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SOME REMARKS ON THE EUROPEAN ALPIDES FROM THE POINT OF VIEW OF SOME ASPECTS OF NEW GLOBAL TECTONICS

Резюме: В этой статье дискутируется о изменениях в земной коре и ее развитии, подчеркивая различия в отдельных областях. В отличии от других мнений, альпийские флишевые троги и флишевые геосинклинали считаются областями уточнения расширения коры похоже как у междуорогенных грабенов Тимок-Среднегорского типа.

Уточнение (расширение земной коры) соответствует по времени с сокращением земной коры в других областях, вызванным складчатостью в неоальпийской структуре (флишевые покровы и депресии) в Западных Карпатах с их тыловой частью в венгерском Среднегорском массиве — являются примером этого.

Периодичность альпийской складчатости имеет более общий широкий задний план. Каждый сегмент Альпид имеет свои особенности развития и структуры, которые являются результатом раличий в зрелости (истории) Предальпийского периода, в отличной пространственной позиции и в отличии характера блоковой структуры.

Abstract: In the contribution a survey of the changes of the earth's crust in the course of development, with the differences in the individual areas, is presented. Also the flysch troghs and flysch geosyncline are being considered as zones of earth's crust thinning-spreading, similarly also the intraorogenic grabens of the Timok-Stredohorje type. Thinning (spreading) of the earth's crust alternates spatially with shortening evoked by folding. The neoalpine structures (flysch nappes-depressions) of the West Carpathians with their hinterland — the Hungarian median mass — are a clear example of it. The periodicity of the Alpine folding displays a wider, more global background.

Each segment of the Alpides, however, shows particularities of development and structure as a result of the difference in earth's crust maturity as early as the pre-Alpine period: of different spatial position and differences in the character of the block structure.

The new ideas are summarized under the common term of global tectonics, concern a number of basic problems of the structure and, in particular, the evolution of the European Alpides, the West Carpathians included.

In the further text, some of these problems will be discussed, which had to face in compiling and editing the Tectonic Map of the Carpatho-Balkan Mountain System. They relate to a) the evolutionary changes of the type of the earth's crust; b) the shortening and spreading of the earth's crust, and the position of folding in the evolution process.

Changes of the earth's crust type during evolution

The essential part of pre-Carboniferous complexes in the Alpides are of eugeosynclinal type with an abundance of magmatic, mainly basic rocks. Frequent ophiolite formations indicate the relics of ancient oceanic crust; aspidic and flysch formations with the predominance of greywackes are regarded as suboceanic. In any case, slight differentiation of facies suggests a developmental immaturity. Limestone masses of considerable thickness are most often associated spatially with basic vol-

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canism. They represented very likely chains of islands (frequent in the pre-Paleozoic of the Rhodope Mts. and the Pelagonian massif, and in the Paleozoic of the Pelagonides, Dinarides and the Marmaros massif).

Frequent acid volcanics, dominantly of ignimbrite type, are most abundant in the Cambrian and Silurian, i. e. in the period of post-Assyntian folding. The first large mollasse complexes appear as late as in the Upper Paleozoic subsequently to the Hercynian orogeny connected with extensive granitization. Only at that time the sialization of the earth's crust did reach a greater intensity. The Hercynian development cycle is thus the first in the evolution of the Alpides that consists oft two stages; eugeosynclinal — Paleohercynian and one of several types — Neohercynian. Some blocks produced by sialization of the earth's crust and by granitization did, of course, exist before the Carboniferous partly possibly as a result of pre-Paleozoic folding, but no specific paleotectonic types of Hercynian rock complexes have developed on them. In the further history, part of these areas formed chains of island. These blocks are represented by the Rhodope, Serbo-Macedonian, Central Carpathian and East Hungarian massifs, which were affected also by distincts Hercynian remobilization of granitoids.

