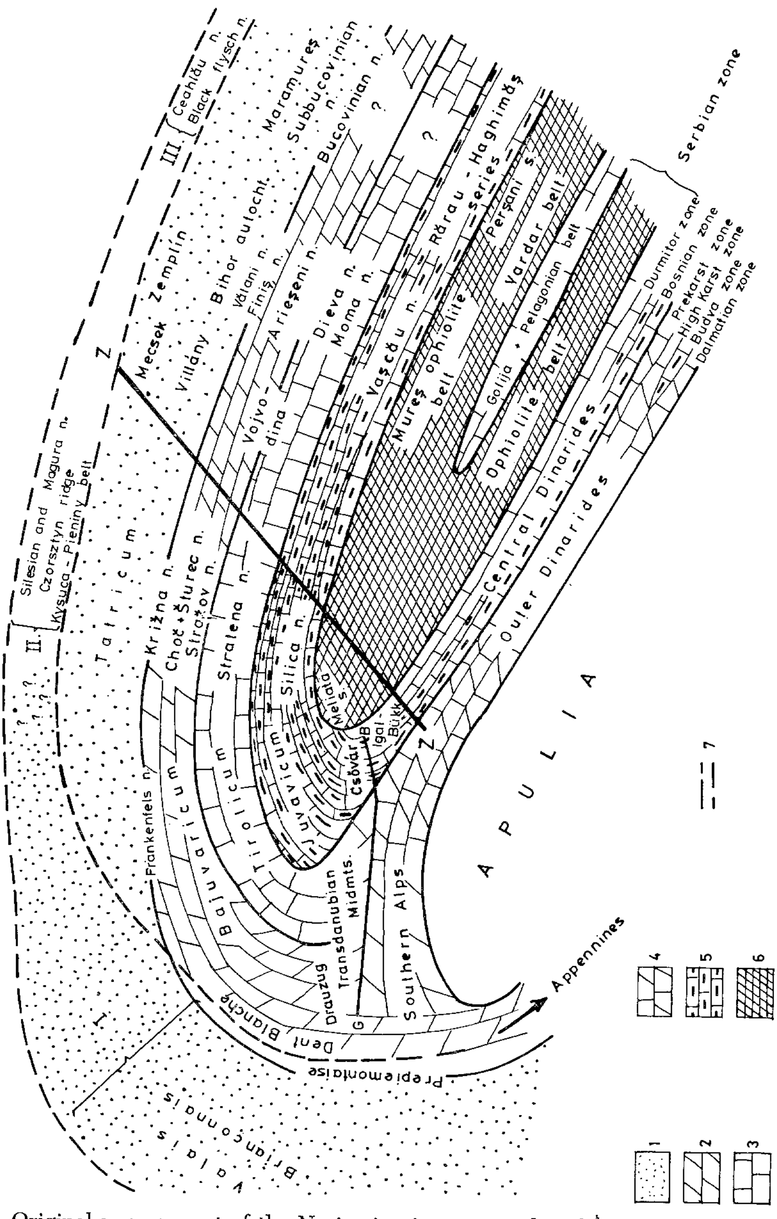


Fig. 3. Original arrangement of the Norian isopic zones in the Alpine-Carpathian-Dinaric system (sketch of principle, without scale).

Legend: 1: Continental detrital deposits (mainly Keuper facies) or hiatuses; 2: Main dolomite; 3: Dachstein limestone; 4: Main dolomite and Dachstein limestone; 5: Hallstatt limestone; 6: Eugeosyncline since the Ladinian; 7: Location of the later opening Penninicum:

I. Penninic ocean (Dietrich, 1976)
II. "Pieniny ocean" (Channel & Horváth, 1976)
III. "Siret ocean" (Herz & Savu, 1974; partly)
G—B: Gailtal-Balaton line; Z—Z: Zagreb-Zemplín line.

in the Northwestern (Ukrainian) Carpathians, between the nappes of the Central West Carpathians (sensu MOCK, 1980), on the one hand and that of the East Carpathians (Inner Dacides), as well as the North Apuseni Mountains on the other, should be sought in "Tisia" itself. The Zemplenides moved together with "Tisia" along the Zagreb-Zemplín line, but separated from it by the formation of the Intrapannonian mobile belt.

