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HETEROGENEITY OF CRUST AND FURTHER FUNDAMENTAL FACTORS OF PARTICULARITY OF DEVELOPMENT AND STRUCTURE OF THE WEST CARPATHIANS

Abstract: The West Carpathians, perhaps from all Alpine segments, display greatest structural dissection with a whole series of tectonic, units, mostly of nappe character but also with numerous depressions.

This structural variety I try to confront with models initiated by new global tectonics, on the basis of relation of dissection of the Mesozoic geosyncline to the character of Hercynian stabilization and to explain some particularities of the structure of the West Carpathians and linking with the adjacent Alpine segments.

Резюме: Наверно из всех альпийских сегментов, у Западных Карпат самое большое расчленение с целым рядом тектонических единиц, в большинстве случаев имеющих покровный характер, но также с многочисленными депрессиями.

Я пытаюсь сопоставить это структурное разнообразие с моделями введенными новой глобальной тектоникой, на основании отношения расчленения мезозойской геосинклинали к характеру герцинской стабилизации и объяснить некоторые особенности структуры Западных Карпат и связи с прилегающими альпийскими сегментами.

1. Relation of crust heterogeneity to dissection of the Mesozoic geosyncline

So far, only two types of the crystalline, Tatraveporide and Gemeride, were distinguished in the Inner Carpathians. On the basis of the types and amout of pre-Carboniferous magmatites, distribution of Hercynian granitoids and intensity of Hercynian folding we distinguish seven zones of the pre-Mesozoic basement in the Inner West Carpathians. The Zagreb—Zemplin line we consider as the southern margin of the Carpathians, the boundary with the Hungarian central massif (Fig. 1), to which we ascribe a particularly important role in development of the West Carpathians. — The southernmost of the seven zones, the Igar—Bükk zone, represented by the Paleozoic of the Upony and Szendrö hills in Hungary, forms the fundament of the southernmost group of Carpathian tectonic units — the Bükkides (M. Maheľ, 1975). Characteristic of it are lacking Hercynian granitization and weaker Hercynian folding; the Permian is partly marine.

— The northern zone, known as core-zone of the Gemerides, is characterized by a thick group (Gelnica group) of Upper Cambrian—Devonian age with a variegated palette of coarse, fine- rhythmical, volcanogenic flysch and subflysch; with thick volcanoclastics and volcanics of acid and intermediate character (P. Snopková — L. Snopko, 1977). Characteristic of this zone are distinct Hercynian folding and Late Hercynian to Alpine granites.

— The North Gemeride zone is represented by an Early Paleozoic group (Rakovec group) predominantly of flyschoid to aspid type with abundant diabases, bodies of gabbros. The ophiolite character of magmatites (pillow-

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lavas and presence of ulthabsics; Š. B a ja ní k, 1976) indicates a paraoceanic type of crust. The basic rocks are also accompanying stilll Carboniferous marine molasse. Only in the Permian are stronger manifestations of acid volcanism.

— The South Veporide region is characterized by thick bodies of granitoids and migmatites, also migmatized paragneisses and a small portion of basics only. It obvinously represented a zone with thicker crust type already in the Paleozoic. In southern areas Late Hercynian granitoids largely take part in the structure, also accompanied by bodies of Alpine granites.

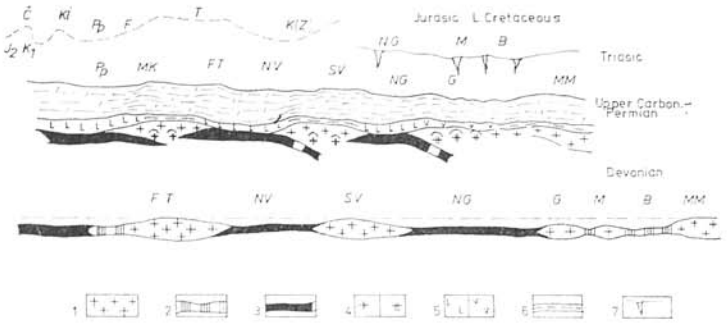

Fig. 1: Scheme of crust development in the West Carpathians during the Paleozoic and relation to Mesozoic geotectonic zones.