The intensity of Hercynian stabilization and sialization in the Alpides is neither uniform nor universal.

a) In the Alpides there are regions, in which the oceanic and/or suboceanic crust type persisted through the Late Paleozoic to the Mesozoic and the Hercynian granitization is of a small intensity. The principal regions of this type are the Dinarides and Hellenides, where both the Carboniferous and Permian are of marine, oceanic type with interlaid mollasse facies. In these regions the Hercynian orogeny manifested itself by short episodes of small intensity of volcanism as well as deformations. The Triassic of the Dinarides and Hellenides with abundant quartz porphyry and with diabase, porphyrite and basalt occurrences is also generally regarded as eugeosynclinal.

b) The Balkan, South Carpathians and northern zones of the East Carpathians, West Carpathians and Alps are of opposite type: they display extensive stabilization and Hercynian granitization. Upper Paleozoic mollasse facies and peri- or semi- platform type of the Triassic.

c) The southern zones of the East and West Carpathians and Alps (Oberostalpin) show a particular type of the earth's crust, the progressive rejuvenation of which started as early as in the Permian. The mollasse-filled troughs of the Permian foredeeps contain, besides quartz porphyry (due after compressive movements of the Hercynian folding) melaphyre complexes of a great thickness, which link up the nearsurface features with the deep-seated ones.

In the Triassic, three main groups of paleotectonic zones can also be differentiated: The Dinaride type is commonly ranked as eugeosynclinal (see the Tectonic Map of Europe, N. S. Šatskij — A. A. Bogdanov 1960) as well as the South Alpine type (with some allowance). The Balkan, Carpathian and West Alpine types may be characterized as periplatform types. Extensive areas of the Eastern Alps and West Carpathains — Oberostalpin and in part Unterostalpin and Bucovinian — have a dominance of shallow-sea limestone-dolomite complexes which, however, show a spectacular facies differentiation pointig to the dynamics of the sedimentary area. They cannot be classed as eugeosynclinal or miogeosynclinal. Some time ago I have termed this geotectonic type as alpine-type geosyncline (M. Maheľ 1964,

A. Tollmann 1968) called it an aristogeosyncline. From the above-said, the geotectonic heterogeneity of the Triasic in the Alpides is apparent.

Outstanding changes in the earth's crust produced by extensive oceanization are in the Alpides of Jurassic date. The extension of deep-sea facies and more marked facies differentiation are apparent. Besides broad sills (Štramberk, mainly in the South Carpathians and West Dinaric types), sills geanticlinales differentiated into blocks (Tatric and Fatric types in the West Carpathian and Bihor type in the Western Apusins), and narrow ridge zones (Briançon type), there are broad troughs filled with bathyal, dominantly carbonate sediments and narrow troughs of the following types:

— types with the marlstone and radiolarite facies and with suboceanic to oceanic crust (Krížna and Pieniny types in the West Carpathians and the Zukali-Budva type in the Albano-Hellenides and Southern Dinarides);

— types more pronouncedly oceanic with basic to ultrabasic rocks accompanied by radiolarites with a thick claystone-argillite complex of the „schistres lustrés" type (Pennine zone of the Western Alps).

Numerous complexes of basic and ultrabasic rocks (diabases, spilites, gabbro, serpentinites, peridotites) accompanied by radiolarites in the troughs are the most marked manifestation of the oceanization of the earth's crust during the Late Jurassic and Early Cretaceous — perhaps sea-floor spreading. In some interior zones of the Dinarides and Albano-Hellenides, also at the northern margin of the Marmaroš Massif of the East Carpathians, the shallow-water facies predominating in the Permian, Triassic and lower parts of the Jurassic were followed by intensive volcanism (porphyrites, diabases). In the West Carpathians, limburgites and harzburgites occur more frequently in the external parts of the Tatrides and the periklippen area; the Tithonian-Albian interval was safely evidenced as the time of their formation.

In the Late Jurassic and Early Cretaceous, when the development of the Alpides experienced a decisive change due to the outbreak of folding in their southern most areas, the deepening of troughs and the volcanism producing mafic lavas were most intensive and a number of flysch troughs were initiated (East Alpine, West Carpathian, Ceahlau-Severin, Niž-Trojanov, Bosna). They are distributed outside the areas of early Alpine folding processes and generally begin with the pre-flysch or carbonate flysch of Sinaia type, often accompanied by basic rocks. Some flysch troughs were preceded by strong deepening of the sedimentary area, whereas other developed from older Jurassic troughs (e. g. Valais trough in the Western Alps, Vardar trough in the Dinarides and Zukali trough in the Albano-Hellenides) filled with deep-sea radiolarites and basic and ultrabasic rocks. In their geotectonic type they are similar to the pre-Carboniferous formations of the Alpides. Although they contain a smaller amount of volcanic material than the latter and their diastrophic character is due to their origin on the unstable crust, reacting sensitively to the pulse of movements, the flysch troughs recall rather eugeosynclines (regions of crust thinning) than miogeosynclines, i. e. regions of thick sialic crust. This, of course, is not true of all flysch areas. The fact that the flysch facies, in particular the coarse flysch is often the direct predecessor of folding led to the assumption that the flysch sedimentary zones were genetically connected with the periods of shortening, and thus thickening and of the earth's crust in result of the folding processes (J. Auboin 1964, A. V. Peive 1970, V. E. Chain 1971). The geotectonic significance of the flysch complexes however, is more varied (M. Mahel' 1971): flysch of some troughs or geosynclines is altogether free of folding affects, as e. g. the Carpathian flysch zone was not affected by folding although it persisted trough two — the paleo-Alpine and meso-Alpine — folding periods. The influence of the folding process is expressed only by the increased supply of detrital material (e. g. in the Cenomanian) or by the changes of the paleogeographical pattern (Albian — Cenomanian: Paleocene).