In this way the idea of *"Tisia"* (Pannonian Median Massif) is preserved in the new mobilistic concept, the plate tectonic theory incorporates and develops it further in the form of a microcontinent surrounded by mobile, eugeosynclinal belts ("microooceans"), which became independent during the Jurassic and got wedged in between the northwestern Dinarides and the Dinaric-type Bükkium. It seems, that in its western part it suffered a weaker deformation during the Alpine orogeny, but at least in its eastern part, in the Apuseni Mountains, multiple

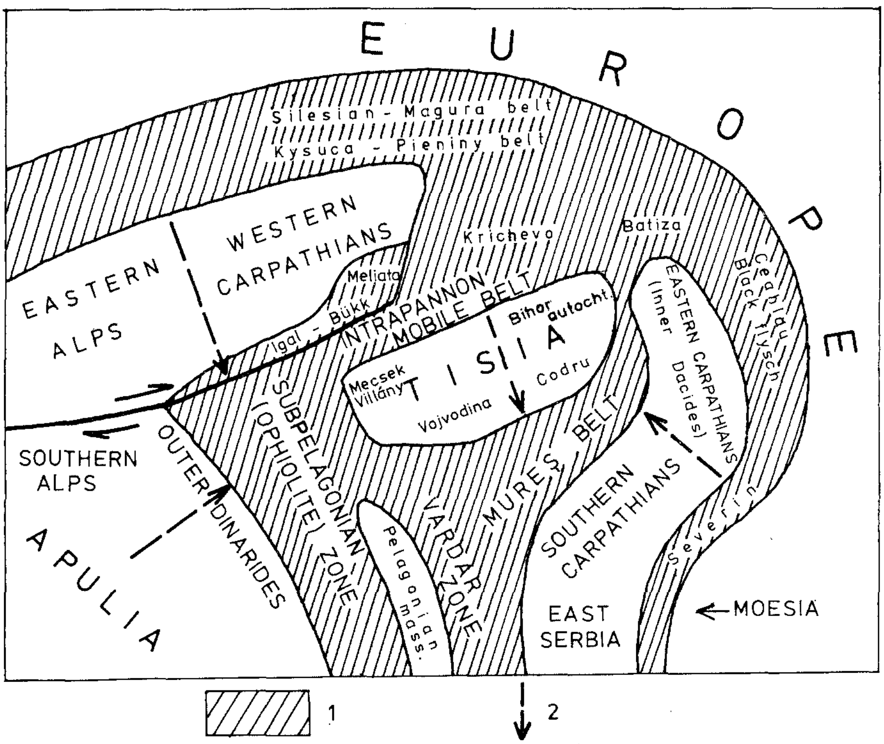


Fig. 4. Approximate position of Tisia at the end of the Jurassic — beginning of the Cretaceous. *Legend:* 1: Eugeosynclinal belts; 2: Direction of proximal ("vorlandnahe") →distal ("vorlandferne") facies during the Lower Triassic — Liassic. *Remarks:* 1: The Gailtal-Balaton and the Zagreb-Zemplín lines are drawn together for the sake of simplicity. 2: The Zemplenides, which are not indicated on the drawing but moved together with Tisia along the Zagreb-Zemplín line for a certain time and separated from it by the formation of the Intrapannon mobile belt, should be located at the eastern neighbourhood of Bükk-Meliata.

nappe-building took place, and, taking into account the southern vergency of the Bükkium, its role as a median craton controlling the vergency of the surrounding mountain chains can no longer be maintained.