1. Granite gneiss layer; 2. Thin dissected continental crust; 3. Oceanic crust; 4. Granite penetrations, a) Late Hercynian to Alpine; 5. Basic volcanics, a) acid volcanics; 6. Sediments; 7. Protrusions of ultrabasics.
FT — Fatra-Tatric zone; NV — North Veporides; SV — South Veporides; NG — North Gemerides; G — Gemerides (Volovec); M — Meliata zone; B — Bükk; MM — Hungarian massif
MK — Little Carpathians; PP — Peripieninic zone (South Penninic); K/Z/ — Krížna (Zliechov) zone; T — Tatric; F — Fatric; KL — Ultrapieninic (Klape) cordiller; Č — Czorsztyn ridge.

— The North Veporide region is characterized by abundant amphibolites accompanied by gneisses and phyllites (S. K l i n e c, 1966). The presence not only of effusive, but also of intrusive basics and ultrabasics testifies to a paraoceanic type of crust. The commencement of Hercynian stabilization was manifested by thinner Devonian — Carboniferous more acid volcanics only.

— The Tatra—Fatric zone includes the essential part of the Tatrides known with large bodies of Hercynian and older granitoids accompanied by migmatites and gneisses.

— The marginal part of the Tatrides we know mainly from the Little Carpathians and Považský Inovec Mts. It is characterized by phyllites, micaschists and gneisses with abundat basics, also gabbrodiorites and gabbros. Probably it represents the southern margin of the wider Periklippen Belt with originally paraoceanic type of crust. Penetrations of granitoid bodies into weaker metamorphosed complexes indicate its transition to the south into

the zone with continental type of crust; to the north perhaps to the Peri—Penninic zone.

Considered from the aspect of global tectonics it is necessary to count with subduction of zones with oceanic or paraoceanic type of crust already in the time of Hercynian folding and so with spatial approaching of zones of different crust type.

In the time of Hercynian paroxysm, in places in the Upper Carboniferous, elsewhere ain the Permian, longitudinal troughs formed at margins of zones with intense granitization. The molasse character and considerable share of acid volcanics, mainly of pyroclastics, are considered as manifestation of general cratonization. The distribution of the Permian, however, in several zones with thinner type of crust or at the margin of granite bodies and the characteristic features of the Permian in each zone show that already in that period the beginnings of dissection of the Carpathian geosyncline were evident.

The heterogeneity of crust, stressed by Hercynian stabilization but partly determined already by the whole Paleozoic development was distinctly manifested in formation of dissection of the geosyncline in the time of the Mesozoic. In the Triassic the southern zones were activated undergoing weakest Hercynian stabilization. In the southernmost part of the Carpathians, in the Igal—Bükk zone, where also the Permian is prevailingly marine, a dissected sedimentation area with not less than five structural-facial zones formed already in the Middle Triassic. There are the complexes: — of carbonates with diabases, porphyries and quartz porphyries in the south in the Bükk Mts., in the north the Meliata group.

— the flysch complex, radiolarites and ophiolites (in the area of the Darnó line; K. Szepesházy, 1971),

— variegated complex of carbonates with pelites and turbidites with pillow-lavas, gabbros and peridotites,

— carbonates with lesser portion of tuffs in the Silica nappe.

Already in the Triassis dissection was manifested also in the North Gemeride zone, in the sedimentation area of the North Gemeride, Strážov and Choč nappes. Besides the complexes with shallow-water facies (also here mainly in the Ladinian and Carnian) there are also a succession of basin facies (Biely Váh group), and weaker manifestations of basic volcanism, also protusions of ultrabasics in the North Gemeride zone.

