The Area of Mesozoic Sedimentation of the Mecsek and Northern Apuseni Mountains Was Not Situated in the West Carpathians

by

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INTRODUCTION

The similarities between the Mecsek-Villány and the Northern Apuseni Mountains are generally accepted and it is generally believed that they had a common area of sedimentation called the Pannonian Massif, or Tisza (Kovács, 1982). In assigning "Tisza" to a wider frame, the opinion that its former area of sedimentation was situated in the West Carpathians has been expressed many times. According to Kovács (1980, Fig. 5; 1982) the Mecsek and Villány Mountains formed a direct continuation of the Tatricum and, through the Zemplin unit, these were linked to the Bihor Autochthon during the Triassic and Jurassic (Fig. 1). Săndulescu (1975) even included the Central West Carpathians and Northern Apuseni in a single unit he called the "Western Dacides." The Tatricum, then, should equate to the Bihor Autochthon and the Subtatric nappes to the Codru nappe system. Săndulescu repeated this idea in later works (Săndulescu, 1978; Debelmas *et al.*, 1980), and it also can be found in the works of other Rumanian geologists — *e.g.*, Patrulius *et al.* (1976) and Bleahu *et al.* (1981). The equivalence of the Bihor Autochthon and the Tatricum has also been postulated by Michalík and Kováč (1982).

In later contributions, the Hungarian geologists assigned to the former sedimentation area of Tisza a still more northerly location. Kázmér *et al.* (1984) considered only the Villány Mountains (which should be linked with the Bihor Mountains) as a continuation of the Tatricum, whereas they placed the Mecsek Mountains farther north in the substratum of the Flysch Belt from the boundary of the West and East Carpathians to the margin of the Scythian Platform. At the Zürich meeting of IGCP Project 198 (September 1986), the Hungarian Working Group presented a further variant, based on the paleogeographic map of the Pliensbachian, in which they placed the areas of sedimentation of the Mecsek and Villány Mountains in the middle segment of the Outer West Carpathians close to the immediate margin of stable Europe (Bohemian Massif). The units would then be a part of the substratum of the Silesian unit and form a continuation of the Gresten Zone of the Austrian Alps.

The reason for this solution is mainly the presence of the Keuper facies, a derivation of clastic material of the Gresten beds of the Mecsek Mountains from the North European mainland, and the data of Géczy (1973) and Vörös (1977, 1984) on the northern provenance of Jurassic ammonites and brachiopods in the Villány Mountains. Our intent is to show that the areas of sedimentation of the Mecsek-Villány-Northern Apuseni cannot have been located in the West Carpathians during the Mesozoic, and to suggest that their relations are with the East and mainly South Carpathians.

COMPARISON OF THE MECSEK-VILLÁNY MOUNTAINS AND THE WEST CARPATHIANS

Precambrian

The thick layers of crystalline limestones of the Ófalu phyllite complex in the Mecsek Mountains have been assigned by Jantsky (1979) to the Proterozoic. In the table of lithostratigraphic formations of Hungary (Fülöp *et al.*, 1983), this complex was assigned to the Devonian, mainly on the occurrence of carbonates. Considering the paleontologic evidence for Silurian normally overlying this complex (Kozur, 1984), we consider the Proterozoic age of the Ófalu Complex as proved. The abundance of carbonates in the Proterozoic argues against attributing it to the European Proterozoic platform. The absence of carbonates in the complex of crystalline schists of the Vysoké Tatry Mountains precludes assigning the Mecsek to the Tatricum.