Acknowledgements

The author is greatly obliged to Academician Dr. J. Fülöp (Budapest) for his guidance and efficient help offered during this work devoted to the study of Paleozoic and Triassic rocks in Hungary. Thanks are due to Dr. P. Gyarmati, Dr. J. Haas, Dr. B. Jantsky, Dr. E. Nagy (all Budapest), Dr. A. Baud (Lausanne), Dr. H. Kozur (Meiningen), Dr. L. Krystyn (Vienna), Dr. J. Marcoux (Orsay), Prof. Dr. D. Patrulius (Bukarest) and Dr. A. Vozárová and Dr. J. Vozár (Bratislava) for discussing some parts of this work.

Special thanks are due to Dr. D. H. Oswald (London) for reading the English text.

References *)

Aubouin, J., Blanchet, R., Cadet, J. P., Celet, P., Charvet, J., Chorowicz, J., Cousin, M., Rampnoux, J.-P.: Essai sur la géologie des Dinarides. — Bull. Soc. géol. France (7), **12**, 6, p. 1060—1095, Paris, 1970.

Balla, Z., Baksa, Cs., Földessy, J., Havas, L., Szabó, I.: The tectonic setting of the ophiolites in the Bükk Mountains (North Hungary). Geol. Zborn. Geol. Carpath., **31**, 4, p. 465—493, Bratislava, 1980.

Balogh, K.: Die geologischen Bildungen des Bükk-Gebirges. Ann. Inst. Geol. Hung., **48**, 2, p. 245—719, Budapest, 1964.

—: Historical review of conceptions referring to the Pannonian Mass. Geol. Práce, Správy **58**, p. 5—28, Bratislava, 1972.

—: Answer to the Paper by T. Szalai on "The Variscan Northern Region and the Marine Upper Carboniferous, Permian and Triassic of the Bükk Mts., NE-Hungary". (In Hung., with English summ.) Ált. Földt. Szemle, **12**, p. 99—106, Budapest, 1979.

—: A magyarországi triász korrelációja. (Correlation of the Hungarian Triassic). Ált. Földt. Szemle. **15**, p. 5—67, 6 tables, Budapest, 1980.

Balogh, K., Barabás, A.: The Carboniferous and Permian of Hungary. Acta Miner. Petr. Szeged, **20**, 2, p. 191—207, Szeged, 1972.

Balogh, K., Körössy, L.: Tektonische Karte Ungarns im Maßstabe 1 : 1 000 000. Acta Geol. Acad. Sci. Hung., **12**, 1—4, p. 255—262, Budapest, 1968.

— —: Hungarian Midd-Mountains and adjacent areas. In: Mahel, M. (Ed.): Tectonics of the Carpathian-Balkan regions, p. 391—403, GÚDS Bratislava, 1974.

Bechstädt, Th., Brandner, R., Mostler, H., Schmidt, K.: Aborted Rifting in the Triassic of the Eastern and Southern Alps. — N. Jb. Geol. Paläont., Abh. **156**, 2, p. 157—178, 1978.

Bleahu, M.: Structural position of the Apuseni Mountains in the Alpine system. Rev. Roum. Géol. Géoph. Géogr., Géol., **20**, 1, p. 7—19, Bucuresti, 1976.

Bodzay, I.: Geological Considerations for Assessing the Hydrocarbon Prospects of the Pre-Neogene Formations in Hungary. (In Hung., with English summ.). Ált. Földt. Szemle, **10**, p. 113—184, Budapest, 1977.

Bóna, J.: Tele-identification of coal-seem groups by palynological methods within the Mecsek Lower Liassic Measures. (In Hung.) Földt Kut., **22**, 4, p. 29—32, Budapest, 1979.

*) Because of shortage of place, only some of the most important non-Hungarian literature and the latest Hungarian works concerned with this region are listed up here: for a more detailed list of reference the reader is referred to the papers of Balogh (1972) and Kovács (1980).

