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ATTITUDE TO SOME ASPECTS OF THE FOLDING PROCESS IN THE ALPIDES AND ITS COURSE IN THE EASTERN ALPS, CARPATHIANS AND DINARIDES

(Fig. 1—3)

Abstract: The principal point of the work is the analysis of folding processes forming tectoine units of the Alpides. Fording movements appear as consisting of many acts, proceeding in time, concentrated in three periods: Cretaceous, Early Paleogene and Early Nogene. The morphostructural plan of the Alpides was completed with movements of the Early Neogene period.

The degree of intensity and differences in time of manifestation of folding characterize certain segments and tectonic units. According to the age and intensity of folding processes was the set of tectonic units in the Alpides divided into 10 groups.

The rich material makes possible to take an attitude to some fundamental tectonic problems, to the intensity of folding, orogenic polarity, division into internides and externides.

Резюме: Ядром работы является анализ складчатых процессов, образующих тектонические единицы альпид. Складчатые процессы являются процессами многоактивными, по времени сосредоточенными в трех периодах: меловом, раннепалеогеновом, и ранненеогеновом. Многоструктурный план альпид заканчивается движениями в познеогеновом периоде.

Степень интенсивности и различия во времени проявления складчатых процессов характеризуют определенные сегменты и тектонические единицы. По времени и степени интенсивности складчатых процессов комплекс тектонических единиц в альпидах состоит из 10 групп.

Богатый материал разрешает автору занять определенное положение по отношению к некоторым главным тектоническим вопросам: к интенсивности складчатости, к орогенической полярности и к разделению на интерниды и экстерниды.

Compiling the tectonic map 1 : 1 000 000 of the Eastern Alps, Carpathians, Balkan, Dinarides and their wide foreland we tried to distinguish tectonic units and fundamental tectonic structures. They are not only abundant in the Alpides but also typical of them (mainly compared to older systems). Structural articulation is namely one of the signs characteristic of the Alpides. As principle most suitable for expressing of tectonic units and structures the age of deformations, the age of folding processes has shown, and that from two standpoints. In the first place, folding processes produce tectonic units but not less important is also the fact that they are regular accomplishment of long-dated development process from foundation of sedimentation troughs through structural-facies zone to formation of tectonic units. Distinguishing of tectonic units according to their age of origin together with position in space and the tectonic style (to a considerable degree also dependent on the intensity of folding) this way represents parametre suitable for consideration of particularities and also more common signs.

The age of tectonic deformation we used as fundamental principle also in compilation of the Tectonic Map of the Crapathian-Balkan System with the endeavour to

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express tectonic units and by means of them fundamental signs and particularities of individual segments.

The Age of Origin of Tectonic Units in the Alpides

The analysis of the degree of tectonic deformation, of individual manifestations of folding has led us to distinguishing of four time sections-periods in the Alpides, in which the structural plan was forming by folding movements. They are the Cretaceous period: Austrian-Subhercynian-Mediterranean (in places perhaps also Late Cimeric); Early Paleogene (Laramide-Illyrian-Pyreneic); Early Neogene (Savian-Styrian) and Late Neogene: Moldavian-Valachian. In this analysis we set out from phases of folding, however, these appeared as too narrow in folding process in many cases and not adequate to many acts of units formation processes and most frequently of time character, difficult to determine more exactly. If we add changes of folding manifestations in time, not only in transversal direction, i. e. from one structural-facies zone to another but also in longitudinal direction (in the same zone or unit) the phase of folding appears as organic part of wider period uneven in time. Its significance rather is rather valid in minor wholes.

Several acts of tectonic compressional movements in periods of folding have been proved. In the Inner Carpathians several acts of Cretaceous folding are indicated by: double schistosity of metamorphic Mesozoic of the Veľký Bok Subunit; great metamorphic throw between thrust Mesozoic of the Murán Plateau and underlying metamorphosed Mesozoic of the Struženík unit; mutual refolding of masses of the Krížna with Choč nappe resp. with Envelope unit; divergence of Cretaceous structures in the autochthon and Krížna nappe (e. g. of the Trangoška syncline and Čertovica Line, also of Veľký Bok structures and underlying crystalline), variety and divergence of strike of Alpine structural elements in the Spišsko-gemerské rudohorie Mts. The values of absolute age measuring in the Veporide crystalline are different: 74 million years — Coniacian; 80 mill. y. — Turonian; 84 mill. y. — Cenomanian; 106—107 mill. y. — Barremian-Hauterivian (J. Kantor 1960). The age of the Gemeride granite, late tectonic, slightly affected by later foldings, mostly corresponding to the latest acts of the Cretaceous paroxysm, is 89 mill. years. Tectoblastesis of the Keuper in the Tribeč Envelope unit shows 95 mill. years; mylonites and diaphthorites in the Račková dolina Valley in the High Tatra 109 mill. years. Several acts of Cretaceous folding are also indicated by time unevenness of hiatuses of the Lower Cretaceous in the envelope groups and of conglomerate layers with exotic material in the Albian-Cenomanian of the Envelope and Krížna unit (M. Maheľ 1963). Distinct orogenetic polarity reflected in succession of changes of carbonate into flyschoid respectively flysch sedimentation. In the Choč zone facies similar to flysch are as early as the Valanginian-Hauterivian (more southerly at the northern margins of the Hungarian Massif in the Gerecse in the Valanginian); in southern areas of the Krížna unit in the Barremian-Albian and in more northern ones in the Albian-Cenomanian respectively Turonian (High Tatra).

Manifestations of folding in the Flysch zone of the West Carpathians, mainly local discordances and the range of hiatuses, which can be considered as reflected phenomena of the Cretaceous paroxysm, also indicate its scattering in time and many acts (Z. Roth 1965).

Several acts of the process of nappe structure formation of the Flysch zone are evident from uneven distribution of age of the youngest members in individual nappes and from mutual relations of the tectonic units. In the Magura unit the youngest member ist the lowermost Oligocene (Menilite and Malcov Beds), in the Dukla and Silesian units it is Upper Oligocene (Krosno Beds), in the outer part the Silesian, Subsilesian and Skole units terminate their sequences with the Aquitanian (in the Stebnik unit of the inner fore-deep the sequence lasted unt'l the Upper Tortonian). The long-dated and diversified process of tectonic formation is attested by the Magura unit (Z. Roth 1965, W. Sikora 1970). The members of the Grzybow unit are found in the core of folds of the Magura nappe (first thrusting of the Magura unit, afterwards mutual folding). The Magura unit with the Grzybow unit folded in rests upon the folded Duklad and Silesian units. In places the frontal part of the Magura unit rests on the Lower Tortonian, which discordantly overlaps the Silesian nappe — indicating lower Tortonian terminal thrusting of the Magura unit.

Several acts of tectonic structures formation process are also apparent in the frontal part of the Flysch zone from mutual relation of the Silesian and Subsilesian unit. The Silesian unit rests on the Subsilesian one (first act); both units are folded together (second act) and transgressively covered with Upper Tortonian after erosion. The Upper Tortonian in Poland is folded and imbricated and thrust northwards with underlying units mentioned above (also after the Upper Tortonian not only overthrust-terminal thrusting but also folding is concerned, also when the latter process is less intense Z. Roth 1964, W. Sikora 1970).

In the Northern Calc Alps the first acts of nappe formation are connected with the Lower Cretaceous as indicated by the material of pebbles, mainly of the Halstatt Limestones, in the upper layers of the Rosfeldschichten (B. Plöchinger 1953). The small portion of the Lower Cretaceous in higher nappes is to stress. On the contrary, finding of continuous cycle of sedimentation of the Neocomian to Cenomanian in the Bajuvaricum and in the Frankenfels nappe indicates Post-Cenomanian movement of nappes in their frontal part. In the easternmost part of the Calc Alps near Alland are evidences of Pre-Cenomanian and Post-Cenomanian folding (B. Plöchinger 1960). The position of the Cenomanian is discordant on strongly folded earlier members of the Frankenfels nappe. On the Cenomanian lies the Lunz nappe there: the boundary between both lower nappes is covered with the Upper Cretaceous of Gosau type. Folding process of several acts is also apparent in other segments, for instance, in the East and South Carpathians (see p. 202).

Attitude to phases of folding. In literature individual manifestations of folding are most frequently put into connection with phases, considered by some authors as contemporaneous, at least in extensive regions, e. g. in the Alpine-Carpathian system (A. Tollman 1966) if not in all-world scale (in the sense of H. Stille 1924). However, if we realize the differences in intensity and also in the character of manifestations of individual paroxysms of folding, very distinct changes transversely through the geosyncline from one structural-facies zone to another but also changes in longitudinal direction and simultaneously the lack of more exact data of time, mainly of the age of individual acts, then it seems more logical if not to leave off completely the term phase, to take it with reserve. Therefore in this article I avoid this term in periods of folding in zones of formation of tectonic units, mainly nappes.