The longitudinal intra-orogenic grabens, such as the Timok graben or the graben-synclinorial system of the Stredohorje, represent a particular type within the Alpides. They are filled with pre-molasse formations of extremely varied and heterogeneous facies ranging from dry-land to deep-sea facies. Their localization to the inter-block boundaries and abundant linear volcanism suggest that they originated in the zone of crust thinning-spreading in the interval between the paleo-Alpine and meso-Alpine folding periods.

The last mollasse stage of the Alpides also lacks geotectonic uniformity of the earth's crust. Whereas the thickening of the crust occurred in the foredeeps (volcanic phenomena are scarce), in the Hungarian median mass and at its boundary with the West Carpathians as well as at the contact of the Transylvanian basin with the East Carpathians of the crust an intensive volcanism took place. Several transversal zones of the Internides, i. e. areas earlier consolidated (part of the Rhodope massif towards the end of the Eocene, Central Slovakian region in the Miocene) underwent a similar development.

The Alpine development cycle differs from the earlier cycles in being complete and geotectonically extremely heterogeneous.

The geological trend of the Alpine cycle is expressed by the following succession of formations: 1. detrital formations (Permian-Triassic) continuing the Neohercynian orogenic cycle; 2. carbonate formations with a) the predominance of shallow-water limestones and dolomites — Triassic; b) the abundance of deeper-water limestone, marlstone and radiolarite types — Jurassic; 3. flysch and pre-mollasse formations; 4. mollasse formations. Compared with the earlier development cycles, the Alpine cycle is the first fully developed and completed.

The differentiation of the cycle into the pre-orogenic, late tectonic and post-tectonic (J. Auboin 1970) stages or the pre-orogenic and orogenic stage (M. V. Muratov 1969, V. E. Chain 1972) is, in my opinion, rather schematic, as the maturity of the individual zones is chronologically very different. The mollase, which is typical of the orogenic to post-tectonic stages, is of Piabonian age in the internal zones of the Balkan Mts., and Late Cretaceous in the hinterland of the West Carpathians, while in the foredeep folding occurred still during the latest Miocene.

All development stages of the Alpine cycle are characterized by a prominent geotectonic differentiation. Some types can be classed, with more or less certainty, as the miogeosynclinal ones, others as the classic eugeosynclinal types: in every case, however, we have to ascertain the narrow of such models, which do not allow to apprehend the actual complexity of the Alpine development cycle. It appears reasonable to interpret this complexity in terms of the complicate process of thinning and thickening — compression and tension of the earth' crust.

Shortening and spreading of the earth's crust: its relationship to the folding processes

The thickening of the earth's crust, i. e. sialization, is chiefly the result of being accompanied by folding and granitizatian. The share of these two processes in the development history of the Alpides in variable. In the pre-Alpine, in particular the Hercynian cycle granitization and metamorphism, i. e. deep-seated processes are intensive, whereas in the Alpine-cycle granitization is weak (most frequently connected genetically with volcanism), but folding distinguished by intensive manifestations of the tangential component is very strong. This resulted in an appreciable shortening of the crust, the formation of abundant often rootless nappes, zones of tectonic melange (Klippen Belt), subthrusts, and zones of „engulfment".

The paleotectonic heterogenenity of the development stages of the Alpides was caused not only by the differences in the thickening of the crust in individual areas and zones, but also by the thinning of the crust resulting from its spreading. This induced the origin of longitudinal troughs with linear volcanism as early as in the Permian, when the foundation to the Alpide geotectonic zones was laid (e. g. the Melaphyre complex of the West Carpathians with the Permian of the Choč nappe).