CHANNEL, J. E. T., HORVÁTH, F.: The African/Adriatic promontory as a paleogeographical premise for Alpine orogeny and plate movements in the Carpatho-Balkan region. Tectonophysics, **35,** 1—3, p. 71—102, Amsterdam, 1976.

CONTESCU, L. R.: Geologic history and paleogeography of Eastern Carpathians: example of alpine geosynclinal evolution. AAPG Bull., **58,** 12, p. 2436—2476, 1974.

DANK, V., BODZAY, I.: Geohistorical background of the potential hydrocarbon reserves in Hungary. Acta Miner. Petr. Szeged, **20,** 1, p. 57—70, Szeged, 1971.

DIMITRIJEVIĆ, M.: Hercynian Metamorphism in the Central Part of the Balkan Penninsula. Z. Deutsch. Geol. Ges., **123,** p. 329—335, Hannover, 1972.

—: The Dinarides: a model based on the new global tectonics: In: JANKOVIĆ, S. (Ed.): Metallogeny and concepts of the geotectonic development of Yugoslavia, p. 141—178, Beograd, 1974.

FLÜGEL, H. W.: Einige Probleme des Variszikum von Neo-Europe. Geol. Rdsch. **64,** 1, p. 1—62, Stuttgart, 1975.

FÜLÖP, J.: Les formations jurassiques de la Hongrie. Ann. Inst. Geol. Hung., **54,** 2, p. 31—63, Budapest, 1971.

GÉCZY, B.: The origin of the Jurassic faunal provinces and the Mediterranean plate tectonics. — Ann. Univ. Sci. Budapestinensis, sect. Geol., **16,** p. 99—114, Budapest, 1973 a.

—: Plate Tectonics and Paleogeography in the East-Mediterranean Mesozoic. — Acta Geol. Hung., **17,** 4, p. 421—428, Budapest, 1973 b.

GRECULA, P., EGYÜD, K.: Position of the Zemplín inselberg in the tectonic frame of the Carpathians. — Miner. Slovaca, **9,** 6, p. 449—462, Spišská Nová Ves, 1977.

GRECULA, P., VARGA, I.: Main discontinuity belts on the inner side of the Western Carpathians. — Miner. Slovaca, **11,** 5, p. 389—404, Spišská Nová Ves, 1979.

HORUSITZKY, F.: Die triassischen Bildungen Ungarns im Spiegel der Großtektonik. — Ann. Inst. Geol. Publ. Hung., **49,** 2, p. 345—363, Budapest, 1961.

HORVÁTH, F., VÖRÖS, A., ONUOHA: Plate-tectonics of the Western Carpatho-Pannonian region: a working hypothesis. Acta Geol. Hung., **21,** 4, p. 207—221, Budapest, 1979.

IANOVICI, V., BORCOS, M., BLEAHU, M., PATRULIUS, D., LUPU, M., DIMITRESCU, R., SAVU, H.: Geologia Munţilor Apuseni. 631 p., Bucuresti, 1976.

JANTSKY, B.: Geologische Entwicklungsgeschichte des präkambrischen und Paläozoischen Untergrundes im pannonischen Becken. Nova Acta Leopoldina, N. F. 224, **45,** p. 303—334, Halle, 1976.

JUHÁSZ, Á., VASS, G.: Mesozoische Ophiolite im Beckenuntergrund der Großen Ungarische Tiefebene. Acta Geol. Acad. Sci. Hung., **18,** p. 349—358, Budapest, 1974.

KEMENCI, R., ČANOVIČ, M.: Preneogena podloga Vojvodanskog dela Pannonskog basena. (Pre-Neogene basement in the Pannonian basin of Vojvodina.) — Radovi Znan. Saveta Jugosl. Akad. Znan., Sekc. Geol. Geof. Geokem., ser. A, **5,** p. 248—256, Zagreb, 1975.