The origin of tectonic units is frequently put into connection with the so called principal phase. The Inner West Carpathians are an example, how with development of our knowledge ranging of the main phasis changed, with which the origin of nappes was put into connection: first the Subtatric and partly the Laramide phase — A. Matějka, D. Andrusov 1938; later the Subhercynian — D. Andrusov, J. Bystrický

1959, then the Late Austrian — D. Andrusov in V. Čúlová, D. Andrusov 1964 and finally the Mediterranean — D. Andrusov (1968). However, regarding polarity of folding, indicated by the age of flysch respectively flyschoid facies accomplishing the cycle of carbonate sedimentation, it is logical to admit the commencement of folding but also its most intense manifestations first in more southern units and termination latest in the outer units and this way the time range of the period of forming of the structural plan is by far wider. Three groups of flysch units of the West Carpathians, besides others also distinguished on the basis of folding manifestations in time, show the Savian, Early and Late Styrian principal „phases" or subperiods of folding to have affected all three groups of nappes but with certain shift in time and intensity from the inner part outwards or with manifestation of orogenetic polarity. The Savian phase is very significant for the Magura group of units, the Early Styrian for the middle (Silesian and Subsilesian) and the Late Styrian for the outer (Skole) group. In determination of the so called principal phase, however, we are faced to the difficult problem, what to consider as more important, as principal phase of folding, forming of unit, its folding or thrust, terminal thrusting, frequently also at a great distance. Folding and overthrust of units above one another are two results of uniform process of transformation of partial-structural-facies zones into structural units, which was taking place in the Flysch zone from the Oligocene until the Upper Tortonian in several acts. The process of folding was somewhat preceding the process of thrusting there. Several acts of folding, even different in their kinematics, can be not always distinguished from each other with lacking younger sediments and ranged to distinct time section. The time spectrum of the same Vepor crystalline (see p. 202) is instructive in the sense that it shows how the whole region of the Inner Carpathians was affected in several „phases" — subperiods by compressional movements, also when polarity of folding process obviously manifested, and thus also the change of folding intensity in the individual zones.

Differences in the manifestations of foldings in time and intensity condition a cosiderable part of specific signs of the individual segments of the Alpides; analogies in folding manifestations are indicator of common features of structure development on the other hand.

The West Carpathians are a typical segment of two intense foldings laterally distributed in space. Cretaceous units are in the Inner Carpathians and Savian-Styrian ones in the Flysch zone. Cretaceous folding is fading out in the Klippen belt on the outer side; in the Flysch zone it is essentially of reflected character only. The zone of overlapping of two foldings is closely limited to the margin — the Periklippen or Manín area — of the Inner Carpathians and the Klippen belt. Lateral distribution of the Cretaceous and Savian-Styrian system is the cause of division of the West Carpathians into two wholes, distinct morphotectonically and independent in structure, the Inner-Internide-Cretaceous Carpathians and the Outer-Externide-Flysch Carpathians — Savian-Styrian. They are only linked up through the narrow Klippen belt folded in the two folding periods and perhaps also partly affected by the Early Paleogene, Laramide-Illyrian-Pyreneic folding. The first folding in the Klippen belt may be considered as Upper Cretaceous there, in the more inner part between the Coniacian and Lower respectively Upper Santonian, in the outer part to the end of the Campanian (V. Scheibner in T. Buday et all. 1967). Bipartity of the West Carpathians is also proved by manifestations of orogenetic polarity, which should be treated apart in each of the two geosynclinal systems. It is polarity of folding periods. The Early Paleogene was not manifested more distinctly in the Inner Carpathians, no particular even no partial tectonic units were formed. Compared to the Eastern Alps this difference is shown by small portion of Upper Cretaceous respectively Paleocene sediments in the Inner Carpathians and their different molasse type.

The affect of the Early Paleogene (Laramide-Pyreneic) folding in the West Carpathians is limited. Its affects are to take into consideration in the westernmost part in the Myjava area, where the Upper Cretaceous is covered with slices of the Choč unit (proved by boreholes in the underlier of the Vienna Basin Neogene near Lakšárska Nová Ves). In the eastern part of the Klippen belt and in the innermost part of the Flysch zone in the Magura unit in East Slovakia the Pre-Upper Eocene, Illyrian folding manifested, not only in the character of sedimentation (change of current directions, which carried clastic material and in slumping bodies) but also in the discordance at the base of Upper Eocene Menilite-Mal'cov Beds (J. Nemčok 1971).

The Upper Cretaceous respectively Paleocene (?) more southerly from the Periklippen area appears sporadically only, scarcely, in less thickness and show the character of early molasse. Strong tectonic disturbing with great dip of strata (uncommon in later Central-Carpathian Paleogene), diagonal schistosity of claystones and paleogeographical discordance in relation to the Lutetian-Priabonian Central-Carpathian late tectonic Flysch indicate manifestation of Laramide respectively Illyrian folding also in the more inner zones of the West Carpathians. Perhaps with these movements accomplishment of the Cretaceous Hron and North Gemeride synclinorium is connected (M. Mahel' 1967).

The area of the Cretaceous folding of the West Carpathians is linked up with the Hungarian Median Mass. However, here the intensity of folding was essentially less than in the West Carpathians. It was the lowest in the Transdanubian Mesozoic. Also in units affected more distinctly by folding, the Bükk, Mecsek, Villany, no regional metamorphism was taking place and even local manifestations of schistosity and mylonitization phenomena common for this folding in adjacent Alpine zones are unknown in the Hungarian Midmountains. The Pre-Alpine substratum was not reworked more distinctly by Cretaceous folding (the less by later ones) (Gy. Wein 1969). This way the Hungarian Midmountains represent a central massif amidst the Alpides. The dynamics of its individual blocks is various. One of the signs of lowered orogenetic activity is also the lack of flysch, the forerunner of Cretaceous folding, also when the more detrital character of Cretaceous sedimentation is evident — sandstones and shales of the Valanginian-Barremian in the Gerecse Mts, shales and sandstones in the Barremian of the Mecsek and partly in the Villany, Gargasian shales, in the overlier of the Aptian limestones and Cenomanian shaly facies — Vertés, Bakony, Mecsek, Reflections of folding processes in the Hungarian Midmountains are regressions and transgressions. Regressions ware distinctly manifested in the Berriasian in some places (Tata, Vertés, North Bakony, Villany), in the Upper Barremian elsewhere (Gerecse, Mecsek, Villany), in the Upper Aptian regression was more common (Tata, Vertés, Bakony) as also in the Upper Cenomanian, Transgressions were taking place in the Lower Aptian and Gargasian (J. Fülöp 1961); however, they are not evident everywhere. Thus when the origin of structures is attributed to the Austrian and Subhercynian phase (F. Szentes 1964, Gy. Wein 1969), also there are phases understood in a wider time-section. Starting from the Laramide folding, later foldings were manifested in activity of the faults, reverse faults (Laramide, Illyrian) respectively normal faults (Pyreneic). Remarkable in the Hungarian Massif is the flysch central trough (Senonian-Eocene, perhaps as late as Oligocene); (K. Balogh, J. Körössy 1968) with manifestations of the Savian folding.

The Northern Calc Alps with Cretaceous units in many aspects near to the West Carpathian ones were affected by folding in the eastern nad middle part, partly imbricated and thrust over the Flysch zone and Helveticum in time of the Illyrian-Pyreneic folding and subsequently thrust also later in the time of the Savian folding. The youngest member of the flysch sequence in the flysch nappes of the Northern Alps is the Paleocene (in the Wienerwald as late as the Middle Eocene) and in the Helveticum the Upper Eocene. This would be also indicated by the commencement of the molasse trough, its southernmost part (the molasse directly reacts, follows paroxysm — J. Auboin 1964). From that it is possible to consider the origin of the nappes of the Flysch zone in the Eastern Alps to have started in the Upper Eocene. Principal movements were taking place in the Upper Oligocene to Aquitanian (S. Prey 1968). The Illyrian-Pyreneic folding caused compression or overlapping of the Flysch zone, its less independence on the outer zone in relation to inner units.

It is to stress that the cause of the difference between the Eastern Alps and West Carpathians is not only the effect of the Early Paleogene folding alone in the Western Alps as often mentioned (D. Andrusov 1960—1969). The extensive development of the Upper Cretaceous, its variability and facies variety with facies genetically bound to diastrophic period (flysch, couches rouges) are indicator of differences of development derived from earlier period. It is sufficient to compare the abundance of flysch and flyschoid facies in the Albian and Cenomanian of the Krížna unit and Tatrides and the lack of these facies, e. g. in the Unterostalpin and their small extension in the Oberostalpin. The bipartity of the Carpathian is in contrast to the Eastern Alps thus disturbed by the Illyrian-Pyreneic folding, which affected the outer part of the internide system and linked it up with the externides.