The spreading of the crust, accompanied by the formations of troughs was most intensive in the Jurassic, mainly during the Tithonian. At that time numerous bodies of basalt, limburgite, serpentinite and periodite were emplaced amidst pelagic deep-sea sediments (R. T r ü m p y, 1971, A. V. P e i v e 1970).

Transitions and lateral interwedging of deep-sea, mainly radiolarite facies with shallow-water cordillera facies are known, for example in the Krížna nappe and especially in the Klippen Belt (between the trough type of Pieniny sequences and the Czorsztyn cordillera type). They furnish evidence of the existence of elongated narrow troughs, hardly 10—30 km wide. The peri-platform type of the underlying Triassic, which is common both for the trough and cordillera units, and the gradual differentiation beginning with the Lower Liassic indicate a progressive oceanization induced by the spreading of the earth's crust.

The regional longitudinal troughs at the inter-block boundaries (West Carpathian, Ceahlau — Severin, Niž. Trojanov, Bosna — Vermos), the filling of which begins with the preflysch and basic to ultrabasic volcanics, suggest that these deposits can also be regarded as the manifestations of the crust spreading. The diastrophic type of their sediments of flysch rather resembles areas of a thin, sensibly reacting, unstable crust. The small thickness of the crust would also account for the rootlessness of these masses caused by later compression.

The Upper Cretaceous Timok and Stredohorje grabens with pre-mollase complexes and interior depressions filled with mollase, as well as transversal fault zones distinguished by andesite-rhyolite volcanism are the product of the expansion processes in the crust during a more mature development stage of the Alpides. Especially in the case of longitudinal grabens this is indicated at the boundary of blocks and by the linear type of volcanism.

The alternation and partial overlapping of shortening and spreading processes is well demonstrated in the Permian, at the turn between the Hercynian and Alpine cycles. In the interior zones of the West Carpathians, for example, the longitudinal mollasse basins showing effects of slackening tangential movements passed into troughs, which laid the foundation to the differentiation of the Alpine geosyncline. The character and quality of movements depends on the geotectonic position and thus also on the state of the crust. This would explain the different character of folding processes in the pre-Alpine incomplete cycles.

The most remarkable alternation of shortening and spreading of the crust is connected with the onset of Alpine folding in the Alpides during the Late Jurassic. In that period a number of new troughs were initiated and many existing troughs underwent deepening and oceanization, and the mafic volcanism was most intensive (Hellenides, Dinarides, the Sinaia, Mureš flysch troughs, also in the periklippen area of the West Carpatians).

The spreading-shortening processes are not synchronous in all areas. They markedly alternate, for example, between the Externides and Internides of the West Carpathians. In the period, when in the Flysch Belt and subsequently in the foredeep the shortening of the crust gave rise to the formations connected genetically with the folding of the post-Savian, Early and Late Styrian subperiods, the post-Savian, post-Early Styrian, post-Late Styrian and post-Moldavian basins originated in the internide zones, in result of release movements and normal faulting.

Distinctive of alpine folding is its periodicity. It is of interest that the folding periods in the Alpides (M. Maheľ 1971) correspond in time to the bottom spreading of the Atlantic Ocean (Le Pichon 1968): Late Jurassic — beginning of Early Alpine folding and of the spreading of Atlantic Ocean; Early Cretaceous — more intensive activity of both these processes, Late Cretaceous — period of intraorogenic sedimentation and relative cessation of orogeny and of retarded or interrupted spreading of the ocean bottom; Eocene — meso-Alpine folding (Laramide-Pyrenean) and respreading of the South Atlantic and accelarated spreading in the North Atlantic; Oligocene — period of sedimentation without strong orogenic activity and of the retardation or cessation of ocean-bottom spreading; Miocene — Neoalpine folding and respreading of the ocean bottom. From the above findings it seems probable that folding may be conditioned by agents of more global character. Beyond doubt, however, is the close relationship between the folding periods and the particular character of folding of individual segments. It shows itself mainly by the differences in the intensity of folding, its extent in space, and in the orogenic polarity, but also by the development and spatial distribution of individual stages. These internal relations depend partly on the deep-seated processes, chiefly the convection currents, and in part on the pre-Alpine maturity and the degree of differentiation of the Alpide segments into blocks.