KONDA, J.: Lithologische und Fazies-Untersuchung der Jura-Ablagerungen des Bakony-Gebirges, Ann. Inst. Geol. Hung., **50,** p. 161—260, Budapest, 1970.

KOVÁCS, S.: Paleogeographical significance of the Triassic Hallstatt limestone facies in the North Alpine faciesregion. Földt. Közl., **110,** 3—4, p. 360—381, Budapest, 1980.

KOVÁCS, S., KOZUR, H., MOCK, R.: Relations of the Szendrő-Uppony and Bükk Paleozoic in the light of the new micropaleontological investigations. — Ann. Rep. Hung. Geol. Inst., **1981,** in press.

KOZUR, H.: Einige Probleme der geologischen Entwicklung im südlichen Teil der Inneren Westkarpaten. Geol. Paläont. Mitt. Innsbruck, **2,** 4, p. 155—170, Innsbruck, 1979.

KOZUR, H., MOCK, R.: Zur Frage der varistischen Orogenese und des Alters der Faltung und Metamorphose im innerwestkarpatischen Raum. Geol. Zborn. Geol. Carpath., **30,** 1, p. 93—97, Bratislava, 1979.

Körössy, L.: The flysch-like formations of the Great Hungarian Basin. (In Hung., with English summ.) Földt. Közl., **89**, 2, p. 115—124, Budapest, 1959.

Mahel', M.: Relations of Carpathian units to the Hungarian Massif. (In Hung., with English summ.) Földt. Kut., **23**, 3, p. 5—10, Budapest, 1980.

Majoros, Gy.: Problems of the Permian sedimentation in the Transdanubian Central Mountains: a paleogeographical model and some conclusions (In Hung., with English summ.). Földt. Közl., **110**, p. 323—341, Budapest, 1980.

Mock, R.: Novel knowledge and some problems as regards the geology of the inner West Carpathians (In Hung., with English summ.). Földt. Kut., **23**, 3, p. 11—15, Budapest, 1980.

Nagy, E.: Triasbildungen des Mecsek-Gebirges. — Ann. Hung. Geol. Inst., **51**, 1, 198 p., Budapest, 1968.

—: Der unterliassische Schichtenkomplex von Grestener Fazies im Mecsek-Gebirge (Ungarn). Ann. Inst. Geol. Hung., **54**, 2, p. 155—159, Budapest, 1971.

Patrulius, D.: Les Formations Mésozoiques des Monts Apuseni Septentrionaux: Corrélation Chronostratigraphique et Faciale. Rev. Roum. Géol. Geoph. Géogr., **20**, 1, p. 49—57, Bucureşti, 1976.

Patrulius, D., Bleahu, M. et al.: Bihor Autochton and Codru nappe system (Apuseni Mountains). Guidebook to Field Trips, IIIrd Triassic Colloquium of the Carpatho-Balkan Geological Association, 2—7 October 1979. 21 p., Bucureşti, 1979.

Săndulescu, M.: Consideraţii asupra posibilitătilor de corelare a structurii Carpaţilor Orientali si Occidentali. D. S. Inst. Geol., **58**, 5, p. 125—150, Bucureşti, 1972.

Schönlaub, H. P.: Das Paläozoikum in Österreich. Abh. Geol. B.-A., **33**, 124 p., Wien, 1979.

Senkowiczowa, H., Szyperko-Slíwczynska, A.: Stratigraphy and Paleogeography of the Trias. In: Special Anniversary Symposium. Geol. Inst. Anniv. Bull. **252**, p. 131—148, Warszawa, 1975.

Szalai, T.: Die Tisia und das Zwischengebirge des Karpatenbeckens. Geofiz. Közlem., **2**, 3—4, p. 166—185, Budapest, 1961.