In the Jurassic, in the period of onset of general oceanization in the Alpides, distinct troughs formed mainly in northern zones with weaker Hercynian stabilization. Conspicuous is the through located in the North Veporide zone: the sedimentation area of the Krížna nappe with pelitomorphic limestones and radiolarites (Zliechov group) and further trough at the northern margin of the Tatrides — Fatric trough. More northerly, was the Kysuca trough (M. Maheľ, 1979) in the Klippen Belt.

The heterogeneity of crust, formed in the Hercynian stage, became decisive for structural-facial dissection of the West Carpathian Mesozoic geosyncline (M. Maheľ, 1978). Splitting and spreading of crust and protrusions of ultrabasics in the Triassic equally as oceanization in the Jurassic and Lower Cretaceous are incontestably manifestations of global character but bound

to zones of thinner crust, thus to zones determined spatially and in extent by the state of crust formed by Hercynian stabilization.

In our conception toughs are a result of thinning of crust of of „activation" of already previously thinner crust and not a result of opening of rifts — quasi-platform or platform. We consider the occurrences of ultrabasics in some zones as protrusions in the time of crust splitting accompanied by manifestation of basic volcanism (e.g. in the North Gemeride Triassic; M. Mahel, 1978). So besides global factors directing development of the geosyncline and securing linking of the West Carpathians with the whole system of the Alpides also factors securing connection of the Alpine geosyncline with the Hercynian pre-history played an important role.

Strutcural— facial dissection, with narrow troughs, is contradictory to wide oceans.

2. Structural-facial dissection and paleotectonic contrastness

Contractness with paleotectonically antagonistic complexes is a feature characteristic of the West Carpathian geosyncline, which we encounter in the southern units from the Triassic (couples trough — ridge of Meliata—Silica, Čierny Váh, Biely Váh); most distinct (the couples: Zliechov—Vysoká, Tatric — Fatric, Czorsztyn — Kysuca) it it in the Jurassic and Lower Cretaceous. It is, however, also shown during the flysch period in the Cretaceous: Godula — Tešín nappe. More noteworthy is that two antagonistic — complementary types often occur in the same trunk tectonic unit, in its partial nappes. Characteristic is large representation of so called transitional sequences. A clear or extreme example is just the Klippen Belt. Complexes with paleotectonically distinct ridge and distinct deep-water members are more rare than mixed, transitional here. Often each structural element — klippe has a different succession of facies; indentation of paleotectonically antagonistic members, changes at short distance also in the same structural element are frequent, that all points to a great dissection but also not great width of the individual paleogeographical elements.

Alternation of various types of crust in the Carpathian geosyncline was reflected not only in its great structural — facial dissection but also in its mobility. Global factors gave impulses to movements, directed time acceleration of compressions (phases) and the direction of movements. The heterogeneity of crust together with the role of the Hungarian central massif, however were taking part in formation of structural particularities of the West Carpathians.

3. Heterogeneity of crust and structural particularities of the West Carpathians

a. The role of the Hungarian central massif

The Hungarian massif represented a hinterland, from which the wave of activation of geosyncline was spreading, which began north of it in the Triassic, equally as the following wave of compression with formation of the oldest Neokimmerian units northerly at its northern margin. Later, at the northern margin of the Hungarian massif mainly in the Oligocene, the trough

of early molasse formed with the first manifestations of intermediate volcanism. There is obviously a back-deep, as reverberation of the fore-deep in the Carpathians. The further three stages o formation of depressions with accompanying late-geosynclinal volcanics in the Hungarian massif as well as in the Inner Carpathians are a reaction to compression in the outer zones. Alternation of compression, accompanied by formation of nappes with dilatation with formation of basin is more distinct in the West Carpathians (M. M a h e l, 1974) than elsewhere in the Alpine system of central and southeastern Europe. So we have Savian, Early Styrian, Late Styrian and Moldavian tectonic units — nappes, also basins (Fig. 2). The accompanying late geosynclinal volcanics are also of four stages, Oligocene, Lower Miocene, Badenian—Sarmatian and Pliocene. Also sinking of the Hungarian massif, connected with thinning of crust, alternating distinct uplifting of the Carpathians to the end of the Neogene, indicates its significant role ni directing subcrustal convection currents.