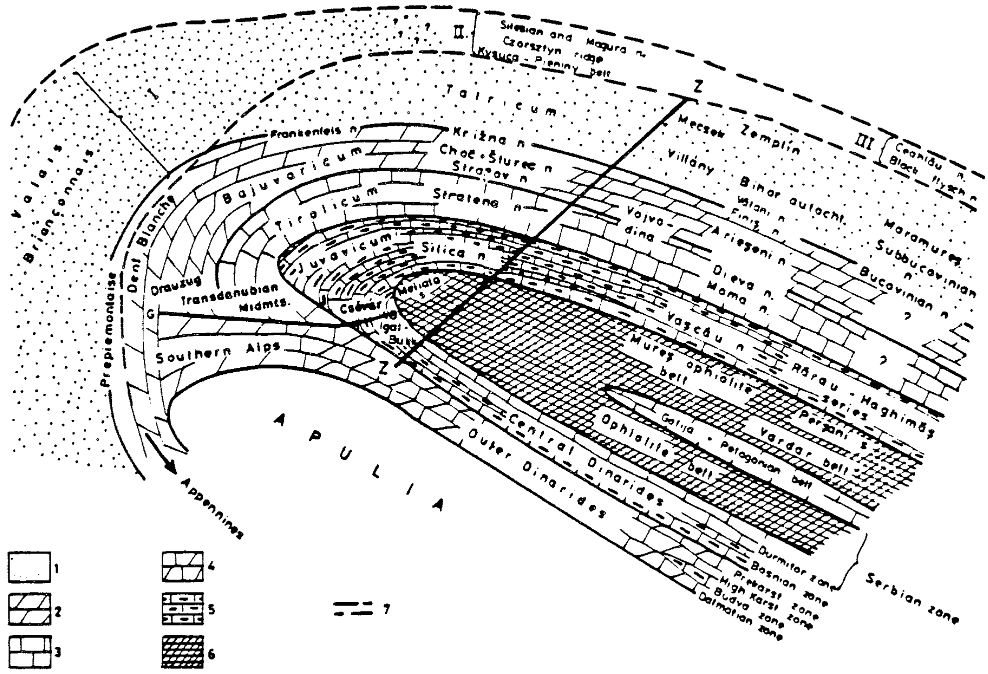

Fig. 1. Location of sedimentary areas in the Alpine-Carpathian-Dinaric system during Norian time, and Norian isopic zones (according to Kovács, 1982).: 1, continental detrital deposits (mainly Keuper facies) or hiatuses; 2, Main Dolomite; 3, Dachstein Limestone; 4, Main Dolomite and Dachstein Limestone; 5, Hallstatt Limestone; 6, Eugeosyncline since Ladinian; 7, Location of later opening (I, Penninic ocean; II, Pieniny Ocean; III, Siret Ocean; G-B, Gailtal-Balaton Line; Z-Z, Zagreb-Zemplín Line). Note the position of Mecsek, Villány, and Bihor.

Silurian

The presence of Silurian in the Mecsek Mountains (Kozur, 1984) excludes the possibility of correlation with the Tatricum. We assume that this new finding stimulated the shift of the original Mecsek area into the substratum of the Flysch Belt (Kázmér *et al.* 1984) and close to the Scythian Platform where the non-metamorphosed Silurian is known.

Carboniferous

The clastic Stephanian sequence with coal seams in the Mecsek and Villány Mountains has no analogue in the Tatricum. In the Outer West Carpathians there are only blocks of Namurian and Westphalian coal; nowhere is Stephanian coal known. A block of coal from the Namurian A (Havlena, 1956) is known in the Klippen Belt near Nosice, blocks of Westphalian coal occur in the Flysch Belt of Moravia, and spores of the Namurian A to Westphalian C (Birkenmajer and Turnau, 1962) have been found in the Aalenian of the Klippen Belt. The coal found in the Nemčičky bore (South Moravia) under Neogene sediments of the Carpathian foredeep, formerly considered Gresten Beds, belongs to Namurian A.

Permian

The uranium-bearing Permian in the Mecsek Mountains is strongly developed (2-3 km thick), with a layer of rhyolite 150 meters thick. In the Tatricum of the West Carpathians the Permian nowhere attains such thicknesses, and rhyolites occur only sporadically in the Malé Karpaty and Považský Inovec Mountains. A palynoflora containing Gondwanian elements occurs in the mid-Permian of the Mecsek Mountains (Barabás-Stuhl, 1981). Palynoflora with Gondwanian elements have not been found in the Permian of the West Carpathians in spite of numerous analyses.

Lower Triassic

The Jakabhegy Formation is a 400 meter thick complex of sandstones and conglomerates in which pebbles (up to 30 cm diameter) of quartz porphyries dominate and pebbles of red granites are present (Kassai and Nagy, cited in Császár and Hass, 1984). This unit has no analogy in the entire West Carpathians.

Middle Triassic

The presence of vermicular limestones in the Middle Triassic of the Mecsek Mountains is hardly an argument in favor of the proximity of the Tatricum (Kovács, 1980, among others) as this facies is widespread. The fauna of brachiopods, lamellibranchs, conodonts, and ammonoids of the Mecsek Mountains (see Kázmér, 1986, p. 83) is unknown in the Middle Triassic of the Tatricum, as are intercalations of crinoidal limestones (the Misina Formation; Ralisch, cited in Császár and Haas, 1984). The Pelsonian fauna of conodonts, in which *Gondolella bifurcata hanbulogi* is the principal form (see Kovács and Papšová, 1986), shows a clear relationship to the Dinarides and other southern units. The presence of conodonts and holothurian sclerites from the West Mediterranean-Arabian province in the Cordevolian of the Northern Apuseni also indicates that it is not possible to link them with the West Carpathians. Nagy *et al.* (1968) mentioned a tuffitic layer with kaolinite and siderite from the base of the Ladinian complex in the Mecsek Mountains; in the Tatricum, such a horizon is completely unknown.

Upper Triassic

The Keuper facies from the Mecsek and Villány Mountains used to be compared with the Carpathian or Germanic Keuper. Below the Keuper in the Mecsek Mountains, however, there is a 120 meter thick sequence of limnic black limestones and marls with gastropods and ostracods (Kantavár Formation), whereas in the Tatricum and Fatricum of the West Carpathians the Keuper is always underlain by light-colored dolomites. It should be pointed out that the Upper Triassic is also known from North Africa in a red clastic lagoonal development. According to Kozur (pers. comm., 1986), the rich ostracod fauna of the Keuper from the Mecsek Mountains has not a single species in common with the ostracod fauna of the German Upper Triassic whereas, for instance, the ostracod associations in Germany and the Pericaspian region are almost identical.