Szádeczky-Kardoss, E.: The belts of subduction in the Carpathian-Pannonian-Dinaric area. In: Mahel', M. (E.), Tectonic problems of the Alpine System, p. 69—76, Bratislava, 1975.

—: Plattentektonik im pannonisch-karpatischen Raum. Geol. Rdsch., **65**, 1, p. 143—161, Stuttgart, 1976.

Szederkényi, T.: Paleozoic magmatism and tectogenesis in southeast Transdanubia. Acta Geol. Hung., **18**, 3—4, p. 305—313, Budapest, 1974.

Szepesházy, K.: Geological setting of the NE-Carpathians and their position in the Carpathian system (In Hung., with English summ.) Ált. Földt. Szemle, **8**, p. 25—60, Budapest, 1975.

—: Mesozoic igneous rocks of the Hungarian Plain. (In Hung., with English summ.) Földt. Közl., **107**, 3—4, p. 384—397, Budapest, 1977.

—: Structural and Stratigraphic Connexions between the basement of the Great Hungarian Plain East of the river Tisza and the Apuseni Mountains in Western Transylvania. (In Hung., with English summ.) Ált. Földt. Szemle, **12**, p. 121—198, Budapest, 1979.

—: Major tectonics of the Trans-Tisza region as related to the Transylvanian Central Mountains (Munţii Apuseni). (In Hung., with English summ.) MÁFI Évi Jel. **1978**, p. 173—186, Budapest, 1980.

Szénás, Gy.: The crustal structure of the Carpathian Basin. (In Hung., with English summ.) Geof. Közl., **17**, 4, p. 17—40, Budapest, 1968.

Tollmann, A.: Bemerkungen zu faziellen und tektonischen Problemen des Alpen-Karpaten-Orogens. Mitt. Ges. Geol. Bergbaustud., **18**, p. 207—248, Wien, 1968.

—: Die tektonische Gliederung des Alpen-Karpaten-Bogens. Geologie, **18**, 10, p. 1131—1156, Berlin, 1969.

—: Zur Gliederung der triadischen Faziesregionen in den Ostalpen. Schriftr. Erdwiss. Komm. Österr. Akad. Wiss., **2**, p. 183—193, Wien, 1974.

—: Die Seitenverschiebung an der Periadriatischen Naht auf Grund des Vergleiches der Triasfazies. Schrift. Erdwiss. Komm. Österr. Akad. Wiss., **4**, p. 179—192, Wien 1978.

TRUNKÓ, L.: Karpatenbecken und Plattentektonik. N. Jb. Geol. Paläont., Abh. **153**, p. 218—252, Stuttgart, 1977.

VADÁSZ, E.: On the problem of the Hungarian median "massif". Ann. Univ. Sci. Budapestinensis, Sect. Geol. **4**, p. 105—119, Budapest, 1961.

VOZÁROVÁ, A., VOZÁR, J.: The Upper Carboniferous and Permian of the West Carpathians. Geol. Práce, Správy **67**, p. 141—152, Bratislava, 1977.

WEIN, Gy.: Tectonic review of the Neogene-covered areas of Hungary. Acta Geol. Hung., **13**, p. 399—436, Budapest, 1969.

—: Zur Kenntnis der tektonischen Strukturen im Untergrund des Neogens von Ungarn. Jb. Geol. B.-A., **116**, p. 85—101, Wien, 1973.

—: Outline of the Development of the Carpathian Basin. (In Hung., with English summ.) Ált. Földt. Szemble, **11**, p. 5—34, Budapest, 1978 a.

—: Alpine-type tectogenesis of the Carpathian basin. (In Hung., with English summ.) Ann. Rep. Hung. Geol. Inst. **1976**, p. 245—256, Budapest, 1978 b.

ZELENKA, T. et al.: Mezozoós ősföldrajzi határvonal-e a Darnó vonal? (Is the Darnó-line a Mesozoic paleogeographic boundary?). Földt. Közl., Budapest, in press.