In the westernmost part of the Austroalpine nappes in Switzerland Cretaceous folding showed slighter manifestations. In places it was partly accompanied by metamorphism (80 mill. years). In genetical connection with this folding is perhaps the Albian-Cenomanian detrital facies of silty shales with sandstone banks in the Oberostalpin and the flysch respectively couches rouges (Cenomanian) in the Unterostalpin unit and in the Penninicum, Cretaceous folding was most probably of reflecting character only, manifested by uplifts. Principal folding of the Austroalpinicum as well as Penninicum, accompanying metamorphism, fell into the period Middle Eocene-Lower Oligocene (R. Trümpy et all. 1969). In the Brianconnais zone it was preceded by flysch of Upper Paleocene-Lower Eocene age; in the more northern Valais zone by the flysch of Upper Cretaceous-Paleocene age. The outer units — Helvetides with Upper Eocene to Lower Oligocene sandstone flysch were folded later, as late as the Miocene, in the time of the Early Neogene folding.

Beside other signs analogous to the West Carpathians appear to be the Northern Apusins also in the age of folding. They also represent a part of the region with Mesocretaceous units unaffected by later folding more distinctly. Upper Cretaceous sediments of molasse type (Turonian-Maastrichtian) represent the filling of late tectonic early depressions. The folding, which terminated after the Cenomanian, was preceding mighty development of Lower Cretaceous flyschoid sediments in the Codru nappe and of Upper Aptian-Cenomanian sediments in the Bihor autochthon (M. Bleahu, D. Patrulius 1967). Tectonic unrest was manifested earlier by interruption of sedimentation in the Upper Jurassic in the nappes Codru-Moma, discordant position of flyschoid strata and interruption of sedimentation with formation of bauxites in the Lower Cretaceous of the Bihor unit. The outer margin of the Apusins, however, is essentially different from the West Carpathians. From the SE side they are bordered by the Mureš synclinal trough with mighty development of Lower and Upper Cretaceous heterogeneous flysch, partly volcanogenic. This zone was affected by folding in two periods. The onset of the diastrophic period is signalized by sedimentation of Middle Aptian discordant flysch. In the middle of the Albian partial uplift and displacement of the axis of the zone of more intense sedimentation outwards was taking place. As reflection of folding should be also considered the molasse type of the Vraconian, followed by Turonian-Senonian flysch (J. Dumitrescu 1964; M. Bleahu, D. Patrulius 1968).

If the Apusins have many features common with the inner zones of the West Carpathians, on the contrary, the East Carpathians have the outer zones common with them, which are proper continuation from the West Carpathians. However, the Savian-Styrian units in the East Carpathians were more intensely affected, subsequently thrust also by later movements (known rejuvenation of the origin of nappe units along the axis of the flysch geosyncline from W to E). However, greater differences are to be seen in the inner units. These were in the East Carpathians in the first place formed by the Mesocretaceous folding. However, analogously as in the Eastern Alps in the period of the Early Paleogene folding tectonic approaching of internide and externide units to overthrusting of the internide units on units of the Flysch zone was taking place. First folding and thrusting of the Median Dacides (internides) on the marginal ones are dated as early as the end of the Hauterivian (D. Patrulius et all. 1968. J. Dumitrescu 1964). At the newly distinguished nappe Haghimas (one from the group of Transylvanian nappes; M. Sandulescu 1969) its thrust is supposed as early as the Barremian more or less synchronnously with the commencement of the origin of the Wildflysch (Barremian-Albian) of the Bucovinian nappes. This contains in its basal part olistolites of the Haghimas nappe. The great thrust of the Haghimas nappe was taking place prior to the Upper Albian. Vraconian-Cenomanian conglomerates overlap the Haghimas and Bucovinian nappes with golded complexes of its Wildflysch. At the further Transylvanian nappe Persani its thrusting in the middle of the Aptian is being evidenced on the basis of its olistolites in the Wildflysch (D. Patrulius et all. 1968). Mighty diastrophism is accompanied by the origin of thick conglomerates, mostly known of which are the conglomerates of Buceci type (paramolasse according to L. R. Contescu 1965).

A particularity of the East Carpathians is the mighty Ceahlau-unit, predominantly built up of carbonate Lower Cretaceous flysch. It represents the so called Outer Dacides, linking up the Dacides (inner East Carpathian units) with the outer units, so called Moldavides, in its flysch content and age of folding. Processes of folding were accompanied in it by effusions of basic magma (in the Sinaja Beds) in the lowermost Neocomian, discordance in the Hauterivian and the middle of the Aptian, supply of great amount of detrital material in the Aptian (Komarnic Beds) and mainly in the Albian, uplift culminating at the end of the Albian. Onset of further cycle of sedimentation is to be seen in places in the Cenomanian, elsewhere in the Turonian to Coniacian (D. Patrulius et all. 1968). Principal folding which affected and accomplished the structural character of the Ceahlau nappe was Early Paleogene, possibly Laramide (it rests on the Upper Cretaceous including the Senonian — M. Sandulescu 1971). The reach of the Laramide folding in the inner zones of the East Carpathians is attested by discordant position of the detrital Eocene on Senonian marls in the Dimboviciora zone (D. Patrulius et all. 1968).

Following the arch of the Eastern Alps-West Carpathians-East Carpathians we state:
1. More or less uniform outer — externide — Flysch zone, essentially Savian-Styrian,

with rejuvenation towards the east; on the outer side they are bordered by fore-deep filled up with molasse. 2. Transitional area linking up externides and internides affected by Mesocretaceous, Early Paleogene folding, partly „en bloc". This zone is narrow in the West Carpathians, almost disappears and widens in westerly direction towards the Eastern Alps and also in easterly direction towards thes East Carpathians.

In further continuation of the Carpathian arch to the S towards the South Carpathians (analogously to the Western Alps) the zone of Cretaceous folding-inner zone as well as that of Savian-Styrian folding is of less importance and the area of Early Paleogene (Laramide-Illyrian-Pyreneic) folding acquires main extension, with gradual rejuvenation of movements from north to south. In the South Carpathians less reach of Cretaceous folding is remarkable although the extent of the Lower Cretaceous flysch is considerable since the Tithonian (Lužnička zone, Krajstides; Severin-Kraina). Only the inner zones ranged as Suprageticum and Geticum on Roumanian territory and as Golubac-Penkovo and Kučaj zone in Yugoslavia and in Bulgaria were also more intensely affected by Middle Cretaceous folding (beside principal Post-Upper Cretaceous folding). In the Geticum formation of the Getic nappe in the Upper Albian and thrusting on the slightly folded Severin unit is put into connection with this folding (Al. Codarcea, Railleanu 1961). Middle Cretaceous diastrophism is preceded by interruption of sedimentation as early as since the Barremian, however, more distinct manifestation is the change of limestone sedimentation into sandstone-claystone one at the end of the Aptian with manifestations of slight discordance (Al. Codarcea, Gr. Pop 1969). Folding and formation of the Getic nappe and its first thrusting were taking place before the Cenomanian. The transgressive Cenomanian and Turonian are of pseudomolasse character (detrital facies with abundant sandstones and conglomerates and also coral limestones). In the Krajstides formation of the Penkovo nappe is put into connection with Post-Lower Cretaceous folding (E. Bončev 1966). In the Turonian displacement of the axis of the area of sedimentation outwards was taking place into the zone Sopot-Semenic. Transgressive Senonian sediments are lying discordantly. Manifestations of folding obviously conditioned displacement of the axis of geosyncline outwards and the origin of the linear trough of the Timok Graben — accompanied by great amount of lavas of „pseudosubsequent" character parallel to the axis of Pre-Upper Cretaceous structures (in P. Stevanovič, M. Anđelkovič et all. 1967). The filling of the trough (Cenomanian-Danian) with variety and variability of facies, with cryptoflysch of couge rouge facies, organogenic limestones and also coal seams, flysch and a whole series of further facies with the amount of further facies with the amount of volcanogenic material may be characterized as tectonogroup of the period of orogenetic activity. Principal folding and far-reaching thrust of the Getic nappe was taking place after the Upper Cretaceous.

The outer zones of the South Carpathians, the Danubicum and the zones linking up southerly Greben-Stara Planina, Poreč, as well as Severin-Kraina represent areas with Post-Upper Cretaceous principal folding (A. Grubič 1967). For these areas considerable extent of Upper Cretaceous flysch (Turonian-Senonian) is characteristic. Slight folding of the Sinaja Beds attests the reach of Mesocretaceous folding to have been weak (M. Sandulescu 1971). There are no direct evidences for more precise age of folding in the northern Roumanian part, it is put into connection with the Laramide phase (J. Dumitrescu 1963). In the Kraina unit (continuation of the Severin zone on Bulgarian territory) the flysch complex in the Koula partial unit reaches as late as the Ypressian and Lutetian so that folding is Post-Lutetian. Reflections of earlier foldings were manifested in this area by regression after the Upper Cenomanian, followed by Turonian transgression and further regression after the Danian, after which transgression of the Ypressian lying discordantly took place (C a n k o v 1968). And one more particularity. It is to stress the reach of Late Styrian movements, thrusting over the Miocene at a distance of about 10 km in the innermost zone of the South Carpathians, the Morava zone adjacent to the Serbian-Macedonian Massif.