Liassic

The conspicuous Gresten coal-bearing formation of the Mecsek Mountains (500-3500 meters or, according to other estimates, 200-1200 meters) is the most notable unit found in this small mountain range. More than 100 coal seams and coal partings (15-38 exploitable seams) are found here. In comparison, the thickness of the Gresten Formation is: near Gresten in the Eastern Alps, only 60 meters with two coal seams; in Bihor, 170 meters with one coal seam; in Brasov 200, meters with one coal seam; in Resica (Banat), 250 meters with two coal seams; and in Anina (Banat), 300 meters and six coal seams (Nagy, 1969). In the contact area between the South Carpathians and Balkans in Yugoslavia, two to three coal seams with thicknesses of up to 2.5 meters occur in the lower Liassic (Lachkar *et al.*, 1984). Their continuation in the westernmost part of Bulgaria contains occurrences of Liassic coal (Jovčec, 1965, map) — for example, in the Forebalkan two localities west of Michajlovgrad and one west of Vraca, and in the more southerly zone two localities close to the frontier with Yugoslavia (in other areas of Bulgaria, a weakly coal-bearing Jurassic is indicated only near Teteven and Kolarovgrad).

The greatest affinity of the Mecsek Liassic is thus with the termination of the South Carpathians. In the work of Nagy (1969), this is considered as "paleogeographical covergence." In our opinion, it indicates spatial linking of facies with the Mecsek Mountains.

There are no Gresten Beds in the Tatricum and Krížna nappe; the deposits formerly considered as the Gresten Beds (the present-day Kopieniec Beds) correspond to the Kalkburg Beds of the Alps. In the Pieniny Klippen Belt, so-called Gresten Beds are mentioned from two klippes of the Kysuca or Nižná development (locality Krásna Hôrka in Orava and locality Jedlovinka near Zázrivá, with respective thicknesses of 50 and 30 meters). These are sandstones and shales with *Arietitidae* without a trace of coal; the whole formation is exclusively marine. In the Czorsztyn unit, the lower Liassic, Hettangian-lower Sinemurian, is present in a different facies, with coquinal-crinoidal limestones with *Gryphaea*. In the Pieniny Klippen Belt in the USSR, only marine Hettangian is known (Kruglov *et al.* 1985, p. 60).

There are no fragments of Liassic coal in the Cretaceous and Paleogene clastic deposits of the Flysch Belt, although fragments of Upper Carboniferous coal do occur (Turnau, 1970). There are no Liassic sporomorphs, although redeposited Permian and Lower Triassic sporomorphs are present (Koráb and Snopková, 1971). It is highly improbable that the thick sequence of the Gresten Beds would not have been uncovered, as pebbles of the upper Liassic are known in the Fleckenmergel development of the Magura unit (mainly the Strihov Beds). The exotic pebbles of the Silesian unit, in spite of their great diversity in composition, have provided no Liassic rocks beyond blocks of limestones with *Amaltheus margaritatus*. The coal found in the Nemčičky-1 well (South Moravia) under the Neogene sediments of the Carpathian foredeep — formerly considered as Gresten Beds — belongs to Namurian A (Adámek, 1986), which precludes placing the Mecsek Mountains in the western sector of the Flysch Belt.

In the Gresten Beds of the Mecsek Mountains, a 10 meter thick layer of rhyolite tuffs is known in the upper Hettangian (or lower Sinemurian) (Kázmér, 1986) over a distance of 25 km. Establishing a volcanic source for these tuffs is a problem, for there is no evidence of volcanism in the Liassic in the whole of the West Carpathians, nor is there any indication in the Gresten Beds of the Eastern Alps. Tollmann (1985, p. 420) mentioned the Porrauer Diabaskomplex from the base of the Mesozoic in boreholes below the foredeep. The "metadiabases" mentioned, and the sediments connected with them, are ranged in the upper Liassic-lower Dogger. They pass laterally into the "Untere Quarzarenitserie," with intercalations of coal and upper Liassic-lower Dogger sporomorphs (Brix *et al.*, 1977). Tollmann originally assigned these to the Gresten Beds, but he later compared them to the Waidhofen Beds (Tollmann, 1985). The volcanics mentioned could not have been the source for rhyolite tuffs in the Mecsek Mountains, as they are not only basic but are essentially younger in age. If the Mecsek Mountains were situated in the substratum of the Carpathian Flysch Belt, the pyroclastic material ought be derived from volcanoes on the adjacent platform in Poland. Such volcanism is not known (Ziegler, 1982, his Encl. 18). It is remarkable, however, that trachytic (and also diabase) volcanism does occur in the Liassic in the Getic nappe in the South Carpathians, but at a higher level, in the Pliensbachian-Toarcian overlying the Gresten coal-bearing formation. Despite their stratigraphic positions, we consider a spatial relationship possible, by analogy with the Barrandian where thin intercalations of acid pyroclastic rocks are known in the Lower Cambrian, but acid volcanics themselves are only found in the Upper Cambrian.