b. S t r u c t u r a l i n d e p e n d e n c e o f t h e g e o t e c t o n i c z o n e s of the West Carpathians is much more distinct than in the Alps and East Carpathians, where the Neoalpine and Paleoalpine area overlaps the area of distinct Mesoalpine folding with a thic inter-orogenic type of thick Upper Cretaceous and Paleocene. In the West Carpathians this Mesoalpine stage is manifested only in the narrow zone at the contact of the Outer and Inner Carpathians, in the Klippen Belt and Perilippen zone. This whole Paleo—Mesoalpine zone from the Alps as far as the East Carpathians has obviously an analogous fundament, mobile basement. It is

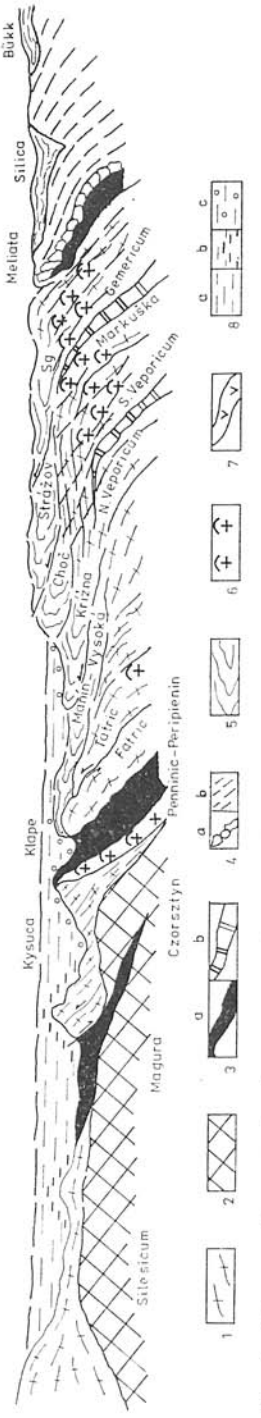

Fig. 2. Scheme of crust development in the West Carpathians to the end of the Albian and in the Lower Cenomanian. M. M a h e l, 1980

1 — Granite — gneiss layer; 2 — Upper mantle; 3 — Subduction zones a) of oceanic, b) paraoceanic crust; 4 — a) occurrences of high pressure metamorphism (glaucophanes); b) regional Alpine metamorphism; 5 — Overthrust units; 6 — Granite penetrations; 7 — Volcanism (acid-basic) of the island zone; 8 — a) Flysch, b) couch rouge, c) wildflych.

perhaps the southern branch of the Penninic. A particularity of the West Carpathians is the Eocene post-tectonic flysch continuing from south, bound to a system of early interarc downwarpings or early depressions, which obviously are a reaction to distinct shortening of the outer zones or to underthrusting of the Penninic below the Tatric (K. Birkenmajer, 1978). The causes of the differences between the Alps and West Carpathians it is necesary to seek in differences in crust dissection.

Owing to great dissection of the geosyncline conditioned by heterogeneity of crust in the West Carpathians are more distinct limiting boundaries of some tectonic units, development and structural independence of the principal zones. Perhaps therefore is there also more distinct orogenetic polarity.

The heterogeneity of crust is mainly manifested in structural independence of tectonic units in the West Carpathians, more distinct than elsewhere. A clear example is the Krížna nappe analogous to the Frankenfels nappe but formed much more independent in content and structure on a different type of crust, in a sedimentation area separated paleogeographically from the adjacent nappes of Oberostalpin type and not as their marginal element as in the Eastern Alps.

c. Linking of tectonic units of the Alps and Carpathians — Penninic in the West Carpathians.

Continuation of the Oberostalpin into the Carpathians is indubitable (A. Tollmann, 1962; D. Andrusov, 1968).