The western block of the B a l k a n as far as the Jablanic Line has many features common with the South Carpathians. In the Stara Planina and also the Fore-Balkan sedimentation of carbonates and marlstones continued from the Albian as late as the Paleogene; the whole complex was folded after the Middle Eocene. Particular features in manifestation of folding shows the central and eastern block of the Balkan. We range to them: early manifestations of Cretaceous folding partly as early as Late Cimeric, spatial overlying of folding of the Cretaceous and Early Paleogene period; lack of folding manifestations in the Early Miocene period.

Early Cretaceous folding, perhaps Late Cimeric, accompanied by distinct metamorphism (E. B o n č e v 1966) affected the Strandža and Sakar units and the Rodopes. Immediately Post-Tithonian age of folding is considered according to the Tithonian age of the youngest, partly flyschoid member of the series in the Strandža unit (shales with intercalations of black marmoritized limestones and with layers of diabases). The younger Upper Cretaceous complex, relatively intensely affected by Laramide folding, commencing with the Cenomanian, rest on the earlier Mesozoic with distinct discordance.

The units situated more northerly were affected by Middle Cretaceous and Pyreneic folding. This is to be seen most distinctly mainly in the outermost unit in the Fore-Balkan. On Pre-Upper Cretaceous complexes folded intensely more slightly folded Pyreneic structures with Upper Cretaceous (Senonian) filling of platform type and Ypressian Lutetian terrigenous deposits respectively sandy flysch are superposed. Middle Cretaceous Post-Aptian folding is preceded by mighty complex of Tithonian-Lower Cretaceous flysch (up to 4000 m thick) in the central block and of flyschoid complexes in the eastern block of the Balkan; the youngest member of the sequence, the Aptian, shows terrigenous development. It is to stress that in the Fore-Balkan as well as in the more southern Stara Planina unit Middle Cretaceous folding was not manifested (at least not distinctly) in the western block, westerly of the Etropol Line. The folding unifying the Balkan is the Pyreneic folding only. Northerly towards the platform the intensity of folding diminishes.

The Fore-Balkan as the outermost zone thus does not represent distinct Flysch zone as the outermost zones of the Eastern Alps and Carpathians. The fore-deep is also missing here. The Balkan Flysch zone is formed by the Luda Kamchiya unit situated at the outer margin of the Srednogorje zone mainly in the eastern block of the Balkan; thus in eastern continuation of the Stara Planina zone. The oldest member is transgressive Cenomanian with abundant conglomerates. The essential mass is represented by thick flysch (only the Turonian reaches thickness of up to 2000 m) and that carbonate one with facies of marly limestones (Biancone), Middle to Upper Cretaceous in age and Lutetian flysch (up to 1500 m thick), predominantly sandstone with Wildflysch facies. Interruptions of sequences are known between the Turonian and Senonian and after the Paleocene. More easterly in the Stara Planina unit, in the Šipka anticlinorium the Turonian terrigenous complex rests discordantly on older formations affected by Middle Cretaceous folding. However, the folding was also manifested after the Upper Cretaceous as the Maastrichtian carbonate complex lies discordantly not only on older formations but also on the Turonian.

Between the unit Luda Kamchiya and the Fore-Balkan the Kotel zone is situated, 2,5—9 km narrow, bizarre tectonically, very compressed, originated on a lineament zone. It is, similarly as the Klippen belt of the West Carpathians, also the product of several intense foldings, mainly Cretaceous and Pyreneic ones. Also in it heterogeneity of development of the members originated in the time between the foldings is remarkable, partly of northern Fore-Balkan type, partly of southern type analogous to that in the Luda Kamchiya unit.

In the Srednogorje with extensive superposed troughs, which start a new cycle of sedimentation after folding at the end of the Lower Cretaceous (in the Turonian, elsewhere in the Senonian) manifestations of folding have been observed at the end of the Turonian and also of the Upper Cretaceous. The Laramide folding was preceded by thick Upper Cretaceous flysch. In spite of distinct manifestations of this folding (in the more northern zones of the Balkan, e. g. in the Luda Kamchiya, problematic), Pyreneic folding was also manifested after the Lower Eocene in the Srednogorje zone.

The pattern of the internides and externides of the Balkan is quite different in structural facies development from the internides and externides of the Eastern Alps-West Carpathians-East Carpathians. It is difficult to make a true picture of polarity of the folding process, i. e. distribution of older tectonic units on the inner side and younger ones on the outer side. The structures of the individual periods of folding are superposed above each other here and not distributed laterally from the inner towards the outer part (as e. g. in the West Carpathians). Orogenetic activity of the individual periods of folding is manifested on the other hand.

The Cretaceous period of folding commenced earlier in the southernmost zones (perhaps as early as the Late Cimeric folding). The more southern zones show earlier onset of folding also in the Early Paleogene period with distinct manifestation of the Post-Upper Cretaceous — Laramide folding.

The Dinarides are distinct by slighter Early Cretaceous folding manifested in the inner zones; considerable extent and intensity of Early Paleogene folding; distinct Paleogene — Early Neogene wave of orogenetic migration, the outermost units are Early Neogene.

Cretaceous folding possibly commenced as early as the uppermost Jurassic (J. Mercier 1966, J. Auboin, J. Ndojaj 1964). Discordances are already present at the base of the Tithonian, in the overlier of the diabase-radiolarite series and that in the Vardar zone, Kopalnik zone, Pelagonic and Mirdita unit. The presence of Tithonian conglomerates and thick detrital limestones in the Lower Cretaceous (in the Mirdita unit) indicate tectonic unrest of longer duration. The Lower Cretaceous is most frequently absent in the internide units. Quite extensive was transgression in the Aptian-Albian. In the Helenides distinct megastructural units are not put into connection with Lower Cretaceous folding. However, the origin of small isoclinal folds and highly metamorphic effects are attributed to them (J. Mercier 1966). In the Vardar and Kopalnik zones Triassic and Jurassic complexes were folded into anticlines and synclines, discordantly overlain by transgressive Albian-Cenomanian complex (J. P. Rampnoux 1969). Indirect evidence of considerable influence of Lower Cretaceous paroxysm in the Inner Dinarides is ascertaining that a considerable part of the so called Durmitor Flysch considered as Upper Cretaceous is found to be Tithonian-Neocomian (including the Aptian) in age being a part of a particular old trough zone at the outer margin of the Inner Dinarides extending along Bosnia and Hercegovina through Černa gora as far as Albania; it forms the particular Bosnia unit (R. Blanchet, J. P. Cadet, J. Charvet, J. P. Rampnoux 1969).

The principal folding which affected the inner Dinaride zones and formed the tectonic units is the Early Paleogene one. Its precise range of time has not been quite clear so far. It was preceded by Maastrichtian, in some places Maastrichtian-Danian flysch (B. Čirič 1963, T. Bicoku, A. Papa 1970, J. Auboin, J. Ndojaj 1964). The origin of late tectonic depressions as early as the Upper Lutetian-Priabonian (Vardar trough, Mesohelenide trough) determined the upper possible boundary of the folding period; folding of the internide zones of the Dinarides is thus Laramide-Illyrian. Compressional movements fading out were still taking place at the end of the Priabonian (Pyreneic), also manifested in thrusting of the outermost internide units Mirdita-Subpelagonic (J. Mercier 1966). The effect of the Pyreneic folding and the slighter Early Styrian one is indicated by the so called Majevica formation in the northern part of the Inner Dinarides; it starts with Eocene flysch, which passes into molasse reaching as late as the Lower Oligocene, less folded.

Early Paleogene folding has also formed the more external units Visoki Krš and Budva-Krasta-Zukali-Pindos, unaffected by Cretaceous folding more distinctly. In the last named group of tectonic units flysch complexes of the Upper Cretaceous to Priabonian preceded strong late Early Post-Paleogene-Pyreneic folding. In the Visoki Krš on Upper Cretaceous and Lower Eocene limestones discordantly lies the Oligocene, also perhaps late tectonic Upper Eocene molasse formation termed Promina: heterogeneous limestone conglomerates, fine grained limestones, calcarenites, breccias, marls, claystones, sandstones, coal seams (B. Čirič 1963).

The Dalmatian units situated more externally (Učka) and Kruja-Gavrovo were formed by Savian folding. In the Kruja-Gavrovo unit Upper Eocene-Oligocene flysch preceded folding in the Aquitanian, being of the character of folded molasse (T. Bicoku, A. Papa 1968). In the Ionian unit situated still more externally the Upper Eocene and Oligocene flysch (partly perhaps also the lowermost Miocene) passes into folded Lower Miocene molassoid (schlier). Moreover, the synclines formed by Early Styrian folding (prior to the Upper Helvetian) are filled up with molasse of the superposed fore-deep starting the Upper Helvetian.

In NW direction (towards the Southern Alps) lateral rejuvenation of Dinaride zones is apparent.