Dogger-Malm

The higher Jurassic members are of generally similar development in the Villány Mountains and Tatricum, especially in the Vysoké Tatry Mountains. But if their sedimentary proximity is admitted, the faunal differences between the above-mentioned regions established by Géczy (1973) and Vörös (1977, 1984) cannot be explained. The hiatus before the Dogger, stromatolites in the lower Callovian, red limestones in the Bathonian, and perhaps also grey limestones with "pelagic oolites" in the Villány Mountains (Szársomlyó Limestone Formation, Oxfordian-Tithonian), which could correspond to the micro-oncolitic limestones of the High Tatric unit, probably stimulated Kovács (1980) to assign the Mecsek Mountains to the Tatricum. However, it is necessary to point out that stromatolites were found only in one profile of the High Tatric unit and in no other core mountains in the Tatricum (elsewhere they are common in this horizon of Tethyan Europe — *e.g.*, in the Betic Cordillera). The ammonite fauna in the Callovian of the Villány Mountains is one of the richest in the world, contrasting with the poor fauna obtained from the limestones of the Vysoké Tatry Mountains.

In the Mecsek Mountains, lapilli of basic volcanic rocks were found in the Callovian-Oxfordian limestones (Főzy *et al.*, 1985). Nothing similar is known from the rocks of this age in the West Carpathians. The Oxfordian volcanic rocks are present in the East Carpathians near Poiana Botizei (Bombita and Savu, 1985). In the Mecsek Mountains, red nodular limestones are found in the Bathonian, Oxfordian, and Kimmeridgian to lower Tithonian (Kázmér, 1986). In the Flysch Belt of the West Carpathians, blocks of red nodular limestones are known but always have only an Oxfordian fauna (Krosno unit near Bachowice, Poland; Magura unit near Cetechovice, Moravia). In the Mecsek Mountains, there are no traces of such a typical Tithonian facies as the Štramberk limestone with its reef detritus, which argues against a location in the external part of the Flysch Belt.

Lower Cretaceous

A conspicuous phenomenon in the Mecsek Mountains (less marked in the Villány Mountains) is strong alkalic basalt volcanism ranging from Berriasian-Valanginian (maximum) to Barremian. An abundant volcanism of similar character (more ultrabasic teschenites) of nearly the same age is present in the Silesian unit of the Flysch Belt (Valanginian to lower Aptian; Menčík *et al.*, 1983); this fact may have been the main stimulus for the variant presented by the Hungarian geologists at the Zürich meeting. An essential difference, however, is that the volcanism accompanies pre-flysch and flysch formation in the

Silesian unit, whereas in the Mecsek Mountains it is found within typical pelagic limestones.

The Hauterivian-Barremian pelagic marls with abundant basalt conglomerates (Magyaregregy Conglomerate Formation) have no analogue in the West Carpathians. In the High Tatric unit, volcanic rocks (limburgites) occur at the upper Tithonian-Berriasian boundary at one locality only.

The position of the Mecsek-Villány-Northern Apuseni at the northernmost margin of the Tethys is contradicted by the presence of bauxites in the Valanginian-Barremian in the Villány Mountains, Bihor Autochthon, and Valani nappe. The formation of bauxites in these more northerly geographic latitudes is improbable for paleogeographic reasons. Bauxites older than Late Cretaceous are unknown in Poland and Czechoslovakia, and even in the Eastern Alps. In the West Carpathians, hiatuses in the Lower Cretaceous are nowhere accompanied by bauxites; there are no traces of redeposited aluminum hydroxides — either in the Pieniny Klippen Belt or in the Flysch Belt. The rare occurrences of bauxite in the West Carpathians are distinctly post-mid-Cretaceous (Senonian, certainly pre-Eocene). In Yugoslavia, in contrast, there are numerous bauxites covered by Valanginian (Vršar, Rovini, Nijegas in Montenegro, and others), or Barremian-Aptian (Bosenska Krupa, Mljet, Nikšic; Ilavský *et al.*, 1979, p. 170). There is still a higher horizon of bauxites in the Villány Mountains, which may be of Albian age. Albian bauxites are also found in the Bakony Mountains (Alsópere Bauxite Formation) and Getic nappe of the South Carpathians (Hateg basin; Săndulescu *et al.*, cited in Mahel' *et al.*, 1974, p. 273).

Based on this information, it would seem that the Mecsek-Villány-Northern Apuseni Mountains must have been in southern positions during the Early Cretaceous, probably in proximity to the Bakony Mountains. In addition to the bauxite data, this assumption may be supported by the presence of the lower Albian pachyodont facies in Bakony, Villány, and Bihor (such an Albian facies is unknown in the West Carpathians) and by layers with *Charophyta* in the Lower Cretaceous of Bakony, Villány, and Bihor (unknown in the Lower Cretaceous in the West Carpathians).