Even some partial nappes may be parallelized, e. g. the Lunz nappe with the Biely Váh nappes, the essential part of the Ötscher with the Strážov nappe. A conspicuous difference is, however, in distribution of the Paleozoic basement there; in the Alps rear part of the system of nappes, in the Carpathians distributed as far as the near-root zone and the presence of thick melaphyre bodies in the Carpathians in the Permian of the Biely Váh and Čierny Váh nappes.

Newer knowledge shows that also the long disputable question of linking of the Tatrides with the East Alpine units is clearing up. The Paleozoic groups in the Little Carpathians essentially represent prolongation or at least analogues of lower Unterostalpin nappes. As a whole, however, the Tatrides display their specific character in the presence of large bodies of Hercynian granites and migmatites.

With assignment of the Tatrides to the Unterostalpin, in our opinion, the question of continuation of the Penninic to the West Carpathians is solved. It is represented by immediately more northern units, than the Tatride units. Such one is also the Klippen Belt with the southerly lying Periklippen zone. We consider the Klippen Belt as dissected Intrapenninic arc, with manifestations of more intense volcanic activity in the so called Ultrapenninic ridge from the Dogger to the Albian (M. Rybár — J. Kantor, 1978). The Southern Penninic, running along the whole Alps and known also from the eastern end of the Alps (Rechnitzer group), most probably continues to the Carpathians south of the Klippen Belt and in the basement of the Periklippen zone, very active from the Upper Cretaceous. The northern part of the Tatride Mesozoic, the so called Fatric with deep water type of the Jurassic and Lower Cretaceous, may be also considered partly as analogue of the Southern Penninic or its inner marginal part (M. Mahel, 1979). The Klippen Belt displays

a whole series of content and structural particularities, unknown in the ridge zone of the Penninic.

We consider as the northern branch of the Penninic the lower structural stage of the Magura nappe in the Flysch Belt, which emerges at surface in slices in the Pieniny Mts. at the northern margin of the Klippen Belt (K. Birkenmajer, 1975). Its part are perhaps the Upper Jurassic—Lower Cretaceous flysch sequences with basic rocks in the western end of the East Carpathians in units of the „Black Flysch" and the Ceahlau nappe.

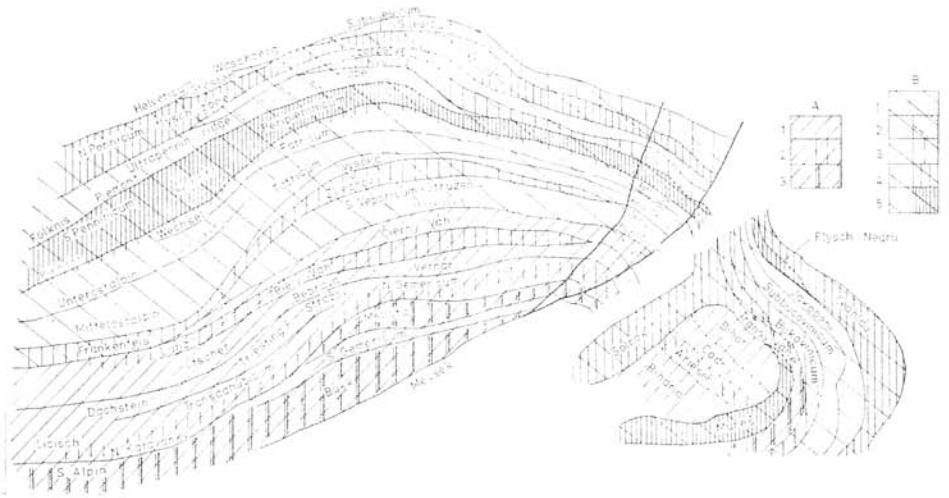

Fig. 3. Scheme of structural-facial zones of the Mesozoic geosyncline of the West Carpathians and their linking to the region of the Eastern Alps, East Carpathians and Apusens. M. Mahel', 1980.