The Southern Alps were affected by slighter folding in the Middle Cretaceous. Its manifestations are: less portion of the Lower Cretaceous in the structure, its frequent absence and mainly discordant position of Upper Cretaceous sediments on older substratum in places. As manifestations of Lower Cretaceous folding should be also considered hieroglyphs and lamination of the upper part (Albian-Cenomanian) of the complex of Biancone facies, e. g. in the Piava Valley as well as silts with glauconite in the Albian respectively locally found layers of conglomerates with material of Biancone facies of regressive conglomerates (in the Dolomites). The complex of varied marls scalia rossa is the main representative of the Upper Cretaceous in the Southern Alps, reaching thickness of up to 500 m in places. This formation (Turonian-Danian) (cryptoflysch-in the sence of Vassoevic), sufficiently characteristic of the orogenetic stage in some places develops from Lower Cretaceous marlstone facies without discordance (Piava area), however, elsewhere it rests on various members of the Lower Cretaceous respectively Jurassic. Northerly of Tolmino the scalia rossa starts with transgressive conglomerates at the base. The Turonian Globotruncana Marls in the Savinian Alps are lying with discordance directly on he Dachstein Limestones (A. Ramovš 1967). More distinct folding of the Southern Alps was taking place in the Early Paleogene period; the molasse filling of the Ljubljana Basin starts with Middle Oligocene conglomerates

However, in formation of the structural plan of the South Carpathians also later folding, mainly Early Neogene one, was manifested more distinctly.

Problem of Externides and Internides

Spatial distribution of the individual periods of folding conditions possibility of division of the geosynclinal system into larger genetic wholes. Lateral distribution of the Cretaceous and Savian-Styrian system is the cause of division of the West Carpathians into the inner-internide, Cretaceous and outer — externide — flysch — Savian — Styrian ones. They are only linked up by the narrow Klippen belt made distinct in both periods of folding and perhaps partly affected also by Illyrian-Pyreneic folding.

In the Eastern Alps as also in the East Carpathians this bipartity is disturbed by the effect of Illyrian-Pyreneic folding, which affected the outer part of the internides and linked them up with the externides. In direction towards the more western segments of the Alps and towards the South Carpathians bipartity of the system becomes less distinct with diminishing significance of Cretaceous and also Savian-Styrian folding, fundamental folding is the Early Paleogene one.

Superposition of Cretaceous and Paleogene folding in the Balkan, in its central and eastern block (thus with the exception of the western block folding out with Illyrian-Pyreneic folding only) as the cause of that division into older internide and younger externide units is not well-founded.

The rule of division of the Alpine system into internides, metamorphides and externides (Kober 1925, A. Tollman 1969) is thus schematic with narrow validity also from the standpoint of spatial distribution.

The intensity of folding is very different from segment to segment (fig. 1) but also in its individual parts, individual units of the same segment. Cretaceous folding intensely affected the inner zones of the Eastern Alps, West Carpathians and East Carpathians, Apusins; it formed also nappes in them. Distinctly affected by this folding but without nappes were also the eastern and central block of the Balkan and the inner units of the South Carpathians (Suprageticum, Geticum), Mecsek, Villany, Bükk, Cretaceous folding affected only slightly the units of the Inner Dinarides and the Transdanubian Mesozoic.

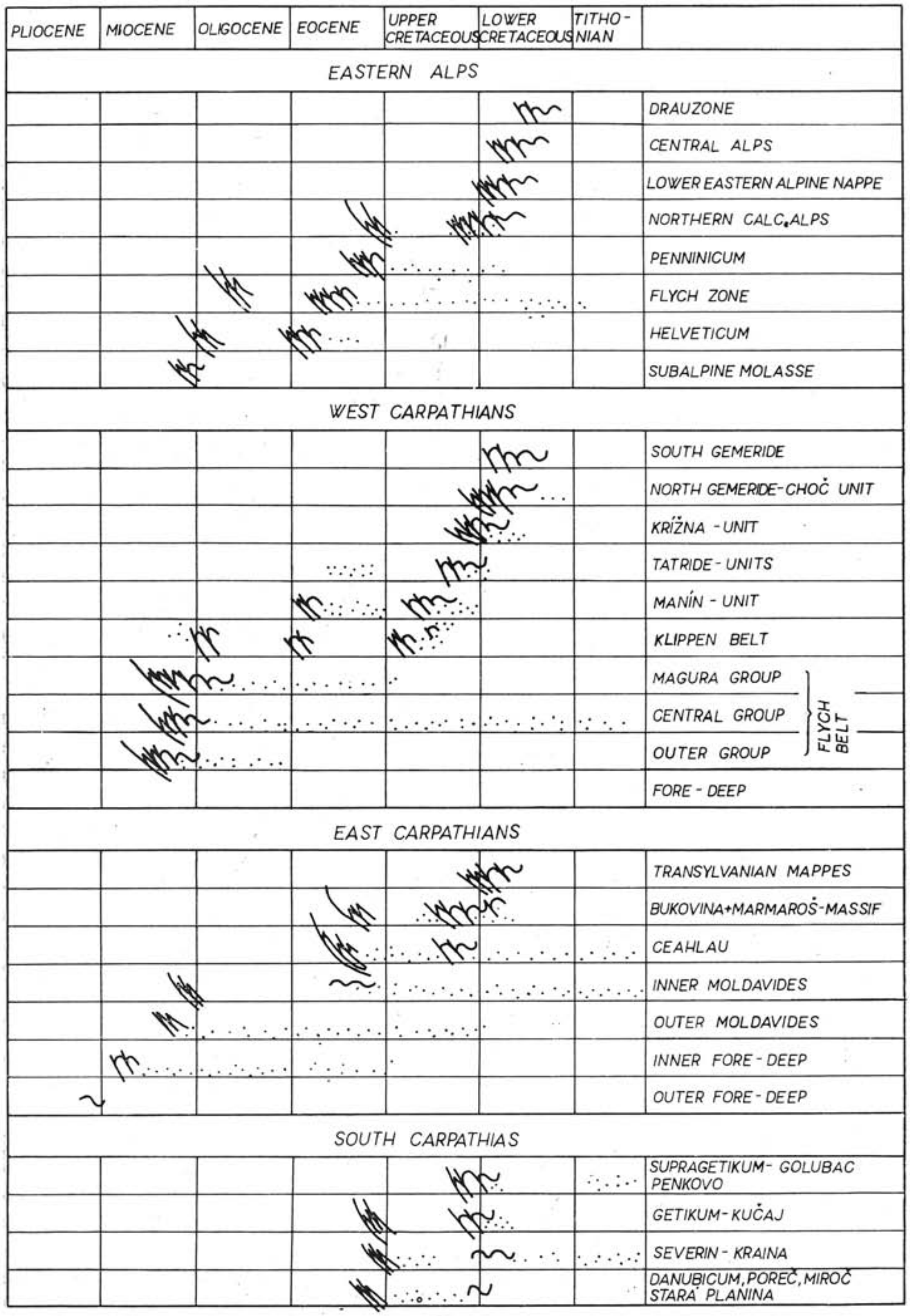
Paleogene (Laramide-Illyrian-Pyreneic) period of folding affected very intensely with nappe structure in the first place regions of the inner Alpides not affected or mostly only slightly by Cretaceous folding. Cretaceous and Early Paleogene folding frequently substitute one another spatially. Intense manifestations may be observed in the Inner and Central Dinarides and Helenides, in the western sections of the Alps (Penninicum); in the Mureš syncline of the South Carpathians (also with nappes as the Getic one), in the western block of the Balkanides. Of superposed character but considerable intensity was this folding also in the central and eastern block of the Balkanides (Luda Kamchiya, Kotel unit). Slighter overlying character accomplishing the structural plan showed the Early Paleogene folding in the Northern Calc Alps and in the inner zones of the East Carpathians. Remarkable is the lack of this folding in the Hungarian Median Mass and adjacent areas including the Apusins and the essential part of the Inner West Carpathians, also in the Drauzone of the Alps, perhaps also in the Central Alps.

The Early Miocene (Savian-Styrian) folding affected intensely with nappe structure the Flysch zone of the Carpathians and Eastern Alps and the outer units of the Dinarides (Dalmatin — Kruja — and Ionian unit — Sazon). Remarkable is the small reach of this folding in the South Carpathians and its absence in the Balkan.

P o l a r i t y is a characteristic sign of development of the geosyncline and the course of folding (J. A u b o u i n 1964). However, our experience indicates considerable differences in manifestation of orogenetic polarity in the individual segments (see fig 2). In some of them periodical time succession of folding from the inner to outer zones is very distinct. A typical case are the Dinarides; the inner zones show Laramide-Illyrian, the central units Late Illyrian and Pyreneic, the outer ones Savian to Savian-Early Styrian folding. In the late tectonic stage, however, polarity disappears; the molasse trough has not formed in the front of flysch structures but is superposed on them in the Ionian zone, partly in the Kruja zone. In the outermost unit, the Sazan, also flysch is even absent. Also with existing migrational orogenetic wave spatial extent of the individual periods of folding, mainly the Early Paleogene one in the Dinarides, is considerable, and that in manifestations of folding and reflected manifestations. A different type of segments is the Balkan, where the Mesocretaceous (with the exception of the western bloc) as well as Laramide-Illyrian-Pyreneic paroxysm afftected the whole region. However, also here polarity was manifested in less advance of folding in the inner zones, one may speak about polarity within the period of folding. In the West Carparthians we may speak about distinct polarity apart in either of the two geosynclinal systems-the Inner Carpathians folded in the Cretaceous period and the Outer Carpathians folded in the Savian-Styrian period.