The fact, that most zones of the oceanic and/or suboceanic crust of the Alpine development cycle are rootless indicates a greater intensity of folding in the zones of crust spreading. On the other hand, the Alpides provide examples which show no relationship between the thickness of sediments and the intensity of folding. The most illustrative example of this kind is the Triassic of the Hugarian median mass, which is slightly folded but its complexes attain a thicknees of 4000 to 5000 m, many times greater than is the thickness of the intensely folded Triassic of the Inner Carpathians, related both spatially and structurally.

Conclusions

The type of the earth's crust in the Alpides was changing in the course of development. The most distinct change represents the Hercynian folding linked with an extensive granitization. The first thicker mollasse complexes (Upper Carboniferous — Permian) originated after these processes only. A clear exemplare are the differences in the state of the earth crust in the turning period of the Permian between the Dinarides and the Balkan.

In the Triassic the type of the earth's crust was relatively more stable but differentiated. A more conspicious differentiation with troughs and ridges set in chiefly in the Jurassic; however, it was most distinct to the end of the Jurassic and at the beginning of the Neocomian. In that period oceanization was manifested by extension of deep-water sediments, also with abundant manifestations of mafic magma; the first flysch troughs and a flysch geosyncline (Carpathian) also formed.

Let us, for instance, compare the extent and distribution of Jurassic troughs originated due to stretching of the earth's crust in the West and South Carpathians. In the West Carpathians there are in the Jurassic the Krížna and Pieninic troughs and to the end of the Jurassic the flysch geosyncline at the margin; in the South Carpathians only bathyal troughs are known between the Danubic and Getic areas; specific is here the Timok graben in the Middle and Upper Cretaceous, such one we have not in the West Carpathians. Great differences are in the extent of the Tertiary basins. In the West Carpathians, for instance, they originated in three stages and divide, the Inner Carpathians into a system of horsts and depressions (in the Eastern Alps are essentially distributed in the marginal parts).

During the young Kimmerian period of spreading of the earth's crust trough parts alternated spatially with the first distinct menifestations of Young Wimmerian folding (southern parts of the Dinarides and of the Balkan-Rhodopes). Alternation of earth's crust shortening and spreading is especially distinct in the West Carpathians to the end of the Oligocene, also in the Neogene. Formation of nappes in the outer zones was synchronous with the time of foundation of post-Savian, post-Early Styrian, post-Late Styrian, post-Moldavian basins in the Inner Carpathians and the adjacent Hungarian median mass, accompanied by late geosynclinal volcanism. The periodicity of the Alpine folding (with paleo-, meso- and neoalpine periods) displays a wider, more global connection; interesting is its contemporaneity with the periods of opening of the Atlantic Ocean (in the sense of P i c h o n).

The processes of compressions as well as those of stretching display a different quantity and a particular position, distribution, in each segment. Consequently a different structural plan has formed in the West Carpathians, a different one in the East or South Carpathians, quite a different in the Balkan or Dinarides. There are great differences in the particularities in the individual segments and areas.

The differences in the intensity and in time manifestations of the Alpine folding in the individual segments of the Alpides are discussed more in detail in a work by the author (M. M a h e ľ 1971); in this connection I intend only to stress that there are particularly distinct differences between the segments of a different pre-Alpine maturity of the earth's crust, e. g. between the Balkan and the Dinarides.

Each segments of the Alpides, however, displays its particularities, also with a uniform tendency ressembling a more global background. These differences became distinct already in the intensity of Hercynian folding and of granitization and are particularly manifested in the differences of the types of the Permian, later in the types of the Triassic and in the particularities of the types and distribution of Jurassic and Cretaceous troughs; but also in the extension and distribution of Tertiary basins and of late geosynclinal volcanics. Considerable differences are evident in chronological and spatial distribution as well as in orogenetic polarity of the Alpine folding in the individual segments (M. M a h e ľ 1971). The rootless character of the majority of folded units and troughs (i. e. zones with oceanic and/or suboceanic type of crust) points to a particularly intensive earth's crust shortening, especially in these zones of former spreading. A consequence of the difference in manifestations of folding processes in individual segments are the differences in their structural plan. The cause should be seeked in the inhomogeneity of earth's crust maturity in the pre-Alpine period; in the differences of spatial position (mainly regarding to the course of convection currents). A particular place. falls to the role of faults — in the differences of development as well as of the structural plan of the individual segments — to the abundance and distribution of directions of faults. and their manifestation in time. i. e. to factors controlling the character of the block structure.

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