A — Triassic geocyncline. 1 — mobile shelf; 2 — intrashelf depressions; 3 — troughs with ophiolitoids. B — Jurassic — Lower Cretaceous geosyncline. 1 — intraoceanic ridges; 2 — insular volcanogenic cordiller; 3 — marginal sea; 4 — troughs with thin continental to paraoceanic crust; 5 — troughs with oceanic type of crust.

In the last years, at models inspired by new global tectonics, the Tatrides are ranged as nappes thrust from the south over the Veporides (J. Horváth et al., 1979; S. Vrána, 1980; B. Lešku, 1978). The presence of newly found extensive occurrences of Alpine granites in the Veporides and earlier known distinct manifestations of Alpine metamorphism (progressive and regressive) are the basis for parallelization of the Veporides with the Penninic. These views do not take into regard paleogeographical and structural relations of the crystalline and Meoszoic units, proved by generations of geologists, according to which the Tatric is unambiguously a unit more northern than the Veporide units. Even new knowledge does not change it, indicating that the allochthonous position of granitoid masses is of much wider extent in the Tatrides than it was supposed.

So far as the Veporides are concerned, already in the first part of the article we mentioned division into two types of crust, the North and South Veporide, changed into basement nappes: the North Veporide with paraoceanic type of the crystalline — root zone of the Krížna nappe and southern, Kráľova hoľa nappe with prevalence of pre-Alpine granitoids and migmatites with the so called Struženík metamorphosed Mesozoic. Both nappes of the crystalline are rooted in the south and just in these root areas are larger bodies of Late Hercynian to Alpine granites and manifestations of intense Alpine overheating. The Kráľová hoľa system of nappes is most probably an analogue of the Mittelostalpin.

An example of greater changes of the Alpides from segment to segment are the Bükkides. These represent in the paleogeographical picture a branch of the Southern Alps (K. B a l o g h, 1952), however, structurally they are indubitably part of the West Carpathians, their southernmost complex of partial units.

It is evident from the above mentioned that the majority of tectonic units are linking the Alps and Carpathians, what is logical for preservation of a uniform system. Several tectonic units, although passing from one segment into other of the Alpides, display changes either in content or in structural relations to adjacent units.

Number of subduction zones

Assignment of the Bükkides to the West Carpathians and the presence of blue schists with glaucophanites (with radiometric values 145; 85 mil.y., oral communication of J. K a n t o r) results in considerations about location of a subduction zone in these southernmost parts of the Carpathians in the Bükkides.

A further subduction zone was represented by the Klippen Belt and adjoining branch of the Penninic. Also here J. K a n t o r mentions glaucophanites, indicating subduction already to the end of the Jurassic (138 mil. y.) induced by plate underthrusting however, difficult to explain. The particularity of deep tectonic styles with directed recrystallization in the individual zones of the crystalline (M. M a h e ľ, 1978) of the Inner Carpathians and squeezing out of the extensive Krížna nappe, its North Veporide root zone and of the Choč and North Gemeride nappes from the North Gemeride zone force to consider further Paleoalpine subduction zones, perhaps of second order.

We think that the extent of crust heterogeneity has influence on structural dissection, also on the type of shortening and number of subduction zones. The movement of plates, including underthrusting, is a more global evidence. This stimulates and processes of compression taking place in the crust are linked with it. Their effects are, however, determined by the conditions in the individual segments, the number of zones with thin continental, paraoceanic and oceanic crust. The degree of crust heterogneity (mainly massifs of granitoids) plays an important role there.

Conclusions

Global factors obviously secured a uniform trend of development of the whole Alpide system, homogeneity of the whole system. The particularities of development and structure of its individual segments, are, however, a consequence of differences in Hercynian consolidation. The dependence of dissection of the Alpine geosyncline on the degree of crust heterogeneity caused by Hercynian consoliation is a manifestation of linking of the Hercynian stage of development with the Alpine, manifestation of inheritance in development of folded mountains.

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