In the Inner Carpathians increasing portion of younger members with more diastrophic facies in outward direction is distinct (see fig. 2) and in manifestation of several acts of folding in the whole extent of the internides a sucession of intense wave of folding from the inner zones towards the outer ones is to admit. As a consequence that the Klippen belt was most distinctly affected as late as the Upper Cretaceous subperiod of folding. In the Outer Carpathians rejuvenation of the youngest member outwards is also connected with manifestation of orogenetic polarity, as a consequence of what the group of the inner units of the externides has been formed in essentials as late as the Savian sub-period, the central group of flysch units is Savian-Early Styrian and the outer group of flysch units Savian-Late Styrian (see p. 202). Particularly distinct not only for the West Carpathians but mainly for the East Carpathians is linking up between the Flysch zone and fore-deep in time and space. The flysch facies in the outer part of the externides gradually pass into molasse, however, which in essential part developed in the fore-deep, first in the inner zone only, founded in the Lower Miocene and folded out by Late Styrian and later folding and then in the outer zone founded in the Tortonian, affected by Late Neogene movements fading out in the southern parts. In the Eastern Alps, mainly in their western part, polarity is less distinct than in the West Carpathians. Characteristic is here disappearing linking up of the molasse with the Flysch zone in time and spatially. Between the flysch genetically bound to the Penninicum and the molasse zone the Helveticum zone widening to the west is wedged in.

T e c t o n i c u n i t s we consider as fundamental elements of the system of structural-tectonic factors. The majority of tectonic units are typical of one or another segment. Each of them reflects in its content local influences and also such ones of more regional character, depending on position of the original areas in the geosyncline; it includes pre-folding history. However, with its origin spatial position also the type of its tectonic formation and its tectonic position impressed by processes of folding are connected. Each segment has a different set and different relations of tectonic units as a consequence of different articulation, development but also different time distribution and intensity of folding movements. In other words: different spatial distribution and


PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
UPPER CRETACEOUS
LOWER CRETACEOUS
TITHONIAN
EASTERN ALPS
DRAUZONE
CENTRAL ALPS
LOWER EASTERN ALPINE NAPPE
NORTHERN CALC.ALPS
PENNINICUM
FLYCH ZONE
HELVETICUM
SUBALPINE MOLASSE
WEST CARPATHIANS
SOUTH GEMERIDE
NORTH GEMERIDE-CHOČ UNIT
KRÍŽNA - UNIT
TATRIDE - UNITS
MANÍN - UNIT
KLIPPEN BELT
MAGURA GROUP
CENTRAL GROUP
OUTER GROUP
FLYCH BELT
FORE - DEEP
EAST CARPATHIANS
TRANSYLVANIAN MAPPES
BUKOVINA+MARMAROŠ-MASSIF
CEAHLAU
INNER MOLDAVIDES
OUTER MOLDAVIDES
INNER FORE - DEEP
OUTER FORE - DEEP
SOUTH CARPATHIAS
SUPRAGETIKUM - GOLUBAC PENKOVO
GETIKUM - KUČAJ
SEVERIN - KRAINA
DANUBICUM, POREČ, MIROČ STARÁ PLANINA

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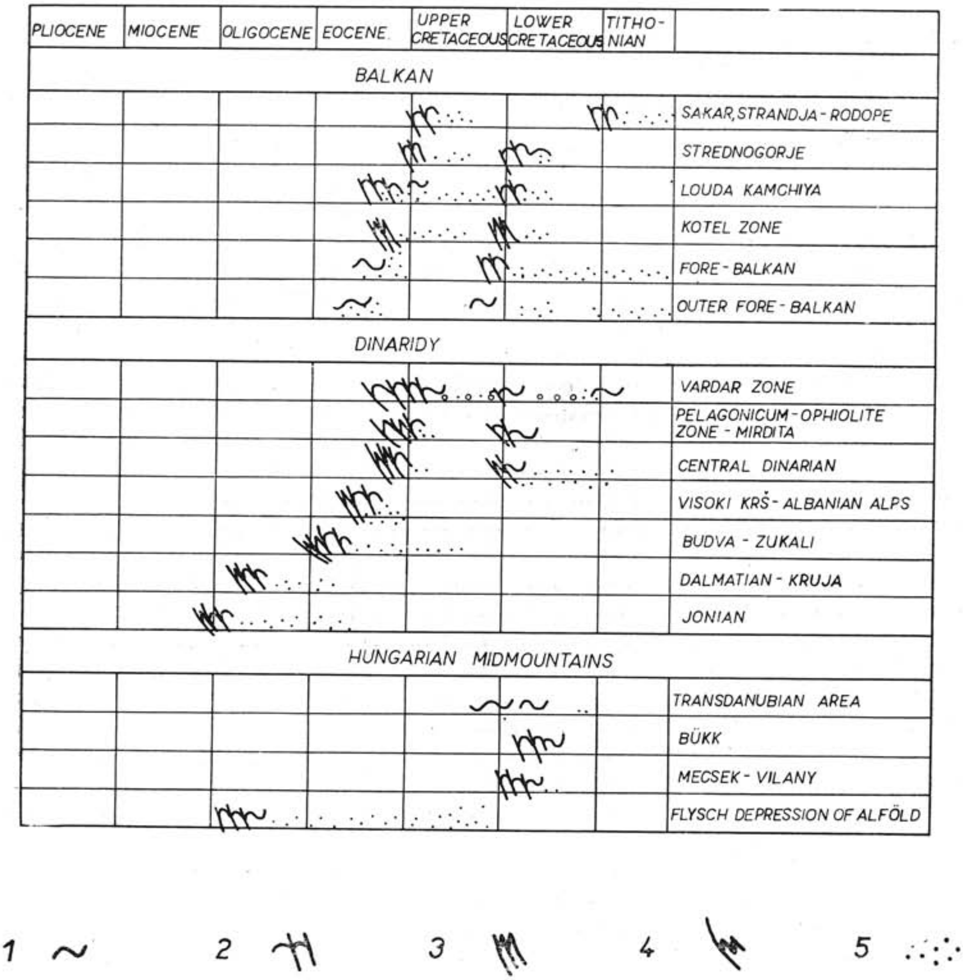

Fig. 1. Table of manifestations of folding in the Eastern Alps, Carpathians, Balkan and Dinarides (M. M a h e ľ). 1 — slight folding, 2 — more intense folding with upthrusts, 3 — intense folding with nappes, 4 — overthrusts frequently „en bloc", 5 — diastrophic facies.

various intensity of the individual periods of folding are the cause of different age and also geotectonical and structural character of the tectonic units. Regarding the age of folding processes in the first place, we distinguished these categories of units in the Alpides compiling the tectonic map (see fig. 3):

a) Early Alpine, possibly as early as Late Cimeric (affected by Laramide folding); the Sakar and Strandža units and the units at the southern margin of the Rodope Massif;

b) Cretaceous units; Drauzone, Unterostalpin; Inner Carpathian units — South Gemeride, North Gemeride, Choč, Krížna, Tatride unit; Apusin units — Ariesani, Codru-

Moma, Bihor unit; Hungarian Median Mass and its margins — Transdanubian, Bükk, Villany, Mecsek.

c) Mesocretaceous units affected by slighter Paleogene folding (frequently thrust en bloc); units of the Northern Calc Alps-Oberostalpin units; the Manín unit in the West Carpathians, the inner units of the East Carpathians — Transyvanian and Bucovinian units.

d) Cretaceous and Paleogene units with principal Paleogene folding but relatively strong Cretaceous folding: inner South Carpathian units: Geticum — Golubac-Penkovo, Kučaj; Mureš units, Srednogorje in the Balkan. A particular subgroup forms the Fore-Balkan, it differs from the foregoing ones in slighter and later Paleogene folding, as late as Pyreneic, while in the foregoing ones the Laramide respectively Illyrian folding is principal.

e) Paleogene-Cretaceous units affected by slighter Cretaceous folding with principal Paleogene folding: Penninicum, Grestener Klippenzone, Ceahlau in the East Carpathians; South Carpathian units: Severin — Kraina, Danubicum — Poreč — Miroč. In the Dinarides there are the units of the Vardar zone and the inner group of Dinarian units: the units of the ophiolite and Centrodinarian zone, the inner units of the Helenides: Korab — Pelagonicum and Mirdita — Subpelagonicum. Into this group we also include the units of the Southern Alps, however, also affected by later Early Neogene folding.