Tectonic Difficulties

Displacement of the Mecsek Mountains from the West Carpathians to their present-day position supposedly took place along transform faults. In all alternatives, the Mecsek Mountains must have crossed several distinct sedimentary facies zones. Such transform faults of transverse orientation must also have been significant in the subsequent history and formation of tectonic units of the West Carpathians, but no evidence of them exists.

COMPARISON OF THE CENTRAL WEST CARPATHIANS AND THE NORTHERN APUSENI MOUNTAINS

Our comparison is based upon the following works: Patrulius *et al.* (1968, 1976), Bleahu (cited in Mahel', 1974), and Bleahu *et al.* (1981). We point out that the Tatricum and the Krížna nappe have no equivalents in the Northern Apuseni, and in the higher nappes there are only some problematic coincidences.

Tatricum and Bihor Autochthon

The Triassic sections of the Tatricum and the Bihor Autochthon have almost nothing in common except the generally widespread facies of the Werfen shales and Gutenstein limestones of the Anisian. The Triassic of the Bihor is 1500-2000 meters thick; in the Tatricum it is only 350-600 meters thick. Although the Upper Triassic is almost completely missing in the Bihor Autochthon, in the Tatricum only Rhaetian is missing in some core mountains (*e.g.*, in the Malé Karpaty Mountains where it may be shown that it was formerly present and was removed by erosion during the Hettangian). Nowhere in the Tatricum is the Wetterstein limestone present (in the Ladinian of the Bihor it is 400 meters thick and contains corals). In contrast, the Tatricum contains dolomites in the Ladinian-Carnian, a Keuper facies in the Norian, followed above by marine Rhaetian (exceptionally continental in the Vysoké Tatry Mountains). In the Carnian of the Bihor Autochthon, red shales and sandstones are mentioned that may resemble the Keuper, although this name is not used. In the Keuper of the Tatricum there are no limestone intercalations as in the Scărita and Ordîncusa Formations of the Bihor; on the contrary, there are dolomite intercalations present that are absent in the Apuseni Mountains.

There are some coincidences in the Tatricum in the Liassic: the facies of black shales is widespread, whereas in the Bihor this facies is rudimentary; in the Bihor Autochthon, oolitic limestones are present in the Bajocian (in the Tatricum there is no oolitic limestone in the Dogger); in the Oxfordian-Kimmeridgian of the Bihor there are coral limestones (nowhere found in the Tatricum); in the Bihor Autochthon there is a Tithonian of Štramberk type (absent in the Tatricum). For the area to the south of the Bihor Autochthon, three hiatuses are mentioned (within the Sinemurian, Bajocian, and Callovian); in the Tatricum they are not known — the only break in sedimentation lies in the Bathonian of the Vysoké Tatry Mountains.

The Valanginian bauxites found in the Bihor Autochthon are absent in the Tatricum where there was no break in sedimentation between the Tithonian and Neocomian. In the Neocomian of the Bihor Autochthon, black lacustrine limestones with characeans occur (absent in the Tatricum); there are upper Hauterivian limestones with Nerinea (in the Tatricum, no organodetrital facies are found in the Hauterivian and Nerinea is absent in the Central West Carpathians). In the upper Aptian and Albian of the Bihor, reef limestones are present (in the Tatricum and the entire West Carpathians, no bioherm limestones have been found in the Albian). The upper Neocomian to Turonian stratum in the Bihor Autochthon has a thickness of 2500 meters (the Tithonian-lower Turonian of the most complete High Tatric succession is less than 250 meters thick). In the Vraconian-lower Turonian of the Bihor, red clayey and marly shales are found; in the Tatricum they are never red.

Krížna and Vălani Nappe, Finiş-Girda Nappes

The Triassic of the Krížna nappe has no analogue in the Codru nappes. The geometric equivalent of the Krížna nappe is the Vălani nappe. According to the stratigraphic table, however, there are no Gutenstein limestones in the Anisian and no dolomites in the Ladinian-Carnian — the latter of which is typical for the Krížna nappe. Instead, dark limestones with cherts (Rosia Formation) — Reifling type — are present. The Reifling limestones, however, are never found in the Krížna nappe. They are even not analogous to the so-called Podhradie limestones of the Krížna nappe, which have no cherts and contain Fassanian-Langobardian conodonts, whereas the Rosia limestones have Cordevolian conodonts and holothurian sclerites of the West Mediterranean-Arabian province (Kozur, 1979). Such an association has not been found in either the West Carpathians and Eastern Alps or in the Germanic region. In the upper Carnian of the Vălani nappe there are limestones similar to the Wetterstein limestones, a type completely unknown in the Krížna nappe in all nine core mountains. Thus, the only coincidence is the occurrence of the Keuper, although the composition of its clastic material has not yet been compared with the Carpathian Keuper. The Rhaetian is missing in the Vălani nappe, whereas in the Krížna nappe it is developed in all profiles. In the Finiş-Girda nappe, the Rhaetian is present in the Kössen facies; however, in this nappe the Dachstein limestones with megalodonts are below the Keuper — a situation completely foreign to the Krížna unit. The Dachstein limestones are underlain by the dark claystones of the Codru Formation, with intercalations of sandstones and limestones containing Norian conodonts. Such a member is unknown not only in the Krížna nappe, but throughout the West Carpathians.