f) Units intensely folded several times, mainly in the time of Cretaceous and later folding: Kotel unit in the Balkan, folded last in the time of Pyreneic folding; Klippen belt of the Carpathians folded out by Late Cretaceous and Savian folding.

g) Paleogene units, Illyrian-Pyreneic are found in two areas: in the western block of the Fore-Balkan and Balkan (Stara Planina), where according to Bulgarian geologists the reach of Cretaceous folding was not reflected in formation of structures and also not in more distinct interrruption of sedimentation. These areas were affected by Early Paleogene folding, perhaps Illyrian. In the time of the Illyrian, partly Pyreneic folding also the Luda Kamchiya unit was formed in the eastern part of the Balkan. In the Dinarides the „central units“, Visoki Krš, Budva, Zukali-Krasta-Pindos are Early Paleogene respectively Pyreneic, partly also affected later.

h) Pyreneic-Savian units were formed in the Flysch zone of the Eastern Alps including the Helveticum. We range to them the Magura unit of the Outer West Carpathians. However, this was also affected more distinctly in the time of Neogene folding. In the Dinarides corresponding in age the Dalmatian folds (Učka) and Kruja-Gavrovo belong to this group. In contrast to the Carpathian units, however, these are not only composed of flysch, their essential part is built up of pre-flysch limestone complexes, on the contrary.

ch) Savian-Early Styrian units represent mainly the so called central group of nappes of the Flysch zone in the Carpathians: the Fore-Magura, Dukla, Fore-Dukla, Rachovo-Curbicostale, Čierna hora — Audia, Silesian, Ždanica — Subsilesian. To this group we also range the units of the Outer Dinarides, the Ionian and Sazan. The latter one is built up of limestone complexes, the Ionian unit of limestone complex, flysch and early molasse (schlier).

i) Savian-Late Styrian units are extended at the outer margin of the Carpathian Flysch zone. Their portion increases in easterly direction: the Waschberg zone and Pouzdřany, Skole — Skibova, Tarcau, Unite marginale units. We range to this group the Subalpine molasse.

j) A particular genetic type of tectonic units are the foredeeps. They were formed in the latest stages of folding out with gradually diminishing intensity of folding in the foreland of the folded system. They are filled up with molasse. In the East Carpathians the fore-deep is differentiated in structure into the inner zone-older, partly folded in the Alpine period by the Late Styrian-Moldavian folding in the East Carpathians and the Rodanian-Valachian folding in the South Carpathians, and the outer, epiplatform zone. In the Dinarides the fore-deep is of overlying character, situated on the synclines of the Ionian zone, founded by folding prior to the Upper Helvetian (J. Auboin, J. Ndojaj 1964, T. Bicoku, A. Papa 1970).

Units folded in two periods show-structure of several stages. The upper stage is represented by complexes originated in the time between two folding periods, being usually of the character of overlying structural forms, Graben-like forms are particularly distinct; the Timok and Srednogorje Graben are the most extensive. On Cretaceous units unaffected by later folding more intensely late tectonic structures, superposed with distinct discordance have been formed in zones active tectonically- early depressions, structures of longitudinal orientation, filled up with flysch; the Central Carpathian and Transcarpathian flysch, but also of transverse orientation (Ostreni in Albania); occasionally also with carbonate molasse accompanied by flysch facies — Promina in the Visoki Krš.

In zones, areas of more tectonic stability (Hungarian Massiv, Apusins, southern areas of the Inner Carpathians, Central Alps) post-tectonic structural forms have been formed as early as the Upper Cretaceous and Paleogene — early inner depressions filled up with early respectively carbonate molasse.

The essential part of basins, however, has formed as late as the post-tectonic stage and reflects movements, predominantly of releasing character with manifestation of vertical component. According to the age of foundation we distinguished the following basins: a) Paleogene or Post-Illyrian-Pyreneic; b) Post-Savian; c) Post-Styrian; d) Post-Moldavian. The latter ones alrealy fall into the post-geosynclinal stage. The older basins have structures of longitudinal course, parallel to the course of older underlying units respectively of important tectonic lines. Most frequently, mainly the oldest basins, originated as superposed on weakened mighty fracture zones. The filling of the oldest basins consist partly of „late tectonic" flysch, occasionally flyschoid respectively turbidity molasse; however, they gradually acquire molasse character. Development of many basins is complicated and their structure consisting of several stages. In their foundation also faults of transverse strike were gradually manifesting.

Each of the Alpide segments shows different complicateness of basins development. For instance, the counter-pole of variety of basins development in the West Carpathians is the Balkan, However, mainly Post-Illyrian and Post-Pyreneic basins are extended here, the portion of Miocene basins is small. A very complicate development of basins in all stages starting from the Palegone was recorded in the Hungarian Median Mass (L. Körössy 1965). In the time of the Styrian phase the Hungarian Median Mass was articulated into seven smaller basins subsiding independently on each other, divided by higher blocks. On these frequent oscillation of the sea in the Miocene conditioned interruption of sedimentation (between the Burdigalian and Helvetian, Helvetian and Tortonian, Lower and Upper Tortonian, Tortonian and Sarmatian K. Balogh, L. Körössy 1968); more continuous series are thus in basins only.

Releasing movements, of desintegrating character in the Miocene, making possible the origin of basins, partly continued also in the Pliocene. New, frequently superposed basins originated. However, uniting movements were combined with them, evoking uplifting and sinking of big wave character of extensive areas, partly with wave-like flexion. This is particularly manifested distinctly in sinking-bending down of the Hungarian Mass. The Transdanubian Alföld Depression (Great Plain) originated with Pliocene sedimentation of thousands of metres (up to 4000 m; K. Balogh, L. Körössy 1965). To a large degree sinking affected also segments of little development in the Miocene, e. g. the Balkan, where the origin of basins corresponds to the Paleogene period in age. Considerable abundance of Pliocene basins is also shown in the Dinarides.

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Review by M. M i š í k.

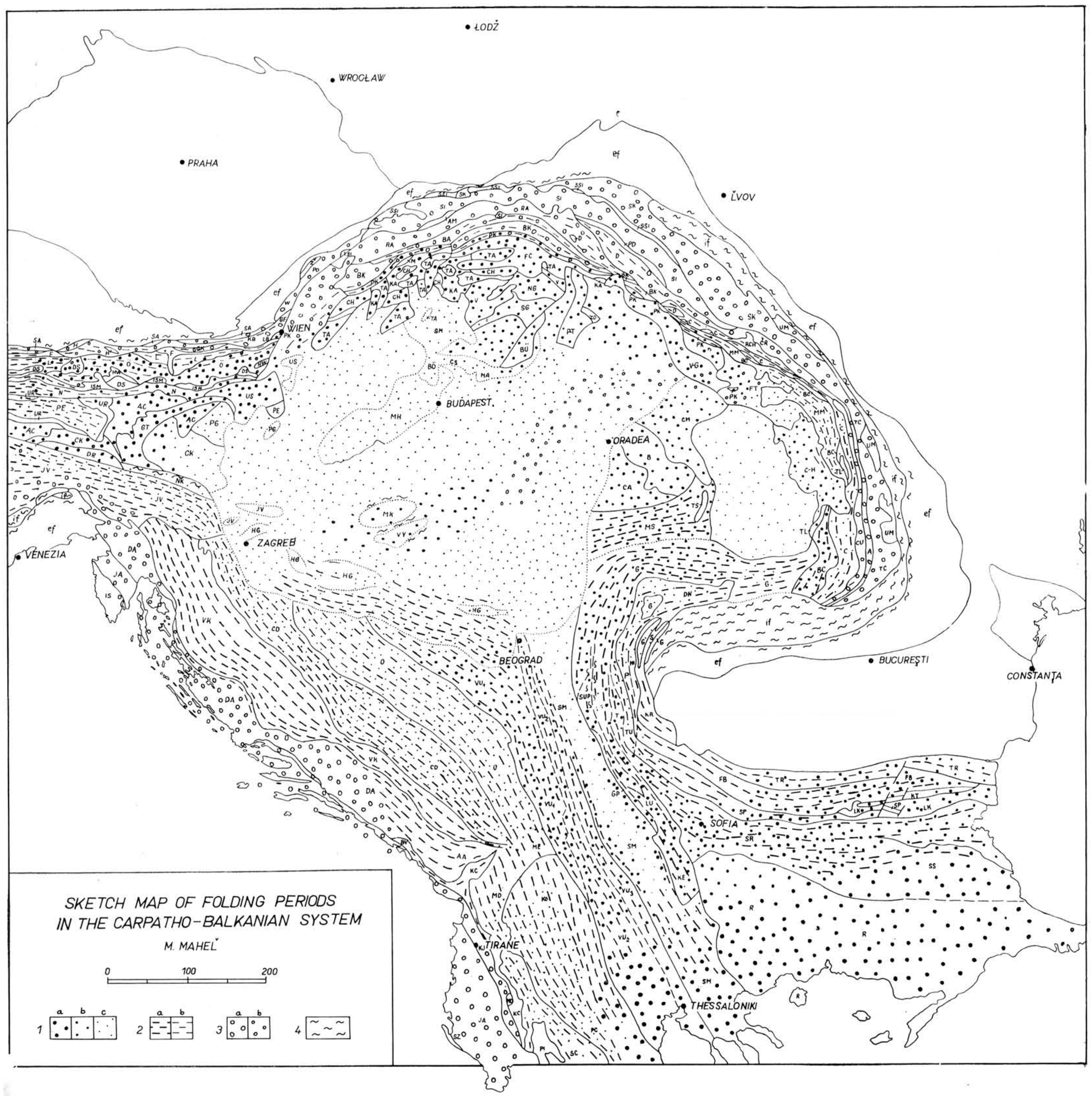

Fig. 2. Explanation to the sketch-map of folding periods in the Carpatho-Balkanian System (M. M a h e ľ). 1 — manifestations of Cretaceous folding: a) intense Early Cretaceous (partly Late Cimeric), b) intense Cretaceous (predominantly Mesocretaceous), c) slighter folding. 2 — manifestations of Early Paleogene folding: a) intense, b) slighter. 3 — manifestations of Early Neogene folding: a) intense, b) slighter. 4 — manifestations of Late Neogene to Quaternary folding.