Due to variability of Liassic facies of the Krížna nappe, certain coincidences with the Vălani and Finiş nappes may be found. However, the Hettangian-Sinemurian red nodular limestones (Moneasa marble) have no analogy in either the Krížna nappe or in the whole of the West Carpathians. In the Liassic of the Codru nappes, the facies indicate deepening from north to south; in the Krížna nappe they become shallower from north to south (for instance, the Veľká Fatra Mountains). In the Codru nappes, upper Dogger-lower Malm radiolarites are not known, yet they are typical for the Zliechov development of the Krížna unit.

It is necessary to remark on the absence of the Middle Jurassic (Toarcian-Oxfordian) in the Finiş nappe. There is no such hiatus in the Krížna nappe (sporadic hiatuses comprise less than one stage). In the Vălani nappe, which should correspond most closely to the Krížna nappe, there are coral limestones to 250 meters thick in the Malm (nowhere present in the Krížna nappe). In the Krížna nappe, there are no Valanginian bauxites as in the Vălani nappe.

The comparison of the higher members of the Cretaceous is only possible with the Finiş nappe, which contains Neocomian flysch similar to the Sinaia beds. In the Krížna nappe, the Neocomian is pelagic and only the Albian locally displays a flysch character.

Choč Nappe and Dieva-Ferice Nappe

There are some similarities between the Triassic of the Biely Váh development of the Choč nappe and the Dieva-Ferice nappe: the Werfen shales, the Anisian dolomites, and the Reifling limestones (Rosia Formation). The Choč nappe includes the Gutenstein limestone, the Carnian Raming bioherm limestone containing *Tubiphytes* and *Sphinctozoa*, and the Lunz Beds. This flysch-like sequence, up to 300 meters thick, with *Carnites floridus* is a typical,member of the Biely Váh development seen in the Choč nappe. In the Finiş-Girda-Ferice nappe there is a sequence somewhat akin to the Codru Formation. It is somewhat similar to the Lunz Beds, consisting of dark marly and clayey shales with intercalations of quartz sandstones. It differs in having a Norian age given by its superposition over the Rosia Formation, which contains Norian Conodonts.

Besides the Biely Váh development, the Cierny Váh development — with continuous dolomites in the Middle and Upper Triassic — has a considerable extent in the Choč nappe but is without equivalent in the Dieva-Ferice-Batrinescu nappe. There is also no equivalent of the Bebrava development with the Wetterstein limestones. Another significant difference is the existence of a hiatus in the Langobardian-Julian, which is not known in the whole of the West Carpathians.

The nearly complete removal by erosion of the Jurassic and Cretaceous makes any correlation problematic. One relevant difference is in the Permian of the Dieva nappe where lower rhyolites, basalts, and upper rhyolites are mentioned, whereas the Permian of the Choč nappe is exclusively characterized by basalts (melaphyres) for its whole length.

Silica Nappe and Vascau Nappe

The highest nappe discussed — the Vascau — is considered the equivalent of the Silica nappe of the Slovak Karst. Both nappes contain Steinalm, Schreyeralm, and Hallstatt limestones and upper Norian-Rhaetian massive limestones (called the Furmanec limestones and Bleskový prameň limestones in Czechoslovakia). The essential difference is the absence of the Ladinian-Cordevolian Wetterstein limestones in the Vascau nappe (the main member of the Silica nappe and also a key member of the Silicicum in the highest Subtatric nappes). In the Vascau nappe, these stages are represented by the Schreyeralm limestones, which are rare in the Silica nappe.

The lower Liassic pink crinoidal limestones are the same as those in the Silica nappe, but in the Vascau nappe the Adneth limestones and Fleckenmergel are missing and the Liassic is cut by lamprophyres unknown in the Silicicum. Higher members have not been preserved in the Vascau nappe.

Of the crystalline rocks, the group of greenschists from the Arieseni nappe was compared with the Rakovec Group of the Gemericum by Bleahu *et al.*, (1981) and the Paleozoic group from the higher Baia de Arieş nappe with the Hladomorná Dolina Group of the Veporicum. In the West Carpathians, however, the Gemericum unit is the higher nappe overthrust onto the Veporicum.

THE NORTHERN APUSENI VERSUS THE WEST CARPATHIANS, AND COINCIDENCES WITH THE EAST AND SOUTH CARPATHIANS

In addition to differences already described in the succession of facies in the Central West Carpathians compared to the Apuseni Mountains, there are differences in their respective tectonic histories. The nappes of the Northern Apuseni are mostly basement nappes with a representation of the crystalline rocks, whereas the Subtatric nappes are superficial. No metamorphism of the Mesozoic in the Northern Apuseni has been described, whereas part of the sequence of the Tatricum, the proximal part of the Krížna nappe, and the Mesozoic of the Veporicum show distinct evidence of Alpine metamorphism.