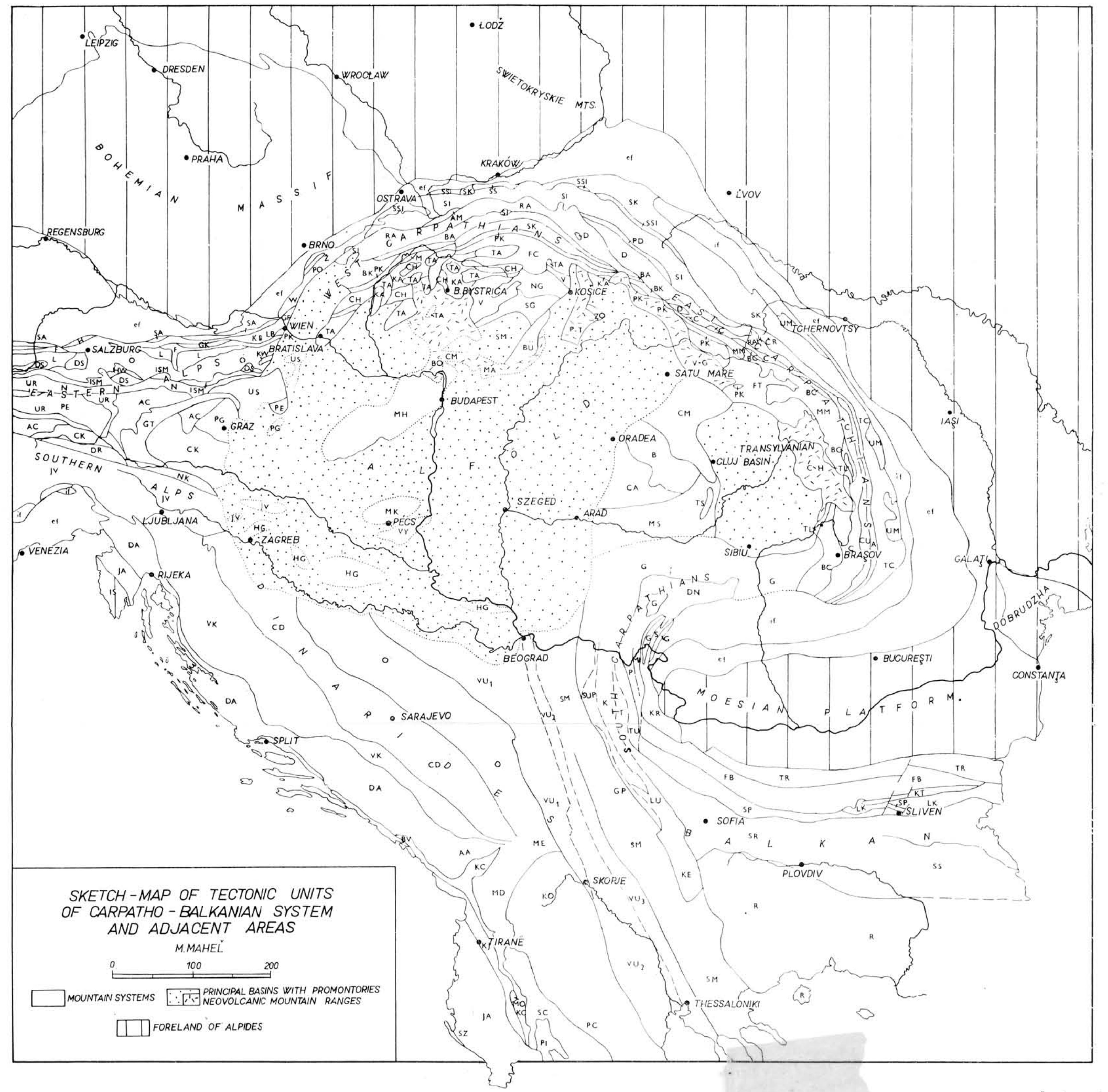

Fig. 3. Sketch map of tectonic units of the Carpathian-Balkan system and adjacent areas (1 : 3 500 000).
Tectonic units:

Eastern Alps: SA — subalpine molasse, H — Helveticum, GK — Gresten Klippen belt, W — Waschberg zone, GF — Greifenstein nappe, KB — Kahlenberg nappe, LB — Laab nappe, F — Frankenfels nappe, L — Lunz nappe, Ö — Ötscher nappe, HW — Nappe of Hallstatt — Hohe Wand, DS — Dachstein-Schneeberg nappe, ISM — imbricate zone of southern margin, N — northern Grauwacken zone, PE — Pennine zone, US — Unterostalpin-Semmering nappe, UR — Unterostalpin Radstadt nappe, GT — Gurktal nappe, PG — Paleozoic of Graz, CK — Crystalline of Koralm with covering beds, AC — East Alpine crystalline, DR — Drauzug, NK — Northern Karawanken, JV — Julian-Venetian Alps.

Carpathians: ef — External zone of foredeep, if — internal zone of foredeep, UM — marginal unit, Ž — Ždánice unit, PO — Pouzdřany unit, SK — Skole nappe, TC — Tarcau nappe, SSI — Subsilenian nappe, SI — Silesian nappe, DP — Pre-Dukla nappe, D — Dukla nappe, ČR — Černa gora nappe, A — Audia nappe, RCH — Rachovo, CU — Curbicorticale nappe, AM — Pre-Magura nappe, Magura: [RA — Rača nappe, BA — Bystrica nappe, BK — Biele Karpaty nappe]; C — Ceahlau nappe, MM — Marmaros zone, BC — Bucovinian nappes, TL — Transylvanian nappes, PK — Pieninic Klippen belt, M — Manín nappe, TA — Tatridas, KA — Krížna nappe, CH — Choč nappe, V — Vepor, NG — North Gemeride nappe, SG — South Gemeride unit, ZO — Zemplin „island", B — Bihor, CA — Codru-Arieçani nappes, MS — Mures zone, TS — Trascau nappe, FC — Central Carpathian Flysch basin, CM — Central Massif, FT — Transcarpathian Flysch basins, DN — Danubicum, MI — Miroč zone, P — Poreč zone, S — Severin, KR — Kraina nappe, G — Geticum, GP — Golubac-Penkovo zone, K — Kučaj zone, SUP — Stara Planina zone, LU — Lužnica zone, TU — Tupižnica zone, — T — Timok zone, KE — Kraištide, SM — Serbo-Macedonian massif.

Balkan: TR — Transitional zone (Northern strip of the Fore-Balkan), FB — Proper Fore-Balkan, KT — Kotel strip, SP — Stara Planina zone, LK — Louda Kamchyja zone, SR — Strednogorie, SS — Strandja-Sakar zone, R — Rhodope massif.

Dinarides-Albanides-Helenides: HG — Horsts and Grabens zone, Vardar zone: [VU_1 — Inner Dinarid unit, VU_2 — central unit, VU_3 — internal unit]; O — Ophiolitic zone, CD — Central Dinaric zone, ME — Area of Metochija, KO — Korab unit, PC — Pelagonic zone, MD — Mirdita unit, SC — Subpelagonic zone VK — Visoki Krš unit, DA — Dalmatian unit, AA — Albanian Alps, BV — Budva unit, KC — Krasta-Cukali unit, PI — Pindos unit, KJ — Kruja unit, JA — Jonic unit, SZ — Sazan unit, IS — Istria.

Central Hungarian Massif and its Projections: MH — Midmountains, BÜ — Bükk, MK — Mecsek, VY — Villany.

Neovolcanic Mountain Ranges: SM — Slovakian Midmountains, BÜ — Börzsony Mts., CS — Cserhát Mts., MA — Mátra Mts., P-T — Prešov-Tokaj Mts., V-G — Vihorlat-Gutin Mts., C-H — Caliman-Harghitei Mts.