The Central West Carpathians is a perfectly distinct unit that cannot be connected to the Northern Apuseni as the Western Dacides. The original distance separating the areas of sedimentation must have been greater than the present-day 200-400 km. Facies analyses show that no equivalents exist for the Tatricum and Krížna nappe and that the similarities between the Choč and Silica nappes and their supposed equivalents are the result of widespread facies that are constant in the more internal units. The comparison of the approximately 100 km belt of the Northern Apuseni with the three times longer (300 km) belt of the Central West Carpathians, which shows more than sixty facies differences, indicates that the regions are basically different. The Central West Carpathians contain many specific features — such as the Melaphyre Zone and Lunz Beds of the Choč unit — that are lacking in the Apuseni.

The proximity of the Northern Apuseni to more internal zones of the Central East Carpathian nappes is shown by several similar facies, such as the red nodular Hettangian-Sinemurian limestones (Bihor, Rarau), the oolitic limestones in the Bajocian (Bihor, Rarau), the coral limestones in the Malm (Vălani, Rarau), and the flysch in the Tithonian (Finiş, Bucovinian nappe). Only those features completely missing in the Central West Carpathians have been mentioned. The tectonic history of the Northern Apuseni is connected with the East and South Carpathians with a common banatite volcanism. This link is also supported by the close relationship of the Mecsek Mountains to the South Carpathians.

THE RELATIONSHIP OF THE MECSEK AND VILLÁNY MOUNTAINS TO THE SOUTH CARPATHIANS

Metamorphosed limestones occur in crystalline rocks of the Mecsek Mountains and also in the Prebaikalian complex of the South Carpathians (gneisses, amphibolites, marbles). The Upper Carboniferous and Permian in both regions are represented by continental facies; Stephanian coal seams are present in both regions. In the Permian, only acid volcanics are found in both regions. In the lower Scythian of the Getic nappe, conglomerates occur as in Mecsek Mountains, but in the West Carpathians they are missing except for sporadic angular fragments of vein quartz in quartzites. Pebbles of red granites present in these conglomerates in the Mecsek Mountains could be derived from crystalline rocks of the South Carpathians. As the Triassic of the Danubian Autochthon was removed by erosion, no direct comparisons can be made; however, this great erosion — which affected even the Permian — may have supplied the clastic material for the Gresten Complex of the Mecsek Mountains. In the Mecsek Mountains as in the Banat, the second greatest number of coal seams is found in the lower Liassic of the whole Alpine-Carpathian region. In the South Carpathians as in the Mecsek Mountains, the continental lower Liassic gradually passes into the marine middle Liassic. In the South Carpathians there occur the only acid volcanics known in the Jurassic of the East-Alpine Carpathian region. These may be linked spatially with the lower Liassic acid tuffites of the Mecsek Mountains (the rocks known from exposures, however, are of younger, mid-Liassic age). A horizon with iron oxides in the upper Bathonian-lower Callovian occurs in the Danubian Autochthon as well as in the Villány Mountains. In both regions, there are two horizons of red nodular limestones — one in the Dogger, the second in the Malm. In the Getic nappe there is a Tithonian-Neocomian pelagic facies as in the Mecsek Mountains, in addition to typical Barremian-Aptian Urgonian facies as in the Villány Mountains. The carbonate flysch of the Sinaia Formation of the Severin nappe contains abundant Tithonian-Neocomian volcanics that can be compared with volcanics of the Mecsek Mountains; however, they are linked with the flysch complex and not with pelagic limestones as in the Mecsek Mountains. In the Getic nappe, Albian bauxites perhaps may be analogous with the higher bauxites in the Villány Mountains. The rotation of the Mecsek Mountains by more than 90° also is probable, in the opinion of several Hungarian geologists (*e.g.*, Balla, 1986), which implies that sediment transport from the north (mainly in the Liassic clastics) in the Mecsek Mountains corresponds to a supply from the east, as proposed here.

The possible link of the Mecsek Mountains with the South Carpathians is also evident in the works of some Hungarian geologists. Vörös (1984) found that the Jurassic molluscs and brachiopods of the Mecsek and Villány Mountains are most closely related to those of the Apuseni, East Carpathians, South Carpathians, Germany, and France; those of West Carpathians are related to the Austroalpinicum, Bakony, and peri-Adriatic region. Márton (1984) deduced from Mesozoic and Paleogene paleomagnetic data the existence of two big blocks: a central unit (Sardinia, Italy, South Alps, western part of the Northern Calcareous Alps, Central Alps, Dinaricum, Bakony, Bükk, West Carpathians) and a southeastern unit (East Carpathians, Mecsek-Villány, Papuk, eastern Serbia, and the northwestern part of Bulgaria). According to these results, the West Carpathians and Mecsek-Villány did not belong to the same realm.

The Mecsek Mountains are also linked with the South Carpathians in the kinematic model of Balla (1986). In his opinion, at the beginning of the Miocene the Mecsek Mountains were still situated south of the Geticum; they underwent clockwise rotation and moved westward toward their present-day position during the Miocene. With this solution it is not necessary to postulate such a conspicuous crossing of so many facies zones as would be the case if they were derived from the West Carpathians. Balla's (1986) model contains some points that are consistent with our opinion — as in the location of the Mecsek Mountains in a more southerly position near the Geticum. The main difference is that, in our opinion, the movement of the Mecsek Mountains to the west probably began in the Early Cretaceous and not just in the late Miocene.

According to Roth's (1986) kinematic model, the "Transylvanian block" (thus including the Mecsek Mountains) lay several hundreds of kilometers to the south, which would explain the formation of bauxite during the Early Cretaceous. Roth (1986) proposed extensive northerly movements with only a weak westerly component. This model diametrically opposes all other variants which required the movement of Tisza to the south or southwest. Mahel' (1968; Fig. 7) has also placed Mecsek and Villány far to the south, in the vicinity of Pelagonicum.

The faunal relations of Tisza are explained by the model of Kozur and Mock (1987. The relationship to Apulia is indicated by the admixture of Gondwanian sporomorphs in the Permian of the Mecsek Mountains. Communication with the southern margin of Tethys in the Middle Triassic is indicated by the occurrence of conodonts and holothurians from the West Mediterranean-Arabian province in the Ladinian and lower Carnian of the Northern Apuseni; this fauna is completely absent in the Eastern Alps, the Carpathians, and the Germanic region as a result of the separation of Tisza from stable Europe by an initial Middle Triassic rift. In the latest Triassic (Kimmerian movements), this rift closed with Tisza adjacent to the margin of stable Europe in places now occupied by the units of the South Carpathians. In the Jurassic, a new rift formed that cut off Tisza, together with the remaining shelf of stable Europe, from the southern margin of Tethys and Tisza displays faunal ties to stable Europe (Fig. 2).

CONCLUSIONS

The area of sedimentation of Tisza (Mecsek, Villány, and Northern Apuseni Mountains) was not situated in the West Carpathians, as documented by detailed comparison of Mesozoic facies. In the Triassic, Tisza was related to the southern regions of Tethys as shown on the basis of conodonts, holothurian sclerites, ostracods, and sporomorphs. From latest Triassic to early Liassic time, Tisza was joined to the northern margin of Tethys near the South Carpathians, and partly also the East Carpathians, as is indicated by both facies and faunal relationships.

We do not consider the complicated problem of location of the original areas of sedimentation of Tisza as definitively solved by our proposal. Given the present state of knowledge, it is useful, however, to replace improbable variants by more probable ones.

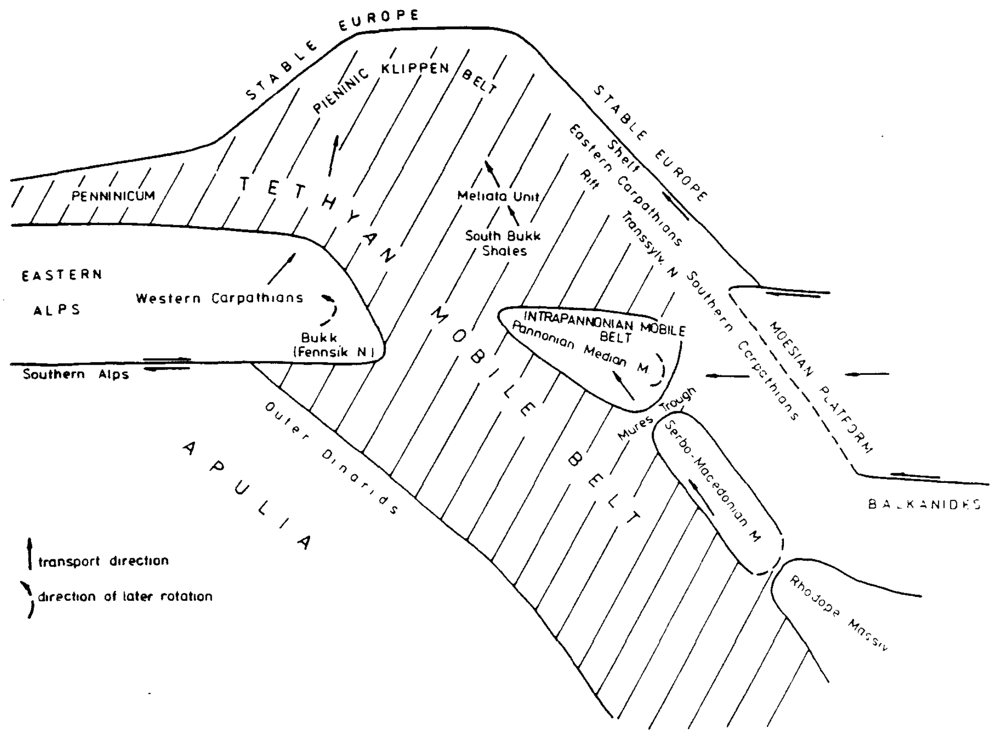

Fig. 2. Location of the Intra-Pannonian mobile belt, including the Mecsek, Villány, and Northern Apušeni Mountains, during the early Malm, according to Kozur and Mock (1987).

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